A Level

Article No. 212

Biology 9700

Paper-2

Topical Workbook
Updated Till – 2022

- All variants
- Mark Schemes
- References of repeated questions added
- Questions order new to old
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Unit 1

CELL STRUCTURE

A Level
Biology Paper 2
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Syllabus

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Unit 1: Cell Structure

1. **O/N 21/P22/Q1/a**
There are two types of cell, prokaryotic and eukaryotic. Bacterial cells are prokaryotic and plant cells are eukaryotic.

(a) There are differences in the structural features that are common to bacterial cells and plant cells. For example, the cell surface membrane in a plant cell contains cholesterol, but in a bacterial cell the membrane contains molecules known as hopanoids. Cholesterol and hopanoids have the same function.

Some of the main structural features common to both types of cell are shown in Table 1.1.

Complete Table 1.1 by giving **one** difference between a bacterial cell and a plant cell for each structural feature listed.

The difference between the cell surface membranes of the two types of cell has been completed for you.

Table 1.1

feature common to bacterial and plant cells	bacterial cell	plant cell
cell surface membrane	contains hopanoids	contains cholesterol
ribosome		
DNA		
cell wall		

[3]

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2. O/N 21/P21/Q1/a(i)

(a) Fig. 1.1 is a transmission electron micrograph of cells from the leaf of a plant.

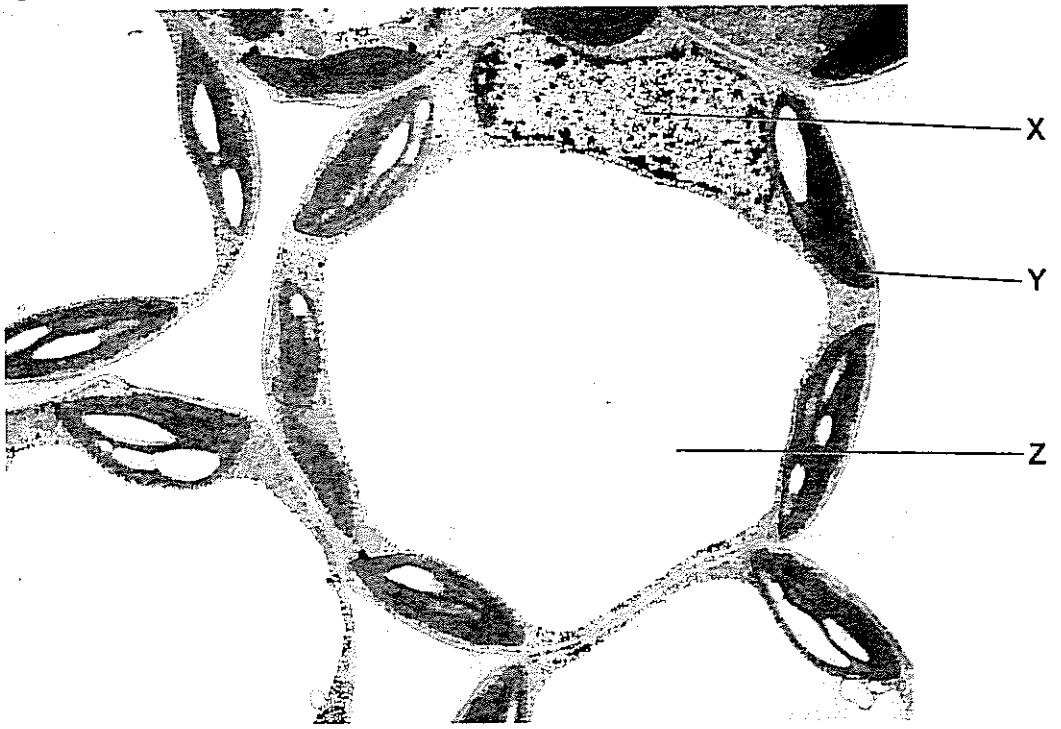


Fig. 1.1

(i) Name the cell structures **X**, **Y**, and **Z**.

X .....

Y .....

Z ..... [3]

3. O/N 20/P22/Q4/a

In the immune system, a plasma cell develops from an activated B-lymphocyte. Mature plasma cells synthesise and secrete antibody molecules.

(a) Fig. 4.1 is a diagram of a transmission electron micrograph of a plasma cell.

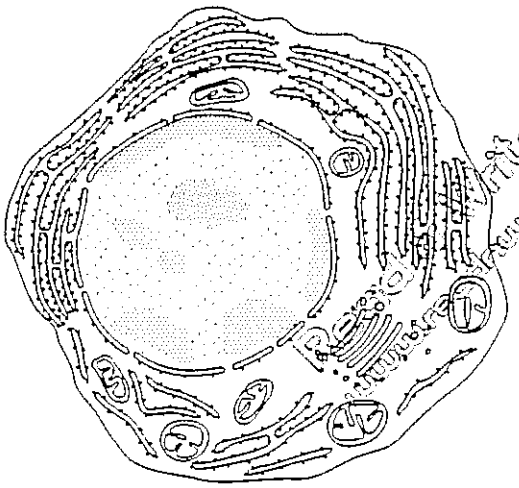


Fig. 4.1

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The plasma cell can be seen in greater detail using an electron microscope compared with using a light microscope.

(i) Describe the **extra** detail of the nucleus that can be seen using an electron microscope.

.....

.....

..... [3]

(ii) Explain why cell structures, such as ribosomes and the rough and smooth endoplasmic reticulum, cannot be seen using a light microscope.

.....

..... [2]

4. O/N 20/P21/Q4/a,b(i)

(a) Fig. 4.1 is a scanning electron micrograph of a section of a plant cell wall.
In living plant tissue cytoplasmic strands form part of structure **W**.

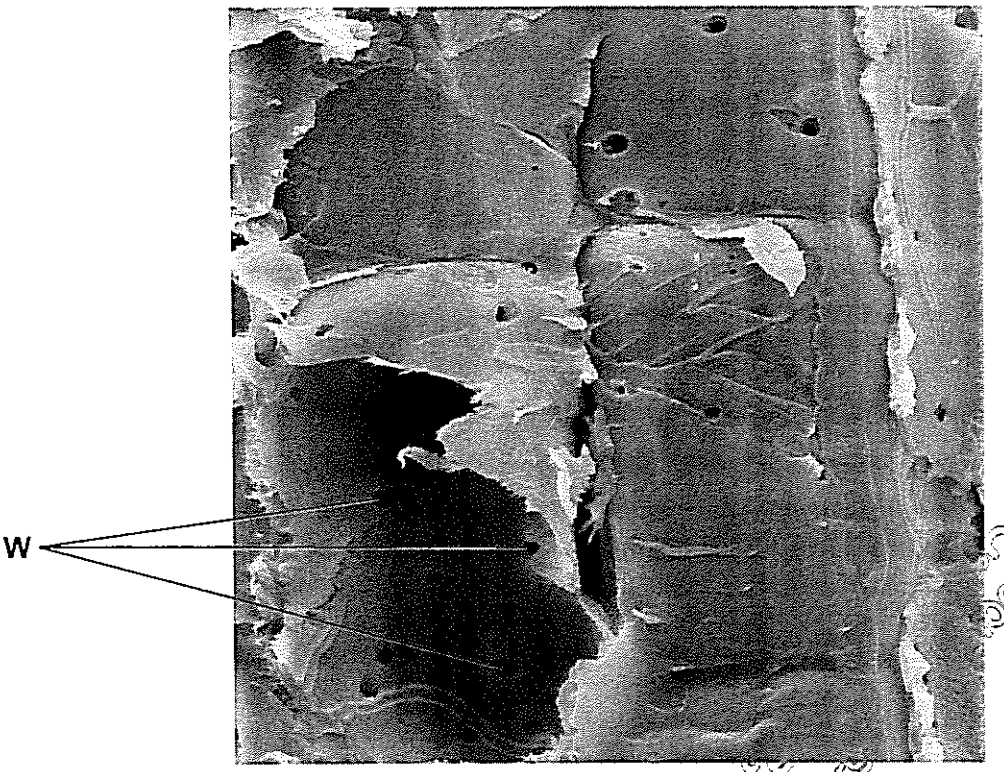


Fig. 4.1

(i) Identify the structures labelled **W** in Fig. 4.1.

..... [1]

(ii) Describe the function of structure **W**

.....

..... [2]

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(b) Viruses can infect plant cells.

(i) Outline the key structural features of a virus.

.....

..... [2]

5. O/N 20/P23/Q6

(a) Fig. 6.1 shows *Vorticella*, which is a single-celled organism that lives in freshwater. *Vorticella* has many cilia which it uses for feeding.

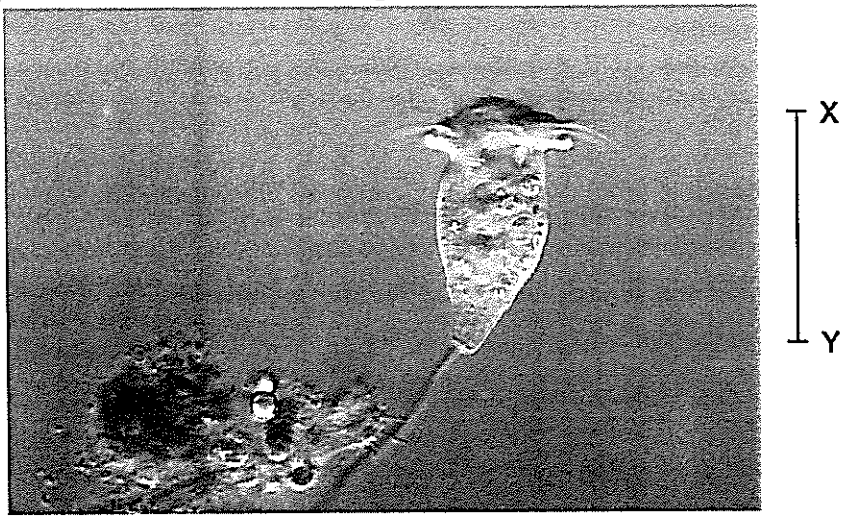


Fig. 6.1

The distance shown by **X–Y** on Fig. 6.1 is 150 μm.

Calculate the magnification of Fig. 6.1.

State the formula that you will use and show your working.

Write your answer to the nearest whole number.

formula

..... [3]

(b) The food particles are taken into the gullet by a current of water created by movement of cilia. Any particles suspended in the water, such as bacteria, are taken into the cell as shown in Fig. 6.2.

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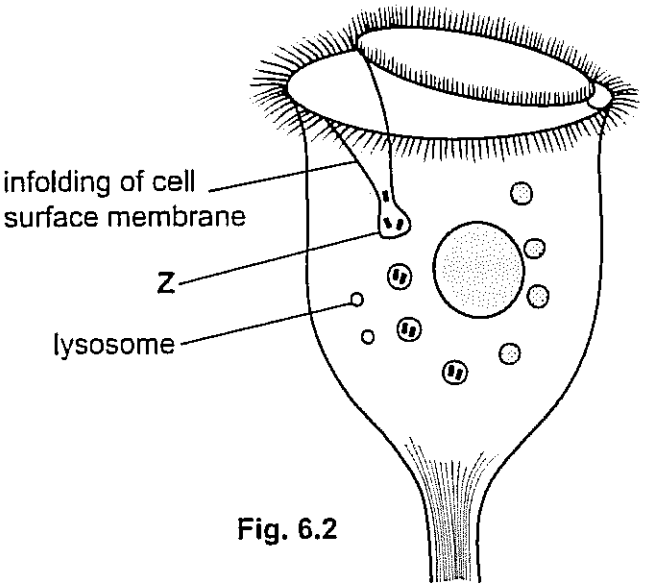


Fig. 6.2

(i) State the name of the process which takes the bacteria into the cell at **Z and** describe the way in which it occurs.

name .....

description .....

..... [3]

(ii) Describe the role of lysosomes in intracellular digestion in *Vorticella*

.....

.....

..... [3]

6. M/J 20/P22/Q1

Picornaviruses are small viruses that are 30 nm in diameter. Picornaviruses are able to enter the cells of mammals and birds and can replicate within these cells.

Fig. 1.1 shows the entry of a picornavirus into its host cell.

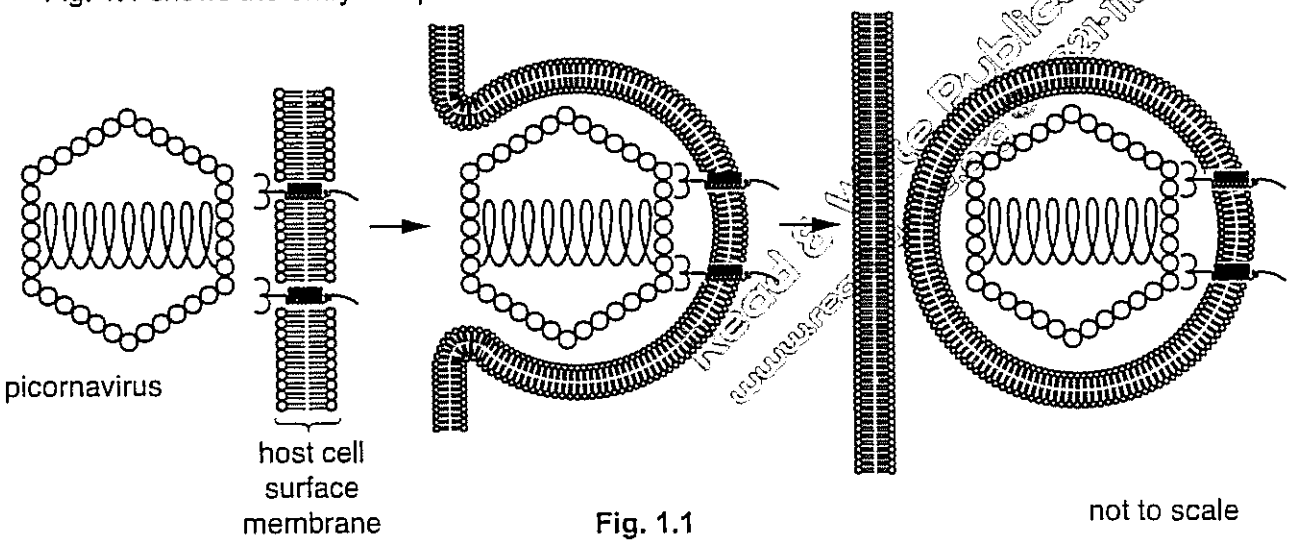


Fig. 1.1

not to scale

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(a) State the key features of a virus, such as picornavirus.

.....

..... [2]

(b) State, with reasons, whether a picornavirus can be seen using the light microscope.

.....

.....

..... [3]

(c) With reference to Fig. 1.1, describe how the picornavirus enters the host cell.

.....

.....

..... [3]

7. **M/J 19/P23/Q2/a**
Fig. 2.1 is a photomicrograph showing a transverse section through a bronchus and the surrounding lung tissue.

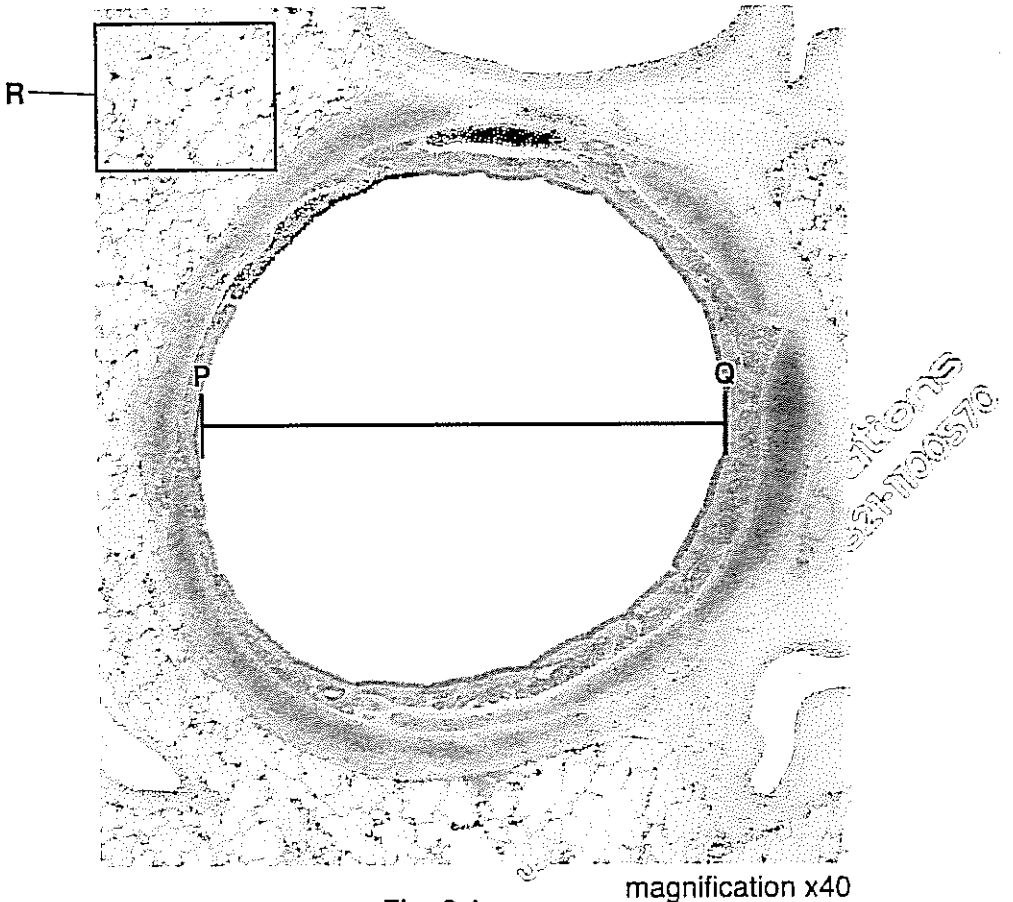


Fig. 2.1

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(a) Calculate the actual diameter of the lumen of the bronchus using 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]

8. O/N 18/P22/Q4/a
Viruses share common structural features. Some viruses, such as human immunodeficiency virus (HIV), also have an outer envelope as part of their structure.

(a) Outline the key structural features of viruses.

.....

.....

..... [3]

9. O/N 18/P22/Q6/a
As a red blood cell matures, cell organelles are lost from the cell. This provides more space for the haemoglobin molecules that have been synthesised.

(a) The red blood cell has a short lifespan due to the loss of the nucleus and other organelles.
State **one** function performed by each of the organelles listed, before they are lost from the developing red blood cell.
rough endoplasmic reticulum

.....
Golgi body

.....
centrioles

..... [3]

10. O/N 18/P21/Q4/a
Fig. 4.1 is a photomicrograph of a cross-section of a tubular structure in the kidney made from epithelial cells.

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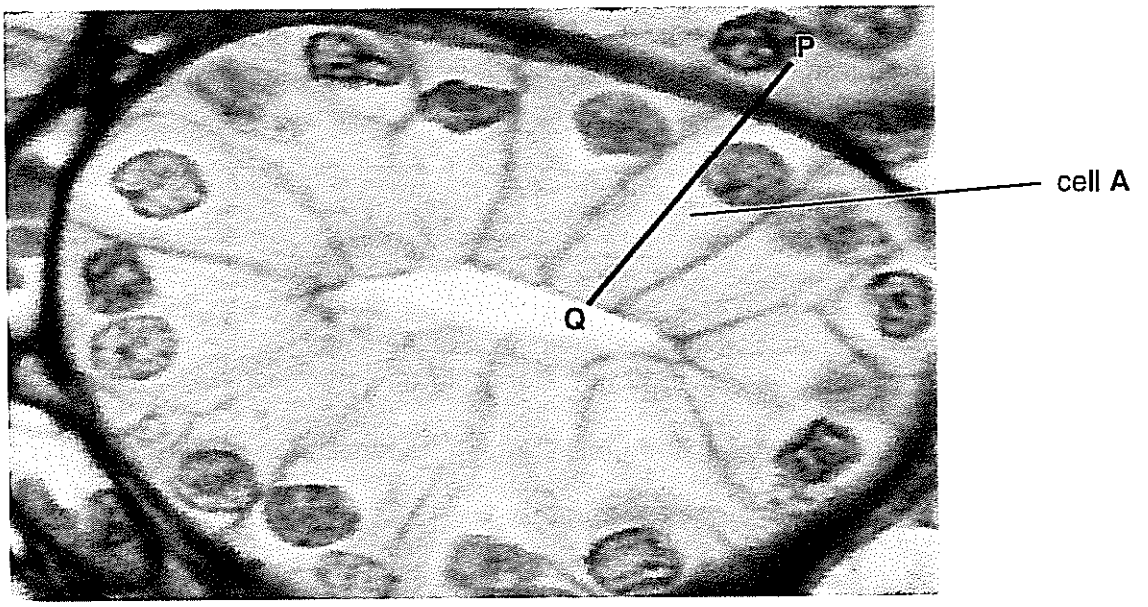


Fig. 4.1

(a) The actual length of epithelial cell **A** along the line **P–Q** is 35 μm.
Calculate the magnification of the image shown in Fig. 4.1. Write down the formula and use it to make your calculation. Show your working.

formula

magnification × ..... [2]

11. O/N 18/P21/Q5/a

(a) Fig. 5.1 shows the structure of a prokaryotic cell.

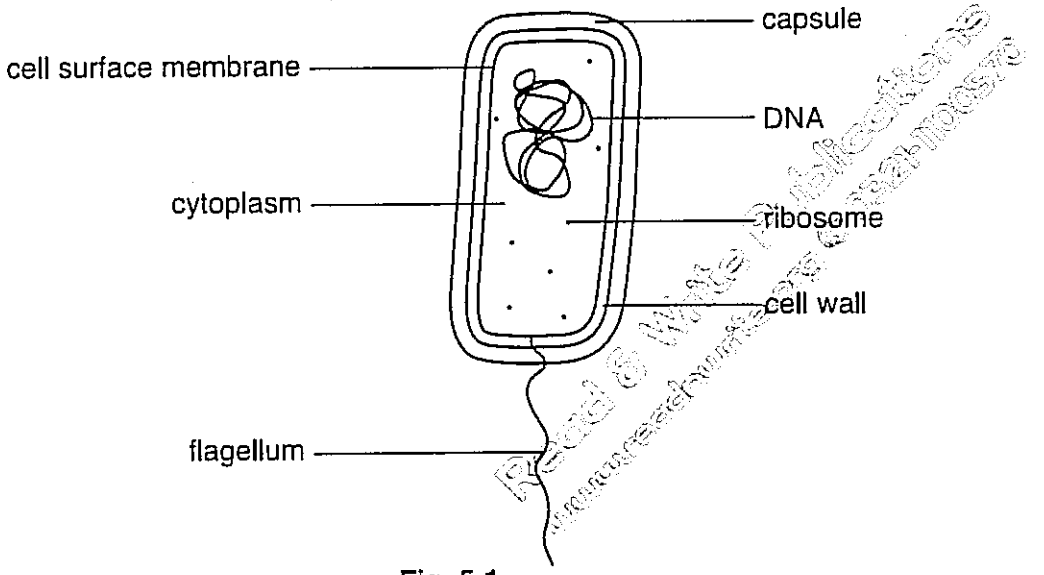


Fig. 5.1

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Fig. 5.1 has **not** been fully labelled to confirm that the cell is prokaryotic.
State what **other** information could be added to **two** of the labels to confirm that this cell is prokaryotic and **not** eukaryotic.

.....

..... [2]

12. O/N 18/P23/Q1

(a) Aphids are small insects which feed directly on phloem sap.
The salivary glands of aphids have secretory cells that make and release a variety of proteins that assist in feeding.
Fig. 1.1 is a transmission electron micrograph of a small area of a salivary gland cell of an aphid.

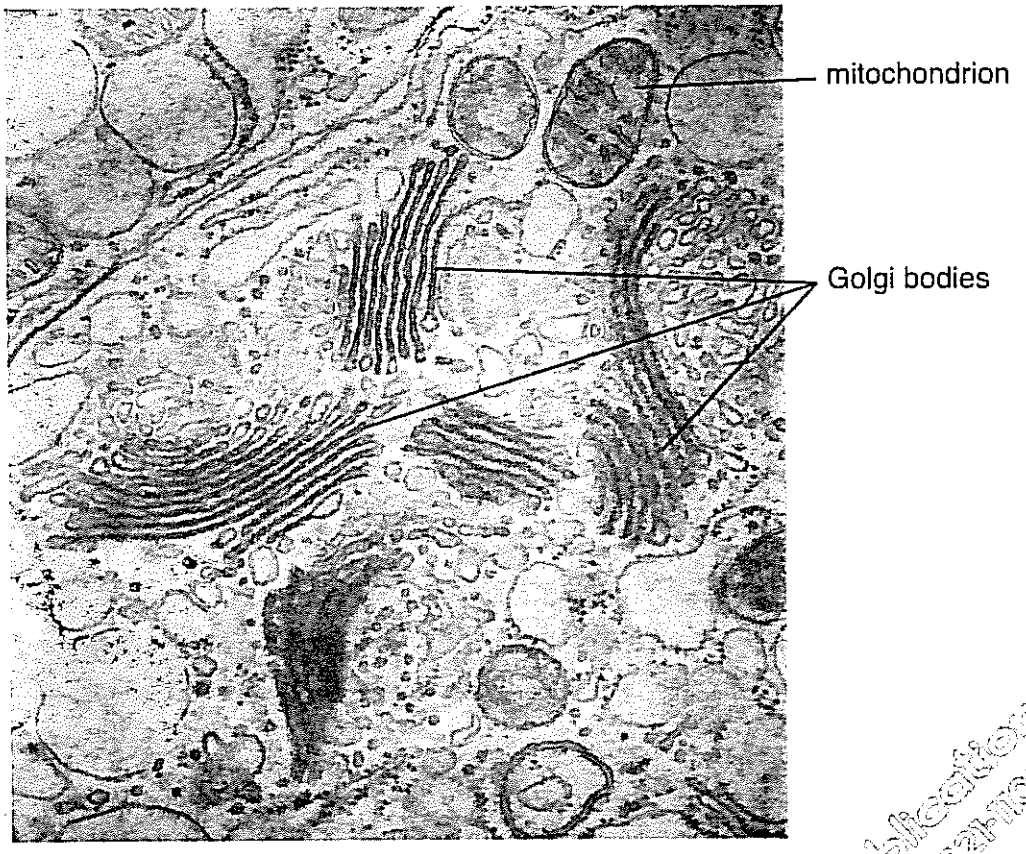


Fig. 1.1

Describe the role of Golgi bodies in secretory cells, such as the salivary gland cells of aphids.

.....

.....

..... [3]

(b) (i) Explain why secretory cells have large numbers of mitochondria.

.....

..... [2]

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(ii) Mitochondria are partly controlled by the nucleus, but can also function independently. Suggest the features of mitochondria that allow them to function independently of the nucleus.

.....

..... [2]

(c) Aphids are important vectors of plant viral diseases.

(i) Describe the structure of a typical virus.

.....

.....

.....[3]

(ii) Suggest how viruses are able to pass from one plant cell to the next without crossing membranes.

.....[1]

13. M/J 18/P22/Q1/a,b,c

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

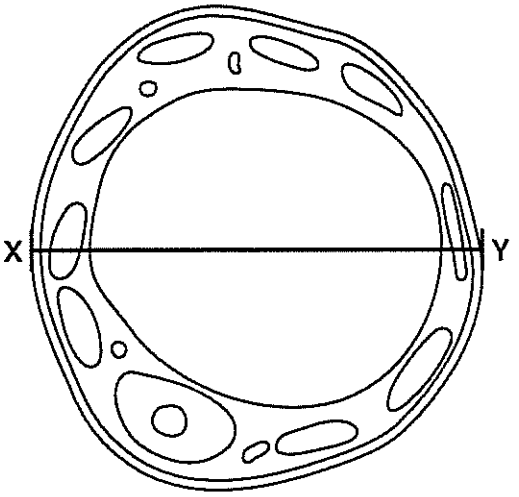


Fig. 1.1

(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**.

.....

..... [2]

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(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]

14. M/J 18/P21/Q1
Fig. 1.1 is a transmission electron micrograph of a cell from the root of thale cress, *Arabidopsis thaliana*.

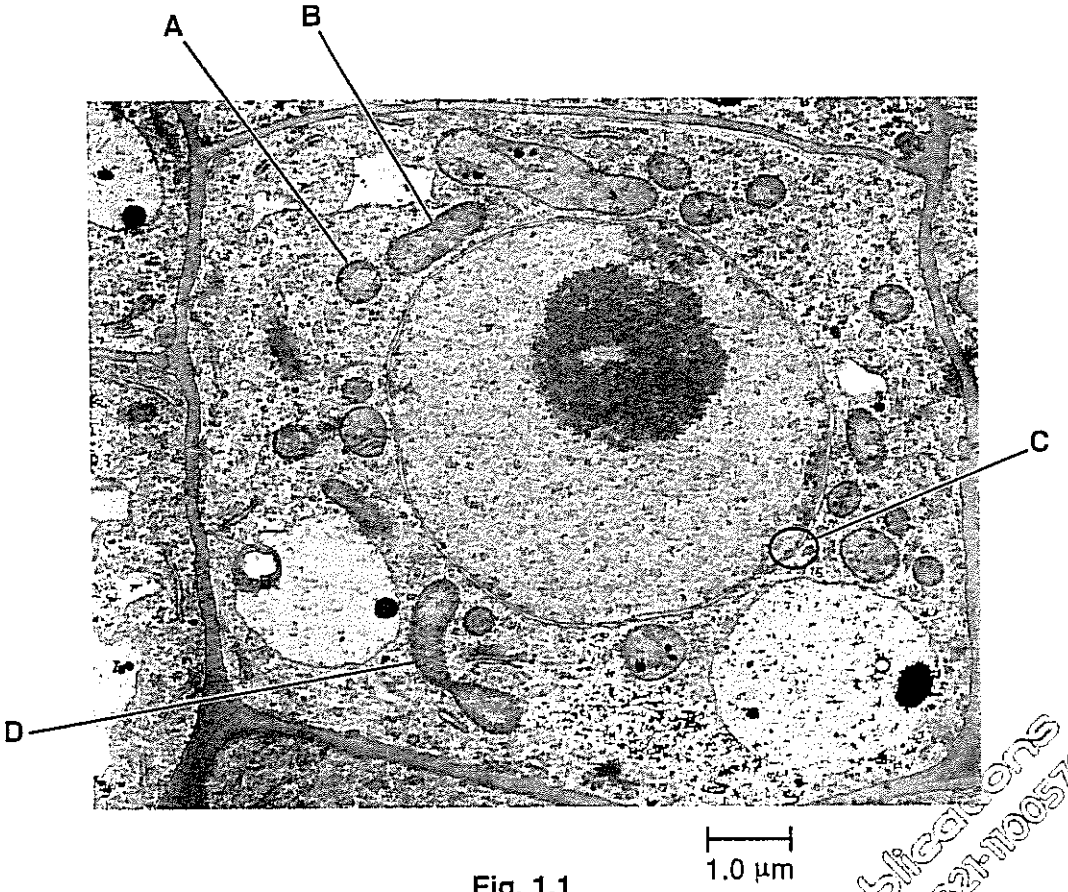


Fig. 1.1

(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.

..... [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.

.....

..... [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.

.....

.....

.....

..... [4]

15. M/J 18/P23/Q6/b

(a) 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]

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16. O/N 17/P21/Q5/a,b,c

Fig. 5.1 is a transmission electron micrograph of part of a cell.

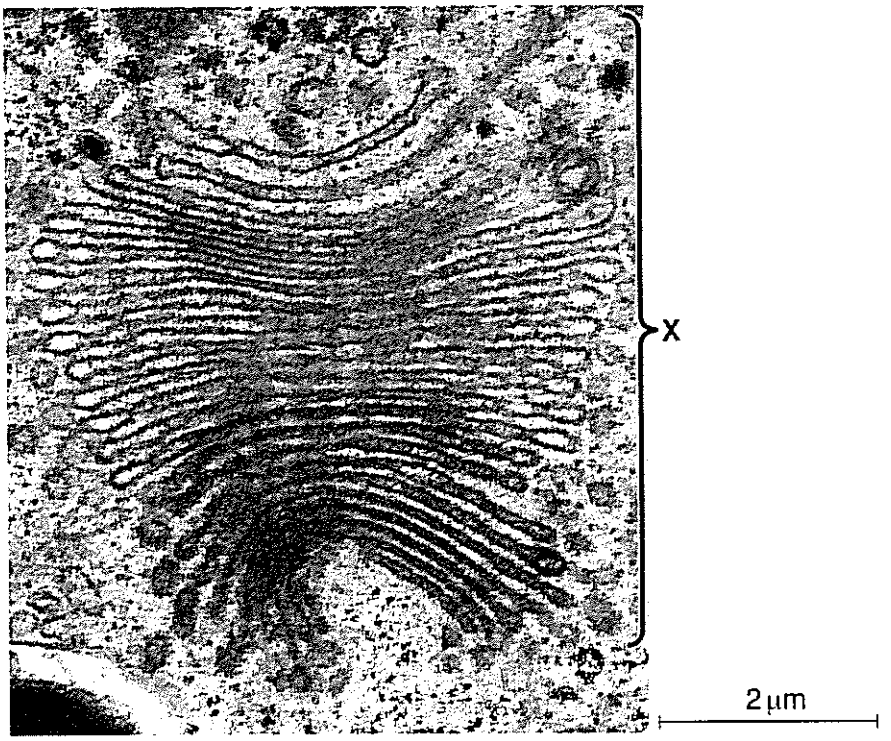


Fig. 5.1

(a) (i) Name the organelle labelled **X**.

.....[1]

(ii) Put a tick (✓) in the box beside the type, or types, of cell that contain this organelle.

animal cell	
plant cell	
bacterial cell	

[1]

(b) Use the scale bar to calculate the magnification of Fig. 5.1.
Write down the formula and use it to make your calculation. Show your working.

formula

magnification × .....[3]

(c) The organelle in Fig. 5.1 is made from structures surrounded by a single membrane.
Name **two** organelles that are surrounded by double membranes.

.....[2]

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17. O/N 17/P23/Q1

Fig. 1.1 is a transmission electron micrograph of a part of an animal cell.

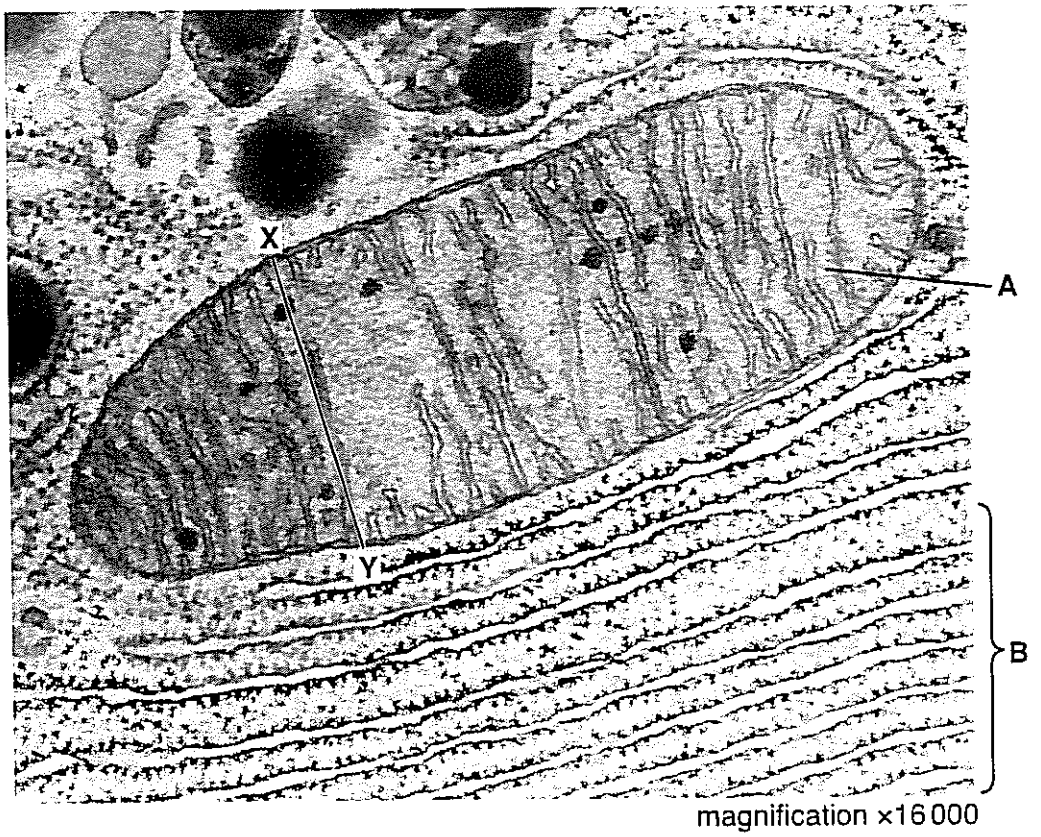


Fig. 1.1

(a) Calculate the actual width of the organelle labelled **A**, as shown by line **X–Y**.
State the formula that you will use and show your working.
Give your answer in μm and to one decimal place.

formula

..... μm [3]

(b) (i) Name the organelle **A** and state its role in cells.

name .....

role .....

[2]

(ii) Name the cell structure labelled **B** and state **one** reason for your answer.

name .....

reason .....

[2]

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18. M/J 17/P22/Q1/a

(a) In multicellular organisms, the structure of different cell types is adapted to their function. Within these cells there are a number of different organelles, each with a particular function. Table 1.1 contains information about the structure and function of five different types of cell. The table also includes, for each type of cell, one example of a cell organelle that is essential for the function to be carried out.

Complete Table 1.1.

Table 1.1

type of cell	function of cell	example of organelle required to carry out function
palisade mesophyll		chloroplast
Leydig	synthesis of steroid hormones	
	production of secretory vesicles for release of antibody	Golgi body
root hair cell	active uptake of mineral ions from the soil	
pancreas acinar	synthesis of enzymes	

[5]

19. M/J 17/P21/Q1

(a) Each of the statements **A** to **D** describes a structure found in eukaryotic cells. Identify the structure that is described in each statement.

A An organelle that contains 70S ribosomes.

.....

B A thread-like structure composed of DNA and histone proteins.

.....

C The organelle that modifies and packages proteins for secretion.

.....

D The structure that synthesises rRNA and combines it with proteins.

..... [4]

(b) Prokaryotes and plant cells have cell walls.
Outline the composition of the cell wall of a prokaryote **and** the composition of the cell wall of a plant cell to show how they differ.

.....

.....[2]

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20. M/J 17/P23/Q2/a,b,c

Fig. 2.1 is a transmission electron micrograph of a cell from a leaf.

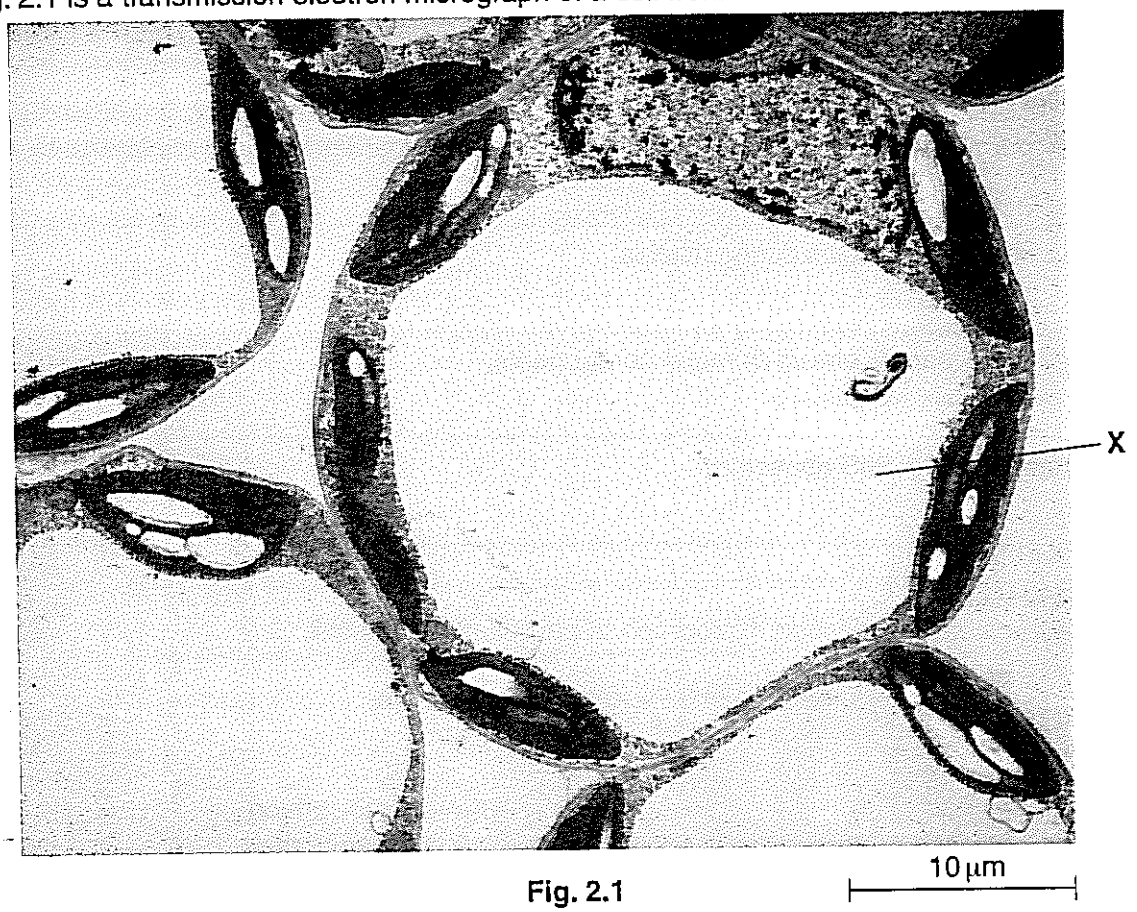


Fig. 2.1

(a) Use the scale bar to calculate the magnification of the image in Fig. 2.1.
Write down the formula that you will use and show your working.

formula

magnification × .....[3]

(b) Name structure **X** and state **one** function of this structure.

name .....

function ..... [2]

(c) Name two structures, **visible** in the cell in Fig. 2.1, that contain DNA.

1 .....

2 ..... [2]

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21. O/N 16/P22/Q1

Match the description for each of statements **A** to **E** to a correct cell structure.

A Double membrane-bound organelle, absent in animal cells, that produces ATP.

.....

B Partially permeable membrane surrounding the large permanent vacuole of plant cells.

.....

C Formed from microtubules during mitosis.

.....

D Has peptidoglycan as one of its major components.

.....

E Site of assembly of 80S ribosomes.

..... [5]

22. O/N 16/P21/Q1/a,b

Fig. 1.1 is a transmission electron micrograph of part of an animal cell.

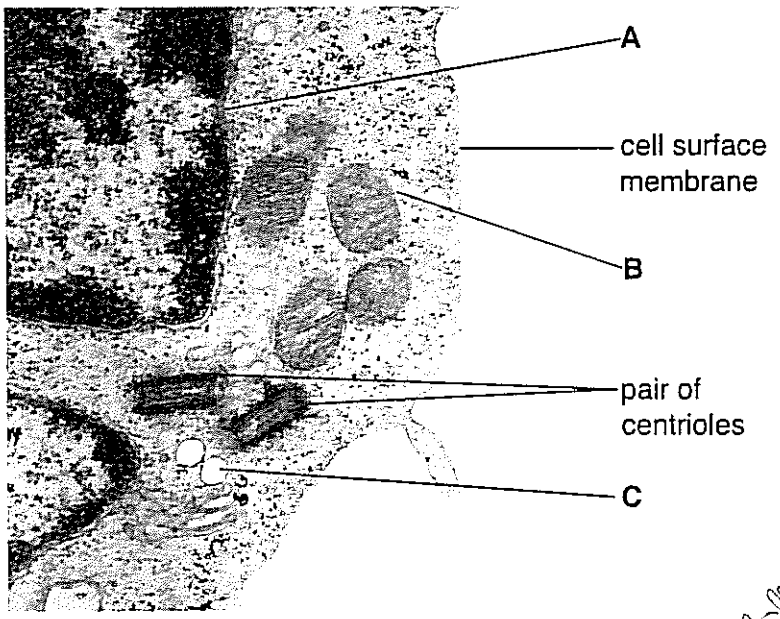


Fig. 1.1

(a) Name the structures **A**, **B** and **C**.

A .....

B .....

C ..... [3]

(b) Name **one** structure, visible in Fig. 1.1, that would also be present in a prokaryotic cell.

.....[1]

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23. O/N 15/P22/Q1

A student compared an image of a plant cell with an image of an animal cell. Both images were at the same magnification.

Parts **(a)** to **(c)** are four correct comparative statements about these images.

(a) Both cells contain large numbers of an organelle, bound by a double membrane. The inner membrane of these organelles is folded. These organelles all have a similar structure but do not always appear to have the same shape.

(i) State the name of the organelles described.

.....[1]

(ii) Suggest **one** reason why the organelles described do not always seem to have the same shape.

.....[1]

(b) Both cells contain cell structures that are approximately 25 nm in diameter and are **not** bound by a membrane.

(i) State the name of the cell structures described.

.....[1]

(ii) Draw a circle around the measurement that has the same value as 25 nm.

0.00025 µm **0.0025µm** **0.025µm** **0. 25µm** **2.5 µm** [1]

(c) There are strands of cytoplasm passing through channels in the cell wall of the plant cell. These are not visible in the animal cell.

(i) State the name of the cell structures described.

.....[1]

(ii) Explain **one** advantage to the plant cell of having these structures.

.....[1]

(d) Fig. 1.1 is a transmission electron micrograph of part of an epithelial cell from the small intestine of a mammal.

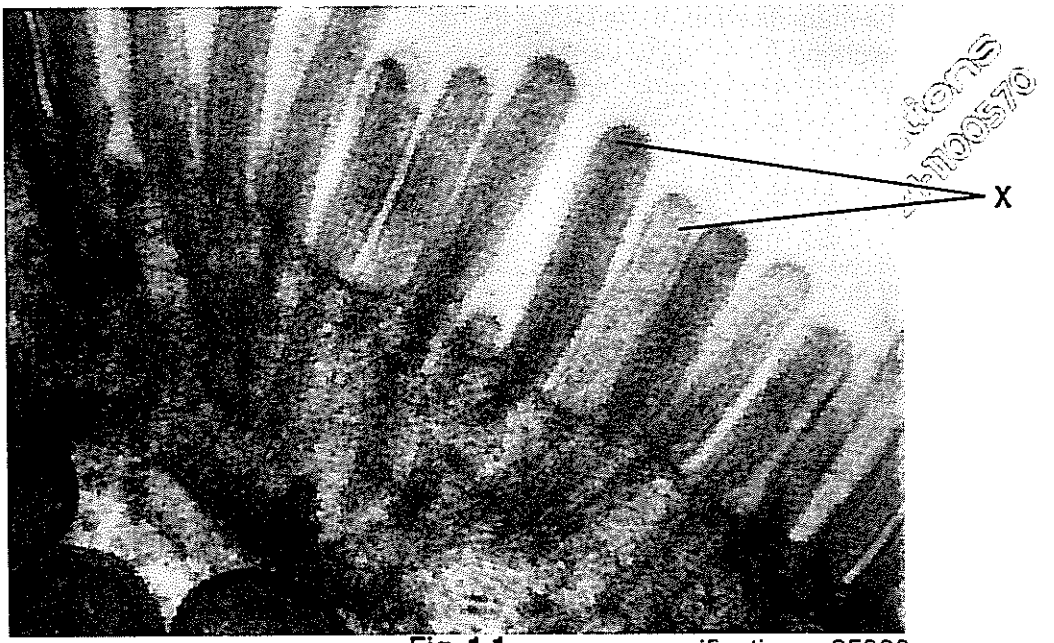


Fig. 1.1 magnification × 65000

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Name the cell structures labelled **X** in Fig. 1.1 **and** state their function.

.....[1]

24. O/N 15/P21/Q1

Fig. 1.1 is an electron micrograph of a mitochondrion.

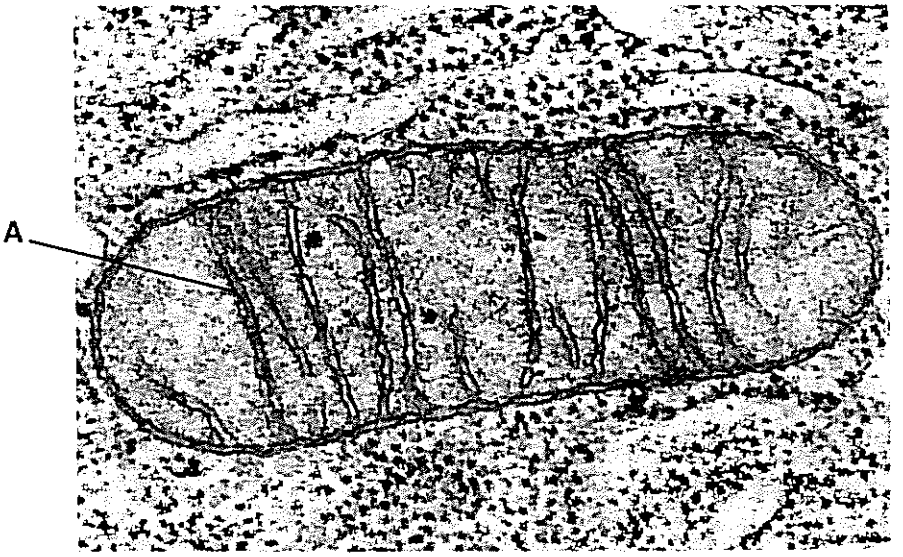


Fig. 1.1

(a) State the function of mitochondria.

.....[1]

(b) Name structure **A**.

.....[1]

(c) Calculate the magnification of the image in Fig. 1.1.
Show your working.

magnification × .....[2]

(d) Explain why the light microscope could **not** be used to produce the image in Fig. 1.1.

.....

.....[2]

(e) Scientists think that mitochondria were once prokaryotes. The evidence for this is that mitochondria have features in common with prokaryotes.
State two features that mitochondria have in common with prokaryotes.

1. .....

2. ..... [2]

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25. M/J 15/P23/Q3/a,b

Fig. 3.1 is an electron micrograph of a type of B-lymphocyte called a plasma cell.
Plasma cells secrete antibody molecules.

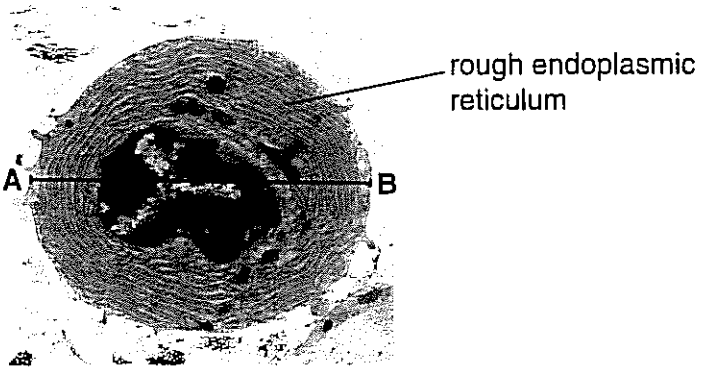


Fig. 3.1

(a) Suggest why plasma cells contain a large quantity of rough endoplasmic reticulum.

.....

..... [2]

(b) The diameter **A – B** of the plasma cell in Fig. 3.1 is 15 μm.
Calculate the magnification of Fig. 3.1.
Show your working.

magnification × .....[2]

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26. O/N 14/P21/Q1

Fig. 1.1 is an electron micrograph of cells from the lining of the small intestine.

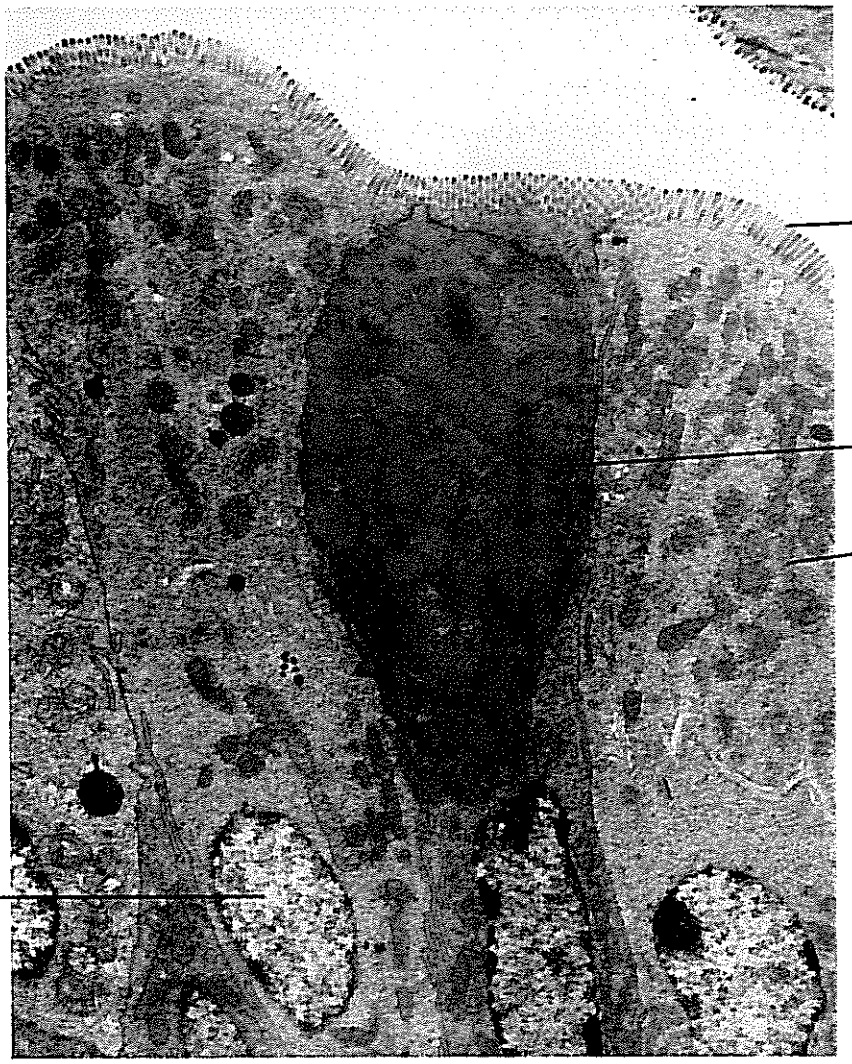


Fig. 1.1

(a) Identify the structures labelled **A** and state their role for the cell.

.....

..... [2]

(b) There are many mitochondria in cell **B**.
Suggest why cell **B** contains a large number of mitochondria.

.....

.....[2]

(c) Calculate the actual length of the nucleus **C**.
Show your working and express your answer to the nearest 0.1 micrometre.

answer ..... μm [2]

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(d) There are many goblet cells within the epithelium lining the trachea and the bronchi in the gas exchange system.
Describe the role of goblet cells in the gas exchange system.

.....

.....

.....[3]

(e) State two ways in which the cells lining the alveoli in the lungs differ from cell **B** shown in Fig. 1.1.

1. .....

2. .....
[2]

27. M/J 14/P22/Q2
Fig. 2.1 is a transmission electron micrograph of cells from a spinach leaf.

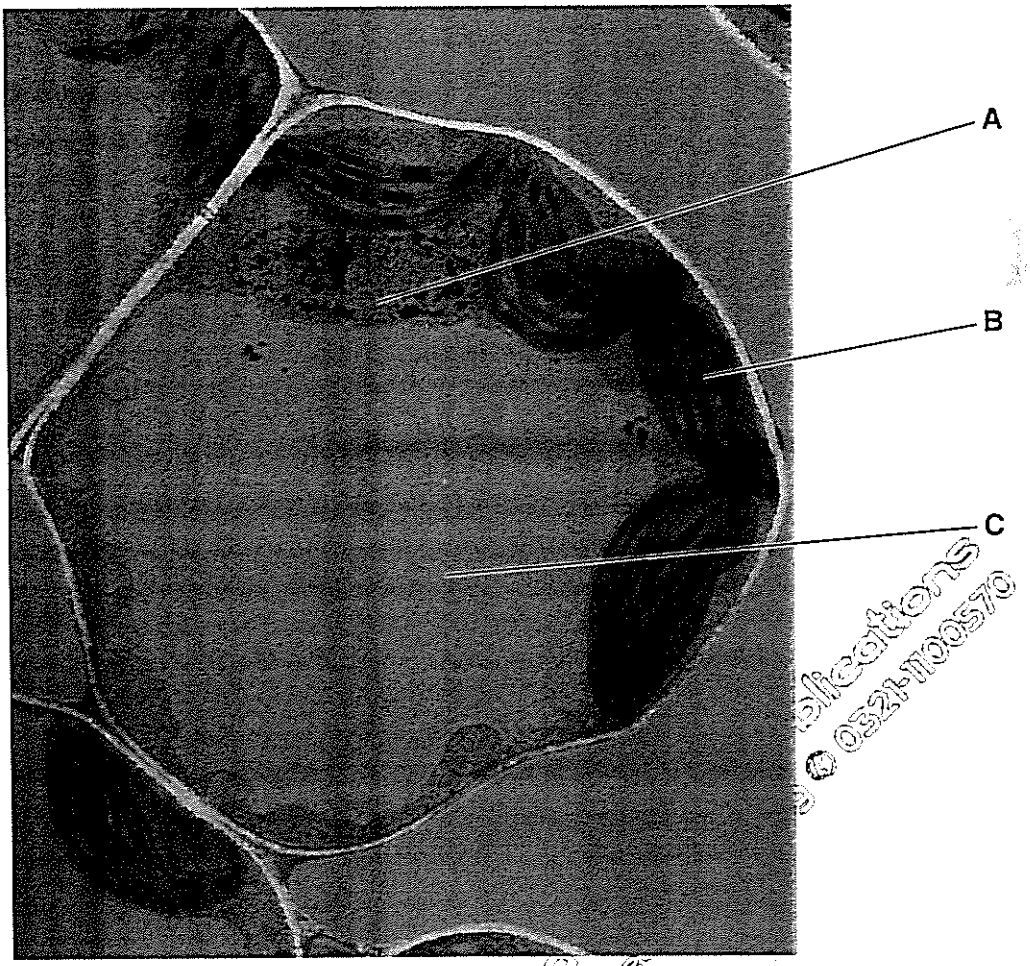


Fig. 2.1

(a) Name the organelles **A**, **B** and **C**.

A .....

B .....

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C ..... [3]

(b) List two cell structures that could be present in animal cells that are not present in plant leaf cells.

1. .....

2. ..... [1]

(c) Water is transported up the stem, to the spinach leaf, in the xylem. Once it leaves the xylem it moves via the apoplast and symplast pathways, to reach the cells in Fig. 2.1.

Outline the differences between the apoplast and symplast pathways after the water has left the xylem.

.....

.....

.....

..... [4]

(d) Water, containing dissolved mineral ions such as magnesium, enters spinach leaf cells.

(i) State **two** ways that water is used in the leaf cell.

1. .....

2. ..... [2]

(ii) State **one** role of magnesium ions in the leaf cell.

..... [1]

28. M/J 14/P21/Q1/a,b,c

Vibrio cholerae is a prokaryotic organism.

Fig. 1.1 shows the structure of a cell of *V. cholerae*.

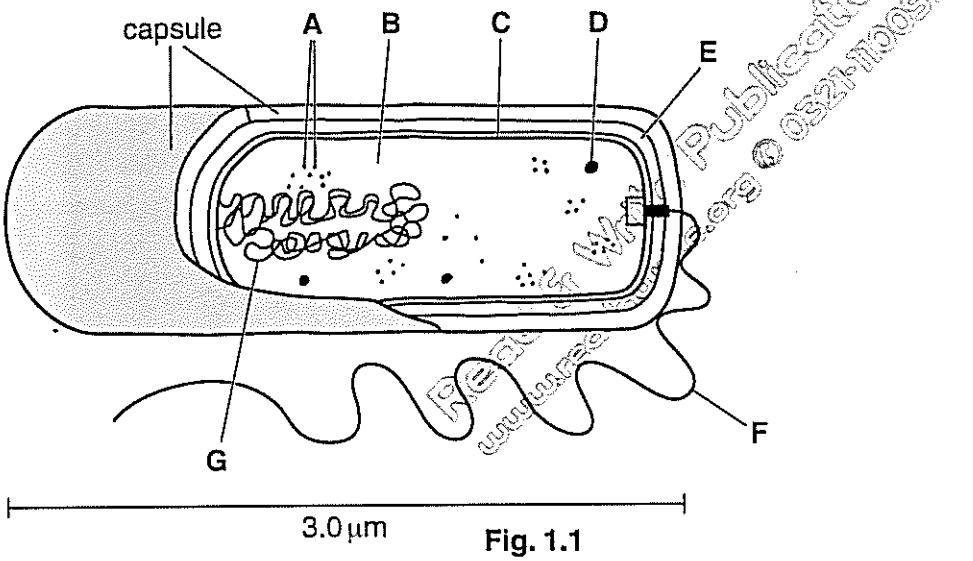


Fig. 1.1

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(a) Calculate the magnification of Fig. 1.1.
Show your working and give your answer to the nearest whole number.

magnification × .....[2]

(b) Locate the structures in Fig. 1.1 that apply to each of the features shown in Table 1.1.
Complete Table 1.1 by writing the appropriate letter and the name of the structure.
You must only give one letter in each case. You may use each letter once, more than once or not at all. The first answer has been completed for you.

Table 1.1

feature	identity	name
provides motility	**F**	flagellum
stores genetic information		
partially permeable		
composed of murein (peptidoglycan)		
site of translation		

[4]

(c) State three **structural** features that are present in a mesophyll cell in a leaf that are **not** present in a prokaryotic cell such as that of *V. cholerae*.

1. .....

2. .....

3. .....[3]

29. M/J 13/P22/Q1/b

(a) Fig. 1.2 is a transmission electron micrograph of a dividing cancer cell.

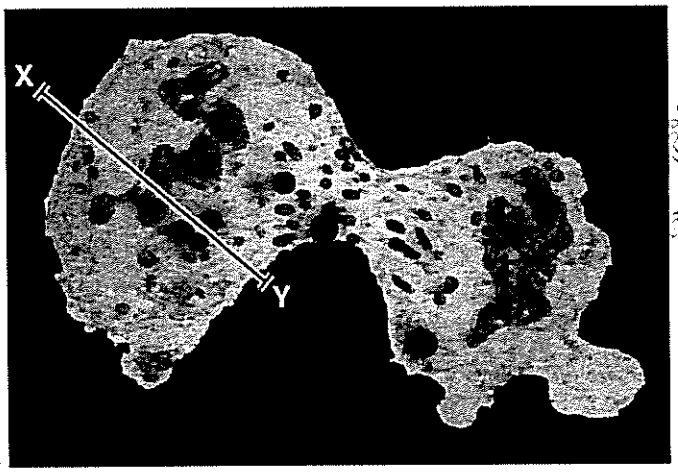


Fig. 1.2 magnification x 3000

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(i) Calculate the actual width of the cell shown in Fig. 1.2 at **X-Y**.
Show your working and give your answer to the nearest micrometre (μm).

answer ..... μm [2]

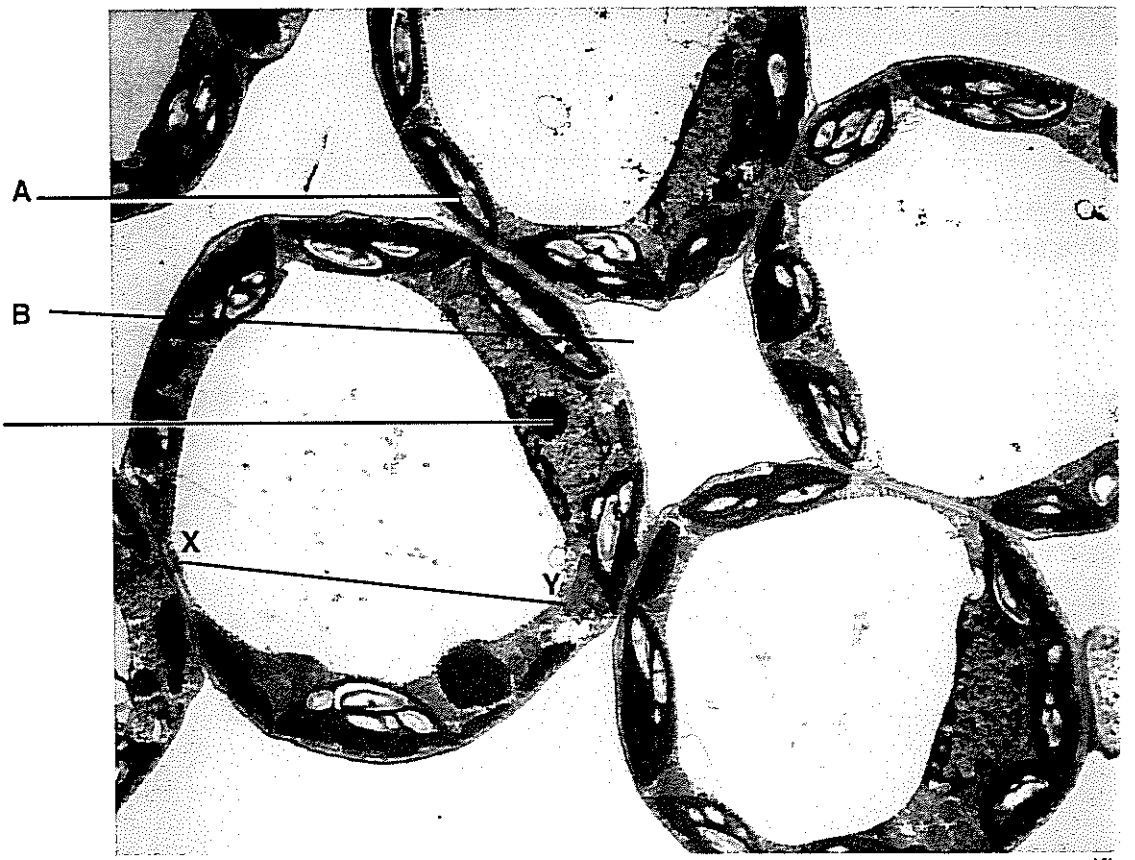
(ii) The cancer cell shown in Fig. 1.2 has more mitochondria and rough endoplasmic reticula (RER) compared to the non-cancerous cell from which it originated.
Suggest why this is so.

.....

..... [2]

30. M/J 13/P23/Q1

Fig. 1.1 is an electron micrograph of a transverse section of palisade mesophyll tissue in the leaf of the flowering plant, *Zinnia elegans* .



magnification × 7000

Fig. 1.1

(a) Name the features labelled **A**, **B** and **C**.

A .....

B .....

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C ..... [3]

(b) Calculate the width of the vacuole across the line **X-Y**.
Show your working and give your answer to the nearest micrometre (μm).

answer ..... μm [2]

(c) The membrane surrounding the vacuole, called the tonoplast, has a fluid mosaic structure.
Describe the structure of this membrane.

.....

.....

.....

..... [4]

(d) Palisade mesophyll cells have very large vacuoles.
Explain how water moves from the xylem in the leaf into these vacuoles.

.....

.....

..... [3]

31. O/N 12/P22/Q1

Fig. 1.1 is a labelled diagram of a leaf palisade mesophyll cell, as seen with a high quality light microscope.

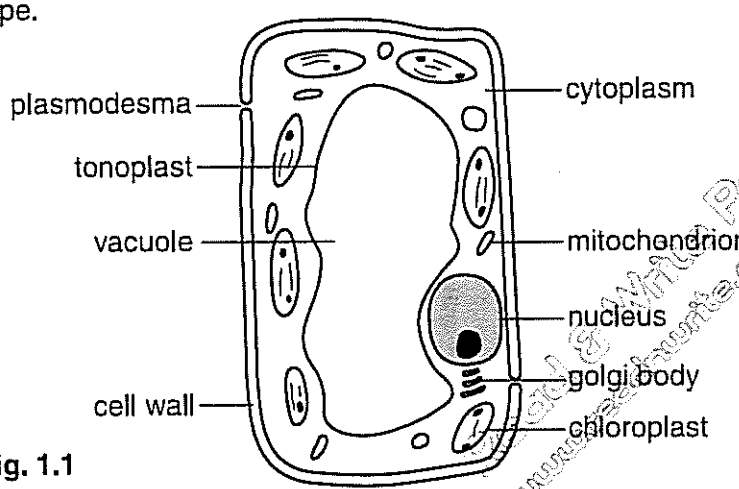


Fig. 1.1

An electron micrograph of the same leaf mesophyll cell at the **same magnification** would show more detail than is shown in Fig. 1.1.

(a) Explain why, at the **same magnification**, an electron micrograph is able to provide more detail than a light micrograph.

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.....

..... [2]

(b) **Describe** three additional features that could be seen on an electron micrograph of the leaf mesophyll cell that are not seen in Fig. 1.1.

1. .....

2. .....

3. ..... [3]

(c) The length of the labelled chloroplast in Fig. 1.1 is 5.0 μm. Calculate the magnification of the cell shown in Fig. 1.1.
Show your working.

magnification × ..... [2]

(d) In Fig. 1.1, starch granules are visible within the chloroplasts. Starch is the most common storage compound of plants. It is composed of amylopectin and amylose.

(i) Describe the structural differences between amylopectin and amylose.

.....

..... [2]

(ii) State **one** role of magnesium ions within chloroplasts.

..... [1]

32. O/N 12/P23/Q1

Fig. 1.1 shows electron micrographs of some eukaryotic cell organelles.

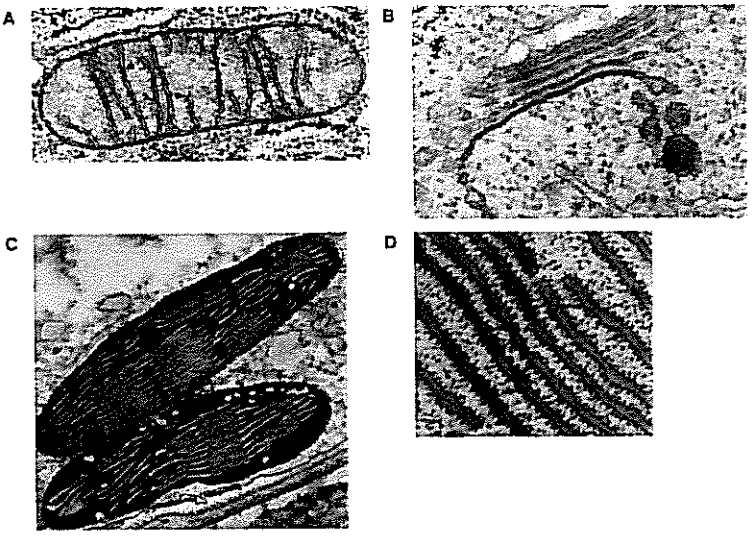


Fig. 1.1

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For each of the organelles **A**, **B**, **C** and **D**, shown in Fig. 1.1, state the name and function of each.

A *name* .....

function.....

B *name* .....

function.....

C *name* .....

function.....

D *name* .....

function..... [8]

33. O/N 12/P21/Q1

Fig. 1.1 is a drawing made from an electron micrograph of a mammalian liver cell.

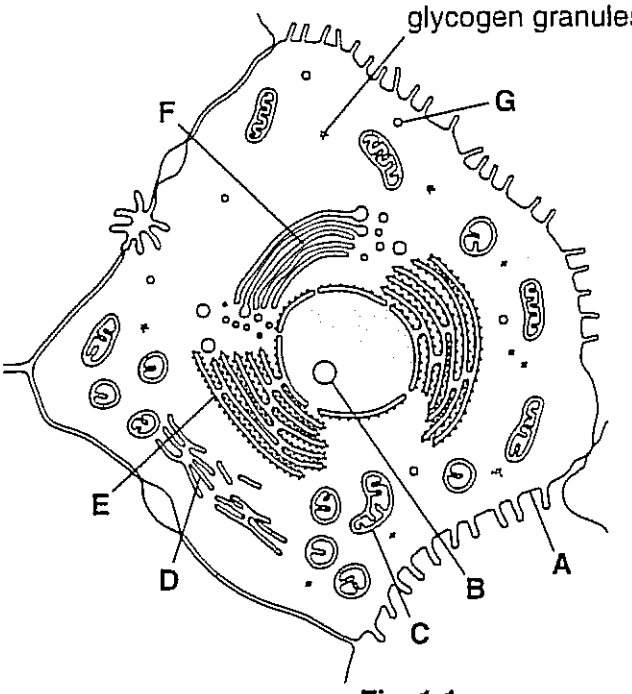


Fig. 1.1

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(a) Complete the table by naming the structures **B** to **G** and stating **one** function of each. The first one (**A**) has been completed for you.

	name of organelle	function
A	cell surface membrane	controls movement of substances into and out of the cell
B		
C		
D		
E		
F		
G		

[6]

(b) As shown in Fig. 1.1, liver cells contain many storage granules of glycogen.
Describe the molecular structure of glycogen **and** explain how this structure makes it suitable for storage.

.....

.....

.....

..... [4]

34. M/J 12/P22/Q2/a

Fig. 2.1 is a transmission electron micrograph of a plasma cell. Plasma cells are antibody-secreting cells that are formed from B-lymphocytes.

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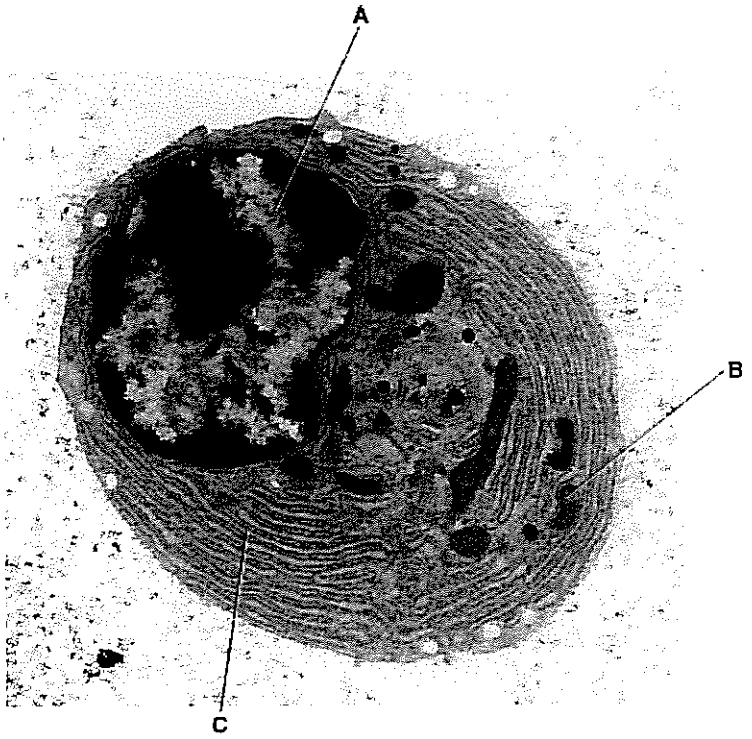


Fig. 2.1

(a) Complete Table 2.1 to:

- name in full, structures **A**, **B** and **C**
- outline how each structure functions to contribute to the **specific role of the plasma cell.**

Table 2.1

structure	name of structure	function of structure within plasma cell
A		
B		
C		

[6]

35. M/J 12/P21/Q2

Fig. 2.1 shows a drawing made from an electron micrograph of two adjacent cells in a leaf.

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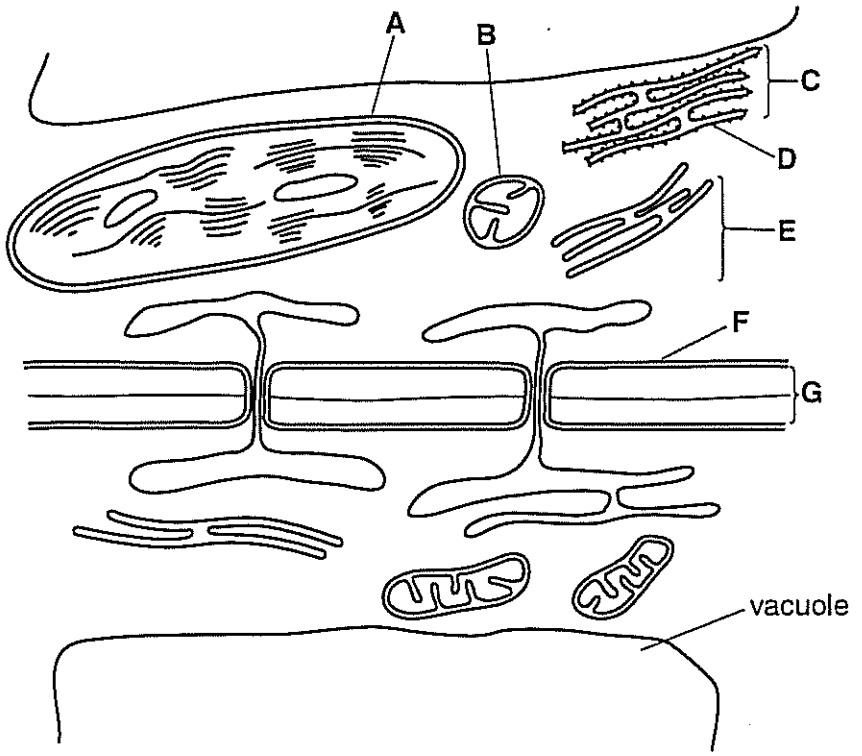


Fig. 2.1

(a) Structures **A** and **B** are both visible using the light microscope, but the internal detail of these organelles shown in Fig. 2.1 is only visible using the electron microscope.

Explain why the internal details of structures **A** and **B** are only visible when using the electron microscope and not when using the light microscope.

.....

.....

..... [3]

(b) Name in full the structures labelled **C**, **D** and **E**.

C .....

D .....

E ..... [3]

(c) State **one** role of vacuoles in plant cells.

..... [1]

(d) Structures **F** and **G** have very different permeability properties.

Explain how the composition of structures **F** and **G** determines the permeability properties of these structures.

.....

.....

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.....

..... [4]

(e) Fig. 2.1 shows two plasmodesmata connecting the adjacent cells.
Describe the roles of plasmodesmata in transport in plants.

.....

.....

..... [3]

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Answers Section

1. **O/N 21/P22/Q1/a**
   (a) *one mark max for each feature*

feature common to bacterial and plant cells	bacterial cell	plant cell
cell surface membrane	contain hopanoids	contains cholesterol
ribosome	70S / smaller / 18-20nm I no 80S ribosomes	80S / larger / 22-30nm ; A and 70S
DNA **max 1 mark** *must be across the dotted rows*	circular / closed loop I ref. to plasmids	linear ; AW
	naked **A** no histones	(complexed) with, histones / (basic) proteins ;
	free in, cytoplasm / cytosol A not enclosed / AW, by nuclear envelope A found in nucleoid region	enclosed by / AW, nuclear envelope ; A in a nucleus
cell wall	(mainly composed of) peptidoglycan / murein	(mainly composed of) cellulose ;

[3]

2. **O/N 21/P21/Q1/a(i)**
   (a) (i) **X** nucleus ;
   Y chloroplast ;
   Z vacuole ; [3]

3. **O/N 20/P22/Q4/a**
   (a) (i) *any **three** from:*
   I heterochromatin / euchromatin
   envelope / two membranes / double membrane / inner and outer membrane
   nuclear pores ; **A** pores in nuclear envelope *for two marks*
   (outer surface of) outer membrane with ribosomes ;
   ref. to (outer nuclear) membrane continuous with RER ; **R** inner membrane
   AVP ; e.g. perinuclear space **A** intermembranous space
   (ii) *any **two** from:*
   resolution / resolving power, is, low / lower / poor / AW / 200 nm / 0.2 µm ;
   (**A** range 100–300 nm)
   A electron microscope has a higher resolution
   further detail ; e.g. ribosomes / ER, smaller than 200 nm
   can only see cell structures greater than (limit of) resolution
   cannot see structures smaller than 200 nm
   cell structures too small for the resolution *(needs ref. to resolution)*
   cell structures, too small to / do not, interfere with light waves ; AW [5]

4. **O/N 20/P21/Q4/a,b(i)**
   (a) (i) plasmodesmata ;
   (ii) *any **two** from:*

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ref. to connecting two cells ; *in context of connecting cytoplasm*
(facilitate) movement of substances between cells ; **A** named substances
ref. to symplast pathway ;
cell to cell communication / passage of cell signalling molecules ;
AVP ; e.g. removes the need to cross the partially permeable cell surface membrane
(when moving between cells) increases the rate of movement of substances between cells

(b) (i) protein coat / capsid ;
DNA or RNA / nucleic acid ; **A** genetic material
ref. to some viruses have envelope ; [5]

5. **O/N 20/P23/Q6**

(a) *formula* (magnification =) $\frac{\text{size of image}}{\text{actual size}}$;
A M = I / A or I = A × M
A magnification triangle
length of line **X–Y** = 30 mm (± 2 mm) / 30 000 µm = 3.0×10^{-2} m
actual length = 150 µm / 0.15 mm = 150×10^{-6} m
working
length of the image (in m, mm or cm) divided by the actual size (**A** ± 2 mm) ;
(x) 200 ; **A** *answer in range* 187 – 213

(b) (i) **1** endocytosis / phagocytosis ;
two from
2 particles / bacteria, reach end of, gullet / AW ;
3 binding / fusion / attachment, (of bacteria / food particles) to, receptors / (cell surface) membrane ; **I** 'makes contact with'
4 membrane engulfs, bacteria / food particles ;
5 fusion of phospholipids / membrane fusion ;
6 (phagocytic) vacuole / vesicle, pinches off from, surface / membrane ;

(ii) **I** bulk transport
1 fuse / bind, with, phagosome / food vacuole / phagocytic vacuole / phagocytic vesicle ; **A** food vacuole, etc. implied
2 contain / add, hydrolytic / digestive, enzymes ; **A** hydrolases
A description of one type of breakdown reaction catalysed by a lysosomal enzyme
3 an example of hydrolase or enzyme ; e.g. protease / lipase / carbohydrase / nuclease / lysozyme [9]

6. **M/J 20/P22/Q1**

(a) *any two from*
protein coat / capsid ; **A** capsomeres
nucleic acid core / DNA or RNA ;
acellular / AW ;

(b) *any three from*
no, because
resolution of light microscope, too low / not high enough ;
only able to distinguish points 200nm or more apart
or
size of virus / 30 nm, too small for resolution of (light microscope) of 200 nm ; **A** range 100-300 nm wavelength of light too long
idea that virus too small to interfere with light waves ;

(c) *any three from*
virus binds to receptors (on host cell surface membrane) ;
ref. to specificity / complementary shapes / complementary binding ;

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endocytosis ;
description ; e.g. membrane infolds / pinches in
vesicle formed ; **A** vacuole [8]

7. M/J 19/P23/Q2/a
(a) correctly stated formula ;
e.g. actual diameter = image length / magnification
magnification = image length / actual diameter
allow a magnification triangle
1750 (μm) ; (*for 70 mm*) *credit also measurements made to 0.5 mm*
A 1700 (μm) (*for 68 mm*)
A 1725 (μm) (*for 69 mm*)
A 1775 (μm) (*for 71 mm*)
A 1800 (μm) (*for 72 mm*) [2]

8. O/N 18/P22/Q4/a
(a) *any three from*
protein coat / capsid ; **I** protein layer
nucleic acid ;
DNA or RNA ; **R** in nucleus
I in cytoplasm
I *ref. to*, double / single, strand
acellular / not made of cells ; **I** absence of named cell structures
AVP ; e.g. *ref. to* capsomeres
size 15 nm to 1000 nm *accept any in range*
(some) are enveloped / have phospholipid bilayer **I** with glycoproteins [3]

9. O/N 18/P22/Q6/a
(a) *rough endoplasmic reticulum*
protein / polypeptide / named protein, synthesis / transport / modification ;
A post-translational modification / examples
named protein e.g. haemoglobin, carbonic anhydrase, membrane proteins
Golgi body
modification / processing, of, proteins / lipids
A post-translational modification / examples / makes proteins functional
or packaging (molecules) into vesicles
or formation of, Golgi / secretory, vesicles
or forms (primary) lysosomes ;
centrioles
formation of, spindle fibres / spindle **or** microtubule organisation ; [3]

10. O/N 18/P21/Q4/a
(a) correct formula ;
(×) 1200 ;
A 1171 (41 000 ÷ 35) 1229 **or** 1228.6 (43 000 ÷ 35)
max 1 if units given [2]

11. O/N 18/P21/Q5/a
(a) *any two from*
cell wall made from, peptidoglycan / murein ;
A not cellulose
DNA free in the cytoplasm ;
or
circular / closed loop, of DNA ;

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or
naked DNA / no histones ;
70s ribosomes ;
AVP ;
e.g. no membrane around flagellum
or
flagellum is not 9+2 (microtubule pattern) ; [2]

12. O/N 18/P23/Q1

(a) *any three from*
1 modification / process / described, of, proteins / polypeptides ;
2 further detail of modification ;
examples of modification
folding of polypeptides / protein folding
assembly of polypeptides to form quaternary structure
addition of (named) prosthetic group
addition of sugars / addition of carbohydrate / glycosylation
cutting of polypeptides
removal of, methionine / first amino acid
making proteins functional
3 packaging into vesicles / formation of Golgi vesicles / formation of secretory vesicles ;
A 'budding off' / 'breaking off' / transport proteins in Golgi vesicles
4 formation of (primary) lysosomes ;
5 AVP ;
e.g. modification of lipids
synthesis of, phospholipids / glycolipids
synthesis of cell wall polysaccharides

(b) (i) (mitochondria) provide / make / produce, ATP ;
A needs a lot of, ATP / energy
R 'produce / make, energy'
(ATP / energy required for) protein synthesis / movement of (secretory / Golgi) vesicles / exocytosis ;

(ii) *any two from*
1 mitochondria have (circular) DNA ;
2 mitochondria, have / make, (70S) ribosomes (for, protein synthesis / translation) ;
R if 80S ribosomes
3 mitochondria can divide ;
R by mitosis
4 AVP ;
5 AVP ;
e.g. (mitochondrial / mt) DNA codes for (some mitochondrial) proteins
mRNA transcribed from mtDNA
mitochondria produce their own tRNA
can replicate DNA
I mitochondria have a double membrane

(c) (i) *any three from*
protein coat / capsid ;
A protein layer
R 'cell wall of protein'
nucleic acid (core) ;
R if 'in a nucleus'
DNA or RNA ;
acellular / non-cellular / 'not a cell' ;
size – *accept within range* 15 nm to 1000 nm ;

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AVP ;
e.g. (protein coat made of) capsomeres surrounded by, membrane / envelope / (phospho)lipid bilayer **I** antigens / enzymes

(ii) *any one from*
(viruses) pass through plasmodesmata ;
A 'cytoplasmic strands, through cell walls / between cells'
via symplast pathway ; [11]

13. M/J 18/P22/Q1/a,b,c

(a) one mark for each label to correct structure on Fig. 1.1 ; ; ;
tonoplast line to anywhere on the vacuolar membrane
R if two or more different structures stated for a single label

(b) ref. to conversion of measured (**X-Y**) line to μm / AW ;
e.g. line is measured in, mm and then multiplied by 1000 / cm and then multiplied by 10 000
evidence that, 60 (±1 mm) is multiplied by 1000 / 6 cm is multiplied by 10 000
measured diameter is 60 000 μm
(and) divide by, magnification / 2000 ;

(c) *two from:*
rough endoplasmic reticulum ; **A** rough ER / RER
smooth endoplasmic reticulum ; **A** smooth ER / SER
endoplasmic reticulum ; *acceptable only if the other structure is <u>not</u> SER / RER*
80S / larger, ribosomes ; **A** 25–30 nm range
plasmodesma(ta) ;
microtubules ; **A** microfilaments
A cytoskeleton
lysosome(s) ;
Golgi (body / apparatus / complex) ;
secretory / Golgi, vesicles ;
AVP ; ; e.g. chromatin
EM detail of chloroplast
EM detail of mitochondrion **A** mitochondrion
nuclear pore
nuclear envelope **R** nuclear membrane [7]

14. M/J 18/P21/Q1

(a) (i) *answers must be comparative*
one from:
idea that the sections are orientated differently / cut in different planes / cut at different angles / AW ;
A is a cross section / AW, and **B** is a longitudinal section / AW
mitochondria show a variety of, sizes / shapes ;
mitochondria, are flexible / change shape ;
A and **B** are of, different ages / stages of development ;

(ii) *two from:*
replace, old / worn out / damaged, mitochondria ;
require more mitochondria as cells, enlarge / grow ;
more mitochondria are needed, for new cells / when cell divides ;
A so numbers remain the same in the new cells / after cell division
A *idea that* mitochondria are shared out (between daughter cells)
(mitochondria) provide (most), energy / ATP ;
I cell needs (much) energy without stating mitochondria provide energy
R energy production
I uses of energy

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(b) *two from:*
nuclear envelope shown as two membranes with closed ends and a gap ;
label to nuclear pore ;

(c) *four from:*
1 contains / AW, chromosomes / chromatin / DNA / genes / genetic material / inherited material / genetic information ;
2 (coded) information for synthesis of, polypeptides / proteins ;
A controls protein synthesis
3 ref. to sequence(s) of bases (in DNA) ;
4 transcription (of genes) / production of mRNA ;
5 contains nucleolus ;
6 manufacture of ribosomal sub-units ; **A** makes ribosomes
7 *idea that* DNA is protected from degradation / enzymes / AW ;
8 AVP ; e.g. responds to signals that control, gene expression / AW
post-transcription modification / modifies mRNA / any example
repairs DNA

I controls cell's activities
I sends mRNA to cytoplasm / mRNA travels through nuclear pores [9]

15. M/J 18/P23/Q6/b

(a) one mark for each correct column ; ;

circular / (closed) loop / **A** ring of	nuclear envelope
murein / peptidoglycan	80S mitochondria / chloroplasts **A** nucleus

[2]

16. O/N 17/P21/Q5/a,b,c

(a) (i) Golgi (body / apparatus / complex) ;

(ii)

animal cell	✓
plant cell	✓
bacterial cell	

;

(b) magnification = scale bar length / actual length ; **A** M = I / A M = I / O
O or magnification triangle
14 500 ;; *for 29 mm scale bar length*
A 14 000 (*for 28 mm*) **or** 15 000 (*for 30 mm*)
allow one mark only for
incorrect answer but correct calculation using scale bar e.g. 29 000 ÷ 2
correct answer but units given
correct measurement and correct calculation but incorrect conversion

(c) *mark first two only*
nucleus ;
mitochondria ;
chloroplasts ; [7]

17. O/N 17/P23/Q1

(a) actual length = image length / magnification ;
A A = I / M M = I / A I = A × M or magnification triangle
2.5 (µm) ;; *for 40 mm **X**–**Y** length*
A 2.6 (*for 40 / 41 mm*)
A 2.4 (*for 38 / 39 mm*)

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max 1 for
incorrect or no answer but correct calculation e.g. 40 000 ÷ 16 000
correct answer but to more than one decimal place
correct measurement and correct calculation but incorrect conversion

(b) (i) mitochondrion ; **A** mitochondria
max 1 for function
produces / makes / synthesises / provides / AW, ATP
or
releases / provides / supplies, energy
or
aerobic respiration ;
AVP ; e.g. part of the urea cycle
β-oxidation of fat
oxidative phosphorylation

(ii) rough endoplasmic reticulum ;
A rough ER **I** RER
ribosomes are attached ;
accept mp2 if organelle identified as endoplasmic reticulum / RER [7]

18. M/J 17/P22/Q1/a

(a) *one mark per blank box*

type of cell	function of cell	example of organelle required to carry out function
palisade mesophyll	photosynthesis ; **A** (absorb light to) synthesise, organic compounds / glucose / starch (from inorganic compounds)	chloroplast
Leydig	synthesis of steroid hormones	smooth endoplasmic reticulum ; **A** SER / smooth ER
plasma cell ; **A** B-cell / white blood cell / leucocyte / (B-) lymphocyte / agranulocyte **R** T lymphocyte / granulocyte / phagocyte / macrophage / neutrophil	production of secretory vesicles containing antibody	Golgi body
root hair cell	active uptake of nitrates	mitochondrion ; **A** cell surface / plasma, membrane **A** cell membrane
pancreas acinar	synthesis of enzymes	rough endoplasmic reticulum ; **A** RER / rough ER **A** ribosomes **A** mitochondrion

[5]

19. M/J 17/P21/Q1

(a) **A** chloroplast / mitochondrion ;
B chromosome(s) / chromatid / chromatin ;
C Golgi (body / apparatus / complex) ;
D nucleolus ;

(b) *max 1 if only written about prokaryote wall or only about plant wall*
1 prokaryote cell wall has, peptidoglycan / murein ;
2 plant cell wall has, cellulose / polymer of β glucose ; **I** lignin
3 AVP ; e.g.
prokaryote wall is made of chains crossed linked by, peptides / amino acids
hydrogen bonds between cellulose molecules (within microfibrils)
in plant cell wall **A** cellulose chains
other components such as pectins / hemicelluloses in plant cell walls [6]

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20. M/J 17/P23/Q2/a,b,c

(a) *one mark for the formula and two marks for the correct answer*

(magnification =) $\frac{\text{image / scale bar (length)}}{\text{actual / object (length)}}$; **A** triangle / letters only

3000 ;;

30 000 ÷ 10 ; *using 30 mm as measured length*

A calculated values for measured lengths of 29 mm or 31 mm

allow one mark if correct answer given with units

allow one mark if incorrect answer and

correct measurement and correct working

correct measurement and formula but incorrect conversion

measurement ± 2 mm and correct working

(b) *name*

(large permanent) vacuole ;

function

one from

store of / holds / AW, cell sap ; **R** if contains organelles

store of / holds / AW, water / ions / named ion(s) / minerals / salts / pigments / sugars / named sugars ; **A** nutrients

I substances / molecules / food **I** storage unqualified

pushes chloroplast to edge of cell ;

gives, turgidity / turgor pressure / hydrostatic pressure / support / AW ;

A makes, firm / rigid **A** controls / maintains, turgidity

I gives shape / strengthen / provides structure

store of / holds, waste (products) ; **A** breakdown of (large) waste products

I reactions occur in vacuole, unqualified

allow function mark even if name of organelle left blank or incorrect

(c) nucleus ;

chloroplast(s) ;

mitochondrion ; **A** mitochondria [7]

21. O/N 16/P22/Q1

A = chloroplast ;

B = tonoplast ; **A** vacuolar membrane

C = spindle / spindle fibre(s) ;

D = (bacterial / prokaryotic) cell wall ; **R** eukaryotic / cellulose / chitin / plant

E = nucleolus ; [5]

22. O/N 16/P21/Q1/a,b

(a) **A** nuclear envelope ; **A** nucleus **A** nuclear membrane **I** nuclear pore

B mitochondrion ; **A** mitochondria **A** mitochondrial envelope

C lysosome / Golgi vesicle / secretory vesicle ; **A** vesicle / vacuole **A** plural **I** qualification e.g. transport / temporary / phagocytic

(b) ribosome(s) / cell surface membrane ; **A** vesicles **A** plasma membrane **I** cytoplasm [4]

23. O/N 15/P22/Q1

(a) **(i)** mitochondria ; **A** mitochondrion

(ii) can change shape / fluid membrane structure / *ref. to* flexible ;

different orientation when section taken / AW ; **A** different sections cut

some may be dividing / *ref. to* mitochondrial fission; **I** growing

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(b) (i) ribosomes ; **A** ribosome **I** *ref. to* size e.g. 70 S / 80 S

(ii) *circle around* 0.025 μm ;

(c) (i) plasmodesmata ; **A** plasmodesma

(ii) *assume answer is in context of between adjacent cells but* **R** if within a cell
I incorrect naming of plasmodesmata
I description of cytoplasmic strands

facilitates / more rapid / allows / AW, transport / communication / exchange / transfer (of substances) ;
substances do not need to cross, cell (surface) membranes / cell walls ;
for, movement / AW, of, substances / materials / nutrients / water ;

named example ;
e.g. movement / diffusion / AW, of sucrose to sieve tube (from companion / transfer, cell)
water travels by, symplastic pathway **I** incorrect mechanism e.g. osmosis
water avoids, apoplastic / cell wall, pathway
proteins too large to cross, cell wall / cell surface membrane

A *idea of* substances moving in and out of cells *only if plasmodesmata given in (i)*

(d) **I** descriptions e.g. extensions / hair-like
microvilli / **A** microvillus **R** villi / villus **R** cilia
and *one from:*

absorption / uptake of products of digestion
secretion / release of (extracellular), enzymes / other named secretion
digestion (at the cell surface) / breakdown of (ingested) food / AW
excretion / release of, waste / excess, substances
increases surface area ; [7]

24. O/N 15/P21/Q1

(a) ATP production ; **A** supply energy (to the cell / for cell reactions) **R** energy production
(site of) aerobic respiration / oxidative phosphorylation ;
AVP ; e.g. lipid metabolism / beta oxidation

(b) crista / cristae / inner membrane ;

(c) (×) 48 571 **or** (×) 50 000 ;;

$\frac{34\,000}{0.7}$ **or** $\frac{35\,000}{0.7}$

if answer incorrect award one mark for:
correct measurement (34 or 35 mm) and correct formula used (M = I/A), as above but incorrect conversion to μm
or
correct calculation but units given
or
correct calculation but decimal places given

(d) 1 resolution / resolving power, too low ;
2 further detail ; e.g. only 250 nm resolution
resolution only half wavelength of light
wavelength of light, too long / not short enough
width of membranes only 7 nm ;

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3 (such) thin sections not possible ;
4 inner membrane / cristae / internal structure, could not be seen ;
5 magnification this high not possible ;
mp1 and mp5 allow correct comparative statement with electron microscope

(e) circular DNA ;
small / similar, size ; **A** 0.5–15 μm
70S / small(er) / 18 nm, ribosomes ;
AVP ; e.g. binary fission / naked DNA [8]

25. M/J 15/P23/Q3/a,b

(a) (endoplasmic reticulum / RER) has ribosomes ;
(ribosomes / RER) site of protein synthesis ;
antibodies are proteins ;
RER for, modification / transport / transport vesicle formation ;

(b) 3000 ;; **A** 2933 / 3067 *if units given allow one mark only*
if incorrect allow one mark for correct length measured 44 / 45 / 46 mm and
knowledge of formula is correct (magnification = image length / actual length –
this can also be seen by workings e.g. 45 mm / 15 μm) but incorrect conversion
factor used for final calculation [4]

26. O/N 14/P21/Q1

(a) microvilli ; **R** villi
increase the surface area for absorption/movement across membrane/AW ;
A excretion/secretion

(b) (mitochondria) synthesis/AW, ATP ; **R** energy **A** provide, energy/ATP
for active, uptake/transport ; **A** any other active method such as pinocytosis/secretion

(c) 4.7/4.8/5.0/5.2 ;; **A** 5

$$\frac{29\text{ mm}/29\,000}{6000}$$

or

$$\frac{30\text{ mm}/30\,000}{6000}$$

Award one mark if answer incorrect or length incorrectly converted but correct formula used
i.e. image length divided by magnification of 6000

(d) secrete/make/produce/release mucus ;
pathogens/bacteria/viruses/microorganism/dust/AW stick to mucus ; **A** trapped by mucus
idea that pathogens/AW do not reach
the cells lining the trachea
or the cells lining the bronchi
or the alveoli ;
prevents pathogens/AW entering the circulatory system ;
reduces chances of infection ;

(e) thin(ner)/flat(ter) ; **A** squamous not columnar ;
(far) fewer mitochondria ;
no microvilli ; [11]

27. M/J 14/P22/Q2

(a) **A** = nucleus; **R** nucleolus **R** nuclear **R** nuclei
B = chloroplast ; **A** chloroplasts
C = vacuole ; **A** vacuoles **A** large / central / **AW**, vacuole

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(b) *both must be correct*

microvillus / microvilli
centriole / centrioles
cilium / cilia
flagellum / flagella
} *any two structures for one mark ;*
A lysosome(s)

(c) **1** apoplast = cell wall (and intercellular spaces) (pathway) ;
A between cell walls
R if cell wall and, cytoplasm / vacuole / plasmodesmata
R if linked to osmosis / facilitated diffusion / active transport

2 symplast = cytoplasmic (pathway) ; **R** if facilitated diffusion / active transport
reference to only cytoplasmic / not including vacuoles

mps 1 and 2 allow one mark only if no ref. to terms apoplast and symplast
e.g. cell wall v cytoplasmic pathway

symplast

3 osmosis, linked to passage across membranes ; *must be in correct context*

4 detail of membranes involved ; *either* tonoplast / vacuolar membrane *or* cell (surface) membrane of, 'first cell' entered directly from xylem / **AW**

5 via plasmodesmata ; *ignore ref. to mechanism*

6 (includes) vacuolar pathway / (through) vacuoles ;
apoplast

7 non-living pathway ; **ora**

8 *ref.* greater volume / higher rate / less resistance / **AW** ; **ora**
A faster / fastest **R** amount *for volume*

9 *ref. to*, hydrogen bonding / adhesion, to cell walls ;

(d) **(i)** (maintain) turgor / turgidity / prevents flaccidity / prevents plasmolysis ;
A provides support for cell **R** provides support for plant
A pushes chloroplast to edge (of cell)
(reactant in) photosynthesis ;
hydrolysis (reactions) ; **A** named reaction that involves hydrolysis solvent
A (medium) for cell, / metabolic / chemical, reactions (to take place)
R *if in context of outside cell or entering cell or as a transport medium*

(ii) (part / used in synthesis, of) chlorophyll (molecule) ;
R gives chlorophyll green colour
in translation / joining of large and small subunits (of ribosomes) ;
enzyme, cofactor / activator / described ; *idea of role in enzyme catalysis*
A correctly named enzymes, e.g. DNA polymerase
AVP ;
e.g. stabilizing, cell wall / proteins / nucleic acids / membranes ;
important in energy transfers / ATP synthesis ;
DNA, synthesis / replication ;
ref. to role in, light absorption / capture (for photosynthesis) ; [11]

28. M/J 14/P21/Q1/a,b,c

(a) *award two marks if correct answer within range 29 000 to 31 000 is given*
allow ±3 mm in reading the line, e.g.

$\frac{90000}{3.0}$ $\frac{90\times10^{3}}{3.0\times10^{-6}}$ $\frac{9.0\times10^{-2}}{3.0\times10^{-9}}$

(×) $30000/3\times10^{4}$;;

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one mark if not rounded to nearest whole number
one mark if a unit (mm, μm) is given
one mark if line is measured and given in mm or cm within accepted range and divided by
3.0 μm but incorrect conversion factor used for the line measurement or 3.0 μm

(b)

feature	identity	name
provides motility	**F**	flagellum
stores genetic information	**G**	DNA ; **I** *any description, e.g. loop of/circular* **A** chromosome(s)/nucleoid **R** plasmid/chromatid
partially permeable	**C**	cell surface/plasma, membrane ; **A** phospholipid bilayer
composed of murein (peptidoglycan)	**E**	cell wall ; **R** cellulose cell wall
site of translation	**A**	(70S/18 nm) ribosome(s) ; **R** 80S/22 nm/larger, ribosome

(c) **A** (double) membrane-bound organelles *only if no examples given* (true)
nucleus/nuclear envelope ; **A** nuclear membrane **I** well-defined
chloroplast ; **A** grana/thylakoid(s) **A** plastid
(permanent) vacuole/tonoplast ; **R** vesicles *unqualified* **A** lysosome
mitochondrion/mitochondria ; **A** cristae
Golgi (body/apparatus/complex)/dictyosome ; **A** Golgi vesicle(s)
rough endoplasmic reticulum/rough (ER)/RER ;
smooth endoplasmic reticulum/smooth ER/SER; **A** endoplasmic reticulum, *if RER and SER not given*
nucleolus ;
linear/**AW**, chromosomes ; **A** DNA + histones
cellulose cell wall ;
starch grain/amyloplast ;
plasmodesma(ta) ;
larger/80S/22 nm, ribosomes ; [9]

29. M/J 13/P22/Q1/b

(a) (i) 13 μm ; ; *two marks for correct calculation* (39 000 / 3000)
allow one mark
if calculation of 12.6 μm or 13.3 μm (i.e. measured as 38 mm or 40 mm and not rounded to nearest micrometre)
measurement of, 39 mm / 3.9 cm, incorrectly converted to μm but correct formula used (i.e. divided by 3000)

(ii) *assume cancer cell unless stated otherwise*
(undergoing) uncontrolled, mitosis / division ; **A** fast / rapid / abnormally
mitochondria, provide / produce, ATP ; **R** ATP energy
A provide energy **R** produce energy
RER, produce / synthesise / make / AW, (more), proteins / enzymes, for (cell) growth / mitosis / division ; *if mp 1 gained, no need ref. to mitosis* [4]

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30. M/J 13/P23/Q1

(a) **A** = chloroplast ; **A** granum / grana
B = (intercellular) air space ;
C = nucleolus ; **A** nucleus

(b) *two marks for correct answer*
9 (μm) ;;
award one mark if not to nearest micrometre, 9.3/9.28
or correct measurement incorrectly converted but correct formula used
64/65/66 mm ÷ 7000

(c) **1** phospholipid bilayer ;
A lipid bilayer
2 phospholipids have, phosphate / hydrophilic, heads, and, hydrophobic tails / fatty acid chains ;
3 ref. to, labile nature of bilayer structure / phospholipid (molecules) moving (within their monolayer) ;
4 protein molecules, interspersed / scattered / not a complete layer / AW ;
5 many / AW, different / AW (protein molecules) ;
6 example of type of protein ;
7 *idea of* (most) proteins, moving / not in fixed position ;
8 reference to cholesterol ;

(d) **1** ref. to movement, down water potential gradient / from high(er) to low(er) ;
2 apoplastic / cell wall, pathway from xylem to cell walls of (palisade mesophyll) cells ;
3 ref. to osmosis ; *in context of* movement, into cell / through cell surface membrane / through tonoplast,
R osmosis from xylem to vacuole
4 symplastic / cytoplasmic, pathway (within cell) ;
5 via plasmodesmata ; *in context of water arriving from adjacent cell*
6 ref. to channel proteins / aquaporins ;
7 solutes / named, in vacuole ; [12]

31. O/N 12/P22/Q1

(a) *electron microscope*
accept ora for light microscope
1 higher resolution / better resolving power;
A high *only if further detail confirms understanding*
2 more easily able to distinguish between two (separate) points / AW;
A *if no comparative but mp 1 or relevant point in mp 3 gained*
3 **AVP**; able to see points closer together than 200 nm **A** range 100 – 300 nm
can see points up to 0.5 nm (0.0005 μm) apart but LM is 200 nm (0.2 μm) **A** range 0.2 – 1.0 nm
electrons have shorter wavelength (than light)
wavelength of electrons shorter than size of additional structures seen

(b) *each feature must be briefly qualified to gain max 3*
penalise once if feature correct but not correctly qualified / or not qualified
1 detail of mitochondria; e.g. inner membrane / crista(e)
double membrane
ribosomes
(circular) DNA
2 detail of chloroplasts; e.g. double membrane
internal membranes
thylakoid(s) / grana / intergrana / lamellae
ribosomes

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3 ribosomes, qualified; e.g. visible as small dots
scattered throughout / in cytoplasm
on RER

4 smooth endoplasmic reticulum / SER, qualified; e.g. no ribosomes / tubular / membranous

5 rough endoplasmic reticulum / RER, qualified; e.g. ribosomes / membranous / flattened cisternae;

4/5 endoplasmic reticulum / ER, qualified; e.g. smooth and rough / membranous / throughout cytoplasm

6 Golgi vesicles / secretory vesicles / lysosomes qualified;
e.g. forming from Golgi
ref. exocytosis (not for lysosomes)
seen as (small) sacs / AW
membranous

7 heterochromatin darker staining / euchromatin lighter staining;
A chromosomes seen as heterochromatin and euchromatin

8 nucleus has, nuclear envelope / two membranes;

9 nuclear pores in nuclear envelope;

10 cell surface membrane, qualified; e.g. to the inside of the cell wall

11 *idea that* (cell) membranes are visible, qualified; e.g. thin / round / within organelles / named organelle

(c) *award two marks if correct answer is given, only one mark if μm (units) given*
× 1600;;
A in range of × 1400 to × 1800

(8 000 / 5 μm)
7 000 / 5 μm = (1400)
9 000 / 5 = (1800)
award one mark if correctly measured and divided by 5 μm but incorrectly converted
award one mark if incorrect measurement (e.g. whole cell) but correct formula used (i.e. divided by 5 μm)

(d) (i) 1 amylopectin branched / AW; **ora**

2 amylose, spiral /spiralled / helix / helical; **ora**
R α – helix
R coiled
allow ecf from mps 1 and 2 to award mp 3

3 amylose (α) 1 – 4 linkages but 1 – 4 and 1 – 6 linkages in amylopectin / amylose has 1 – 4 linkages only;
accept from clearly labelled diagram(s)

(ii) *any one valid; e.g.*

1 for chlorophyll, structure / synthesis / formation / AW
2 for ATP functioning **A** required for energy transfers
3 for enzyme, functioning / cofactor
4 signalling ion / regulates carbon fixation
5 for, DNA / RNA, synthesis
6 stabilises, DNA / RNA, structure
7 required in, translation / joining, small and large subunits (of ribosomes) [10]

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32. O/N 12/P23/Q1

accept first on row
accept phonetic spellings

A	*name*	mitochondrion ; **A** mitochondria
	function (site of) ;	ATP, synthesis / production / AW aerobic respiration link reaction Krebs cycle oxidative phosphorylation AVP **R** ATP energy
B	*name*	Golgi (apparatus / body / complex) ; **A** dictyosome **A** Golgi
	function (site of) ;	modification of protein / glycosylation / described modification of lipid pack(ag)ing (of), protein / lipids production of (Golgi / secretory) vesicles / lysosomes **ignore** synthesis of protein *(incorrect name)* *lysosome function* = contains / storage of hydrolytic / digestive, enzymes *Golgi / secretory, vesicles* = transport, protein / lipids
C	*name*	chloroplast(s) ;
	function (site of) ;	photosynthesis light-dependent, reactions / stage (of photosynthesis) light, absorption / AW light-independent, reactions / stage (of photosynthesis) Calvin cycle carbon fixation photophosphorylation **A** ATP synthesis **ignore** *(treat as neutral) ref. to, glucose / oxygen, synthesis* **ignore** *chlorophyll* **R** light / dark, stage / reactions
D	*name*	rough endoplasmic reticulum ; **R** RER or rough ER **R** endoplastic
	function (site of) ;	protein / polypeptide, synthesis translation modification of protein / described (e.g. folding) protein transport (to Golgi) *(incorrect name)* *smooth endoplasmic reticulum* = lipid / steroid / cholesterol, synthesis / AW *endoplasmic reticulum = ecf as above for RER / SER*

[8]

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33. O/N 12/P21/Q1

(a) *one mark per row*
penalise once for stated ecf and then mark to max 4

	name of organelle	function
A	*cell surface membrane*	*control of movement of substances into and out of the cell*
B	nucleolus	production of, ribosomes / rRNA / tRNA ;
C	mitochondrion **A** mitochondria	one from ; aerobic respiration ATP synthesis/ production / AW link reaction Krebs cycle oxidative phosphorylation **R** produces energy / ATP energy
D	smooth endoplasmic reticulum **R** SER or smooth ER	lipid / sterol / cholesterol / steroid, synthesis ; *ecf if SER, or Golgi is named organelle*
E	rough endoplasmic reticulum **R** RER or rough ER	one from ; protein / polypeptide, synthesis translation modification of protein / described (e.g. folding, glycosylation) protein transport (to Golgi) *ecf if RER*
F	Golgi (body / complex /apparatus)	one from ; modification of protein glycosylation / described modification of lipid pack(ag)ing (of), protein / lipids production of, (Golgi / secretory) vesicles / lysosomes ***ignore*** synthesis of protein *allow ecf if smooth endoplasmic reticulum*
G	lysosome *or* Golgi / secretory, vesicle	contains /storage of, hydrolytic / digestive, enzymes *or if Golgi vesicle* transfer / transport, of, protein / lipids ;

(b) *max 3 if only structure or only explanations given*
polysaccharide ;
chains of α-glucose (residues) ; *only need α once*
α1–4 glycosidic bonds / links ;
branches ;
(because of) α 1–6 glycosidic bonds ; *only need glycosidic once*
idea that many 'ends' to easily, add / remove, glucose ;
compact / AW ;

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insoluble ;
will not affect, water potential / ψ ; AW
AVP ; [10]

34. M/J 12/P22/Q2/a

(a) *allow immunoglobulin for antibody*

structure	name of structure	function of structure within plasma cell
A	nucleus ; **A** (eu)chromatin **R** heterochromatin **R** chromosome	ref. gene(s) / genetic information / genetic material / DNA, (coding) for, antibody / protein / polypeptide ; transcription (occurring) / mRNA synthesis ; AW (ref. antibodies) *allow ecf for nucleolus*
B	mitochondrion ; **A** mitochondria	provides / synthesises / produces / makes, ATP (for antibody synthesis / exocytosis) ; *treat as neutral other uses of ATP* *allow ecf for lysosomes*
C	rough endoplasmic reticulum ; ignore RER	synthesis / modification / processing / transport, of, antibody / protein / polypeptide ; **A** translation *allow ecf for Golgi or SER or ER*

[6]

35. M/J 12/P21/Q2

(a) **1** electron microscope has, higher / AW, resolution (than LM) / ora ;
2 explanation of resolution as ability to differentiate between two points (close together) ;
3 ref. to (internal) membranes (of **A** and **B**) which cannot be seen in LM ;
A named membranes e.g. cristae, grana
4 AVP ; e.g.
(resolution of) EM is 0.5 nm (0.0005μm) and LM is 200 nm (0.2μm)
A 0.5 to 1 nm (0.001μm)
resolution is equal to half the wavelength (of medium used)
ref. to shorter / AW, wavelength (of electrons) / ora (must have a comparison)
ref. to, width of membranes / distance apart of membranes, e.g. width of membranes in A and B is 7 nm (+/– 1)

(b) **C** – rough endoplasmic reticulum ; *penalise once only for ER instead of endoplasmic reticulum*
D – ribosome ; **A** ribosomes ignore 70S
E – smooth endoplasmic reticulum ; **A** smooth ER *if full term used for* **C**
award one mark if ***E*** *= rough endoplasmic reticulum and* ***C*** *= smooth endoplasmic reticulum*

(c) *any one relevant e.g.*
store of / holds, cell sap; **R** if contains organelles
store of / holds, water / ions / named ion(s) / minerals / salts / pigments / (named) sugars ;
R substances / molecules
R storage unqualified

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pushes chloroplast to edge of cell ;
gives, turgidity / turgor pressure / hydrostatic pressure / support / AW ;
A makes, firm / rigid
A controls / maintains, turgidity
R gives shape / strengthen
store of / holds, waste (products)
R reactions occur in vacuole, unqualified

(d) *no marks for identifying **F** and **G***
*if only **F** or **G** described max 3*
*if **F** and **G** incorrectly identified, accept mark points correctly linked to membrane and wall to max 3*

1 **F** partially permeable A selectively permeable
and **G** (fully / freely / AW), permeable / porous ;
F is partially permeable cell surface membrane
2 phospholipid (bilayer);
3 permeable to, lipid-soluble molecules / oxygen ;
A other terms for lipid-soluble
treat reference to water as neutral
4 impermeable to, water-soluble / AW, molecules / ions / AW ;
A other terms for water-soluble
treat reference to water as neutral
5 aquaporins / proteins, provide (increased) permeability to water ;
6 transport proteins provide permeability to, ions / polar molecules ;
A channel / pore / carrier, proteins
G is permeable cell wall
7 cellulose ;
8 fibres ;
9 ref. to, spaces / gaps / holes / pores, (between, fibres / other cell wall components) ;

(e) 1 allows transport of, water / sucrose / amino acids /organic substances / ions /minerals / salts / lipids / hormones / ATP, (from cell to cell / between cells) ;
R if linked to an incorrect transport mechanism e.g. sucrose moves by osmosis
2 without crossing, membranes / walls ; **A** without going through protein channels
3 this is movement through the symplast ;
4 any e.g. ; companion cell to (phloem) sieve tube (element / cell)
between mesophyll cells
mesophyll cell to companion cell
cortical cell to cortical cell / across cells of the cortex
cortical cell to endodermal cell
endodermal cell to, pericycle cell / xylem / phloem
ignore between sieve tube elements
5 allows, communication / signalling, between cells ; [14]

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Unit 2
BIOLOGICAL MOLECULES

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

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Syllabus

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Unit 2: Biological Molecules

1. M/J 22/P21/Q4

Adipocytes are cells found in adipose tissue in mammals. These cells absorb glycerol and fatty acids to make triglycerides for long-term storage.

Fig. 4.1a shows a glycerol molecule and three fatty acids. Fig. 4.1b shows the triglyceride molecule formed from these components.

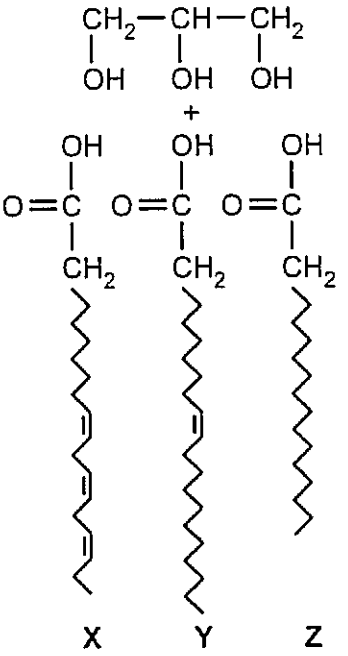


Fig. 4.1a

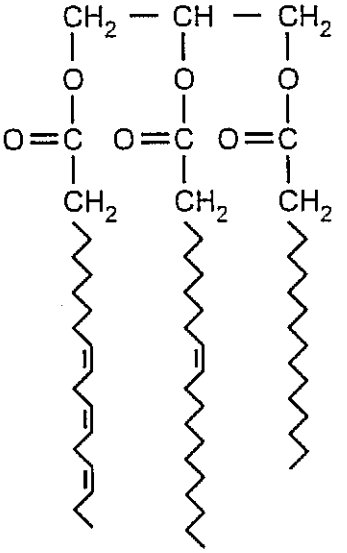


Fig. 4.1b

(a) (i) State the name of the bonds that form between glycerol and fatty acids.

..... [1]

(ii) When a bond forms between glycerol and a fatty acid, water is a product of the reaction. State the name given to this type of reaction.

..... [1]

(iii) Describe the differences between the fatty acids, **X**, **Y** and **Z**, shown in Fig. 4.1a.

.....

.....

..... [3]

(b) (i) State reasons why triglycerides are described as hydrophobic.

.....

..... [2]

(ii) Explain why triglycerides are **not** suitable as a component of cell surface membranes.

.....

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..... [2]

2. M/J 22/P23/Q2

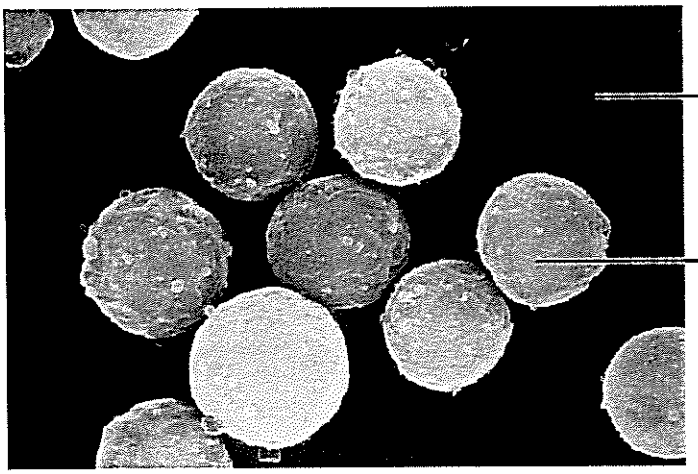
Bacterial cells are prokaryotic. The cells of plants are described as eukaryotic.

(a) Complete the passage comparing a bacterial cell with a plant cell.

A bacterial cell and a plant cell have a cell wall, but the main component of the bacterial cell wall is ..... and not cellulose. The same organelle is used for protein synthesis in both cell types, but a bacterial cell only has smaller, 70S, ... A bacterial cell does not have a large ..... surrounded by a tonoplast. [3]

(b) Protoplasts are plant cells that have had their cell walls removed by treatment with enzymes. Scientists often use protoplasts when researching ways to improve the yield of crop plants.

Fig. 2.1 is a scanning electron micrograph of protoplasts of cells from the tobacco plant, *Nicotiana tabacum*.



magnification ×256

Fig. 2.1

Explain why scientists keep the protoplasts in a solution that has the same water potential as the cell.

.....

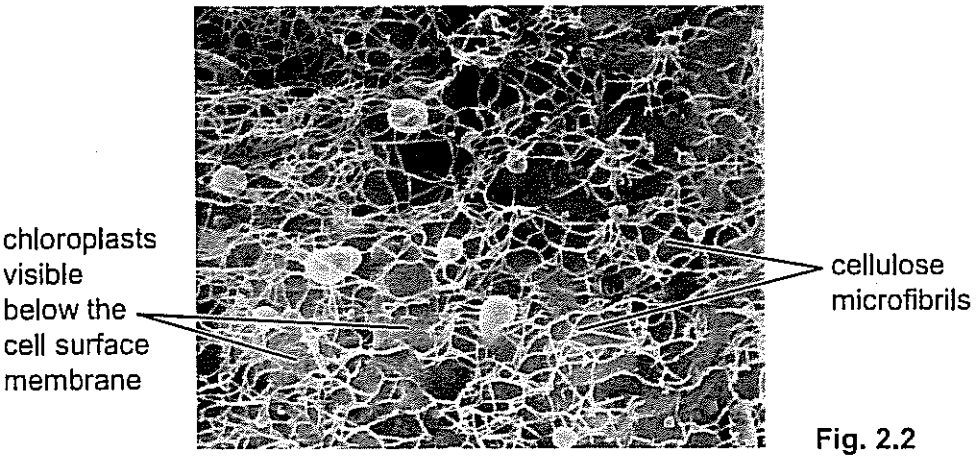
..... [2]

After protoplast treatment, the cells can be stimulated to synthesise new cell wall material.

Fig. 2.2 is at a higher magnification than Fig. 2.1 and shows a scanning electron micrograph of part of a protoplast in an early stage of cell wall synthesis.

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magnification ×3075

Fig. 2.2

(c) The cellulose microfibrils visible in Fig. 2.2 will form cellulose fibres. Each microfibril is formed from cellulose molecules. Each cellulose molecule is a polymer of β-glucose.

(i) Describe the structure of a cellulose molecule **and** a cellulose microfibril.

.....

.....

..... [3]

(ii) Name **one** substance that may be added to the network formed by the cellulose microfibrils in the formation of a cell wall.

..... [1]

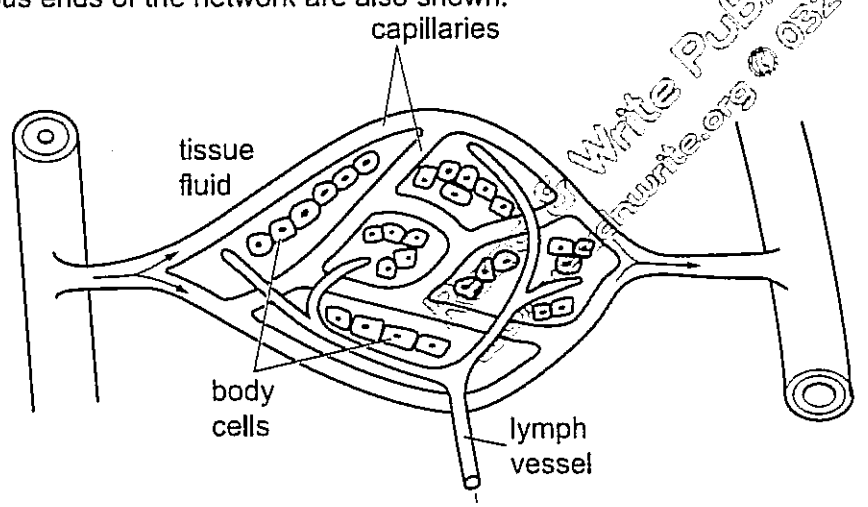
(d) Name the type of plant cell that could have been used to produce the protoplast shown in Fig. 2.2.

..... [1]

3. O/N 21/P22/Q2/b

The high blood pressure at the arterial end of a capillary network results in some components of blood leaving the capillaries and forming tissue fluid. At the venous end, the presence of plasma proteins allows movement of water by osmosis back into the capillaries.

Fig. 2.1 is a diagram showing a capillary network. The lymph vessels and the blood vessels at the arterial and venous ends of the network are also shown.



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(a) Name the chemical reagent or reagents used to test for proteins in a sample of blood plasma **and** state the colour change that will be seen if protein is present.

reagent or reagents .....

colour change ..... [2]

4. O/N 21/P22/Q6

Amylase is an enzyme that catalyses the hydrolysis of starch into reducing sugars.
A student carried out an experiment to investigate the hydrolysis of starch using immobilised amylase. Fig. 6.1 is a diagram of the apparatus that was used in the investigation.

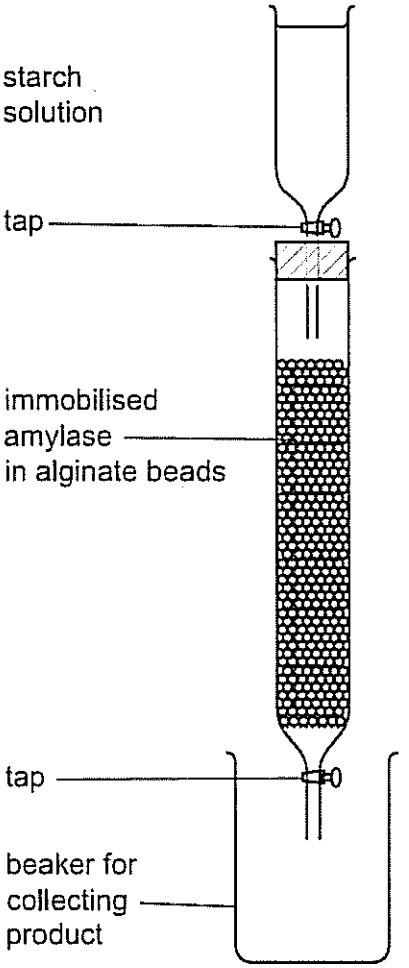


Fig. 6.1

The alginate beads were all the same size.
Both taps were opened to allow the starch solution to flow down the column and for the product to be collected.
The product was tested for the presence of reducing sugar and starch.

(a) The results of the investigation showed that the product collected in the beaker contained reducing sugar **and** starch.
With reference to Fig. 6.1, describe a method that would allow the student to use the immobilised amylase to collect a product that contains **only** reducing sugar.

.....

.....

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..... [3]

(b) One standardised variable in the investigation is the size of the alginate beads.
Suggest **one** reason why using larger or smaller alginate beads in the column would affect the results obtained.

..... [1]

5. O/N 21/P21/Q1/a(ii),b

(a) Fig. 1.1 is a transmission electron micrograph of cells from the leaf of a plant.

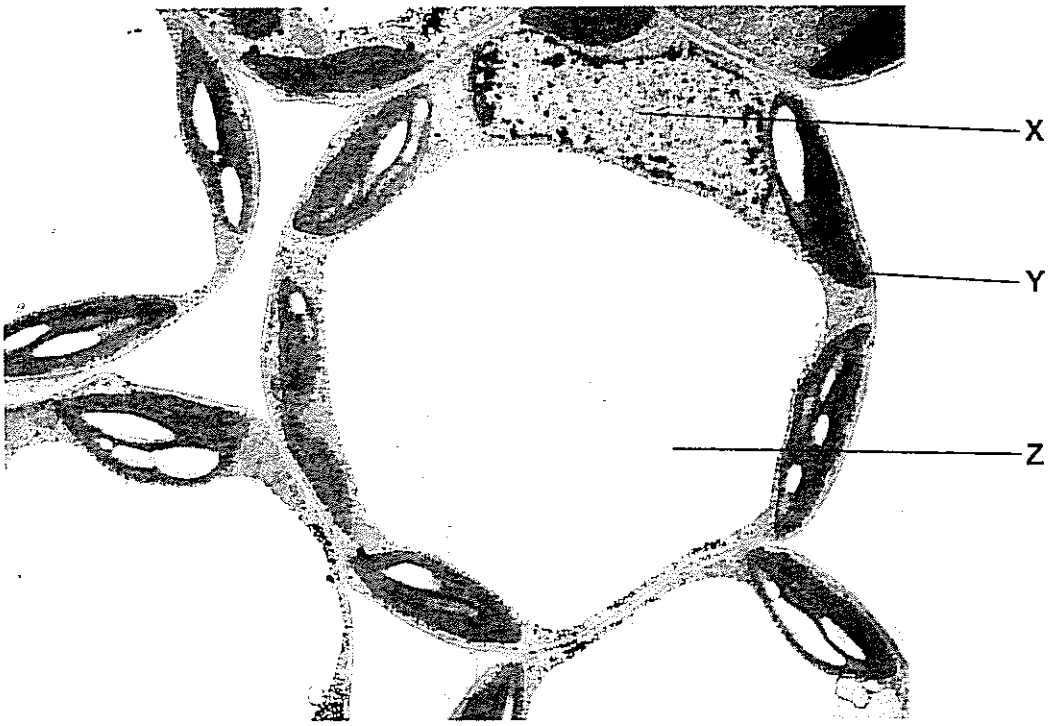


Fig. 1.1

(i) State **two** ways in which the structure of an animal cell differs from plant cells such as those shown in Fig. 1.1.

1 .....

2 .....[2]

(b) (i) Cell structure Y in Fig. 1.1 contains a large starch granule (grain).
Name the chemical reagent used to test for starch **and** state the colour change that will be seen if starch is present.

reagent .....

colour change ..... [2]

(ii) Starch granules contain amylose and amylopectin.
Describe the similarities **and** differences between the structure of amylose and the structure of amylopectin.

.....

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.....

.....

..... [4]

6. O/N 21/P23/Q6/a,b

(a) Table 6.1 compares some of the features of DNA with the protein collagen.
Complete Table 6.1.

Table 6.1

feature	DNA	collagen
elements		C H O N
monomers		
bond between monomers		
site of production in eukaryotic cells	nucleus	

[6]

(b) Most of the DNA in a eukaryotic cell is located in the nucleus.
State how the structure of a nucleus is suited to its function of containing DNA.

.....

..... [2]

7. M/J 21/P21/Q1

Fig. 1.1 is a transmission electron micrograph of cells from duckweed, *Spirodela oligorrhiza*.

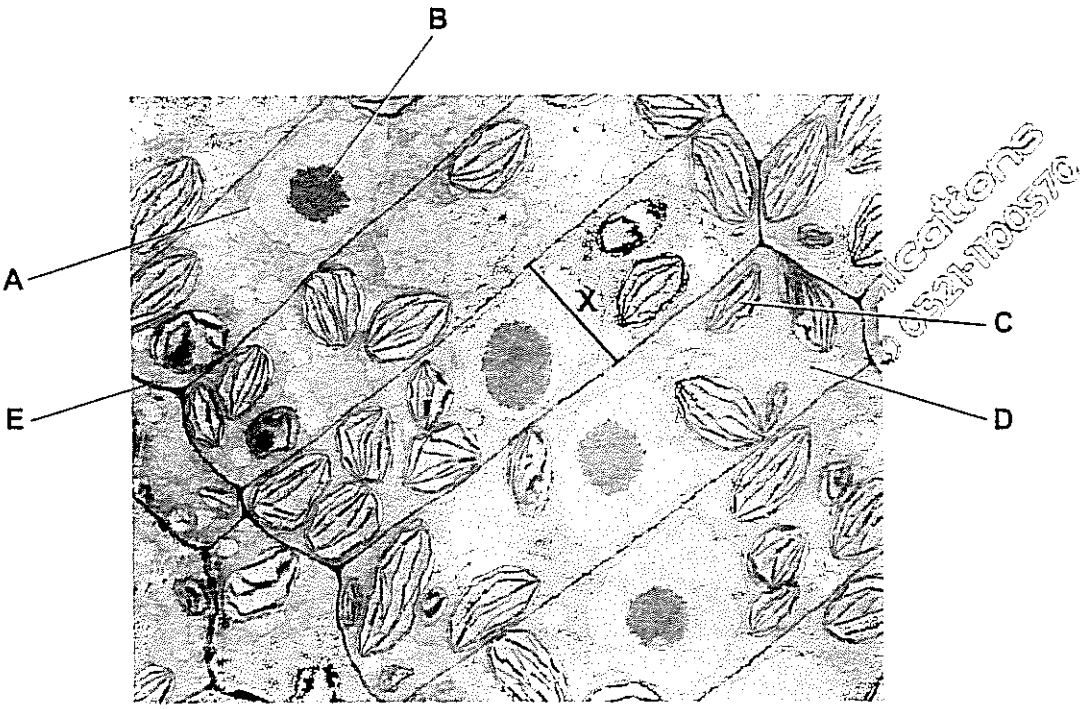


Fig. 1.1 magnification ×4275

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(a) Calculate the actual width of the cell labelled **X**.
Write down the formula you will use to make your calculation.
Show your working and give your answer in micrometres to one decimal place.

formula

..... μm [3]

(b) (i) Table 1.1 lists some biological molecules found in plant cells.
Complete Table 1.1 by choosing **one** letter from Fig. 1.1 that indicates a cell structure where each biological molecule is found.

Table 1.1

biological molecule	letter from Fig. 1.1
DNA	
cellulose	
phospholipid	
histone proteins	

[4]

(ii) State the name of a cell structure, **visible in Fig. 1.1**, where ATP is synthesised.

..... [1]

(iii) Name a cell structure that produces mRNA.

..... [1]

(c) Describe the evidence from Fig. 1.1 that shows that the image is a transmission electron micrograph.

.....

..... [2]

8. M/J 21P21/Q2
Fig. 2.1 shows three molecules of water.

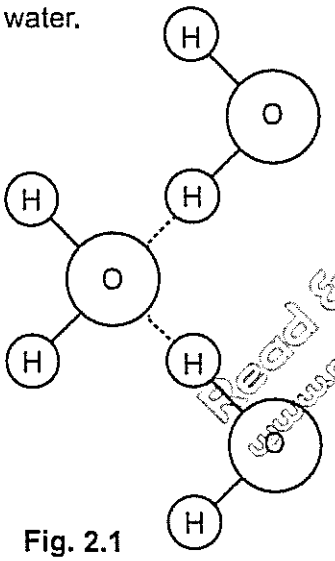


Fig. 2.1

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(a) Describe the hydrogen bonding that occurs between the water molecules shown in Fig. 2.1.

.....

.....

..... [3]

(b) The human enzyme, salivary amylase, is composed of one polypeptide. Fig. 2.2 represents the structure of a molecule of salivary amylase.

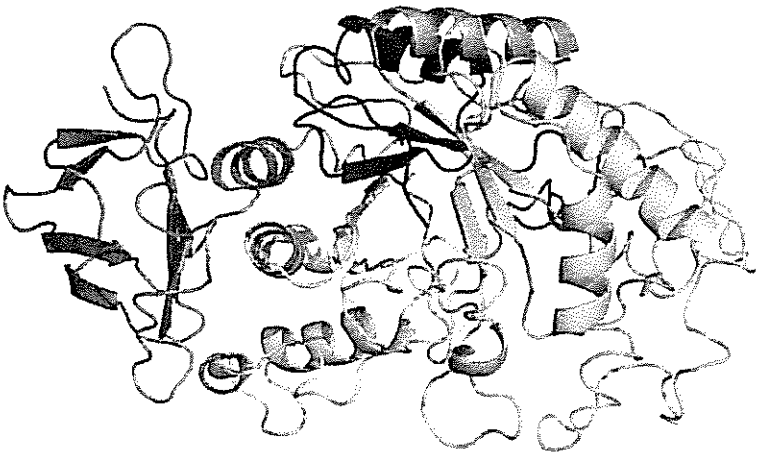


Fig. 2.2

(i) Explain the role of hydrogen bonding in maintaining the secondary structure of proteins, such as salivary amylase.

..... [1]

(ii) Explain the role of hydrogen bonding in maintaining the tertiary structure of proteins such as salivary amylase.

.....

..... [2]

(c) Outline the importance of water as a solvent in **plants**.

.....

.....

..... [3]

9. O/N 20/P21/Q2/a

(a) Fig. 2.1 shows the molecular structure of a triglyceride molecule.

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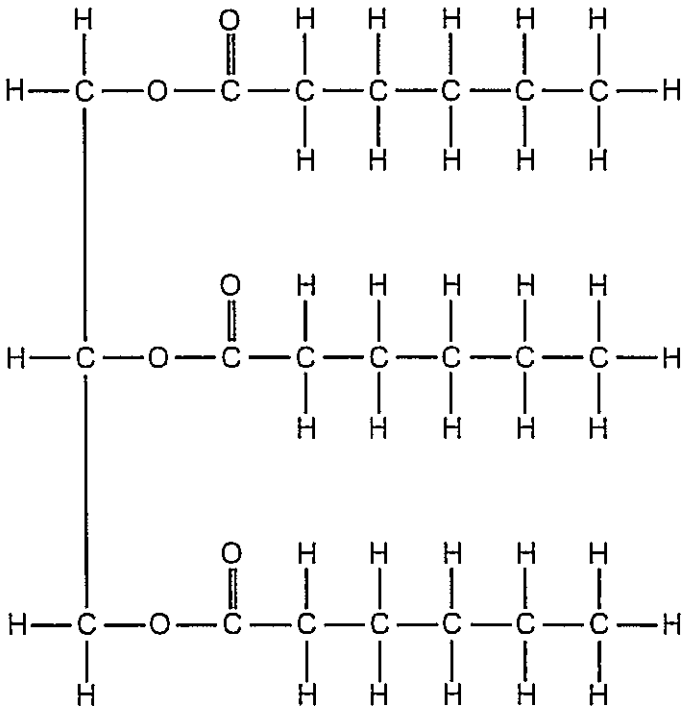


Fig. 2.1

(i) Draw a circle around an ester bond shown in Fig. 2.1. [1]

(ii) Name the type of reaction used to produce a triglyceride from its components.
State the number of water molecules produced during this reaction.

type of reaction .....

number of water molecules produced .....[2]

10. O/N 20/P21/Q5/b(iii,iv)

(a) Fig. 5.2 is a photograph of two African elephants, *Loxodonta africana*.



Fig. 5.2

(i) The feet of elephants are protected by structures under the skin known as cushions. The cushions are made up of a large number of cells surrounded by connective tissue containing many fibres of collagen. The fibres help to maintain the structure of the cushion.

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The collagen fibres are made of collagen molecules.
Describe the structure of a **collagen molecule**.

.....

.....

.....

..... [4]

(ii) The cushion in the foot is very strong and is able to resist extremely large forces acting on it due to the large mass of the elephant.
Suggest how the structure of a **collagen fibre** can help the cushion resist these large forces.

..... [1]

11. M/J 20/P22/Q4/b(ii),c

Collagen is a major component of the cartilage found in some of the structures of the human gas exchange system. Cells that synthesise and secrete the components of cartilage are known as chondrocytes.

(a) (i) Outline the function of cartilage in the human gas exchange system.

.....

..... [2]

(c) Fig. 4.2 shows part of the primary structure of a collagen polypeptide.

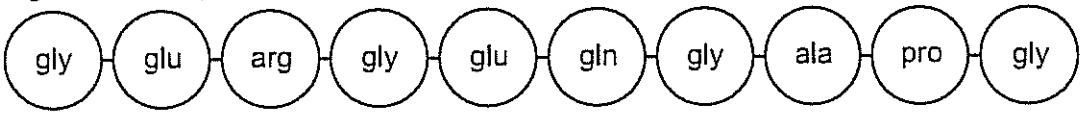


Fig. 4.2

(i) Name the type of covalent bond formed between the amino acids shown in Fig. 4.2.

..... [1]

(ii) Fig. 4.3 shows the molecular structure of the amino acid glycine (gly).

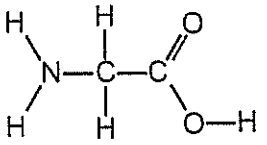


Fig. 4.3

With reference to Fig. 4.2 and Fig. 4.3 and the function of collagen, explain how the structure of a collagen polypeptide makes it suitable to form a collagen molecule.

.....

.....

..... [3]

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12. M/J 20/P22/Q5/c

(a) UDPG is used in some algae (photosynthetic protoctists) to synthesise a storage compound known as floridean starch.

The molecular structure of floridean starch has been described as an intermediate between amylopectin and glycogen, with little or no amylose.

Describe the molecular structure of floridean starch by completing the passage.

Floridean starch is a polysaccharide composed of ..... monomers.

The monomers are joined by ..... and ..... linkages,

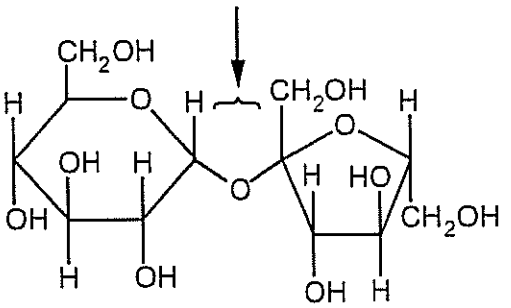
to give a branching structure that is less highly branched than

..... . [4]

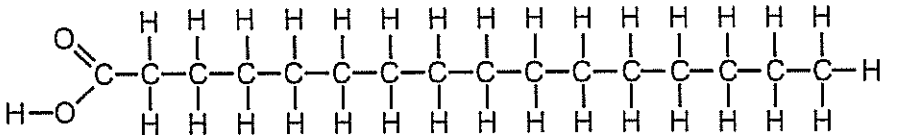
13. M/J 20/P21/Q1

Fig. 1.1 shows five biological molecules.

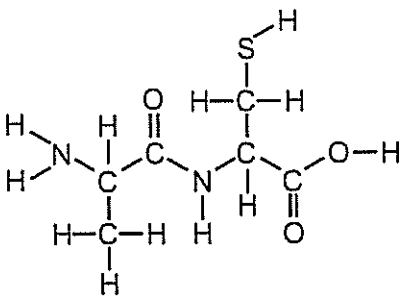
A



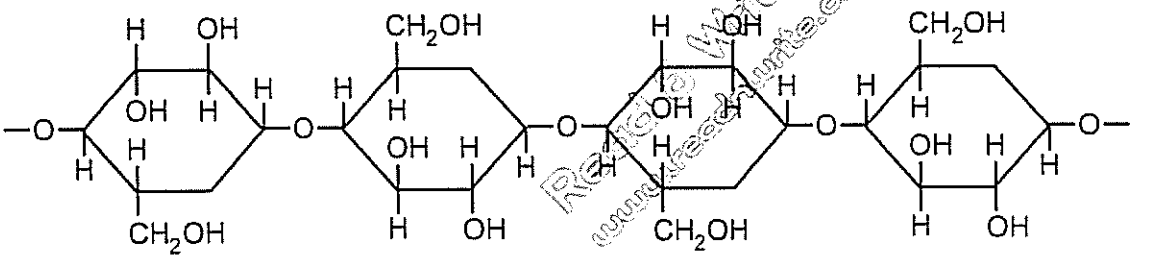
B



C



D



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E

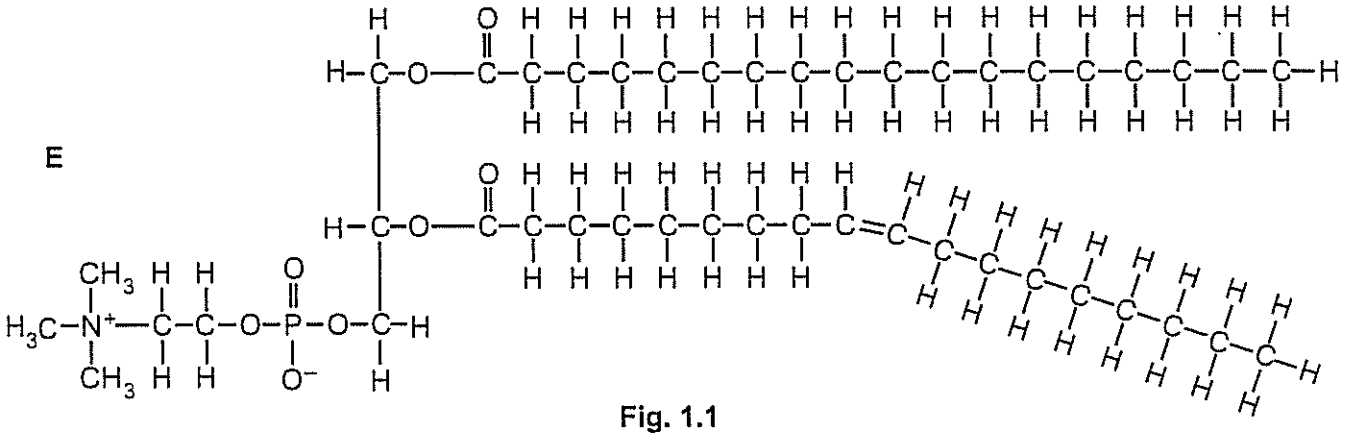


Fig. 1.1

(a) State the name of the bond in molecule **A** indicated by the arrow.

..... [1]

(b) Molecule **B** is described as a saturated fatty acid.
State why molecule **B** is described as a saturated fatty acid.

..... [1]

(c) Molecule **D** is a polymer.
State the name of the monomer that is used to synthesise this polymer.

..... [1]

(d) State the letter of the molecule that could be formed during the hydrolysis of a polypeptide.

..... [1]

(e) State the letter of the molecule that forms part of the cell surface membranes of eukaryotic cells.

..... [1]

(f) Molecule **A** and molecule **C** dissolve in water. Molecule **B** does **not** dissolve in water.
Explain why molecule **A** and molecule **C** dissolve in water, but molecule **B** does **not** dissolve in water.

..... [1]

14. M/J 20/P23/Q4/a,b,c,d

Saccharomyces cerevisiae is a unicellular fungus that is important in the brewing and baking industries.

Fig. 4.1 is a diagram of a transmission electron micrograph of *S. cerevisiae*.

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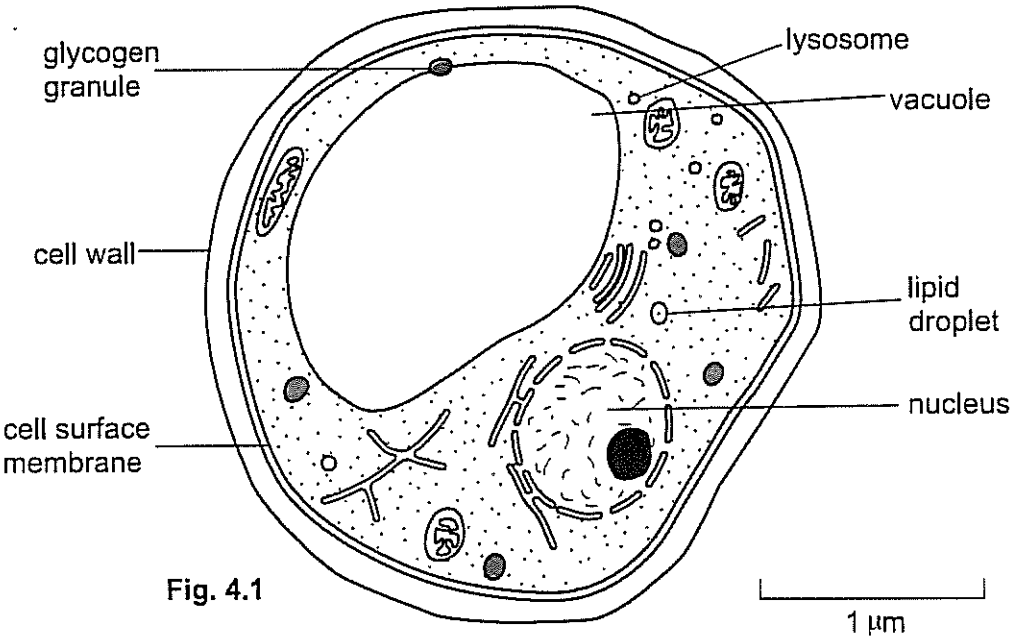


Fig. 4.1

(a) A student was asked to calculate the magnification of the image shown in Fig. 4.1.
The student began by measuring the length of the scale bar in millimetres using a millimetre ruler.
State what the student should do next to obtain the correct answer.

..... [1]

(b) One function of the lipid droplets shown in Fig. 4.1 is to store triglycerides.
The triglycerides in a lipid droplet are surrounded by a single layer (monolayer) of phospholipids.
Suggest **and** explain why phospholipids, rather than triglycerides, are used for the outer monolayer of the lipid droplet.

.....

..... [2]

(c) The lysosomes and vacuole of *S. cerevisiae* contain acid hydrolases (hydrolytic enzymes) that function in an acid pH.
Explain why lysosomes need hydrolases to carry out their function.

..... [1]

(d) A disaccharide, trehalose, is a reserve store of energy for *S. cerevisiae* when glycogen stores decrease. The monomer of glycogen and trehalose is α-glucose.

(i) Complete Fig. 4.2 to show the ring structure of **one** α-glucose molecule.

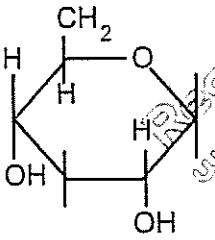


Fig. 4.2 [2]

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(ii) A student carried out tests on a solution of trehalose and correctly concluded that trehalose is a **non-reducing** sugar.
Outline the procedure carried out by the student **and** state the results that were obtained.

.....

..... [3]

15. O/N 19/P22/Q4

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.

.....

..... [2]

(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.

.....

.....

.....

.....

..... [5]

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16. O/N 19/P21/Q1/a

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

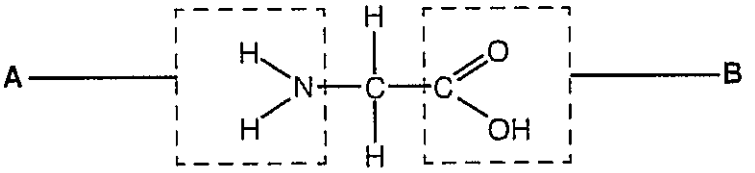


Fig. 1.1

(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.

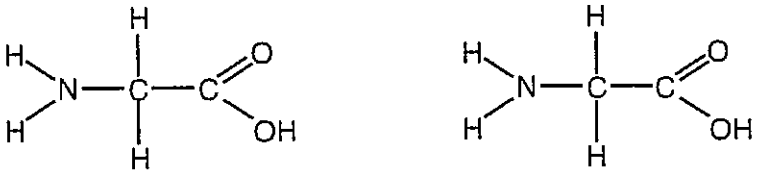


Fig. 1.2 [3]

17. O/N 19/P23/Q1

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

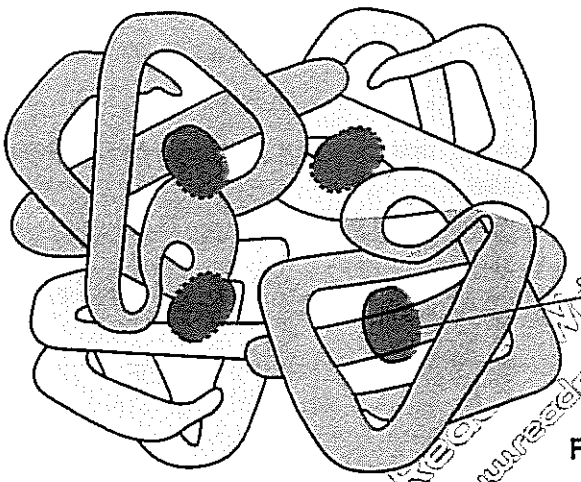


Fig. 1.1

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

..... [1]

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

..... [1]

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

.....

..... [2]

(c) The gene *HBB* codes for the β-globin polypeptide.
State why a polypeptide, such as β-globin, is described as a polymer.

.....

..... [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.

.....

.....

..... [3]

(e) Haemoglobin interacts with carbon dioxide and carbon monoxide.
Outline the role of haemoglobin in the transport of carbon dioxide.

.....

.....

..... [3]

18. M/J 19/P22/Q5
Cells contain carbohydrates, proteins, lipids and nucleic acids.

(a) Fig. 5.1 is a list of biological molecules, some of which are components of larger molecules.

cellulose
thymine nucleotide
α-glucose
β-glucose
messenger RNA
glycogen
glycine
α-globin

Fig. 5.1

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Complete Table 5.1 by using **only** the molecules listed in Fig. 5.1.

- Each example can be written under **one or more** correct headings.
- **All** the examples in Fig. 5.1 should appear at least **once** in Table 5.1.

Table 5.1

examples			
monomers	polymers	monosaccharides	polysaccharides

[5]

(b) Explain how the structure of phospholipids allows the formation of the phospholipid bilayer of cell membranes.

.....

.....

..... [3]

19. M/J 19/P21/Q1/a

(a) Antibody molecules are proteins that show primary structure, secondary structure, tertiary structure and quaternary structure.
Fig. 1.1 shows a ribbon diagram of an antibody molecule.

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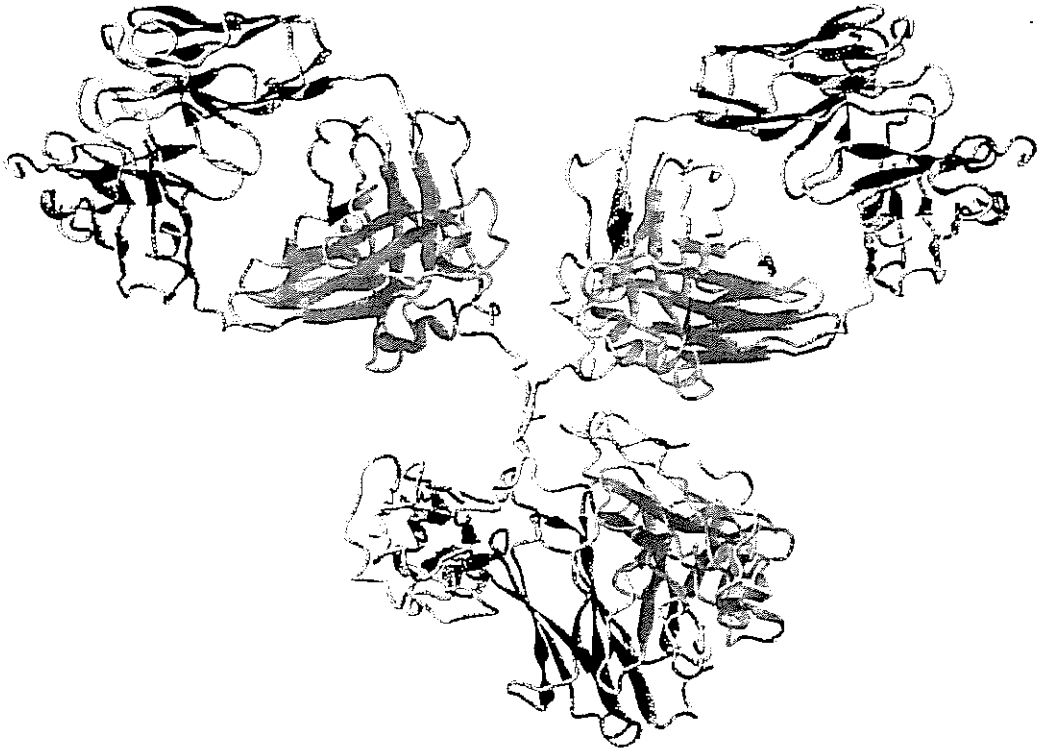


Fig. 1.1

Describe how Fig. 1.1 shows the secondary structure **and** tertiary structure of the antibody molecule.

secondary structure .....

tertiary structure .....

..... [3]

20. O/N 18/21/Q3

(a) Fig. 3.1 is a transmission electron micrograph showing two adjacent cells in a leaf.



Fig. 3.1

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(i) Cellulose is the main polysaccharide in cell walls of plants.
Describe the structure of cellulose.

.....

.....

..... [3]

(ii) State **one** feature **visible** in Fig. 3.1, other than the cell wall, that identifies the cells as plant cells.

..... [1]

(iii) Outline the role of ATP in a leaf cell.

.....

.....

..... [3]

Water is a main component of plant cells.

(b) Fig. 3.2 shows two water molecules linked by a hydrogen bond.

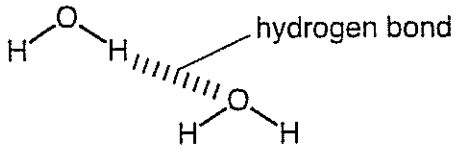


Fig. 3.2

Explain how hydrogen bonding occurs between water molecules.

.....

..... [2]

(c) Suggest why water is an excellent solvent for ions.

.....

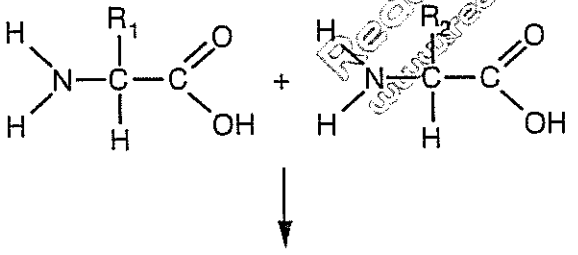
..... [2]

21. O/N 18/P23/Q2

(a) Proteins are macromolecules composed of many amino acids.

(i) Two amino acids are represented in the diagram in Fig. 2.1.

Complete the diagram to show how the two amino acids react together to form a dipeptide.



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Fig. 2.1 [3]

(ii) State what is represented by R_1 and R_2 in Fig. 2.1.

.....

.....[2]

(b) Amylose and cellulose are polysaccharides.
Fig. 2.2 shows the structure of part of a cellulose molecule.

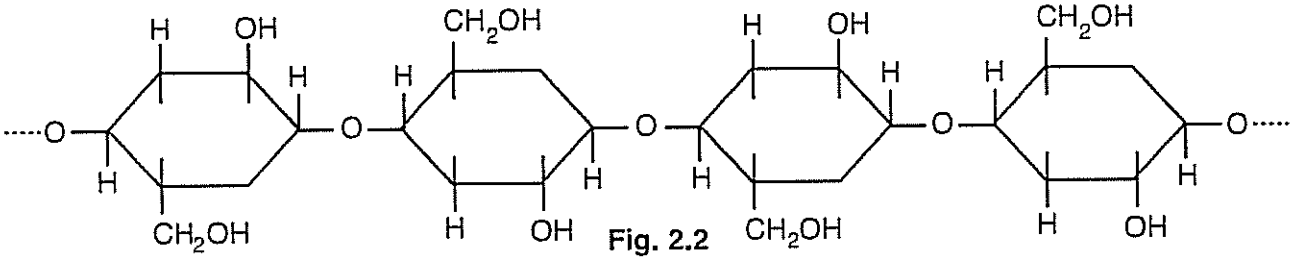


Fig. 2.2

With reference to Fig. 2.2, state how the **structure** of a cellulose molecule differs from the **structure** of an amylose molecule.

.....

..... [2]

(c) Cellulose is the main component of plant cell walls.
Explain why cellulose is suitable as a component of plant cell walls.

.....

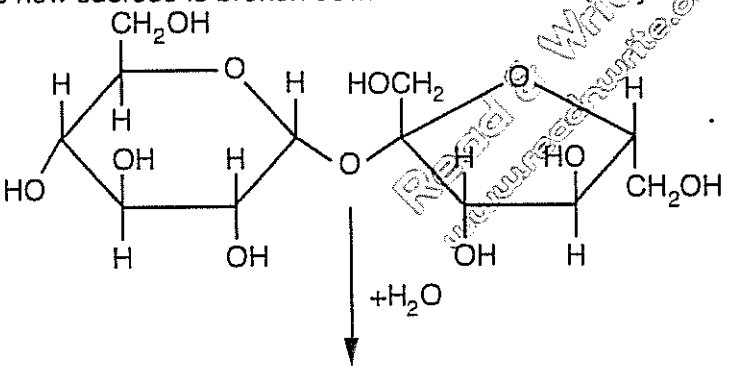
.....

.....

..... [4]

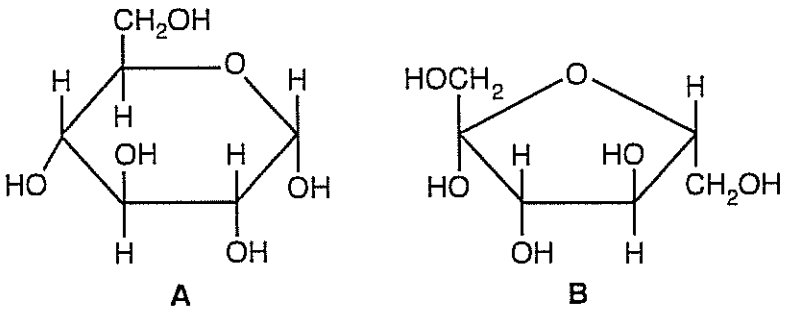
22. M/J 18/P21/Q2/a,b

(a) Sucrose is a disaccharide.
Fig. 2.1 shows how sucrose is broken down in a reaction with hydrochloric acid.



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A B

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.

.....

.....[2]

23. M/J 18/21/Q4/a
Fig. 4.1 is a ribbon model of a molecule of haemoglobin.

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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]

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24. O/N 17/P22/Q2

Triglycerides and phospholipids are types of lipid.

Fig. 2.1 shows the structure of one type of phospholipid known as phosphatidylcholine.
F1 and F2 are fatty acid residues.

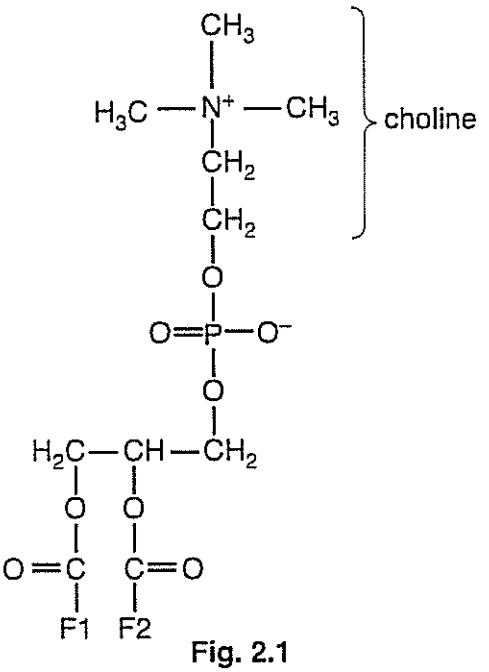


Fig. 2.1

(a) Phospholipase is an enzyme that can break down phospholipids. This enzyme is found in the venom of some insects, such as bees.
Bee venom can destroy red blood cells, a condition known as haemolysis.
Suggest how bee venom destroys red blood cells.

.....

.....[2]

(b) Compare, stating similarities and differences, the structure of the phosphatidylcholine shown in Fig. 2.1 with the structure of a triglyceride molecule.

similarities .....

.....

differences .....

.....[4]

(c) Name **and** describe the cell structure in which the synthesis of triglycerides and other lipids takes place.

.....

.....

.....[3]

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25. M/J 17/P23/Q2/d

(a) Plant cells can be infected with viruses.

Fig. 2.2 shows the key features of a plant virus.

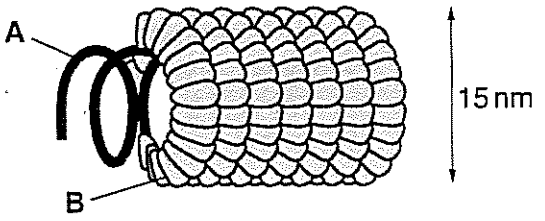


Fig. 2.2

Identify the structures labelled **A** and **B** in Fig. 2.2.

A .....

B .....[2]

26. M/J 17/P23/Q4/a,b

(a) Complete Table 4.1 by using a tick (✓) to indicate which statements apply to each of the molecules. Use a cross (✗) for statements that do **not** apply.

Some of the boxes have been completed for you.

Table 4.1

statement	ATP	cellulose	haemoglobin	phospholipid
contains phosphorus	✓		✗	
found in plants				
contains iron				✗
has a structural role				

[4]

(b) Fig. 4.1 shows two amino acids.

Complete Fig. 4.1 to show how a peptide bond forms between these two amino acids.

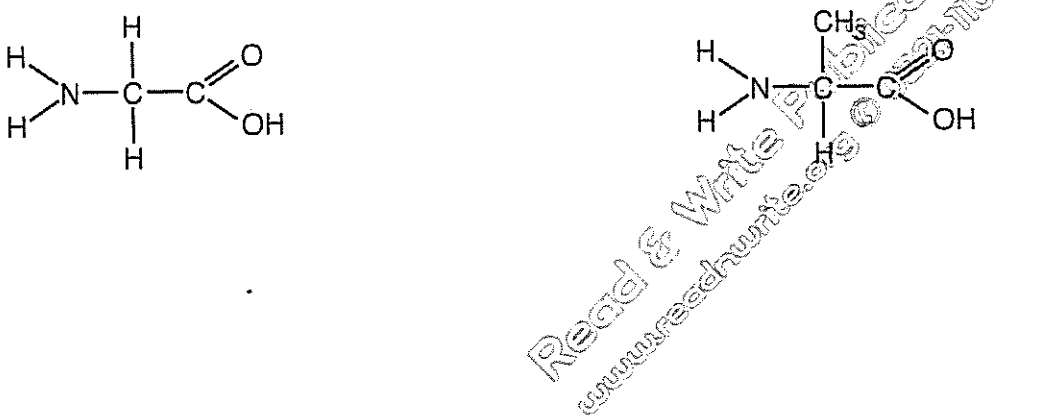


Fig. 4.1

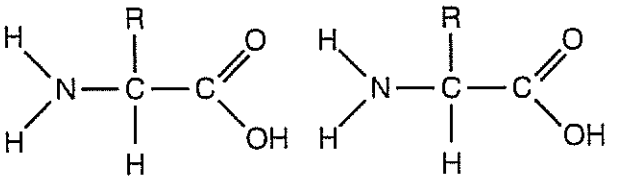
[3]

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27. O/N 16/P22/Q2/c

(a) Amino acids synthesised in the mesophyll cells of leaves are also transported in phloem sap to other locations where they are used to synthesise polypeptides.
Amino acids are joined by peptide bonds to form the polypeptides.
Two amino acids are shown below. Describe the formation of a peptide bond between these two amino acids. You may use the space below.



.....

..... [2]

28. O/N 16/P22/Q3/a,b

High fructose corn syrup, made from maize, can be used as a replacement for sucrose to sweeten food and drink products.
Commercial production of high fructose corn syrup involves the enzyme glucose isomerase, extracted from bacteria.

(a) Fructose and sucrose are both sugars.
State two structural differences between fructose and sucrose.

1 .....

2 ..... [2]

(b) The glucose isomerase used in the production of high fructose corn syrup is extracted from a strain of a bacterium, *Thermus thermophilus*, which is found in hot springs. The enzyme has an optimum temperature of 95 °C.
Suggest **and** explain the advantages of using glucose isomerase from *T. thermophilus* to produce high fructose corn syrup, rather than using glucose isomerase that has an optimum temperature of 37 °C.

.....

.....

..... [3]

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29. O/N 16/P21/Q3/a

Fig. 3.1 shows the structure of the enzyme lysozyme.

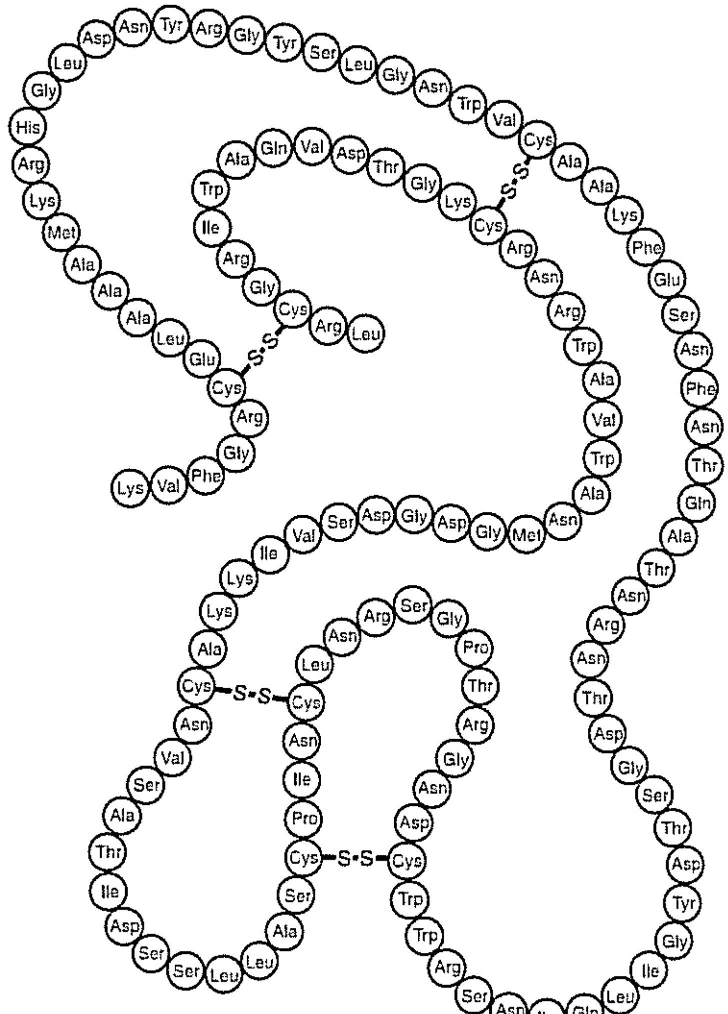


Fig. 3.1

(a) (i) Name the **two** types of covalent bond in the structure in Fig. 3.1.

.... [1]

(ii) The primary structure of lysozyme is shown in Fig. 3.1.

Explain the meaning of the term *primary structure*.

.... [1]

30. O/N 16/P23/Q1

(a) Table 1.1 shows some features of four biological molecules that are all polymers.

Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

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Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

(b) Fig. 1.1 is a simple diagram of a phospholipid molecule.
Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate Fig. 1.1 as part of your answer.



Fig. 1.1

.....

.....

.....[3]

(c) State two components of a cell surface membrane **other than** phospholipid molecules and describe their function.

component 1 .....

function .....

component 2 .....

function ..... [4]

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31. M/J 16/P22/Q6/a

One of the enzymes involved in glycogen synthesis is glycogen synthase. The monomer of the glycogen polymer is α-glucose.

(a) (i) Draw the ring form of α-glucose in the space provided.

[2]

(ii) Glycogen synthase catalyses the formation of a covalent bond between two α-glucose molecules during glycogen synthesis.

Name the type of bond formed.

.....[1]

(iii) Glycogen branching enzyme is another enzyme that is required for glycogen synthesis.

Suggest why glycogen branching enzyme is needed in addition to glycogen synthase.

.....[1]

32. O/N 15/P23/Q4/a

Glycogen is a highly branched polysaccharide molecule that is stored in the liver, kidney and muscles of mammals.

Fig. 4.1 shows a small part of a molecule of glycogen.

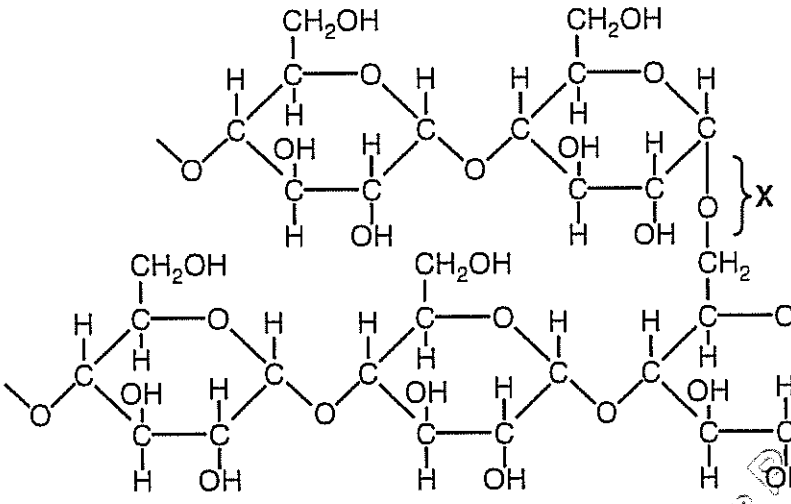


Fig. 4.1

(a) (i) Name the bond at **X**.

..... [1]

(ii) State the advantages for a mammal of having a storage molecule that is highly branched.

.....

..... [2]

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(iii) State two ways in which the structure of cellulose differs from the structure of glycogen.

1. .....

2. ..... [2]

33. M/J 15/P21/Q5/a,c

Fig. 5.1 shows a diagram of the molecular structures of tristearin (a triglyceride) and phosphatidylcholine (a phospholipid).

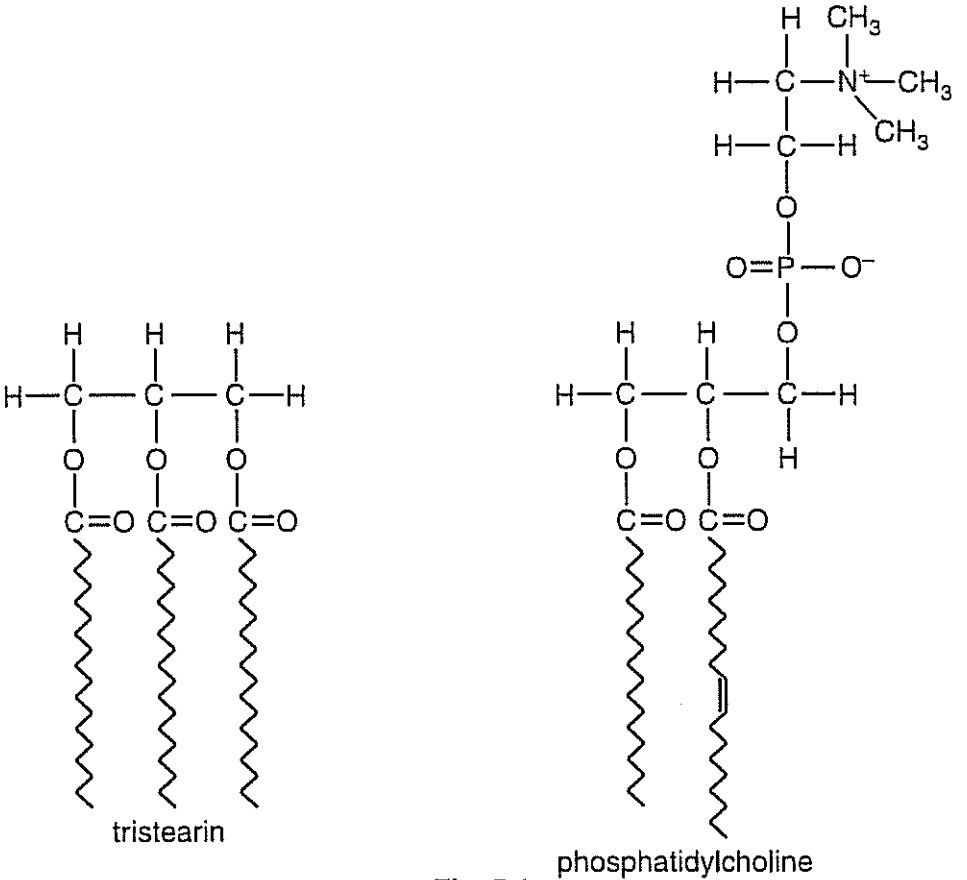


Fig. 5.1

(a) Table 5.1 shows a structural difference between the two molecules shown in Fig. 5.1. Complete Table 5.1 with two further structural differences **other than** in numbers of different types of atoms.

Table 5.1

structural feature	tristearin	phosphatidylcholine
length of fatty acid chains	all the same length	different lengths

[2]

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(b) Water has many significant roles to play in cells and living organisms.
Complete Table 5.2 below by stating the property of water that allows each of the following to take place.

Table 5.2

role of water	property of water
solvent for glucose and ions	
movement in xylem	
helps to decrease body temperature in mammals	

[3]

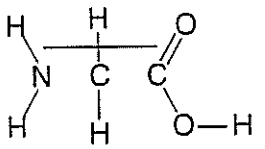
34. O/N 14/P21/Q3/a,b
There are many types of amino acids, but only twenty that are polymerised to make polypeptides and proteins in animals.

(a) Name the type of chemical reaction that occurs when two amino acids form a dipeptide.

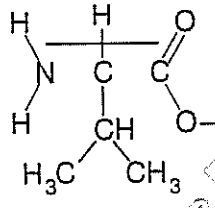
..... [1]

(b) Fig. 3.1 shows two amino acids, glycine and valine. Use the space below to make a drawing to show what happens when these two molecules join together to form a dipeptide.

glycine



valine



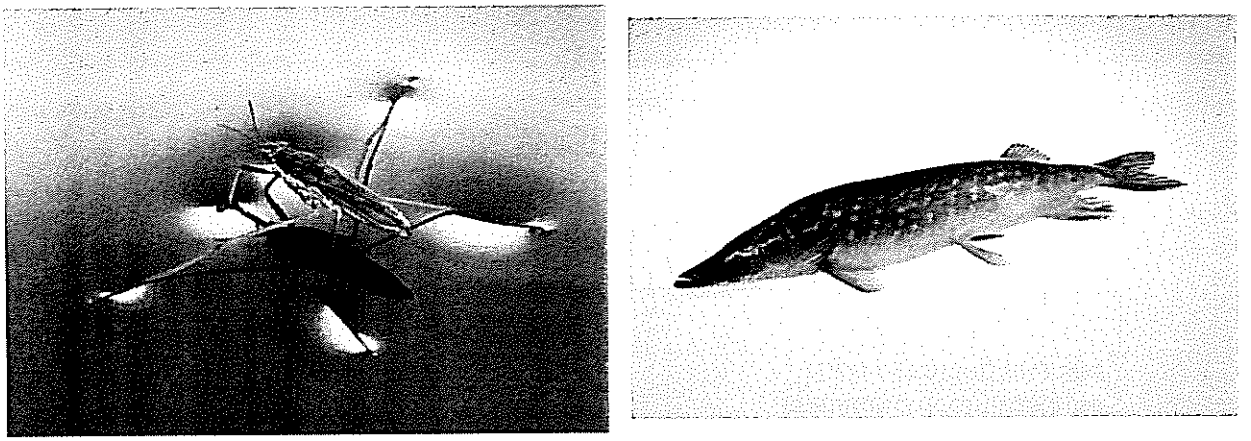
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Fig. 3.1 [4]

35. O/N 14/P23/Q2/d

Fig. 2.2a shows a pond skater walking on the surface of the water.
Fig. 2.2b shows a northern pike.
These are not shown to the same scale.



a **b**

Fig. 2.2

Both animals live in northern countries of the world, where temperatures often drop below 0 °C.

(a) Describe the importance of water as an environment for the pond skater **and** the northern pike.

.....

.....

.....

..... [4]

36. M/J 14/P21/Q3

Starch is composed of two polysaccharides, amylose and amylopectin.
Fig. 3.1 shows a molecule of α-glucose before being added to the end of a molecule of amylose.

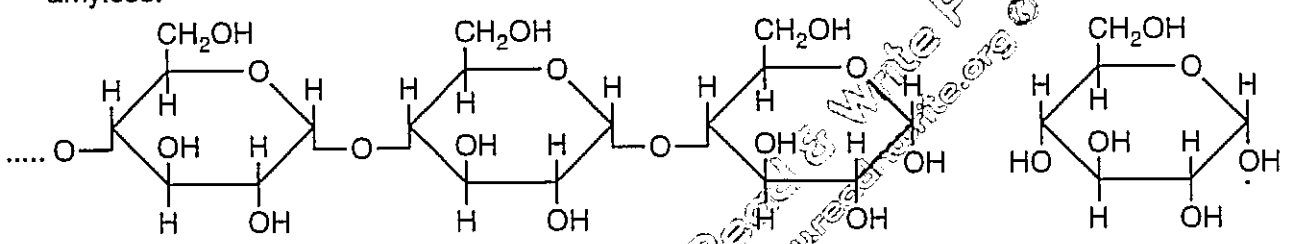


Fig. 3.1

(a) (i) Complete Fig. 3.1 to show how a molecule of α-glucose is added to the amylose.

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[3]

(ii) Name the bond that forms between glucose molecules in polysaccharides, such as amylose.

..... [1]

(b) Glycogen and cellulose are two other polysaccharides.
Complete Table 3.1 to compare glycogen and cellulose with amylose.

Table 3.1

feature	amylose	glycogen	cellulose
monomer	α-glucose		
branched or unbranched molecule	unbranched		
role in organisms	energy storage		

[3]

(c) Type 2 diabetes (insulin-independent diabetes) is a non-infectious disease.
If not treated, this disease is characterised by large fluctuations in the concentration of glucose in the blood.
Maltase is an enzyme that completes the digestion of starch in humans. Molecules of maltase are bound to the microvilli of epithelial cells in the small intestine.
Ascorbase is a drug used in the treatment of type 2 diabetes. Molecules of ascorbase have a very similar shape to that of the substrate for maltase.

(i) Explain how ascorbase acts to inhibit these membrane-bound enzymes.

.....

.....

.....[3]

(ii) Suggest why ascorbase can be used to treat people who have type 2 diabetes.

.....

.....[2]

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37. M/J 14/P23/Q1

Fig. 1.1 shows the structures of four biological molecules **A**, **B**, **C** and **D**.

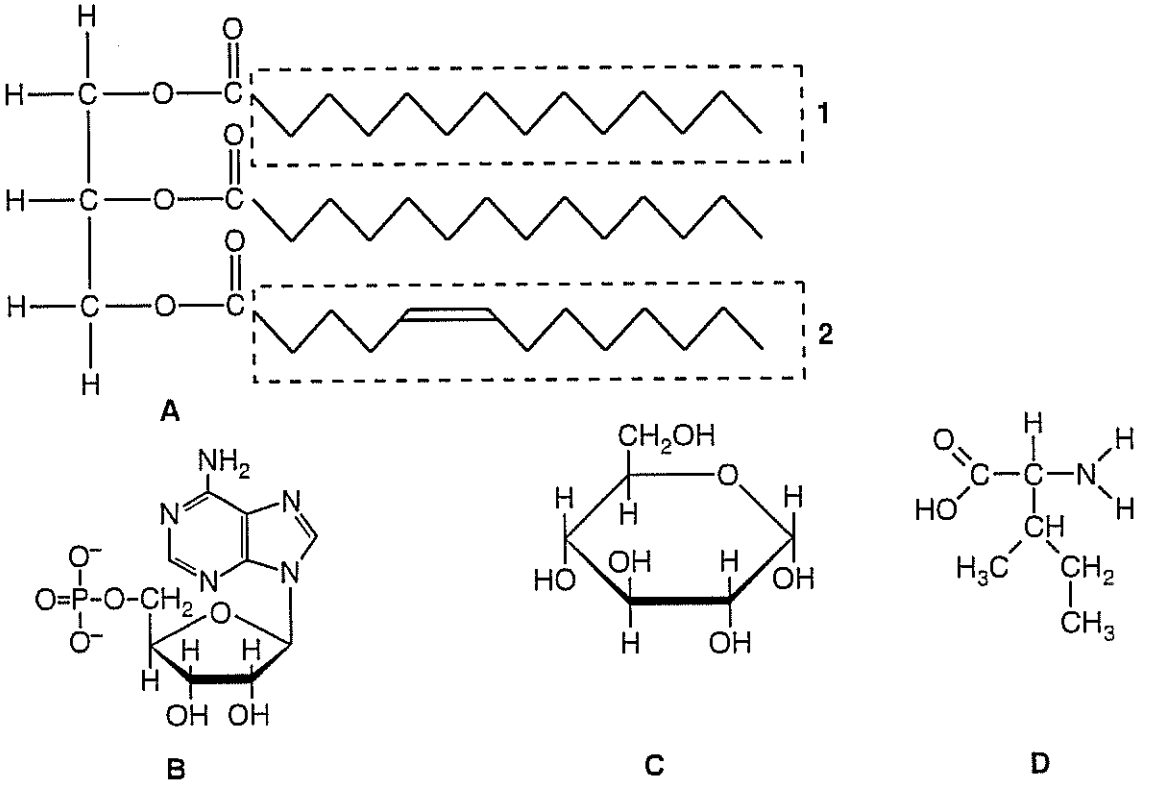


Fig. 1.1

(a) Give the letter, **A** to **D**, of the molecule in Fig. 1.1 which:

(i) is a nucleotide .....

(ii) can form peptide bonds .....

(iii) contains ester bonds. ..... [3]

(b) Some of the molecules in Fig. 1.1 can form polymers.

(i) Name a polymer which can be formed only from many molecules of **C**.

..... [1]

(ii) State one way, visible in Fig. 1.1, in which the part labelled **1** of molecule **A** differs from the part labelled **2**.

..... [1]

(iii) Molecule **D** can form macromolecules with other similar monomers.
These macromolecules have three dimensional shapes held in place by interactions or bonds other than those between adjacent monomers.
Name two of these interactions or bonds.

1. .....

2. ..... [2]

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38. O/N 13/P22/Q2/a

Keratin and chitin are two important biological molecules. Keratin is found in hair, fur and skin. Chitin is a modified polysaccharide found in a number of different organisms, for example in fungal cell walls and the hard outer skeletons of insects.

(a) Features of chitin and keratin are shown in the boxes in Fig. 2.1.

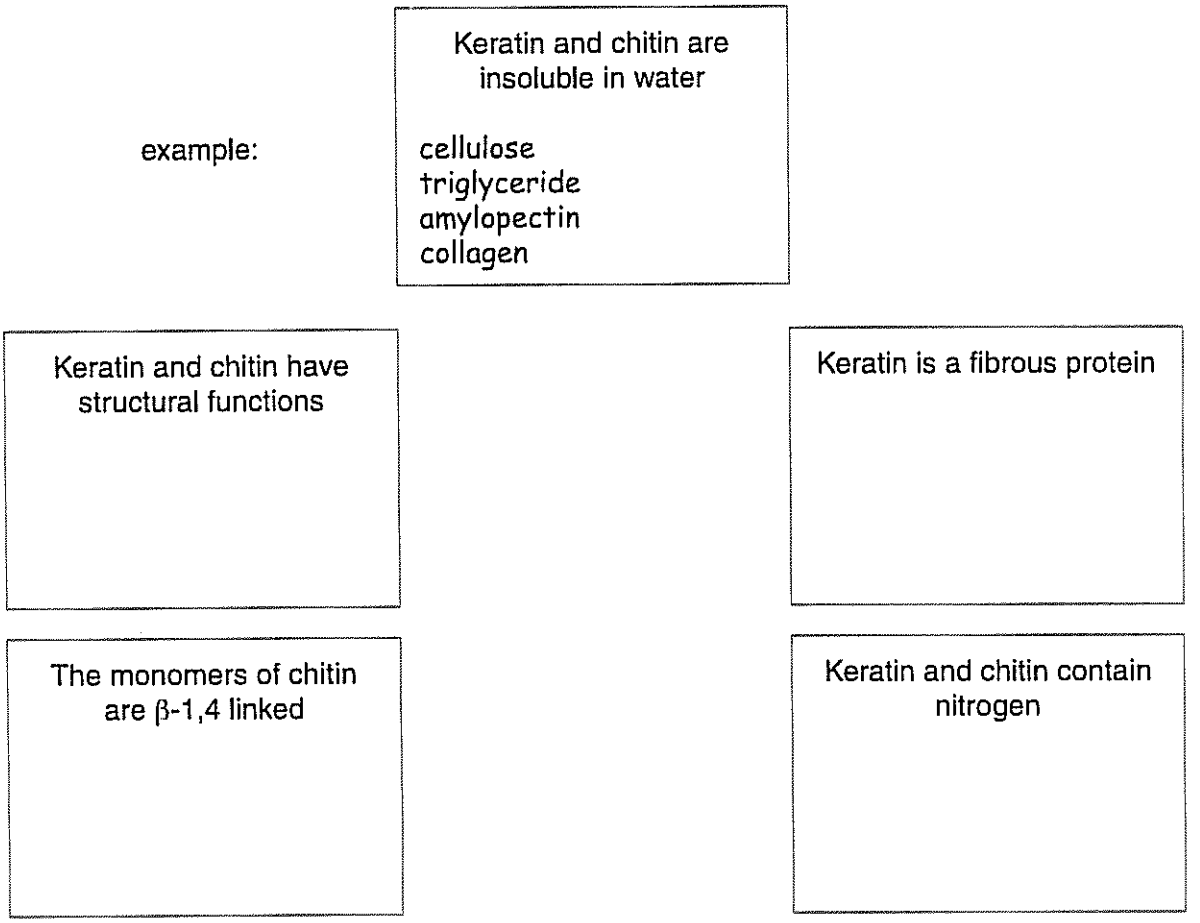


Fig. 2.1

Write, in each box, the biological molecules from the list below that have the same feature.

Each box may contain one, or more than one, biological molecule. The first box has been completed as an example.

amylopectin
cellulose
collagen
haemoglobin
mRNA
triglyceride

[5]

39. O/N 13/P23/Q5/a,b

(a) Describe the structure of a cellulose molecule and explain how cellulose is a suitable material for the cell walls of plants.

description

.....

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.....

explanation

.....

..... [4]

Animals do not have the ability to produce enzymes to digest cellulose. Most herbivores have bacteria in their digestive systems that can digest cellulose.

Fig. 5.1 shows the results of a study on 24 different herbivores. The percentage of cell wall material that was digested by each animal was determined. The time taken for the plant material to pass through the digestive system, the retention time, was also recorded.

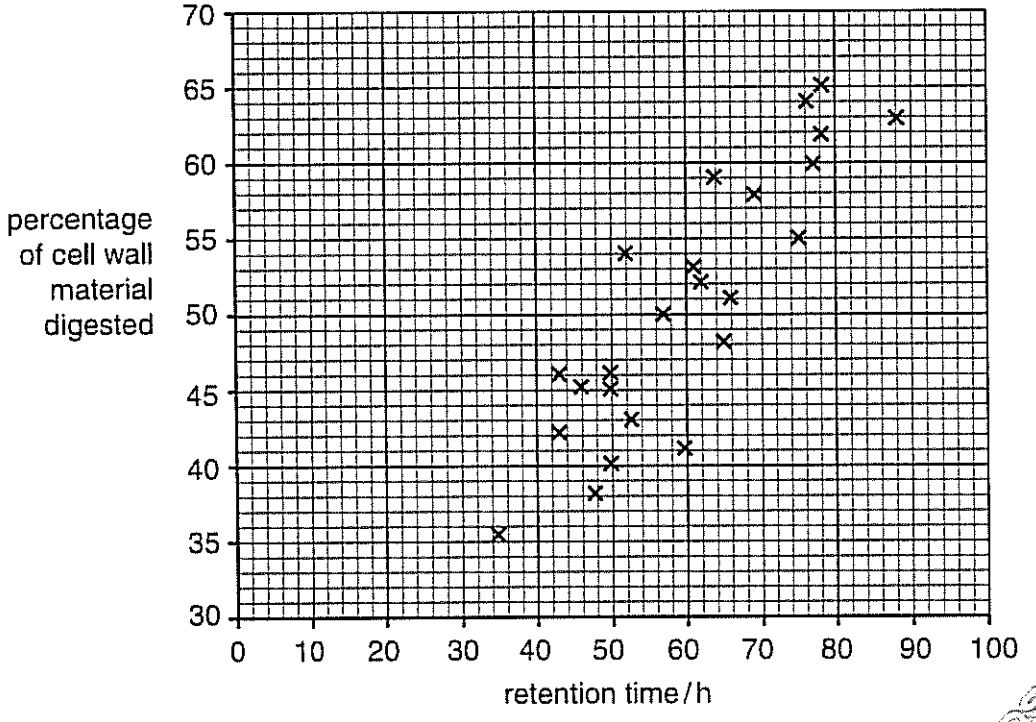


Fig. 5.1

(b) (i) With reference to Fig. 5.1, describe the results of this study.

.....

.....

..... [3]

(ii) Explain, in terms of energy flow in ecosystems, the importance of the results in Fig. 5.1.

.....

..... [2]

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40. O/N 13/P21/Q2/a,b

(a) Table 2.1 shows eight ions that are biologically important.

Table 2.1

ammonium (NH_4^+)	**A**
hydrogen (H^+)	**B**
hydrogen carbonate (HCO_3^-)	**C**
iron (Fe^{2+})	**D**
magnesium (Mg^{2+})	**E**
nitrate (NO_3^-)	**F**
phosphate (PO_4^{3-})	**G**
sulfate (SO_4^{2-})	**H**

Choose one ion to match each of the following statements. In each case write **one** letter from Table 2.1. You may use each letter (**A** to **H**) once, more than once or not at all.

(i) A component of polynucleotides.

..... [1]

(ii) Ion produced by enzyme activity inside red blood cells.

..... [1]

(iii) Ion used in the production of all amino acids in chloroplasts.

..... [1]

(iv) Ion that diffuses through carrier proteins with sucrose into companion cells in phloem tissue.

..... [1]

(v) Component of haem group in haemoglobin that binds oxygen.

..... [1]

(b) The enzyme nitrogenase is found in free-living and symbiotic nitrogen-fixing bacteria. Nitrogenase catalyses the reaction:

$$N_{2\,(g)} + 6\,e^- + 8H^+_{(aq)} \longrightarrow 2NH_4^+{}_{(aq)}$$

Some nitrogenase enzymes have vanadium ions in their active sites; others have molybdenum ions.

Explain how the enzyme nitrogenase functions in the fixation of nitrogen.

.....

.....

.....

..... [4]

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Answers Section

1. M/J 22/P21/Q4

(a) (i) ester ;

(ii) condensation ;

(iii) **1** (hydrocarbon chains of) different lengths / **Y** is longest / **Z** is shortest ;
A correct numbers of carbon atoms in each fatty acid (**X** 18, **Y** 20 and **Z** 16)
if no ref. to different lengths

2 **Z** saturated, **X** and Y unsaturated ;
A only Z is saturated

3 **X** polyunsaturated, **Y** monounsaturated ;

4 **X** 3, **Y** 1, **Z** 0 double (C=C) bonds ; **only Z** only has single / C-C) bonds
or
(for whole molecule) **X** 4 double bonds , **Y** 2 double bonds, **Z** 1 double bond ;

(b) (i) *any **two** from:*

1 (hydrocarbon / fatty acid tails, are) non-polar / have no polar groups / not charged ;
A equal sharing of electrons in molecule

2 not soluble / insoluble, (in water) ;

3 cannot form hydrogen bonds with water ; **I** repel water

(ii) *any **two** from:*

1 no, hydrophilic / polar / phosphate, head / part, to, interact with / AW, water ;
I triglycerides are hydrophobic

2 cannot form hydrogen bonds with water ; **I** repel water

3 cannot form a bilayer ;

in water triglycerides, form micelles / form spheres / ball shaped / form globules / do not form thin films / AW ; [9]

2. M/J 22/P23/Q2

(a) peptidoglycan / murein ;
ribosomes ;
(permanent / large) vacuole ;

(b) *any **two** from:*
to prevent, lysis / bursting / AW **or** to prevent, (protoplast) shrinking / shrivelling / AW ;
I damaged
ref. to no net movement / AW, of water (occurs) ;
(otherwise movement of water) by osmosis / down a water potential gradient / AW ;

(c) (i) *max 2 if stated as a protein or includes protein features*
*any **three** from:*
cellulose molecule max 2
(β-glucose(s) joined by) glycosidic / glucosidic, bonds / linkages ;
(monomers / β-glucose(s)) joined by (β) 1,4 (glycosidic) bonds ;
R α-1,4 bonds
R (β)1,4 and 1,6 bonds
adjacent, monomers / β-glucoses, rotated through 180° ; AW
straight / linear, chain ;
cellulose microfibril max 2
parallel, molecules / chains, of cellulose ;
hydrogen bonds, between molecules / form cross bridges / between OH groups ;
idea that between adjacent cellulose molecules,
beginnings and ends in different places /
overlap between starts and ends /

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staggered starts and ends ;

(ii) *any **one** from:*
hemicellulose ;
pectin ;
lignin ;
AVP ; e.g. expansin

(d) spongy mesophyll / palisade mesophyll / palisade / mesophyll, (cell) ; [10]

3. O/N 21/P22/Q2/b

(a) biuret (solution / reagent) ;
A copper sulfate solution and, sodium / potassium, hydroxide
(change from light) blue to, lilac / purple / violet / mauve ; [2]

4. O/N 21/P22/Q6

(a) 1 (open top tap and) keep bottom tap closed / close bottom tap for a longer time
(and then open bottom tap to collect product)
A close bottom tap for complete hydrolysis to occur
or
run starch solution through column, collect product, repeat (a number of times) / AW
or
only allow a small quantity of starch solution through at a time / AW ;
if a different idea suggested to set-up in Fig. 6.1, method must be related to an increase in contact time between beads and starch to award mp1

*any **two** from:*
2 suggestion of modification to experimental set-up in Fig. 6.1 ;
e.g. use smaller beads
use more, beads / enzyme in beads I use more immobilised enzyme
use of visking tubing attached to end of column (so only reducing sugar passes out)
use longer, narrower column
I *ref. to* filtering with filter paper / adding buffers to control pH
3 test (sample of) product with iodine solution, qualified ;
A iodine in potassium iodide solution / I in KI solution
e.g. to confirm no starch present
stays orange (colour)
does not change to blue-black (colour) to confirm no starch present
4 ref. to using optimum temperature (for amylase) ; A e.g. 35 °C temperature

(b) *any **one** from:*
surface area to volume ratio / SA:V, decreases with increasing size / increases with decreasing size ;
SA:V ratio is different, with consequence ; e.g. smaller beads means increased contact of substrate with enzyme (in same conditions)
idea that overall, larger surface area exposed using smaller beads ; **ora**
(for the same experimental set up)
larger beads, slows rate of diffusion into beads / increases diffusion time to reach enzyme ; **ora**
larger beads will increase rate of flow through column ; **ora** [4]

5. O/N 21/P21/Q1/a(ii),b

(a) (i) *any **two** from:*
no, large / permanent, vacuole / (temporary) small vacuoles ;
this is in context of large permanent vacuole
no, chloroplast / chloroplasts ;
no cell wall ;
no plasmodesmata ;
glycogen granules
or

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no, starch, granules / grains ;
nucleus, (more) central / AW ; **A** nucleus not at, periphery / edge, of cell
centrioles (present) ;
AVP ; e.g. fewer Golgi bodies

(b) (i) iodine solution ; **A** iodine in potassium iodide solution / I in KI solution
(change in colour from) orange / brown, to, blue / black / purple ;

(ii) *any **four** from:*
similarities to max 3
polymers / polysaccharides / described ;
composed of α-glucose ;
(monomers joined by) glycosidic bonds ;
contain 1–4 (glycosidic) bonds / linkages ; **A** glucosidic
differences to max 3
amylose molecules are unbranched / amylopectin molecules are branched ;
amylopectin molecules contain 1–6 (glycosidic) bonds ;
amylose helical ;
amylose is a smaller molecule ;
amylopectin is more compact ; [8]

6. O/N 21/P23/Q6/a,b

(a)

feature	DNA	collagen
elements	C H O N P ;	CHON
monomers	(DNA) nucleotide(s) ;	amino acid(s) ; ***ignore*** any named amino acid
bonds between monomers	phosphodiester ;	peptide ;
site of production in eukaryotic cells	nucleus	ribosomes / rough endoplasmic reticulum / RER / rough ER ; **A** cytoplasm / Golgi (body / apparatus / complex)

(b) *any **two** from:*
1 two membranes forming, nuclear envelope ;
A nuclear envelope is composed of a double membrane
2 nuclear pores too small to allow DNA to, pass through / escape ;
A ora
3 AVP ;
e.g. prevents DNA from being broken down (by enzymes)
I DNA damage by enzymes
protects DNA from hydrolytic enzymes
idea of nuclear envelope is a barrier, between / that separates, nucleus and, cytoplasm / rest of cell [8]

7. M/J 21/P21/Q1

(a) actual width = image width ÷ magnification ;
A A = I ÷ M M = I ÷ A I = A × M or magnification triangle
working = width divided by 4275 ;
e.g.
16 000 ÷ 4275 17 000 ÷ 4275 18 000 ÷ 4275 19 000 ÷ 4275 ;
3.7 (μm) 4.0 (μm) 4.2 (μm) 4.4 (μm) ;
R answer if given to more than 1 dp or whole number

(b) (i) DNA – **A / B / C** ;
cellulose – **E** ;
phospholipid – **A / C** ;
histone proteins – **A / B** ;

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(ii) chloroplast / mitochondrion ;
(iii) nucleus ; **A** chloroplast / mitochondrion
R nucleolus

(c) *any two from*
1 (section at) high <u>resolution</u> ;
A suggestion of a correct value of resolution for a TEM
2 any named structure visible in Fig. 1.1 that can, only be seen in a TEM / not be seen in a photomicrograph ;
e.g. internal structure of chloroplasts / thylakoid(s) / grana
e.g. internal structure of mitochondria / cristae
3 high magnification / higher magnification (magnification > 1000 / higher than with light microscope) ;
in context of higher than light microscope
4 (very) thin ;
5 2D / no surface contours / no surface features / AW ; **A** not 3D [11]

8. M/J 21/P21/Q2

(a) *any three from*
1 (diagram shows) hydrogen bond is a weak bond ;
2 each oxygen (atom) forms two hydrogen bonds / each hydrogen (atom) forms one hydrogen bond ;
3 (attraction) between oxygen (atom) of one water molecule and hydrogen (atom) of another (forms a hydrogen bond) **R** cohesion / adhesion – *if used for attraction*
4 water is <u>dipolar</u> ;
5 detail ;
e.g. electrons not shared equally between oxygen and hydrogen
A oxygen is more electronegative (than hydrogen)
A *ref. to* (two) lone pair(s) (of electrons) on oxygen
A uneven distribution of, electrons / charge
e.g. oxygen has, <u>small</u> / <u>slight</u>, negative charge / δ^-, **and**, hydrogen has, <u>small</u> / <u>slight</u>, positive charge / δ^+ *only needs to state 'small' once*

(b) (i) *idea that* (H-bonds) maintain / AW, (shape / structure, form of) α-helices / β-pleated sheets ;
A allows formation of, α-helices / β-pleated sheets
R if bonds are between R groups

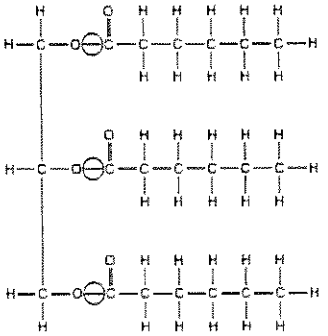
(ii) *any two from*
1 *idea that* hydrogen bonds help to, stabilise / AW, further folding of, amylase / polypeptide / protein ;
2 between, R groups with amine and carboxyl groups ;
A between R groups with -NH and, -CO / -OH
3 *idea that* may be between amino acids far apart in primary structure ;
4 *either* helps to maintain / form / AW, globular shape / 3D shape / structure (of amylase / polypeptide / protein)
or
maintains / forms / AW, (specific) shape / structure, of, active site / binding site ;

(c) *any three from*
1 dissolves / AW, ions / minerals / salts, <u>and</u> (named) polar molecules ;
A 'assimilates' as polar **I** substances / nutrients
2 transports, solute(s) / named solutes / dissolved substance, in, xylem / phloem / xylem and phloem ;
3 storage of, solutes / named solutes, in vacuoles ;
4 metabolic / chemical / cellular, reactions occur in water ;
5 dissolves, carbon dioxide / oxygen, with ref to, respiration / photosynthesis; [9]

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9. O/N 20/P21/Q2/a

(a) (i) circle around any one correct bond ; **R** if circle includes the double bond O



(ii) condensation ; **A** dehydration (synthesis) **A** esterification
three ; [3]

10. O/N 20/P21/Q5/b(iii,iv)

(a) (i) *any **four** from:*
three polypeptide chains ;
(three polypeptides) form triple helix ; **A** coil around each other **R** *ref. to* alpha helix
hydrogen bonds hold the three. polypeptides / strands. together ;
the three polypeptides, lie close together / form a tight coil / are tightly wound ;
every third amino acid (in the polypeptide chain) is glycine /
many glycine-proline alanine repeats / many gly-pro-ala repeats ;
glycine is found on the inside of each, polypeptide / strand;
AVP ; e.g. detail hydrogen bonds, between peptide bond NH (of a glycine)
and C=O group in adjacent polypeptide

(ii) *allow reference to collagen fibrils instead of collagen molecules, in correct context*
(collagen molecules form fibrils, which form fibres)
*any **one** from:*
(many) collagen molecules lie parallel ;
no weak points because
strong / covalent, (cross) links between molecules ;
(ends of) molecules (in, fibril / fibre), are staggered ; [5]

11. M/J 20/P22/Q4/b(ii),c

(a) (i) *any two from*
keep airways open ;
provides support ;
allow flexibility ; *allow described e.g. bending neck, swallowing food*
rings allow, lengthening / widening, during, breathing in / inspiration / inhalation ;

(b) (i) peptide (bond) ;

(ii) *any three from*
collagen, structural / fibrous, protein
or
collagen gives strength / flexibility ;
glycine / gly, small / smallest, amino acid ; **A** has H as, R-group / side chain
glycine / gly, regular / every third amino acid ;
(so) triple helix tightly packed / three polypeptides closely associated / AW ;
ref. to (peptide bond) NH of gly can form hydrogen bond with (peptide bond) C=O
of adjacent amino acid (in other polypeptide) ; [6]

12. M/J 20/P22/Q5/c

(a) <u>α-glucose</u> ; A glucose R β-glucose
α, 1-4 ;

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α, 1-6 ; *bond types either way round*
glycogen ; [4]

13. M/J 20/P21/Q1

(a) glycosidic ;

(b) *any one from:*
no double, bond / bonds, in hydrocarbon chain ;
each carbon (atom) in the hydrocarbon chain is bonded to two hydrogen atoms ;
there is, a full complement / maximum number, of hydrogen atoms on the hydrocarbon chain ;
A aliphatic chain *for hydrocarbon chain*
A hydrogens *for hydrogen atoms*

(c) β-glucose / beta-glucose ;
R B-glucose

(d) **C** ;

(e) **E** ;

(f) *any one from:*
A and **C** are, polar / hydrophilic ; **A** has many, OH / hydroxyl groups
B is, non-polar / hydrophobic ;
A has, only one OH / no groups, that interact with water [6]

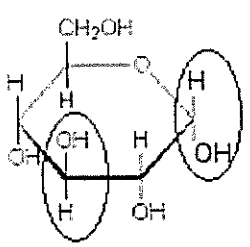
14. M/J 20/P23/Q4/a,b,c,d

(a) converted the measured length (in mm) to μm (and dropped the, μm / units)
or
multiplied the measurement by 1000 ;

(b) phosphate(-containing) heads are hydrophilic
or
triglycerides do not have a hydrophilic portion ;
lipid droplet is stored in / phosphate heads can interact with, cytosol / aqueous environment / watery environment ;

(c) to, digest / break down, worn out organelles / waste metabolic products / toxic substances / AW ; **A** invading pathogens

(d) (i) correct orientation of H and OH on, C1 and on C3 ;
OH added to carbon 6 ;



(ii) positive result is coloured precipitate ; *only allow if hydrolysis noted*
A green / yellow / orange / brown / red, *for colour*
any two from
ref. to (heat with) Benedict's (reagent / solution) and, negative test / no colour change / remains blue, and test again with Benedict's ;
boil with (hydrochloric) acid ; **A** hydrolyse with, acid / enzyme
AVP ; e.g. use a fresh sample to hydrolyse
boil for 5-10 minutes with acid
cool before neutralising
neutralise (remaining acid) with alkali
test with universal indicator paper (to check for pH7)

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compare with a control
allow one mark for heat with Benedict's and coloured precipitate [9]

15. O/N 19/P22/Q4

(a)

polymer	constituent monomer	type of bond between monomers
amylose	glucose	glycosidic glycosidic ; **A** glucosidic **I** details of bond
cellulose	glucose	
collagen	amino acid ; **R** protein (amino acid)	peptide
DNA	DNA nucleotide	phosphodiester ;
glycogen	(α-)glucose ; **R** β-glucose	glycosidic

(b) *two from*
1 amylose composed of α-glucose (monomers) and cellulose composed of β-glucose (monomers) ;
2 (amylose) α-1,4 v. (cellulose) β-1,4 (glycosidic) bonds ;
R if amylose stated to have α-1,6 bonds
I *ref. to* cellulose also has hydrogen bonds
If mp 1 and 2 not stated allow one mark for amylose has α-glycosidic bond and cellulose has β-glycosidic bond
3 (cellulose) adjacent, monomers / glucose(s), rotated through 180° ; AW
R *ref. to* heads / tails
4 amylose has an (energy) storage function v. cellulose has structural function / description relating to cell wall ;

(c) *max 2 from mp 1 and 2 if transcription described or mix and match transcription and replication*
any five from:
1 DNA (double helix / molecule) unwinds ;
I unzips
R DNA, strand / α helix, unwinds
2 hydrogen bonds break between, base pairs / bases / strands ;
A hydrogen bonds break between nucleotides *only if clear that two strands are separated*
3 both strands used as templates ; *concise statement*
4 DNA polymerase, qualified ;
e.g. involved in polynucleotide formation / phosphodiester bond formation / catalyses synthesis
R joins phosphates
5 *ref. to* (free) activated (DNA) nucleotides / AW ;
A phosphorylated nucleotides
R RNA nucleotides
6 complementary (DNA) nucleotides added ;
R RNA nucleotides
A described in terms of complementary base pairing

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A A pairs with T and C pairs with G

7 *idea that* process, occurs / continues, along whole DNA molecule ;

8 *ref. to* Okazaki fragments / movement of polymerase in one direction / nucleotides added in one direction ;

A correct ref. to leading and lagging strands

9 each newly formed molecule contains one original and one newly synthesised strand ;

10 AVP ;

e.g. replication bubbles form / described

ref. to repair / proofreading

ref. to helicase (unwinding) / ligase (joining Okazaki fragments) *in correct context*

R ligase joining phosphates

process occurs, step-by-step / sequentially / AW

ref. to RNA primers [11]

16. O/N 19/P21/Q1/a

(a) (i) **A** amino / amine group ;

B carboxyl (group) ; **A** carboxylic acid

(ii) peptide bond joining nitrogen from amine group to carbon of carboxyl group on adjacent amino acid ; C = O and N – H shown correctly in the dipeptide ;

formation of water molecule ; [5]

17. O/N 19/P23/Q1

(a) (i) haem ; **A** heme / prosthetic group

I iron / iron ion / Fe / Fe^{2+}

I porphyrin ring

(ii) *one from*

combines with / binds / carries / transports / AW, oxygen (in lungs) ;

R forms bonds

releases / AW, oxygen, in tissues / at low oxygen concentrations ;

allows haemoglobin to transport oxygen ;

(b) *two from*

1 spherical / ball-like / rounded / AW ;

R circular / round **ignore** 3D shape

2 (water) soluble / forms H bonds with water ;

3 hydrophilic R-groups on outside of molecule / hydrophobic R-groups on inside ; **R** *ref. to* 'tails'

4 dynamic / metabolic / physiological / AW, function ;

(c) made of amino acids ;

one from

joined by peptide bonds ;

R 'peptide bond between two amino acids' **R** 'dipeptide bond(s)'

macromolecule / long-chain (molecule) / large molecule ;

repeated / many, (sub-)units / monomers ;

(d) three from

1 (R-group of) glutamic acid / glu, is polar / hydrophilic and (R-group of) valine / val, is non-polar / hydrophobic ;

2 change in tertiary structure ;

A 'change in globular shape / less globular in shape'

3 change in quaternary structure of haemoglobin ; **R** of β-globin

4 ref. to haemoglobin forms fibres (with other Hb) ; **A** 'sticky molecules'

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5 haemoglobin is less (water) soluble ; **I** insoluble
6 haemoglobin is less efficient at, binding / transporting, oxygen ;
A less oxyhaemoglobin
A haemoglobin / β-globin, has lower affinity for oxygen
A reduced oxygen carrying capacity
I haemoglobin, does not / cannot, bind oxygen
7 AVP ;

(e) three from
1 haemoglobin combines with carbon dioxide ;
2 carbon dioxide reacts with (terminal), amine group(s) / $-NH_2$ / –NH ;
3 to form carbaminohaemoglobin ;
R carboxyhaemoglobin / carbonylhaemoglobin
4 each polypeptide can carry a molecule of carbon dioxide / haemoglobin can carry four molecules of carbon dioxide ;
5 carbon dioxide remains, bound / AW, to Hb until in, region of low pCO_2 or high pO_2 / pulmonary circulation / lungs / alveoli ;
6 ref. to (carbonic acid dissociates to form) hydrogen ions, which bind to / AW, haemoglobin ; **A** H^+ forms haemoglobinic acid or HHb
I hydrogen unqualified
7 AVP ; e.g. hydrogencarbonate ions to plasma [12]

18. M/J 19/P22/Q5

(a) glycine in monomer column only ;

monomer	polymer	monosaccharide	polysaccharide
thymine (nucleotide), α-glucose, β-glucose ;	cellulose, messenger RNA, glycogen, α-globin ;	β-glucose, α-glucose ;	cellulose, glycogen ;
	I glycine	**I** glycine	**I** glycine

I incorrect spellings
if α-globin appears once and is in monomer column instead of polymer column, and the monomer and polymer columns are otherwise correct, allow one mark (ecf)

(b) *any three from:*
allow points from an annotated diagram
1 phosphate head = hydrophilic / polar ;
2 fatty acid / hydrocarbon, tail / chains = hydrophobic / non-polar ;
if mps 1 and 2 not gained, allow one mark for, hydrophilic / polar, heads and, hydrophobic / non-polar, tails
3 (so) heads face, watery environment / tissue fluid / cytoplasm / cytosol / aqueous environment ;
4 (fatty acid) tails, form hydrophobic core / form area away from water / face each other / AW ;
5 ref. tails and hydrophobic interactions ; [8]

19. M/J 19/P21/Q1/a

(a) *any three from:*
secondary structure
I α-helix
1 (many) β-pleated / beta-pleated, sheets ; **R** 'B'
2 random structure / irregular structures / loops / beta turns / AW ;
tertiary structure

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3 folding / coiling, of, (each) polypeptide chain(s) / secondary structure ;
R *idea of* polypeptide chains interacting (quaternary structure)
4 *ref. to* globular **A** description, e.g. spherical **I** circular / round
or
ref. to 3D, shape / structure ; **A** 3D arrangement [3]

20. O/N 18/21/Q3

(a) (i) *any three from*
(polymer / polysaccharide of) β-glucose ;
glycosidic, bonds / linkages ;
A glucosidic
(β) 1–4 (glycosidic) bonds ;
R if 1–6 also given
ref. to (β) glucose units, linked at 180° to each other / alternately orientated / AW ;
unbranched (polymer) / straight chain / linear ;
able to form hydrogen bonds with parallel chains / AW ;

(ii) chloroplast / granum / thylakoid / middle lamella / large vacuole / nucleus at edge of cell ;

(iii) provide energy (for the cell) ;
R produce energy
any two examples ;;
e.g. biosynthesis **A** named example
active transport / proton pumping
movement / described, e.g. movement of, vesicles / chromosomes
endocytosis / exocytosis

(b) *any two from*
water molecules are dipoles ;
A polar
(each water molecule has) $\sigma+$ hydrogen (atoms) and a $\sigma-$ oxygen (atom) ;
the positively charged hydrogen (atom) of one water molecule is attracted to the negatively charged oxygen (atom) of another
water molecule ;
weak attraction between water molecules ;

(c) *any two from*
water molecules are polar ;
ions are charged ;
ref. attraction between water molecules and ions ;
AVP ;
e.g. oxygen $\sigma-$ faces positive ion [11]

21. O/N 18/P23/Q2

(a) (i) water shown formed from –OH and –H ;
A H_2O formed without indicating where from
peptide bond shown correctly between C of carboxylic acid and N of amino group ;
complete dipeptide drawn ;
A hydrogen 'up or down'

(ii) R group / side chain / variable group / residual group / functional group ;
indicate, different amino acids / type of amino acid ;
A specific to each amino acid
A the two amino acids are different
A two examples of R groups, e.g. –H and $–CH_3$
both amino acids have different R groups = 2 marks

(b) *any two from*
straight chain / linear, v helix / helical ;
I coil(ed)

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R branched / branching

β-glucose, not α-glucose ;

A β-1:4 glycosidic bond v α-1:4 glycosidic bond

(β-)glucose / monomers / residues, are arranged, rotated 180° to each other / AW ;

AVP ;

e.g. more hydrogen bonds

(c) *any four from*

1 (molecules) form fibrils and fibres ;

2 hydrogen bonding between (cellulose) molecules ;

3 (cellulose molecule) is straight / linear ;

4 (straight chain allows) molecules lie parallel to each other ;
mp4 dependent on mp3

5 gives strength (to cell wall) to, prevent cell bursting / withstand (turgor) pressure / AW ;
R if only in context of a cellulose molecule

6 *ref.* to fibres at angles / criss-cross / AW ;

7 *idea of* many gaps, in wall / between fibres, allowing passage of water / named) substances / making cell wall permeable ;
I plasmodesmata
R partially / AW, permeable

8 AVP ;
e.g. cellulose is insoluble
many –OH groups (for hydrogen bonding) [11]

22. M/J 18/P21/Q2/a,b

(a) (i) **A** – (α-) glucose ; **R** any qualification of glucose other than α, e.g. β-glucose
B – fructose ;
I hexose sugar
I any qualification of fructose, e.g. α

(ii) glycosidic ; **R** glucosidic
I any qualification of glycosidic, e.g. 1–2, 1–6

(iii) hydrolysis ; **A** acid hydrolysis

(b) *two from:*

sucrose is, a non-reducing sugar / non-reducing / not a reducing sugar ;
A no reducing sugars present

no (hydrochloric) acid used (to break down sucrose to reducing sugars) ;
A sucrose not hydrolysed (to monomers / monosaccharides / reducing sugars)

AVP ; (sucrose will not reduce) (blue) copper II ions to (red) copper I ions
cannot donate electrons
idea that reactive groups are not available (to react with Benedict's solution / copper ions) no (free), aldehyde / ketone, group [6]

23. M/J 18/21/Q4/a

(a) **E** – haem / porphyrin (ring) ;
I iron / iron-containing group
A conjugated group / prosthetic group

F – α helix ; **R** a helix

G – tertiary structure ; **A** 3° structure

H – primary structure ; **A** 1° structure

J – quaternary structure / 4° structure / 2α and 2β globins ;
A polypeptides for globins [5]

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24. O/N 17/P22/Q2

(a) *two from*

cell (surface) membrane / plasma membrane / phospholipid bilayer, damaged / AW ;
A phospholipids are in cell surface membrane (and will be broken down by phospholipase)
cell, bursts / lyses / lysis / ruptures ; *haemolysis is neutral*
cell contents / AW / haemoglobin, leaks out / AW ; **I** water

(b) *allow, fatty acids / fatty acid tails / hydrocarbon chains, for fatty acid residues*
both have / similarities (max 3)
glycerol (residue) ;
fatty acids ; **I** *ref. to* saturation, **R** both have, two / three, fatty acids
ester, bonds / linkages ;
C and H and O ;
double bonds ; **A** both have C=O
differences (max 3)

triglyceride / fat / oil / lipid		phosphatidylcholine / phospholipid
no, choline / nitrogen **A** no / small / delta, charges	**or**	has, choline / nitrogen ; **A** choline / nitrogen, ion **A** charged / ionic
three fatty acid residues **or** one extra fatty acid residue ; **A** triglyceride has three ester bonds		**R** *if comparison includes phosphatidylcholine and the number of fatty acid residues is incorrect*
no, phosphate (group) / phosphorus **A** no, phosphoester / phosphodiester bond	**or**	has phosphate ; **A** has phosphoester / phosphodiester bond

(c) smooth endoplasmic reticulum ; **A** smooth ER **R** SER
R if more than one organelle given **R** endoplastic
two from
membranous / membranes ; **A** *ref. to* vesicles, formed / bud off **R** envelope / double membrane
tubular ; **A** cisternae but **R** if described as flattened
fluid filled, channels / sacs ;
not associated with ribosomes ; [9]

25. M/J 17/P23/Q2/d

(a) ***A***
nucleic acid / DNA / RNA ; **A** genetic material **I** strand **R** circular DNA
B
protein coat / capsid / capsomere / protein subunit ; [2]

26. M/J 17/P23/Q4/a,b

(a)

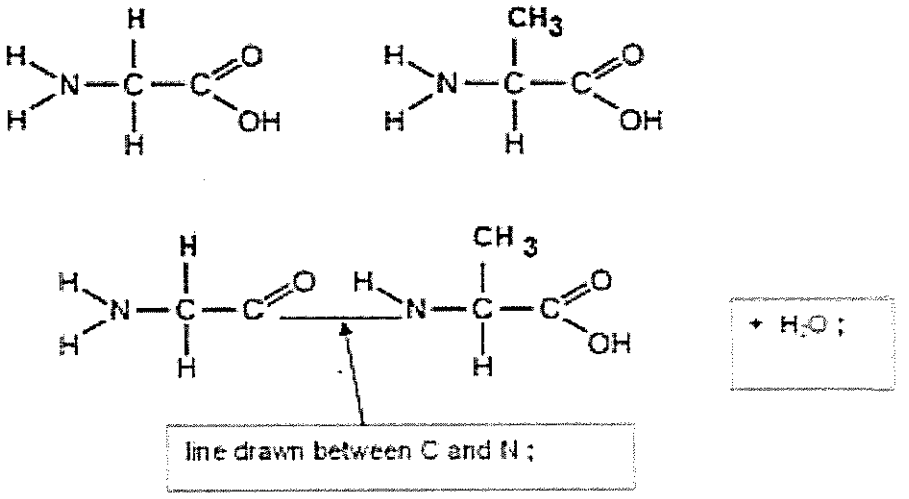
✓	×	×	✓
✓	✓	×	✓
×	×	✓	×
×	✓	×	✓

one mark per column ;;;;

(b) *allow diagrams with glycine on right*

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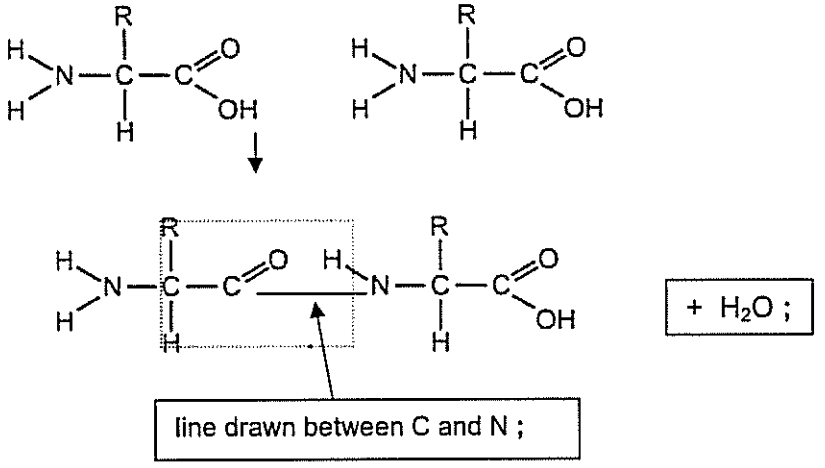
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bond forms between the C of the carboxyl group and the N of the amino group ; **A** amine
for amino water / H_2O, is formed ; **A** condensation (reaction) **R** hydrolysis
amino acid residues correctly drawn ; [7]

27. O/N 16/P22/Q2/c

(a) *can gain 2 marks if printed diagram is clearly modified to show correct bond and formation of water or/and if described as text*



dotted line area is minimum to gain mark
'peptide bond' label not required to gain mark
bond forms between the C of the carboxyl group and the N of the amino group ;
A amine *for amino*
water / H_2O, is formed ; **A** condensation (reaction) **R** hydrolysis [2]

28. O/N 16/P22/Q3/a,b

(a) *two from*

fructose		*sucrose*
no glycosidic bond ;	(v	glycosidic bond) *look for ora*
monosaccharide / one sugar unit	v	disaccharide / two sugar units / fructose and glucose ;
A monomer *('sugar', is in question)*		**A** two monomers / dimer
		I polysaccharide

R if a disaccharides is stated as one of the two monomers
A sucrose is a disaccharide made from the monosaccharides glucose and fructose

one ring (structure)	v	two rings ; **A** *sketch to show one ring v two rings*
$C_6H_{12}O_6$	v	$C_{12}H_{22}O_{11}$;

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A fewer / less, C and H and O atoms ora

additional points accepted

powder	v	crystalline
linear or ring structure	v	two rings / only ring(s)
reducing, end / AW	v	(no reducing ends)
I reducing sugar		**I** non-reducing sugar

(b) *look for ora throughout if describing the other enzyme with low optimum*

three from

1 *idea of* can use high(er) temperatures for process ;
2 increased temperature increases, number of collisions (between enzyme and substrate) / number of ES complexes (formed) ;
3 more product / high(er) rate of reaction ; AW
4 less prone to denaturation ; **A** won't denature
A described in terms of loss of active site
5 more stable / lasts longer ; **A** thermostable **A** reused over and over
I temperature resistant [5]

29. O/N 16/P21/Q3/a

(a) (i) peptide and disulfide ; **R** sulfide

(ii) sequence / arrangement / order, of amino acids ; **I** *ref. to* disulfide bonds [2]

30. O/N 16/P23/Q1

(a) *one mark per column* [4]

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				✓
contains glycosidic bonds	✓	✓		
polymer is branched	✓			
contains nitrogen			✓	✓
can be found in both animal and plant cells	;	;	✓ ;	✓ ;

(b) *points can be awarded as annotations to the diagram*

*max 2 for structure – **mp1** to **mp3***

1 *ref. to* hydrophilic / polar, phosphate, head / group
and
hydrophobic / non polar, hydrocarbon / fatty acid, tails / chains ;
R *if labelled correctly but incorrectly described in the text*
2 *ref. to* forms part of a bilayer ;
3 (fatty acid) tails / chains, may be saturated or unsaturated ;

*max 2 for function – **mp4** to **mp7***

head
4 forms hydrogen bonds with water / interacts with water / AW ;
5 stabilises the membrane ;
tails
6 *idea that* unsaturated fatty acids contribute to fluidity (of membrane) ;
7 barrier to, hydrophilic substances / water soluble substances / polar substances / ions / AW ; **ora**
A movement of, non-polar / AW, substances

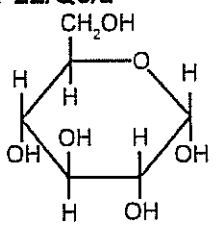
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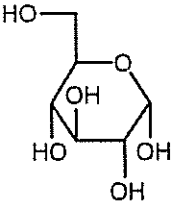
(c) *max two components, one mark each*
one mark for function to match the stated component
I carbohydrate chains *for component but allow ecf 'cell recognition' for function*
glycoprotein ;
one of
antigen / markers / tags / described in terms 'self' ;
receptor (for signalling molecule) / AW ;
cell recognition ;
cell adhesion ;
interacts / AW, with water to stabilise the membrane ;
cholesterol ;
one of
stabilises membrane ;
regulates / maintains / AW, fluidity of membrane ;
A in low temperatures increases fluidity / in high temperatures decreases fluidity
prevents passage of ions / polar molecules, through membrane ;
glycolipid ;
antigen / markers / tags / described in terms 'self' ;
cell adhesion ;
interacts / AW, with water to stabilise the membrane ;
protein ; **I** *any qualification of component* e.g. *channel / carrier / transport*
receptor (for signalling molecule) / AW ;
enzyme / co-enzyme ;
anchoring cytoskeleton ;
for cell to cell adhesion / any named type *e.g. desmosome, tight junction* ;
channel / carrier, allows facilitated diffusion / description ;
A for, protein / carrier protein / channel protein / transport protein
carrier, for active transport / description ;
A for protein / carrier protein / transport protein [11]

31. M/J 16/P22/Q6/a

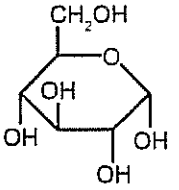
(a) (i)



1



2



3

two marks for correct drawing of ring structure ;;
all atoms shown **or** *one of diagrams 1–3 above*
one mark if, inconsistent / incomplete, drawing:
diagram 1 – one missing H from any of carbons 2–6 (OH groups and rest of drawing must be correct)
diagrams 2 and 3 – adding the H to one of carbons 1–5 (OH groups and rest of drawing must be correct)

(ii) glycosidic ; **A** glucosidic

(iii) to form / has, (glycosidic α) 1–6, bonds / links (to make branches) ;
ref. to different shaped / specific / complementary, active site required to form bonds (for branching) ; [4]

32. O/N 15/P23/Q4/a

(a) (i) (α 1–6) glycosidic ; **A** glucosidic

(ii) many, terminals / ends, for, attachment of glucose / removal of glucose ;
glucose can be stored quickly ;

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glucose can be, mobilised / AW, when required / quickly ;
A more easily mobilised / AW **A** glycogen can be hydrolysed easily
makes it more compact / takes up less space / high density ;

(iii) no branching / single unbranched chain / straight / linear ;
different monomer / beta glucose / β glucose ; **ora**
alternate position of monomers in cellulose / AW ; e.g. rotated 180°
only one type of (glycosidic) bond / 1–4 only / no 1–6 ;
forms hydrogen bonds with other cellulose molecules (to give parallel chains) ;
forms, microfibrils / fibres ; [5]

33. M/J 15/P21/Q5/a,c

(a)

structural feature	triglyceride	phospholipid
phosphate (group) / contains phosphorus	×	✓
nitrogen	×	✓
charged / polar	×	✓
(number of) fatty acids	3	2
number of ester bonds	3	2
number of phosphate ester bonds	0	1
award one mark for any of the following comparisons		
number of double bonds (in hydrocarbon chain)	0	1
number of saturated fatty acids / ORA	3	1
presence of double bonds	×	✓
presence of unsaturated fatty acids	×	✓

These are alternatives – award one mark only

(b)

role of water	property of water
solvent for glucose and ions	dipolar / polar ; **A** description of polarity of water
transport in the xylem	hydrogen bonding ; **I** cohesion / adhesion
helps to decrease body temperature in humans	high latent heat of vapourisation / high specific heat (capacity) / high enthalpy heat of vapourisation / lots of energy required for evaporation ;

[5]

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34. O/N 14/P21/Q3/a,b

(a) condensation ; **A** dehydration

(b) accept glycine-valine or valine-glycine
peptide bond drawn correctly ;
amino and carboxylic acid ends shown ;
correct R-groups ;
water eliminated ; [5]

35. O/N 14/P23/Q2/d

(a) 1 *pond skater*
can stand on water / use surface for habitat, because of surface tension ;
A strong surface because of, hydrogen bonding / cohesion between water molecules
I adhesion

2 *ref. to* its food comprising animals that fall onto water ;
pike – to max 3

3 solvent, provides (dissolved) oxygen ;

4 solvent for, carbon dioxide / excreta / ammonia ;

5 water, has high density / is a medium that, provides support / buoyancy ;

6 liquid so pike can move ;

7 transparent, so pike can see ;

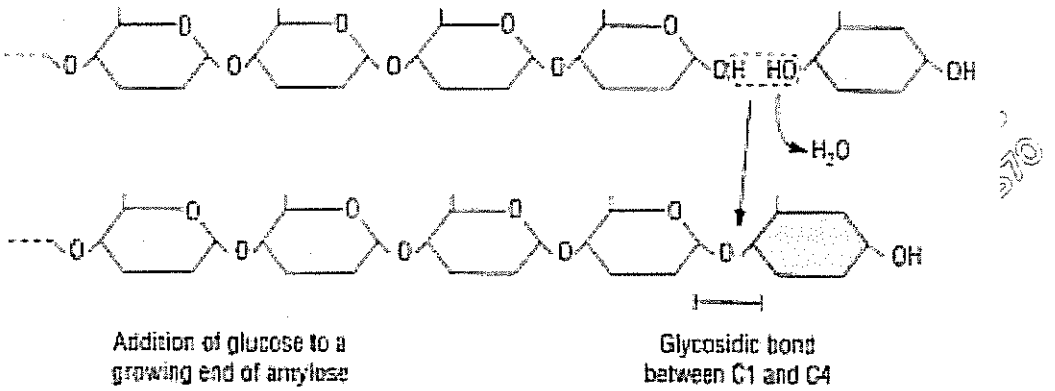
8 high specific heat capacity (of water), provide stable temperature / environment ;

9 ice less dense than water / ice floats, so can survive (when water freezes) ;
A idea of life beneath the ice / insulation

10 AVP ; e.g. high latent heat of fusion, water does not freeze easily [4]

36. M/J 14/P21/Q3

(a) (i) –H and –OH indicated ; **A** *–OH on end of amylose and –H on alpha glucose*
water eliminated / condensation ; **A** dehydration
oxygen bridge / glycosidic bond, drawn between C1 and C4 ;



If the whole glucose molecule and/or the end of the amylose molecule has not been drawn, then only award mp3 if C1 and C4 are indicated in some way, e.g. by numbering them or putting in the hydrogens.

(ii) (1,4 / 1,6) glycosidic ; **A** glucosidic **A** phonetic spelling of glycosidic

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(b)

feature	amylose	glycogen	cellulose
type of glucose	α-glucose	α-glucose	β-glucose ;
branched or unbranched molecule	unbranched	branched	unbranched / not branched ;
role in organisms	energy storage	energy storage	structural / (component of) cell walls / tensile strength / dietary fibre / roughage ; **I** support

(c) (i) *maltase and maltose must be correctly referenced*
ignore references to reversible/irreversible
(ascorbase) binds to / fits into / enters active site ;
complementary (shape) to active site ;
so substrate / maltose, cannot enter / cannot bind ;
A no / few, ES complex
A prevents formation of ES complexes
A ascorbase forms enzyme inhibitor complex
competes with substrate / competitive inhibition ;
slows the (rate of), digestion / hydrolysis / breakdown, of maltose ;
R 'stops the reaction'
R if in context of starch
alternative answer if candidates assume ascorbase is an enzyme:
ascorbase, breaks down / digests / hydrolyses, maltase ;
A ascorbase destroys the active site of maltase
so no enzymes to digests maltose ;
slows / stops, reaction / digestion / hydrolysis / breakdown, of maltose ;

(ii) inhibits / slows down / prevents, breakdown / (catalysing) hydrolysis / digestion, of maltose (to glucose) ; **I** starch
less glucose is absorbed / passes across membranes / enters blood ; [12]

37. M/J 14/P23/Q1

(a) (i) **B** ;
(ii) **D** ;
(iii) **A** ;

(b) (i) amylose / amylopectin / glycogen ; **A** starch

(ii) part **1** is saturated / part **2** is unsaturated ;
part **1** has no double bonds / part **2** has one double bond ;
part **1** has 27 hydrogens and part **2** has 25 ;
A part **1** has more hydrogens **ora**

(iii) *any two from:*
ionic / electrovalent (bond) ;
hydrophobic (interaction) ;
hydrogen (bond) ;
disulfide (bond) ;
A Van der Waal's (forces) [7]

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38. O/N 13/P22/Q2/a

(a)

Keratin and chitin have structural functions cellulose ; collagen ; *allow <u>only one</u> incorrect molecule to be listed for max 1*	*Keratin is a fibrous protein* collagen ; *no marks if other molecules given*
The monomers of chitin have β-1,4 linkages between them cellulose ; *no marks if other molecules given*	*Keratin and chitin contain nitrogen* collagen / haemoglobin ; *1st mark* mRNA ; *2nd mark* *allow <u>only one</u> incorrect molecule to be listed for max 1*

[5]

39. O/N 13/P23/Q5/a,b

(a) *mark both parts together to a maximum of four marks*

1 (polymer / polysaccharide of) β-glucose ; *allow glucose if β given for bond*
2 (1-4, β) glycosidic, bonds / linkages ; **A** glucosidic
R if 1-6 also given
3 ref. to (β) glucose units, linked at 180 ° to each other / alternately orientated / AW ;
4 many –OH groups projecting out (in different directions) ;
5 unbranched (polymer) / straight chain / linear ;
6 many hydrogen bonds <u>between</u> molecules ;
7 (straight chain allows) molecules lie parallel to each other ;
8 (form) microfibrils ;
9 many microfibrils form (cellulose) fibres ;
10 ref. to fibres at angles / criss-cross / AW ;
11 (cellulose) <u>cell wall</u> is permeable ;
A *idea* of many gaps, in wall / between fibres, allowing passage of water / (named) substances
12 ref. to strength to, prevent cell bursting / withstanding (turgor) pressure / AW ;

(b) (i) *data quote may help to decide if mp2 is matched*
units must be used at least once in the answer to award mp3

1 as retention time increases percentage of cell wall material digested increases / positive correlation ;
A 'time for digestion' / reverse relationship
R directly proportional
2 results scattered / not all animals fit the pattern / varying percentages for the same retention time ; *not just a data quote*
3 data quote with units (% and h) using both axes ;
e.g. (highest percentage) 65% at 78 hours
(lowest percentage) 35.5 ± 0.5%, 35 hours
4 no retention time shorter than 35 hours <u>and</u> none longer than 88 hours ;
A lowest / shortest <u>and</u> highest / longest
A reverse relationship **A** 'time for digestion'
5 none of the (24) herbivores can digest the cell wall material completely ;
A no more than 65% is digested

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not just a data quote

(ii) more digestion means that there is more energy available to the animal ;
ora = undigested material means less energy to the animal

2 more digested material means more energy for, secondary consumers / carnivores / next trophic level / for the food chain ; ora

3 more digested material means more trophic levels ; ora

4 more undigested material provides more energy to decomposers / AW ;

5 AVP ; e.g. ref. to (named) animal productivity
A secondary, production / productivity [9]

40. O/N 13/P21/Q2/a,b

(a) (i) G ;

(ii) B / C ;

(iii) A / F ;

(iv) B ;

(v) D ;

(b) 1 nitrogen and hydrogen / substrates, bind to / AW, active site ;

2 enzyme-substrate complex (forms) ;

3 ref. lock and key / induced fit, mechanism ;

4 activation energy of reaction is lowered ;

5 example of how activation energy lowered ;
e.g. strain on (triple) bond of, N_2 / (di)nitrogen
A bond broken between nitrogen (atoms)
nitrogen and hydrogen ions held close together for bond formation
transfer of electrons
alternative pathway

6 product / NH_4^+, leaves active site ;

7 ATP, required / used / provided from respiration ;

8 ref. anaerobic conditions for enzyme action ;

9 suggestion as to use of, vanadium / molybdenum, in active site ;
e.g. act as cofactor / coenzyme
transfer of, electrons / protons [9]

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Unit 3

ENZYMES

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

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Syllabus

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Unit 3: Enzymes

1. M/J 22/P21/Q3

A tyrosine kinase receptor (TKR) is a protein complex found in the cell surface membrane of mammalian cells.

TKR has two components involved in the process of cell signalling:

- a receptor for the signalling molecule (ligand)
- an enzyme that catalyses the transfer of a phosphate group from ATP to an intracellular protein.

Fig. 3.1 is a diagram to show how TKR is involved in cell signalling.

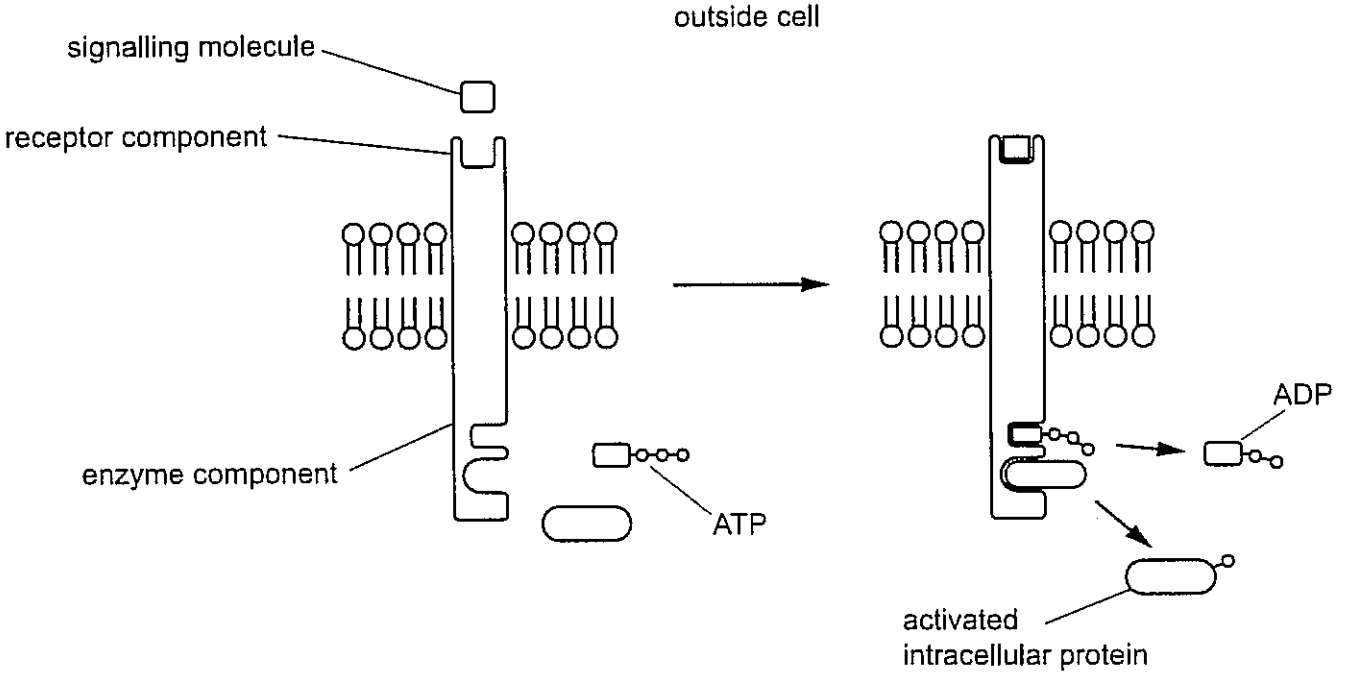


Fig. 3.1

(a) Most enzymes are specific to one reaction.

With reference to Fig. 3.1, explain how the structure of an enzyme provides its specificity.

.....

..... [2]

The drug GNF-5 is used in the treatment of some cancers. GNF-5 affects the activity of TKR by binding to the enzyme component of the complex.

Researchers investigated the effect of GNF-5 on the activity of TKR using different concentrations of ATP solution. In an experiment the activity of TKR was measured with no GNF-5 **and** with GNF-5.

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The results are shown in Fig. 3.2.

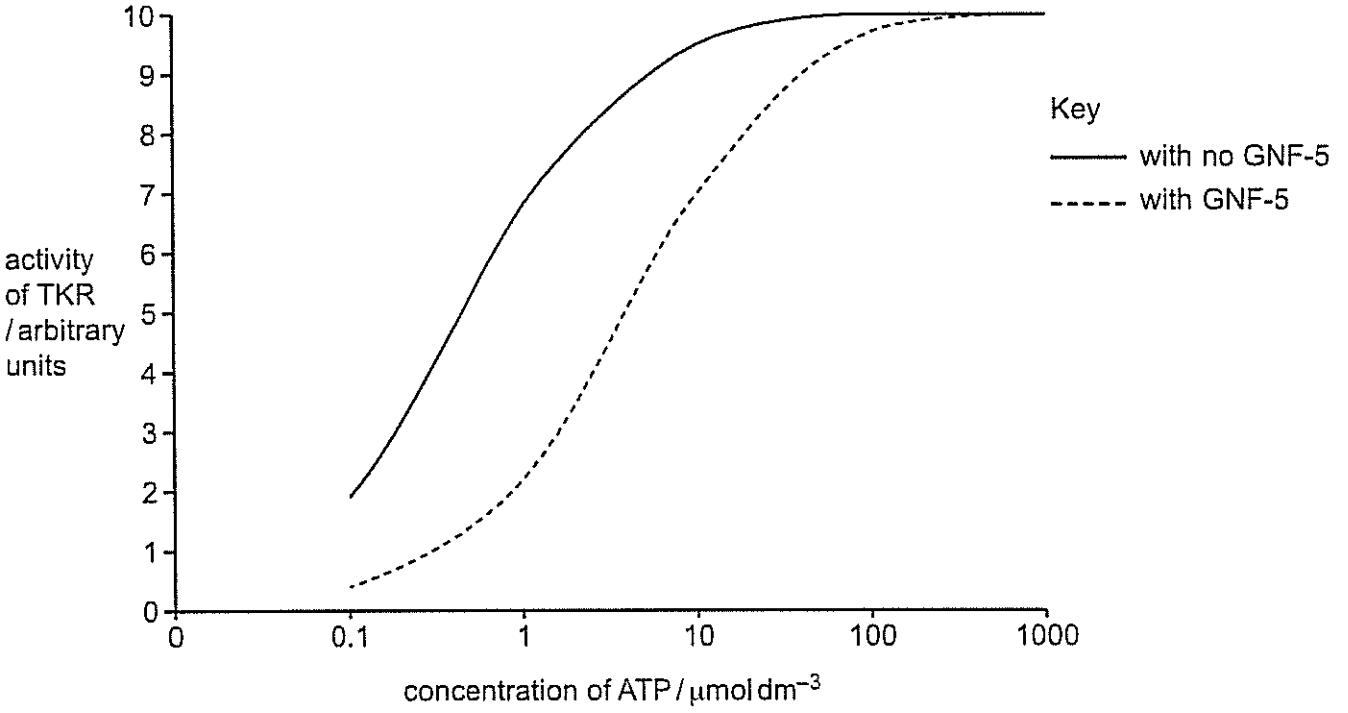


Fig. 3.2

(b) The researchers concluded that GNF-5 acts as an inhibitor of the enzyme component of TKR **and** that it is a competitive inhibitor.

Use Fig. 3.2 to provide evidence for these conclusions.

.....

.....

..... [3]

(c) A mutation of the gene coding for TKR results in changes to the enzyme component of TKR. This altered form of TKR is known as T315L.

The effect of GNF-5 on the activity of T315L was also investigated.

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The results of this investigation are shown in Fig. 3.3.

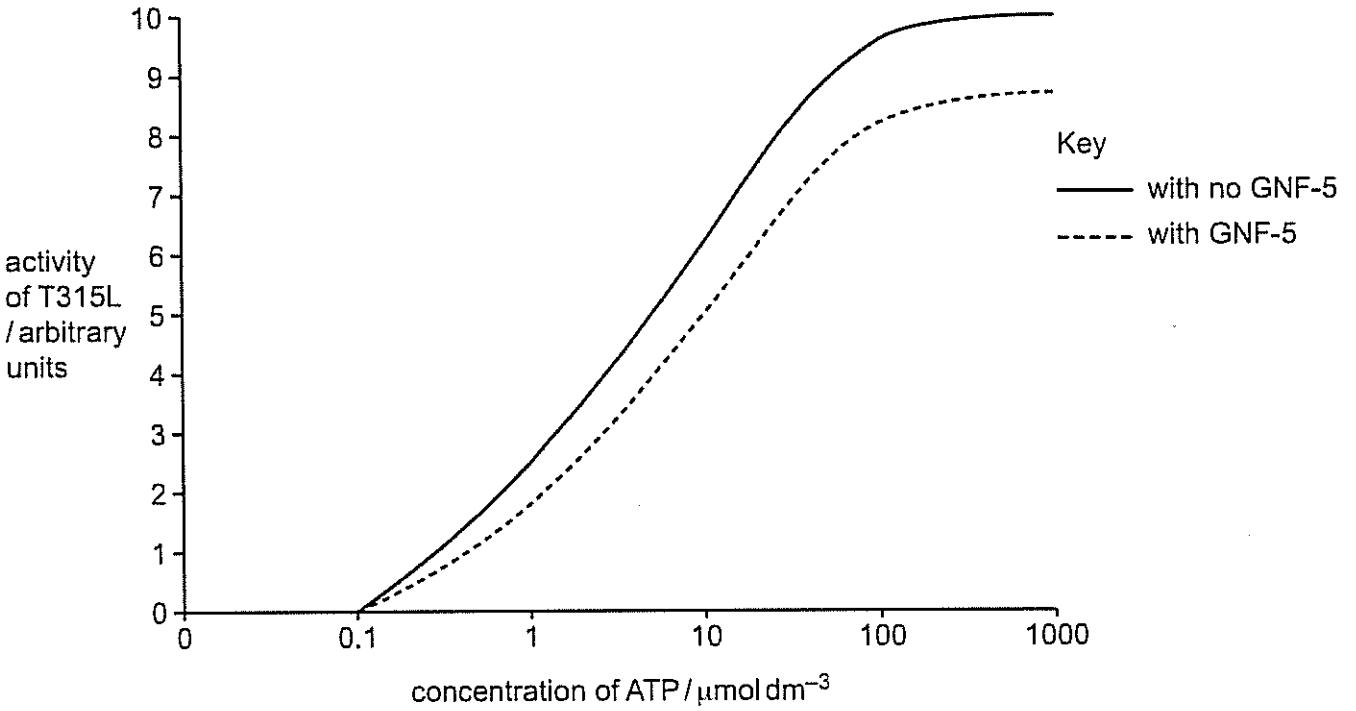


Fig. 3.3

Use Fig. 3.2 **and** Fig. 3.3 to:

(i) State how the activity of T315L differs from TKR when **no** GNF-5 was present.

..... [1]

(ii) State how the effect of GNF-5 on T315L differs from the effect of GNF-5 on TKR.

.....

..... [2]

2. O/N 21/P23/Q2

Pepsin is an enzyme that hydrolyses proteins (protease). Some students used pepsin from the stomach of a mammal.

The activity of the pepsin was investigated by placing a small quantity of the enzyme with a known concentration of the protein albumen.

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Fig. 2.1 shows the progress of the enzyme-catalysed reaction that was carried out at 20 °C.

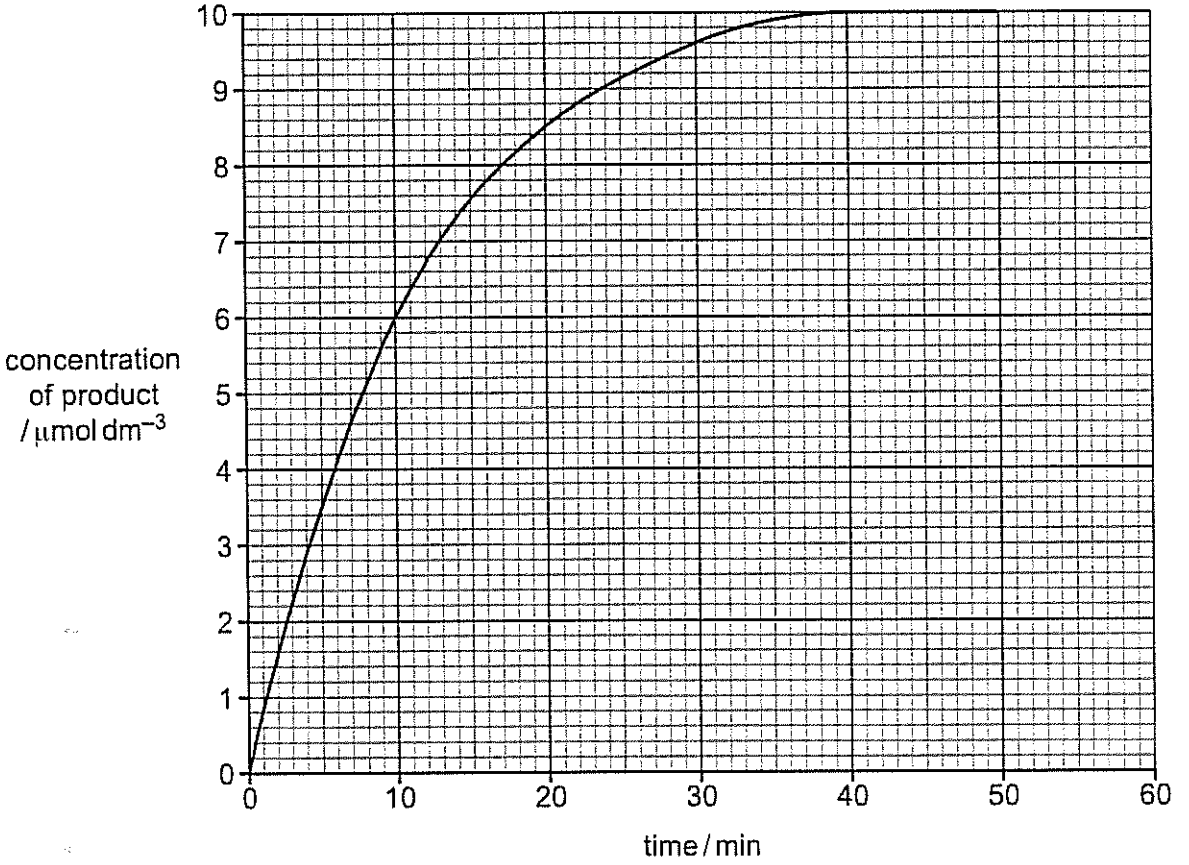


Fig. 2.1

(a) Calculate the initial rate of the reaction.

initial rate of reaction = ... [2]

(b) (i) The procedure was repeated to find the effects on the activity of the pepsin using a competitive inhibitor at the same temperature, 20 °C.
Predict the results that will be obtained using the competitive inhibitor.

.....

..... [2]

(ii) The procedure was repeated **without** the competitive inhibitor but at the higher temperature of 30 °C.
Predict the results that will be obtained at 30 °C.

.....

..... [2]

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(c) The students extended their investigation by using pepsin from a different species of mammal. The experiments were carried out at 20 °C and **without** a competitive inhibitor.

With reference to Fig. 2.1, explain the advantage of calculating the initial rate of reaction in each experiment.

.....

..... [2]

3. M/J 21/P22/Q5/c,d

Juices that are extracted commercially from fruits can be made less cloudy by the breakdown of the cell wall using the enzymes cellulase, pectinase and xylanase:

- cellulase hydrolyses cellulose
- pectinase hydrolyses pectin
- xylanase hydrolyses hemicellulose.

(a) Fig. 5.2 is a graph showing the effect of cellulose concentration on the activity of cellulase, which is used in making fruit juice less cloudy.

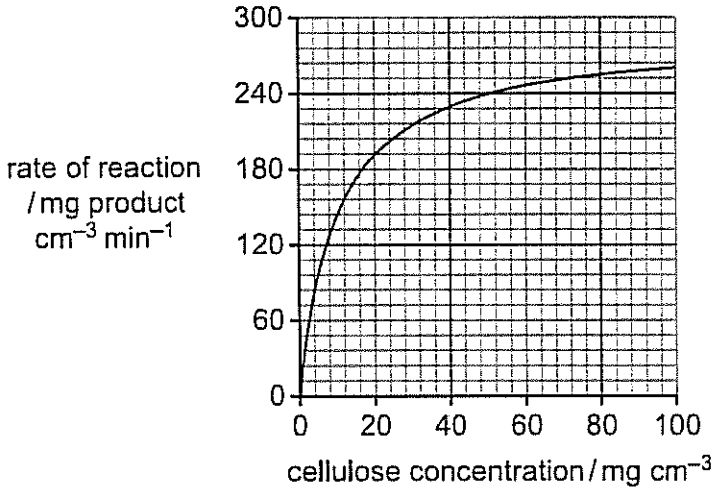


Fig. 5.2

Describe **and** explain the curve shown in Fig. 5.2.

.....

.....

..... [3]

(b) Ultrasound is one possible method that can be used to destroy microorganisms that contaminate fruit juices. Ultrasound is the term given to sound waves that are out of the range of human hearing.

An investigation was carried out into the effect of ultrasound on the activity of cellulase, pectinase and xylanase used in fruit juice manufacture.

For each enzyme, the effect of ultrasound was compared with no ultrasound on the:

- maximum rate of reaction (V_{max})
- Michaelis-Menten constant (K_m)
- catalytic efficiency (V_{max}/K_m)

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Table 5.1 summarises the results. A higher V_{max}/K_m indicates a higher catalytic efficiency.

Table 5.1

enzyme	method	comparison of V_{max}	comparison of K_m	V_{max}/K_m /min^{-1}
cellulase	ultrasound	higher	higher	34
	no ultrasound	lower	lower	29
pectinase	ultrasound	same	lower	945
	no ultrasound	same	higher	759
xylanase	ultrasound	higher	same	146
	no ultrasound	lower	same	125

(i) In terms of changes in the interaction between enzyme and substrate when ultrasound is used, suggest explanations for the lower K_m for pectinase and the higher V_{max} for xylanase, as shown in Table 5.1.

.....

.....

..... [3]

(ii) Explain whether the data shown in Table 5.1 supports the recommendation that ultrasound can be used in the manufacture of fruit juices.

..... [1]

4. M/J 21/P21/Q4

(a) The induced-fit hypothesis and the lock-and-key hypothesis are used to describe the mode of action of enzymes.
Explain the induced-fit hypothesis.

.....

.....

..... [3]

(b) Radish plants contain the enzyme peroxidase that catalyses the breakdown of hydrogen peroxide.
Students investigated the effect of increasing the concentration of hydrogen peroxide on the activity of peroxidase extracted from radish.

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The results of their investigation are shown in Fig. 4.1.

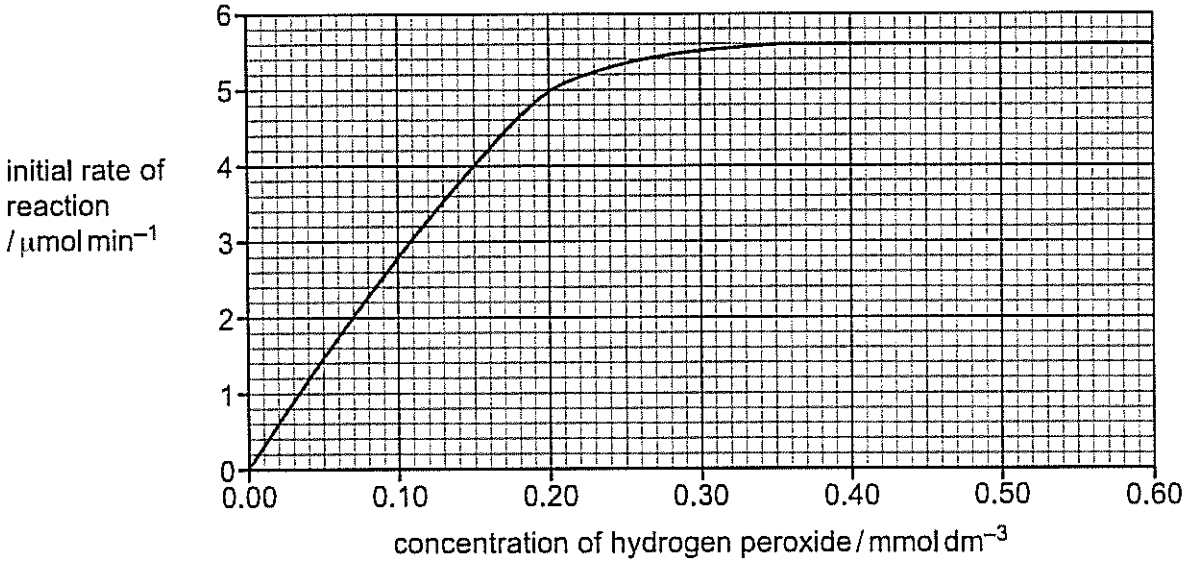


Fig. 4.1

(i) Explain the effect of increasing the concentration of hydrogen peroxide on the initial rate of reaction as shown in Fig. 4.1.

.....

.....

..... [3]

(ii) The students determined the K_m for radish peroxidase as 0.10 mmol dm^{-3}.
With reference to Fig. 4.1, describe how they determined the K_m.

.....

..... [2]

(c) A further investigation found that the K_m for carbonic anhydrase is 12 mmol dm^{-3}.
Describe the role of carbonic anhydrase in the transport of carbon dioxide.

.....

.....

..... [3]

5. O/N 20/P22/Q5

Sucrose phosphorylase is an enzyme found in some species of bacteria. One function of this enzyme is for the production of compounds that help to protect the cell from harmful osmotic changes in the external environment.

Fig. 5.1 shows the reversible reaction that takes place within the bacterial cell.

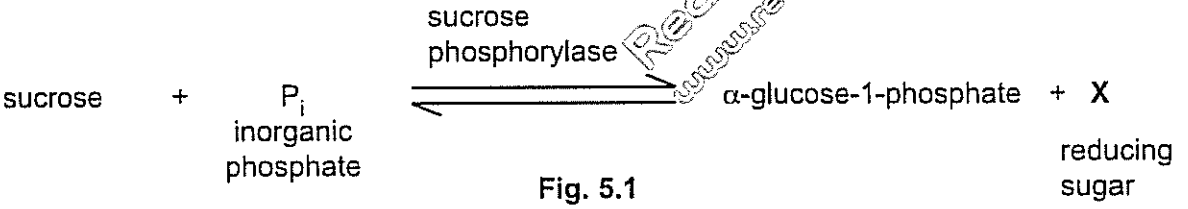


Fig. 5.1

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(a) Name reducing sugar **X** in Fig. 5.1.

..... [1]

(b) In the absence of sucrose phosphorylase as a catalyst, the reaction shown in Fig. 5.1 would take too long to occur to allow the bacterial cell to function efficiently.

Explain why the reaction shown in Fig. 5.1 proceeds at a much faster rate in the presence of the enzyme.

.....

..... [2]

(c) An enzyme that catalyses a reaction of commercial interest needs to be investigated to see if it is suitable for use in industry.

For example:

- immobilised enzymes may be used as they have a longer shelf-life than the enzyme free in solution
- many industrial reactions are carried out at higher temperatures to minimise contamination of products by microorganisms.

Fig. 5.2 shows the results of an investigation to compare the activity of sucrose phosphorylase free in solution (free enzyme) with immobilised sucrose phosphorylase (immobilised enzyme) at different pHs.

Fig. 5.3 shows the activity of the free enzyme and immobilised enzyme at different temperatures.

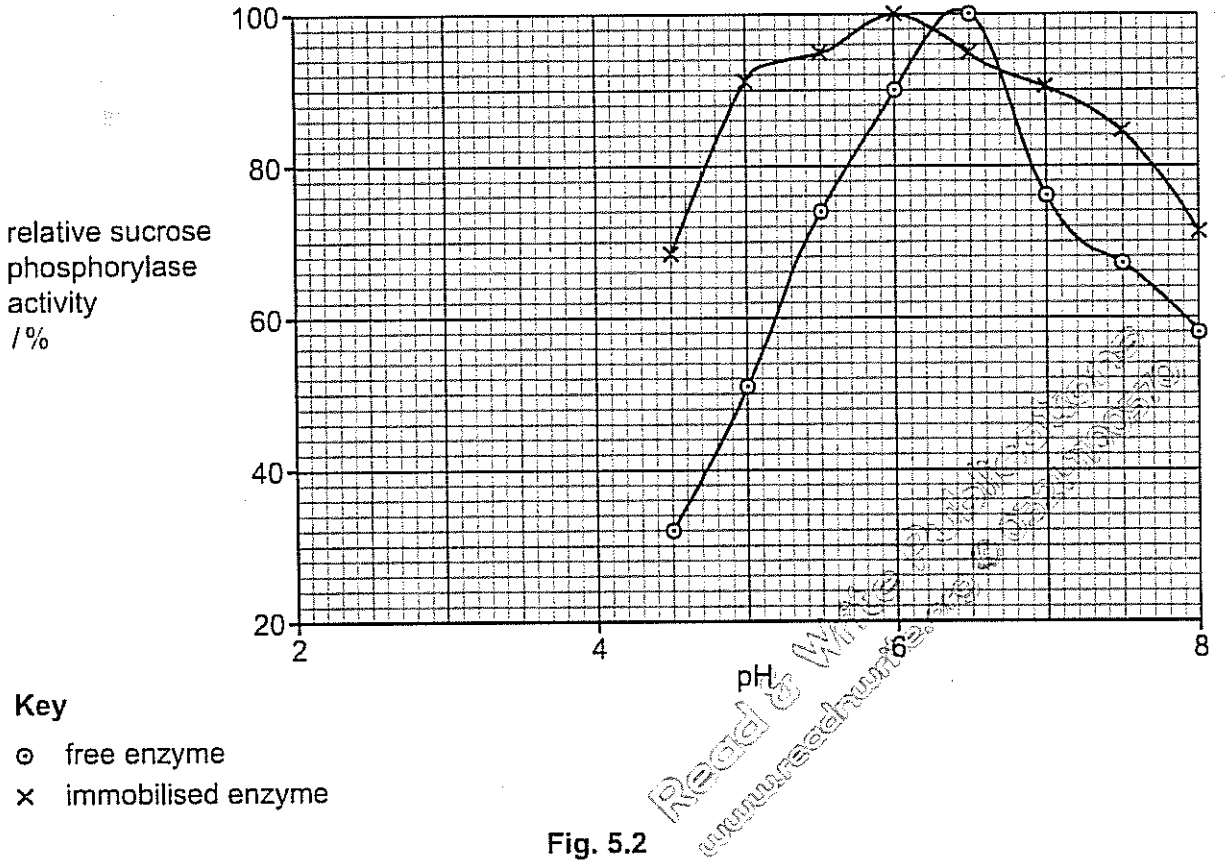


Fig. 5.2

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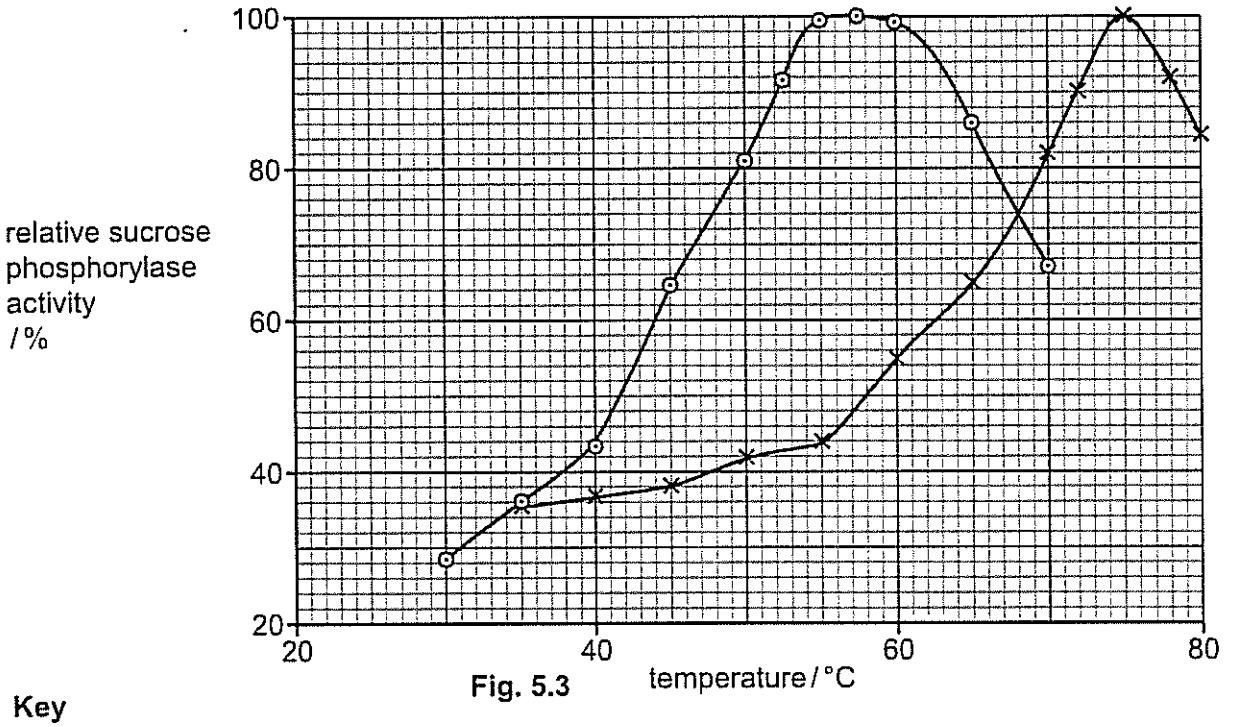


Fig. 5.3

Key

⊙ free enzyme

× immobilised enzyme

With reference to the results shown in Fig. 5.2 and Fig. 5.3, discuss which sucrose phosphorylase enzyme, free or immobilised, is better for use in industrial reactions.

.....

.....

.....

..... [4]

6. O/N 20/P21/Q2/b

(a) Lipases are enzymes that digest triglycerides in the lumen of the human intestine. These enzymes are released by exocytosis from intestinal epithelial cells.

(i) Underline **all** the terms from the list that are used to describe these lipases.

macromolecule **extracellular enzyme** **fibrous protein** **polysaccharide** [1]

Scientists have found that treating milk with lipase can improve its taste.

The scientists carried out an experiment to determine the effect of lipase activity on the triglycerides found in milk.

- Lipase was immobilised in alginate beads.
- The pH of a known volume of milk was adjusted to pH 8 by adding an alkali.
- The beads were then mixed with this milk in a beaker.
- The pH of the reaction mixture was recorded over a period of 24 hours.

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The results are shown in Fig. 2.2.

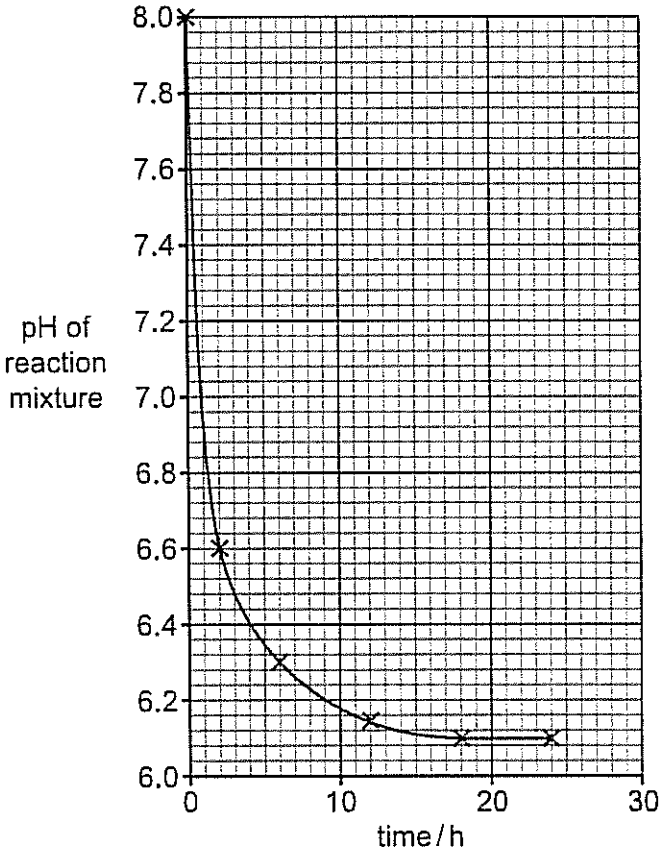


Fig. 2.2

Fig. 2.2 shows that the pH decreases steeply and then, after 18 hours, remains constant.

(ii) Calculate the time taken for the pH to decrease from pH 6.6 to pH 6.3.

time taken = ... h [1]

(iii) Explain the results shown in Fig. 2.2.

.....

.....

.....

..... [4]

(iv) The scientists repeated the experiment using a higher concentration of lipase. All other variables remained constant.
Predict how an increase in the concentration of the lipase would affect the results of the experiment.

.....

..... [2]

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7. O/N 20/P23/Q5/c,d

(a) The enzyme collagenase catalyses the breakdown of collagen molecules. This enzyme acts by using an induced fit mechanism.

Describe the mode of action of collagenase.

.....

.....

.....

.....

..... [5]

(b) Students investigated the effect of pH on the activity of collagenase extracted from the bacterium *Bacillus licheniformis* at 50 °C.

The results are shown in Fig. 5.2.

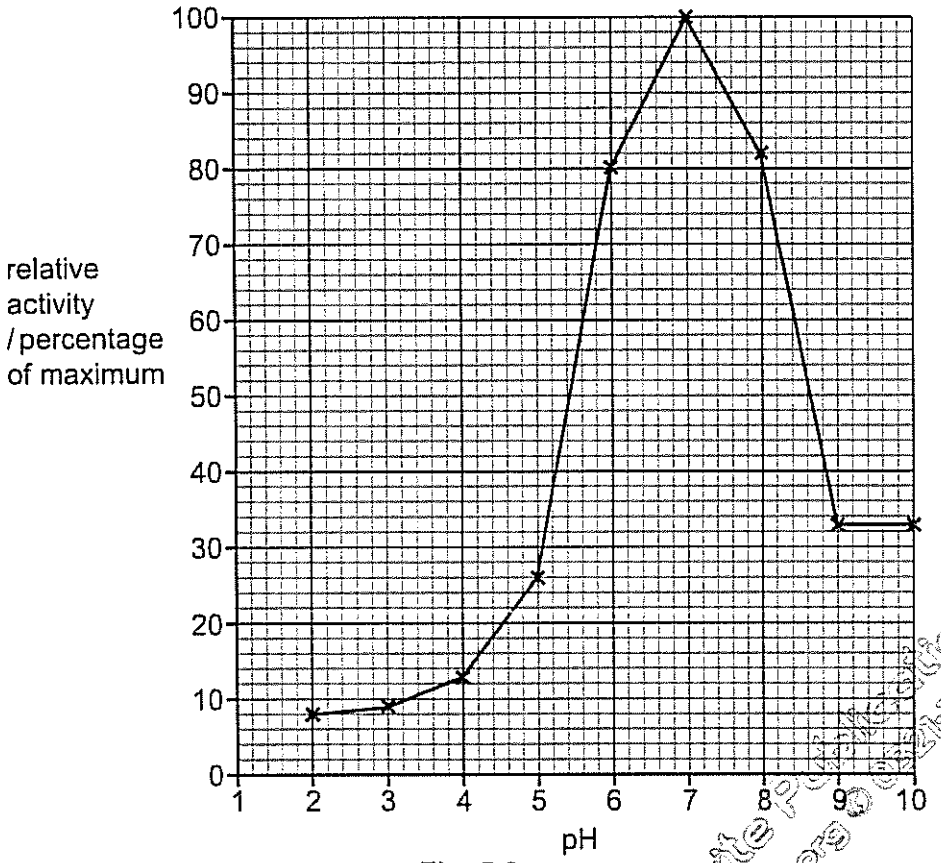


Fig. 5.2

With reference to Fig. 5.2, describe **and** explain the effect of pH on the activity of collagenase.

.....

.....

.....

..... [4]

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8. M/J 20/P22/Q5/b(iii)

(a) Fig. 5.1 shows part of one pathway that is used in plant cells to synthesise sucrose. The enzyme sucrose synthase catalyses the transfer of glucose from UDPG (uridine diphosphate glucose) to fructose.

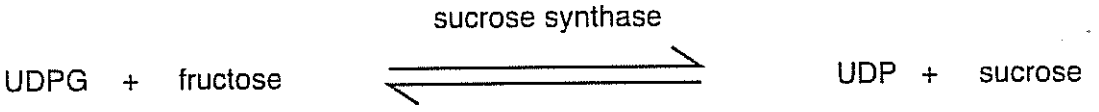


Fig. 5.1

The structure of UDPG is shown in Fig. 5.2.

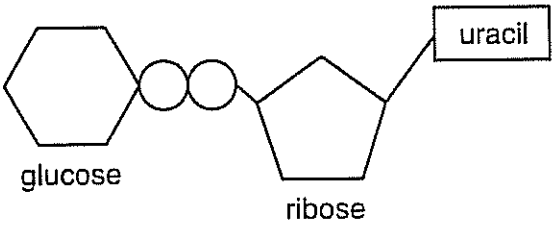


Fig. 5.2

(i) Sucrose synthase acts by using an induced fit mechanism rather than a lock and key mechanism.
With reference to sucrose synthase and the **synthesis** of sucrose, outline the difference between the induced fit mechanism and lock and key mechanism of enzyme action.

.....

.....

.....

..... [4]

9. M/J 20/P21/Q3

The enzyme glucose 6-phosphate dehydrogenase (G6PD) is composed of two identical polypeptide chains.

(a) Students investigated the activity of two forms of G6PD, **J** and **K**, at different concentrations of substrate. **K** is a form of the enzyme that results from a mutation that changes one amino acid in the polypeptide.

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The results are shown in Fig. 3.1.

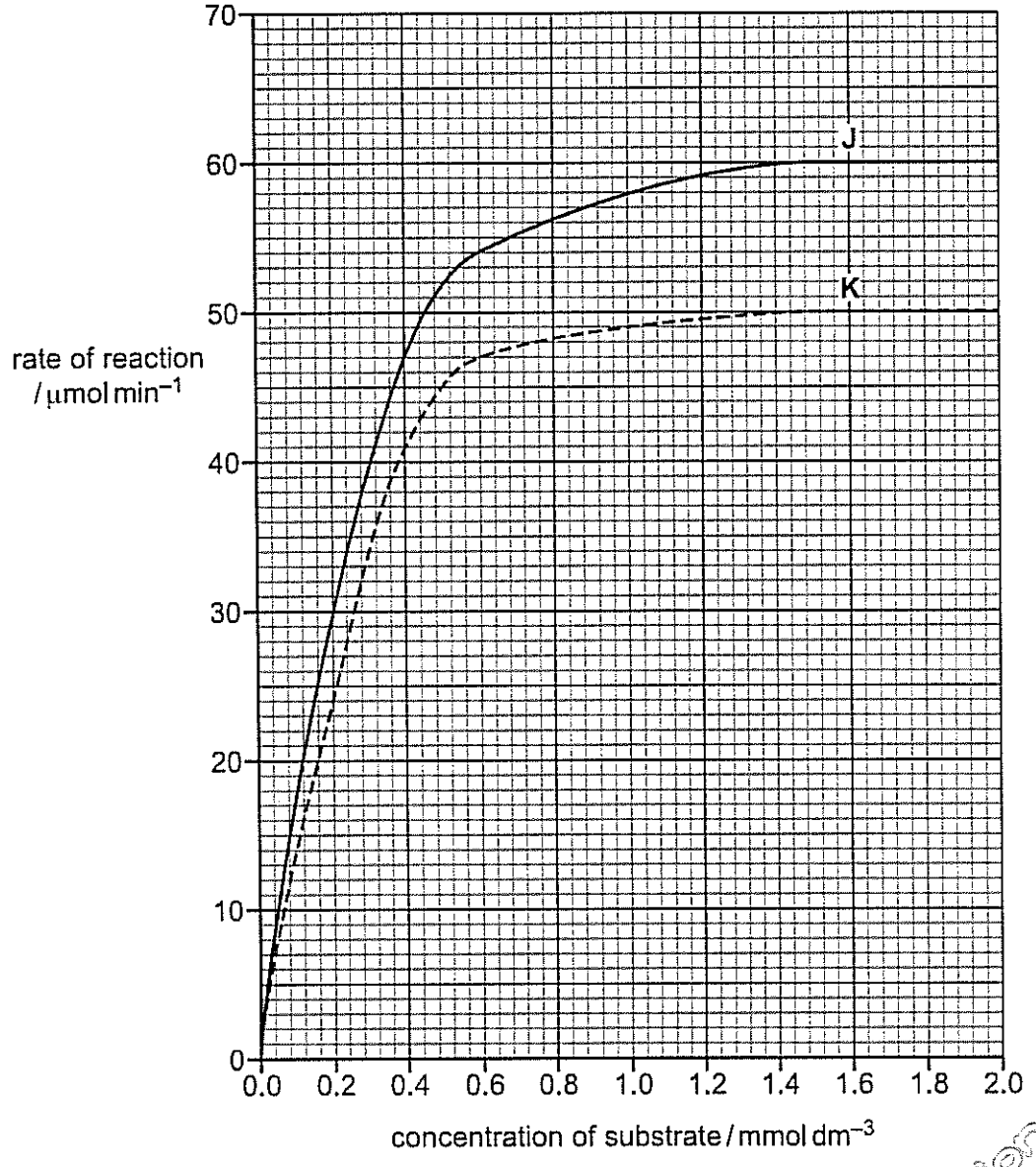


Fig. 3.1

(i) Use Fig. 3.1 to complete Table 3.1 by stating:

- the V_{max} and the K_m for enzymes **J** and **K**
- the units for V_{max} and K_m.

Table 3.1

	V_{max} /	K_m /
J		
K		

[3]

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(ii) With reference to Fig. 3.1 and Table 3.1, describe the effect of the mutation on the activity of G6PD **and** suggest an explanation for this effect.

.....

.....

.....

..... [4]

(b) In certain conditions, G6PD may also exist as four identical polypeptide chains rather than two identical polypeptide chains.

Explain why both of these types of G6PD have all four levels of protein structure.

.....

..... [2]

10. M/J 20/P23/Q4/e,f

(a) The hydrolysis of trehalose is catalysed by two different enzymes produced by *S. cerevisiae*, regulatory trehalase and non-regulatory trehalase.

A study was carried out to compare regulatory trehalase and non-regulatory trehalase extracted from *S. cerevisiae*.

The results of the study showed that:

- regulatory trehalase had a higher K_m value (Michaelis-Menten constant) than non-regulatory trehalase
- the optimum pH of regulatory trehalase was pH 7.0–7.8
- the optimum pH of non-regulatory trehalase was pH 4.5–5.0.

(i) Explain what is meant by a higher K_m value.

.....

..... [2]

(ii) Regulatory trehalase is found only in the cytosol, the fluid part of the cytoplasm.

Non-regulatory trehalase has been found on the external surface of the cell surface membrane and inside the cell.

State the location inside the cell where non-regulatory trehalase is likely to be found **and** explain the reason for your answer.

.....

..... [2]

(iii) Explain whether both types of trehalase, regulatory and non-regulatory, can be described as intracellular enzymes.

..... [1]

(b) *Saccharomyces boulardii* is a strain of *S. cerevisiae*. It has been researched for its possible health benefits for some gut diseases.

Researchers investigating trehalase extracted from *S. boulardii* concluded that only one type of trehalase was present in the extract.

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Fig. 4.3 shows the effect of pH on the activity of the trehalase extracted from *S. boulardii*.

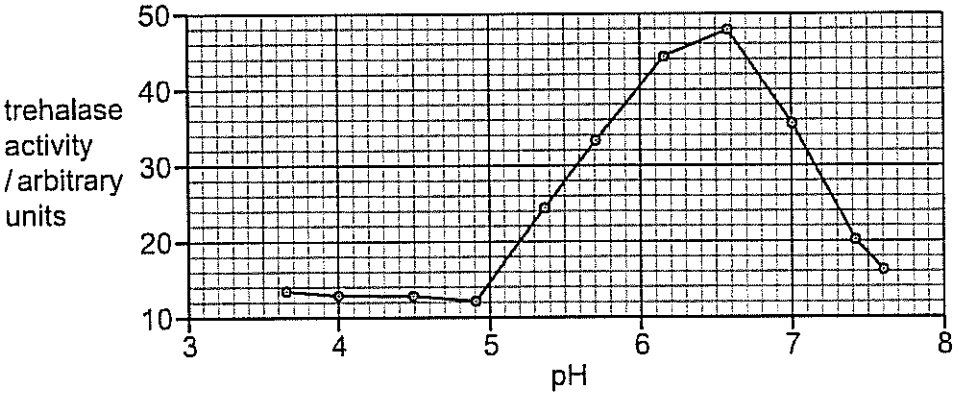


Fig. 4.3

With reference to Fig. 4.3 and to the two different types of trehalase enzyme produced by *S. cerevisiae*, state **and** explain what can be deduced about the type of trehalase present in *S. boulardii*.

.....

.....

..... [3]

11. M/J 19/P22/Q6

Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide, which is a waste product of cell metabolism.

The reaction catalysed by catalase is shown in Fig. 6.1.

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Fig. 6.1

(a) A student carried out two experiments to investigate the progress of the reaction shown in Fig. 6.1. Potato tissue was used as the source of the enzyme.

Six pieces of potato were cut, each measuring 20 mm × 10 mm × 10 mm.

In the first experiment, hydrogen peroxide solution was added to three of the pieces of potato tissue and the progress of the reaction was measured.

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Fig. 6.2 shows how the first experiment was set up.

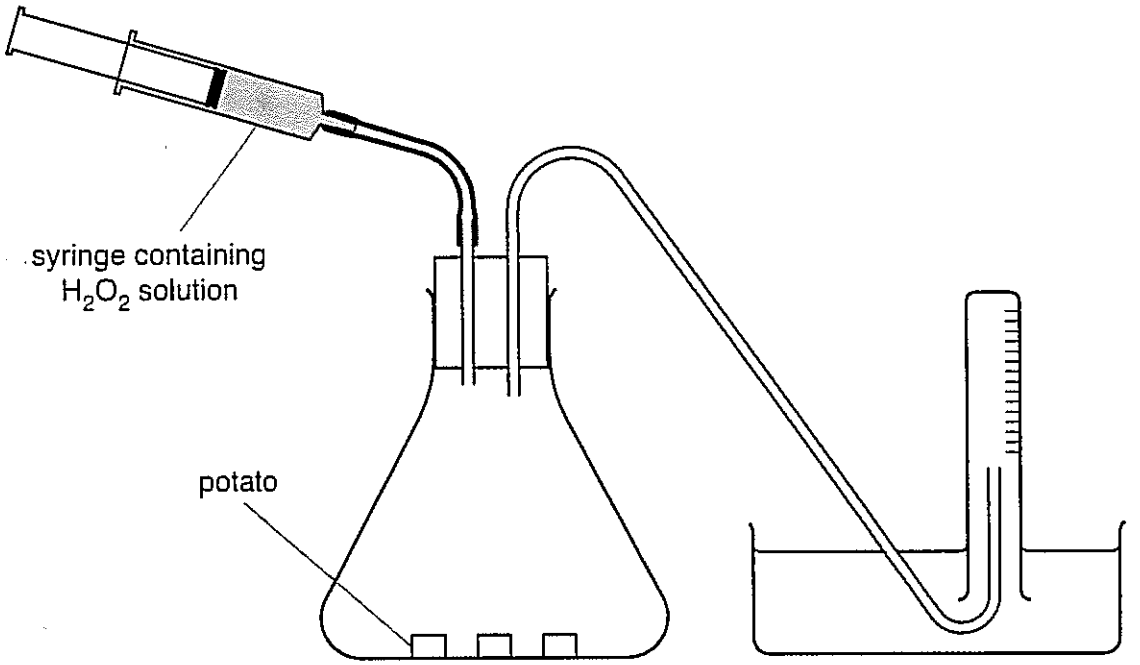


Fig. 6.2

(i) Suggest how the progress of the reaction could be measured.

.....

..... [2]

(ii) In the second experiment, the student cut each of the three remaining pieces of potato to obtain six pieces, each measuring 10 mm × 10 mm × 10 mm.
Using exactly the same conditions, the student measured the progress of the reaction and obtained different results to the first experiment.
Explain why the results of the second experiment were different from the results of the first experiment.

.....

..... [2]

(b) The student then investigated the effect of temperature on the activity of catalase.
On Fig. 6.3, sketch a curve to show how temperature affects the activity of an enzyme such as catalase.

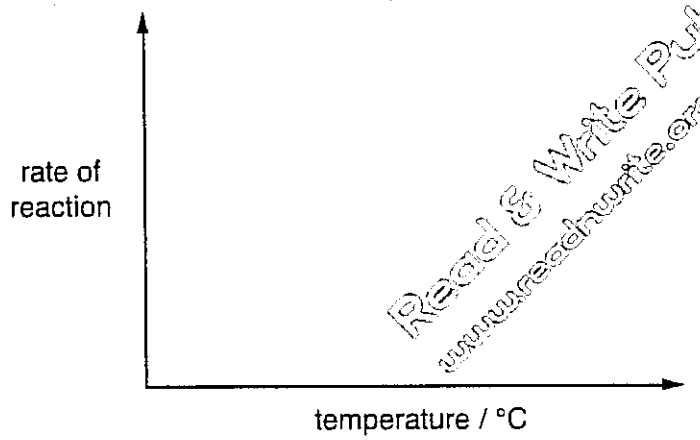


Fig. 6.3 [1]

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12. M/J 19/P21/Q3

Neutrase® is an enzyme that is used to hydrolyse proteins in solution. When the enzyme is mixed with a 2% protein solution the reaction mixture changes from white to colourless.

A student carried out an experiment to find the effect of copper sulfate and potassium sulfate on the activity of Neutrase®.

The student made four reaction mixtures in test-tubes **A** to **D**. Test-tubes **A** to **C** contained equal volumes of protein solution and 0.1 cm^3 of solutions of copper sulfate or potassium sulfate. Test-tube **D** contained the same volume of protein solution and 0.1 cm^3 of water.

0.5 cm^3 of a 1% Neutrase® solution was added to test-tube **A** and immediately placed into a colorimeter. The colorimeter was used to measure the intensity of light that is absorbed by the solution (absorbance) over 100 seconds. The procedure was repeated with the other reaction mixtures, **B**, **C** and **D**.

The results are shown in Fig. 3.1.

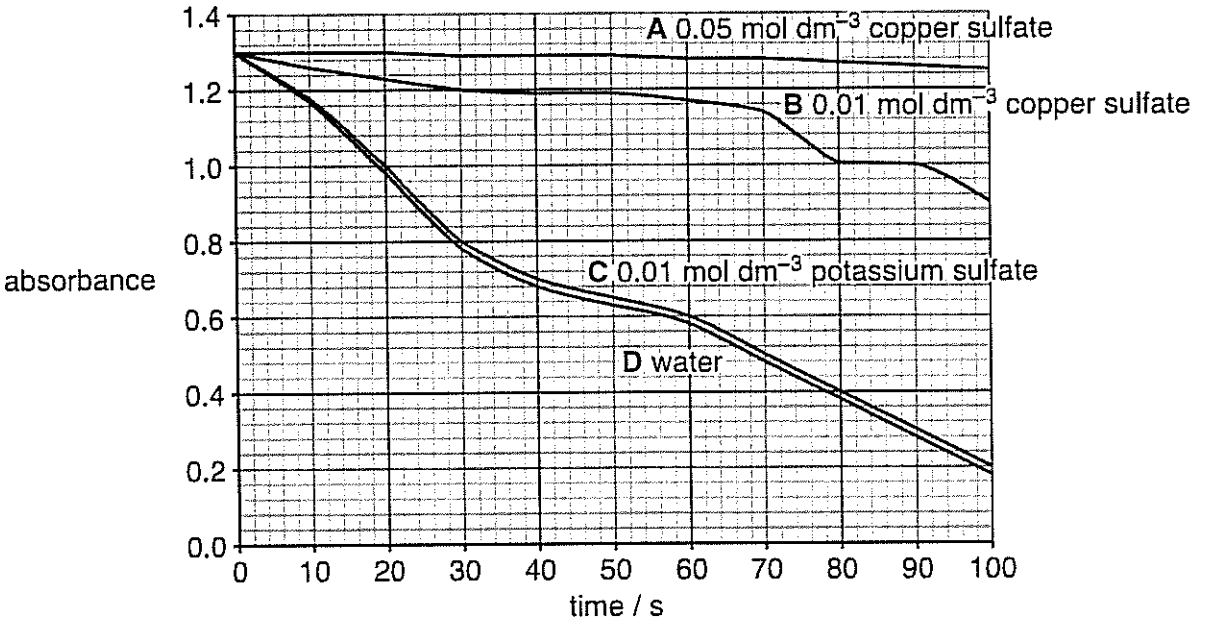


Fig. 3.1

(a) (i) Suggest **and** explain why measuring the absorbance of the reaction mixture over 100 s is a suitable method for determining the activity of Neutrase®.

.....

..... [2]

(ii) With reference to Fig. 3.1:

- describe the effects of copper sulfate solution and potassium sulfate solution on the activity of Neutrase®
- suggest explanations for the effects that you have described.

.....

.....

.....

.....

..... [5]

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(b) Neutrase® can be immobilised in alginate. Immobilised Neutrase® is used in the food industry to produce foods with high nutritional content.

Explain the advantages of using immobilised enzymes, such as Neutrase®, compared with using the same enzymes free in solution.

.....

..... [2]

13. O/N 18/P21/Q2

Fig. 2.1 shows the disaccharide lactose, which is found in milk.

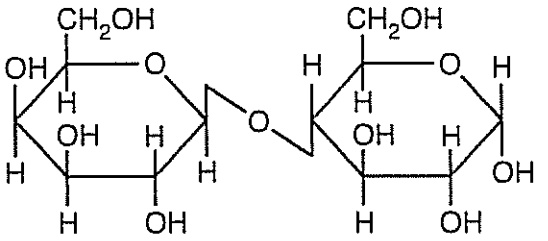


Fig. 2.1

(a) Name the type of bond that joins the two monosaccharides in lactose.

..... [1]

(b) The enzyme lactase catalyses the breakage of the bond between the two monosaccharides in lactose.

(i) Name the type of reaction that breaks this bond.

..... [1]

(ii) Some people do not produce the enzyme lactase, so cannot digest lactose.
The presence of lactose in the lumen of the intestine reduces the volume of water absorbed into the blood, resulting in diarrhoea.

Suggest why the presence of lactose in the intestine reduces the volume of water absorbed.

.....

..... [2]

(c) Enzymes, such as lactase, are often immobilised for use in the food industry.
A scientist carried out an investigation to determine the effects of temperature on the activity of lactase when it was immobilised and when it was free in solution.
The scientist produced alginate beads containing lactase for use in this investigation. The beads varied in size. The scientist selected small beads for the investigation and put them into a glass column.

(i) Suggest the advantage of using small beads rather than large beads.

.....

..... [2]

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(ii) Fig. 2.2 shows the results of the investigation to determine the effects of temperature on the activity of lactase when it was immobilised, **I**, and when it was free in solution, **F**.

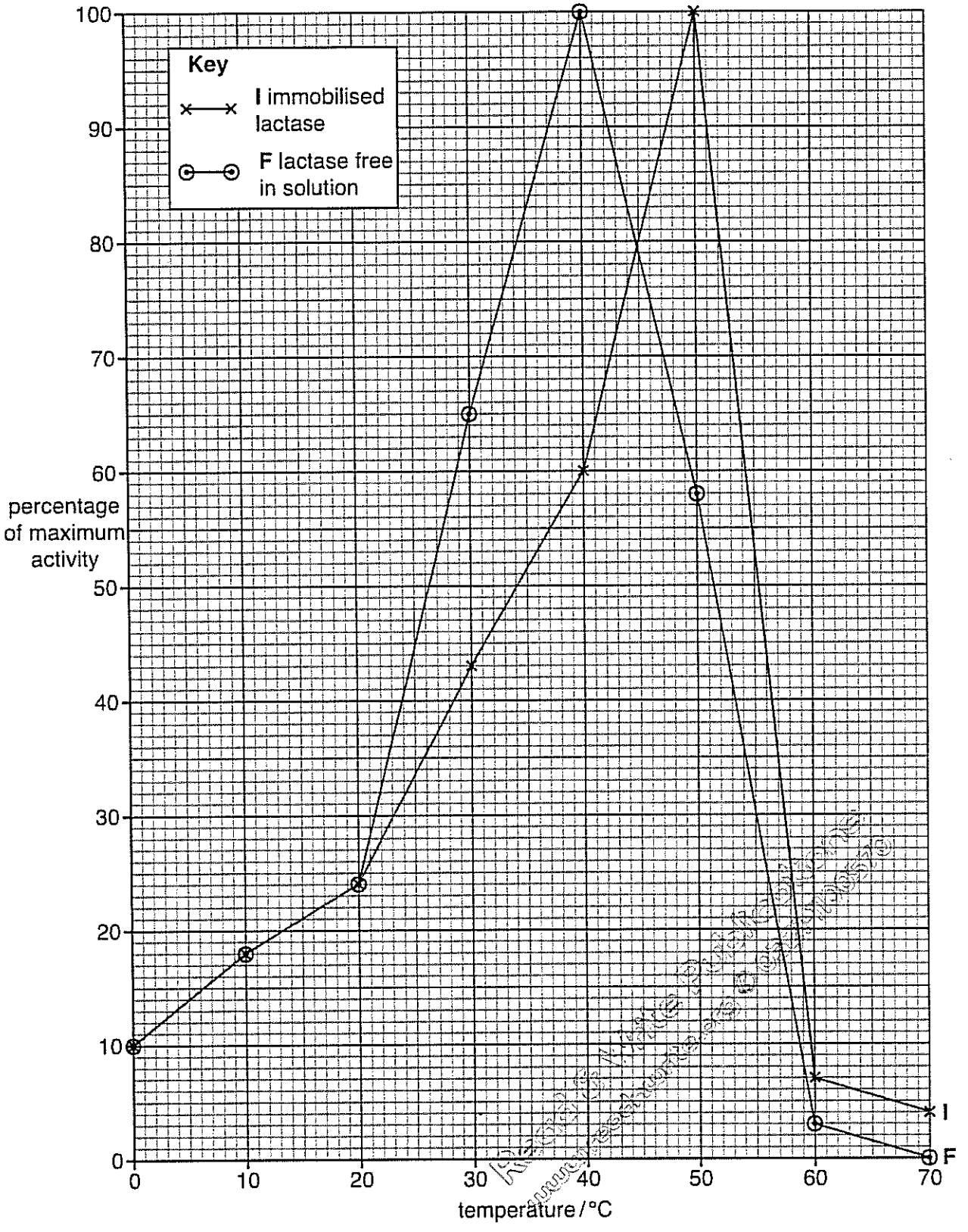


Fig. 2.2

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With reference to Fig. 2.2, compare the effect of temperature on the activity of immobilised lactase, **I**, and lactase free in solution, **F**.

.....

.....

..... [3]

14. M/J 18/P21/Q3

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.

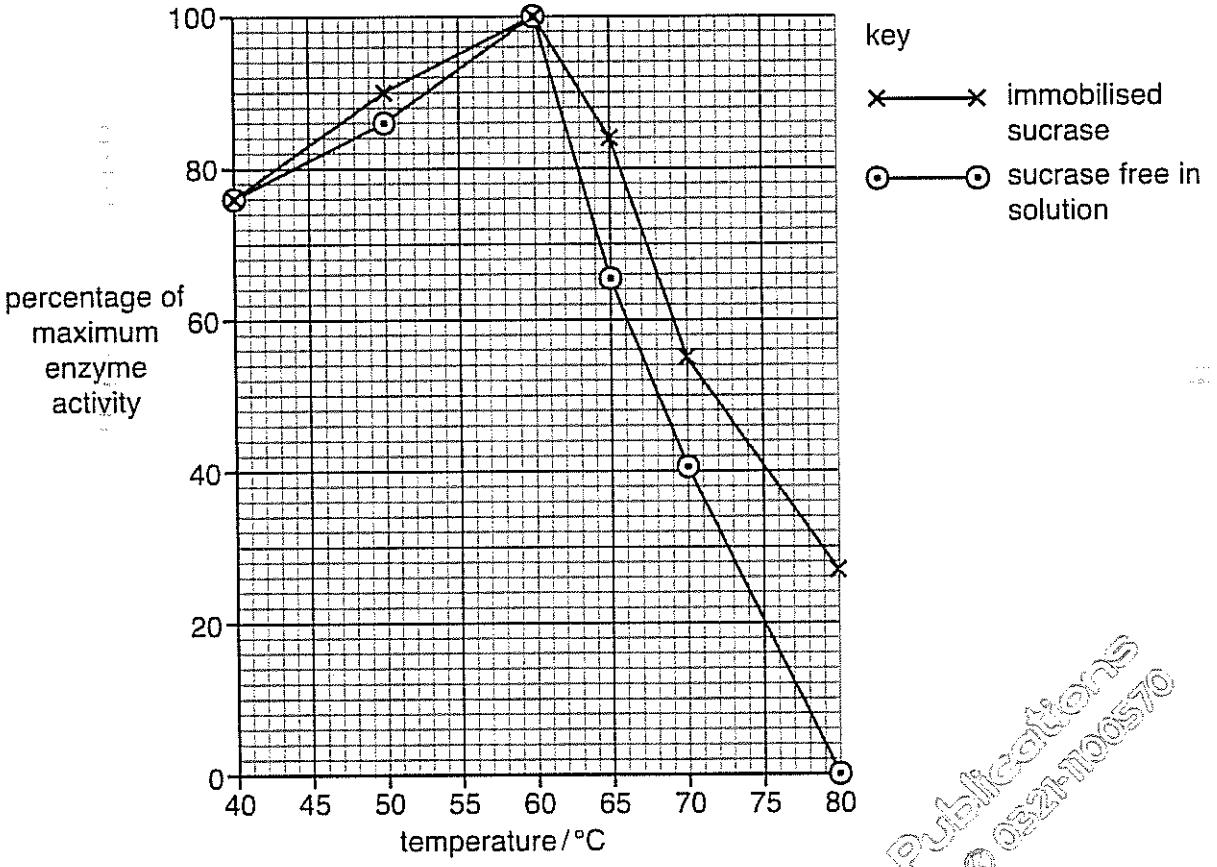


Fig. 3.1

(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.

.....

.....

.....

..... [4]

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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.

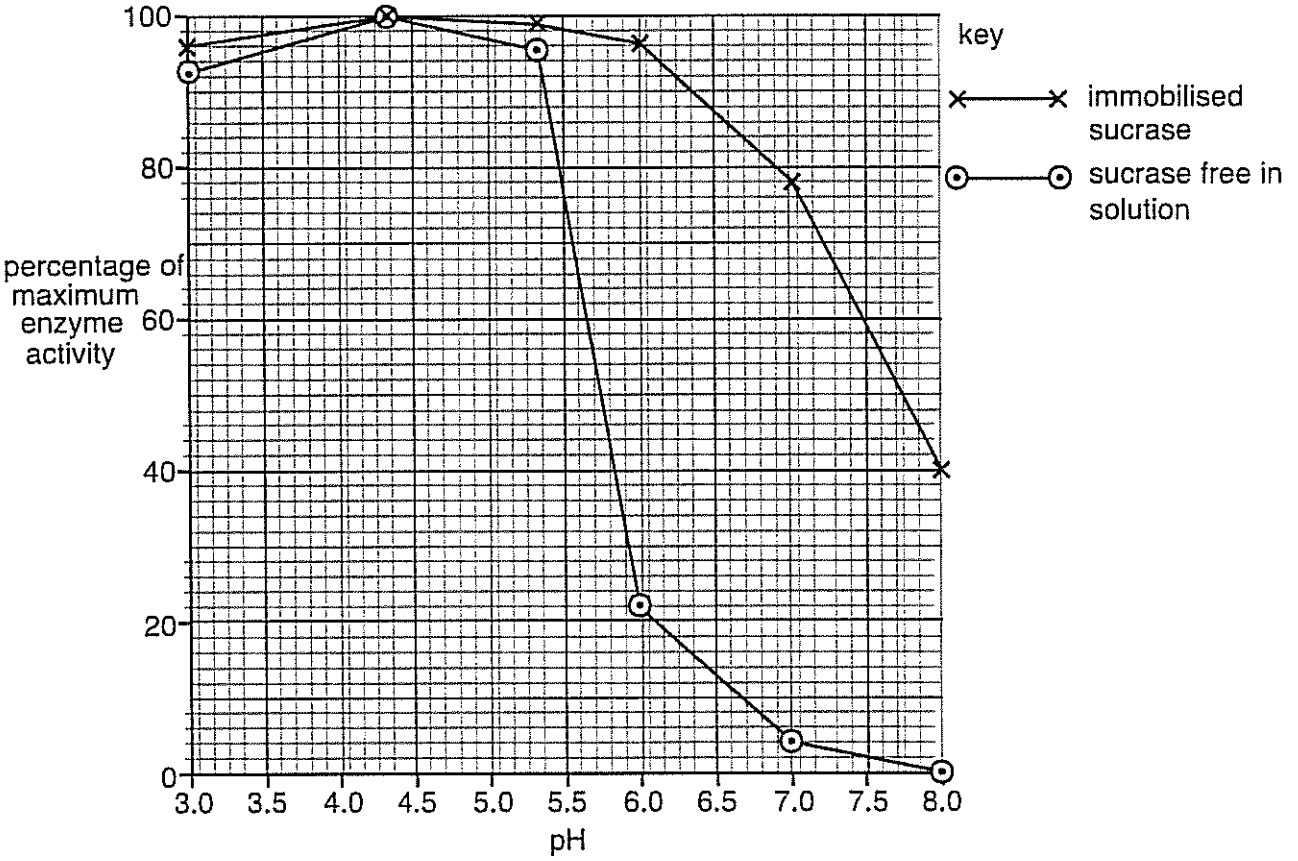


Fig. 3.2

(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.

.....

..... [2]

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

variable .....

explanation ..... [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.

.....

..... [2]

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15. M/J 18/P23/Q5

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.

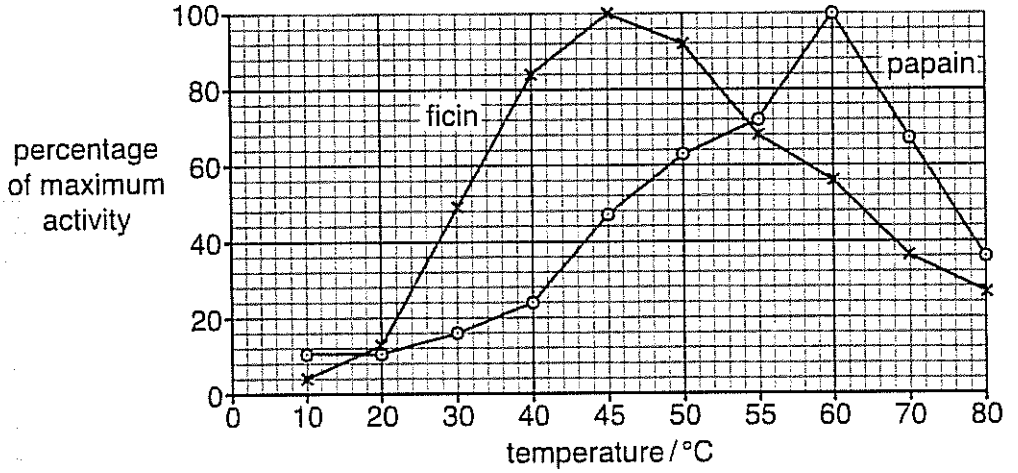


Fig. 5.1

(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.

.....

.....

..... [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.

..... [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.

..... [1]

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(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]

16. O/N 17/P22/Q3/a,b,c,d
Hydrolytic enzymes can function within the cell or can be secreted by the cell, where they are able to catalyse reactions.

(a) State the term used to describe an enzyme that functions within the cell.

.....[1]

(b) The rates of reaction of two different hydrolytic enzymes, enzyme **G** and enzyme **H**, were measured at different substrate concentrations. The results are shown in Fig. 3.1.
The two enzymes have different values of the Michaelis–Menten constant (K_m).

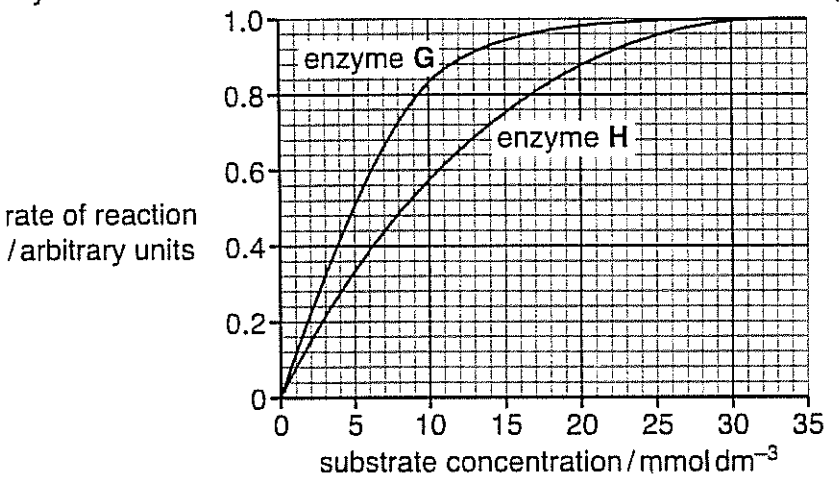


Fig. 3.1

(i) The K_m value of enzyme **G** is 5 mmol dm^{-3}.
Use Fig. 3.1 to derive the K_m value for enzyme **H**.
Show your working.

.....

..... [2]

(ii) With reference to Fig. 3.1, explain how the values of K_m for these enzymes provide information about the relationship between the enzyme and their substrates.

.....

..... [2]

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Cells can break down an old or damaged organelle, such as a mitochondrion, by enclosing the organelle in a membrane formed from the endoplasmic reticulum. This forms a vacuole. Vesicles containing hydrolytic enzymes fuse with the vacuole and the organelle is then digested.

(c) Name the vesicles in the cell that contain hydrolytic enzymes.

.....[1]

(d) The cell has internal chemical messengers that signal when an old or damaged mitochondrion should be broken down.

Suggest **one** feature involving mitochondrial structure or function that could lead to the release of these internal signals.

.....[1]

17. O/N 17/P21/Q4/d,e,f

An investigation was carried out to find out how the activity of starch phosphorylase varied with temperature, when free in solution and when immobilised in alginate.

The results are shown in Fig. 4.2.

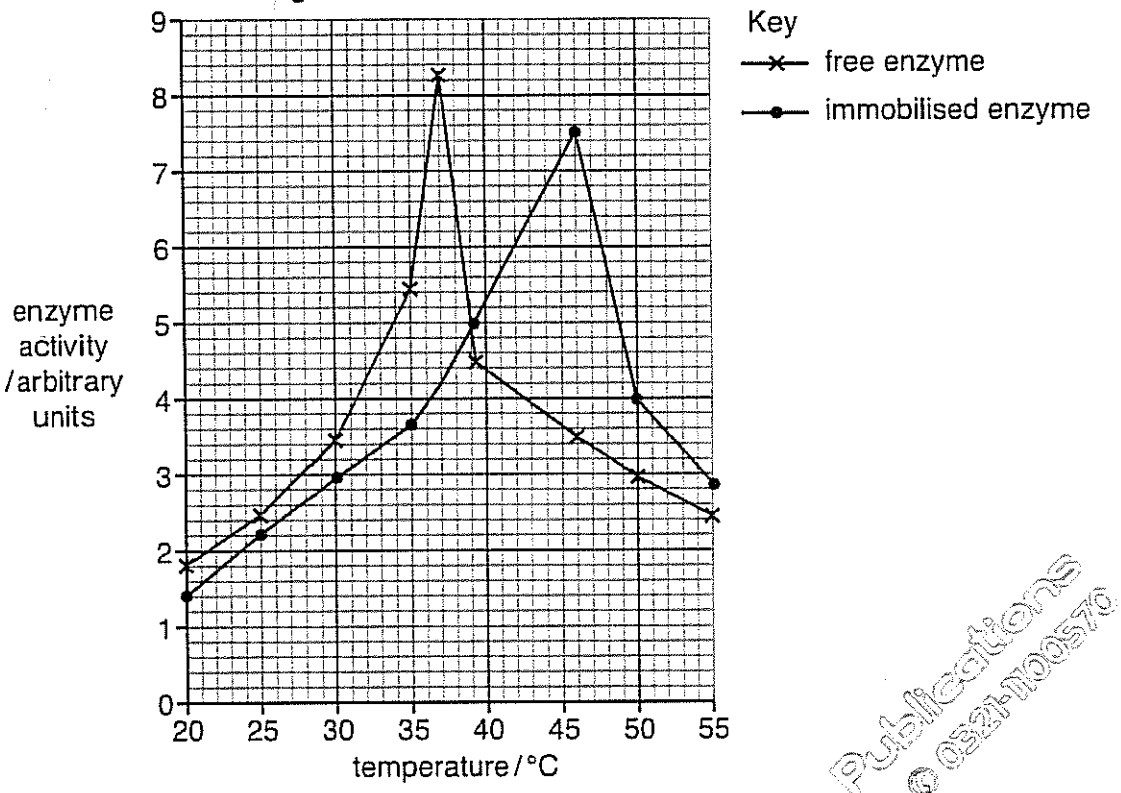


Fig. 4.2

(a) With reference to Fig. 4.2, compare the results for the enzyme activity when free in solution and when immobilised.

.....

.....

.....

..... [4]

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(b) State how the Michaelis–Menten constant (K_m) is derived from V_{max} for an enzyme.

..... [1]

(c) The K_m values for starch phosphorylase were determined when free in solution and when immobilised.
The K_m values were:

- free in solution, $K_m = 0.34\,mmol\,dm^{-3}$
- immobilised, $K_m = 0.84\,mmol\,dm^{-3}$.

Suggest an explanation for the difference between the two values.

.....

..... [2]

18. M/J 17/P22/Q2

Lipase is an enzyme with many commercial uses. Some species of bacteria are of great interest as they produce large quantities of lipase.

(a) Complete Fig. 2.1 to show the hydrolysis of triglyceride by lipase.

triglyceride + ... $\xrightarrow{\text{lipase}}$ .....

Fig. 2.1

[2]

Researchers carried out investigations into lipase extracted from a bacterium found in hot springs.

(b) To measure the activity of the bacterial lipase during their investigations, the researchers used a method based on the biological test for triglycerides.
Outline a biological test that could be carried out to show the presence of triglyceride in a liquid mixture **and** describe the positive result for this test.

.....

.....

..... [3]

(c) The researchers investigated the effect of pH values between pH2.0 and pH10.5 on the activity of bacterial lipase in hydrolysing triglyceride at a temperature of 37 °C.
The results are shown in Fig. 2.2.

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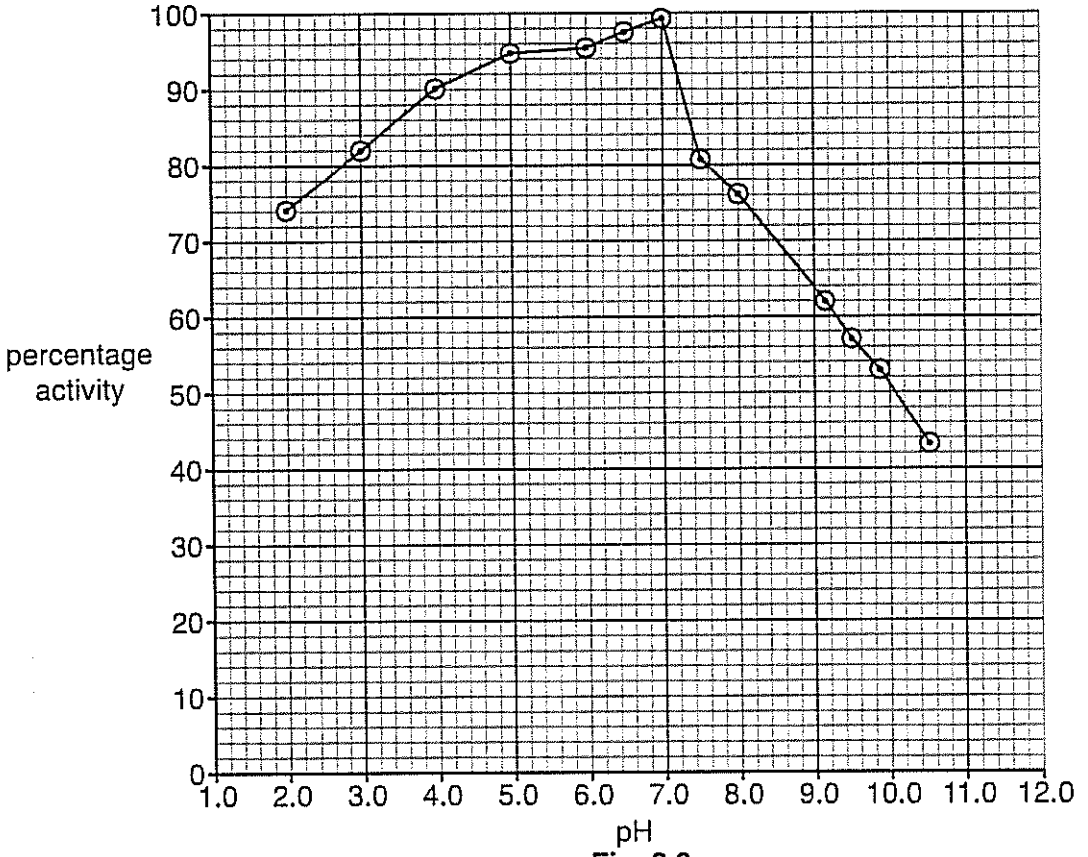


Fig. 2.2

With reference to Fig. 2.2, describe the effect of pH on the activity of bacterial lipase.

.....

.....

.....

..... [4]

(d) A separate investigation into the effect of pH on the same bacterial lipase compared the enzyme free in solution with the enzyme immobilised by physical attachment to a stable polymer.

At a temperature of 37 °C, the optimum pH of the enzyme free in solution was the same as that shown in Fig. 2.2. The optimum pH of the immobilised enzyme was measured as pH 4.

(i) Suggest **one** reason to explain why the enzyme free in solution has a different optimum pH compared to the immobilised enzyme.

..... [1]

(ii) Suggest **one** advantage of immobilising the extracted lipase for commercial use.

..... [1]

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19. M/J 17/P21/Q2

Phosphatases are enzymes that catalyse the removal of phosphate groups from organic compounds.

Some students investigated the effect of substrate concentration on the rate of the reaction catalysed by an acid phosphatase (enzyme **A**). The results are shown in Fig. 2.1.

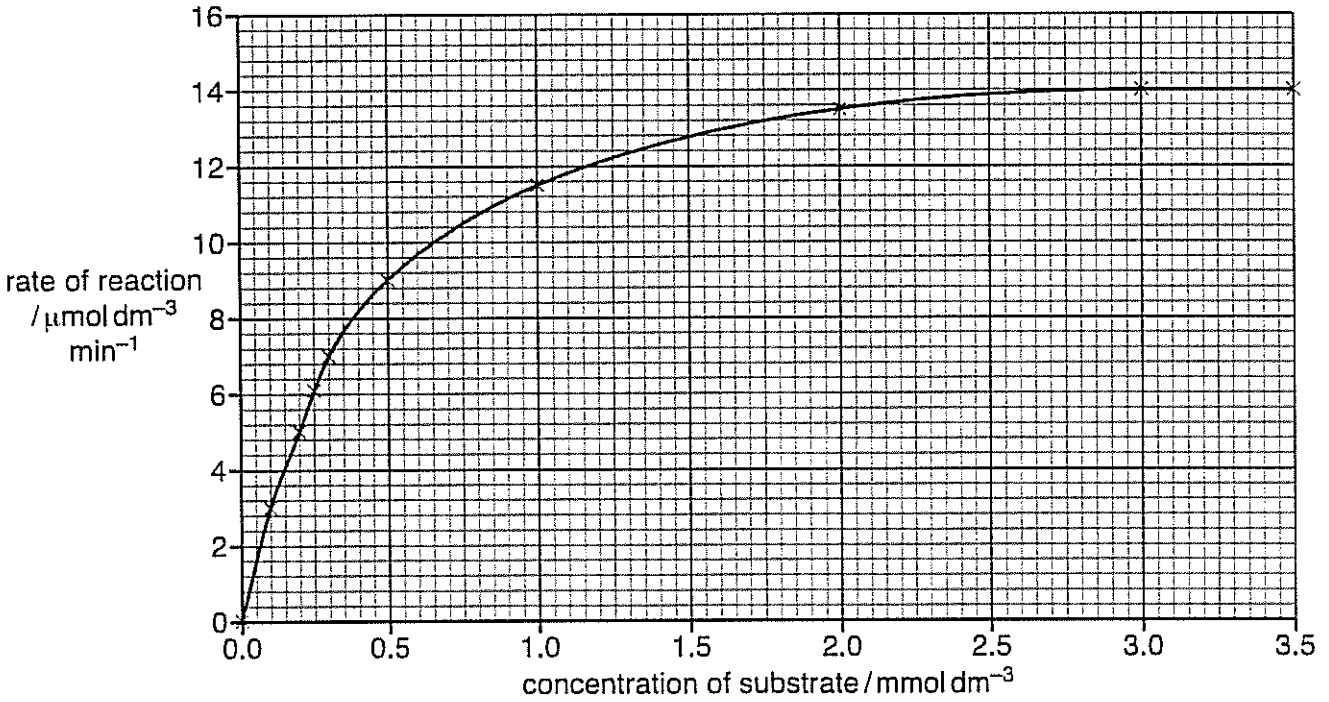


Fig. 2.1

(a) The students used Fig. 2.1 to derive the Michaelis-Menten constant (K_m) for enzyme **A** as 0.3 mmol dm^{-3}.
Explain how they derived K_m.

.....

..... [2]

(b) The students investigated a different phosphatase enzyme (enzyme **B**) and found the value of K_m to be higher than 0.3 mmol dm^{-3}.
Explain the difference between the values of K_m for these two phosphatase enzymes.

.....

..... [2]

(c) The students repeated their investigation on enzyme **A** with a competitive inhibitor.
They used the same concentrations of substrate as before, but added a competitive inhibitor to each reaction mixture.
They used the same concentration of the inhibitor in each reaction mixture.
The students found that V_{max} was the same as before, but K_m was higher than 0.3 mmol dm^{-3}.
Explain how the addition of the competitive inhibitor results in the same value for V_{max} but a higher value for K_m.

.....

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.....

.....

..... [4]

20. O/N 16/P22/Q3/c

High fructose corn syrup, made from maize, can be used as a replacement for sucrose to sweeten food and drink products.

Commercial production of high fructose corn syrup involves the enzyme glucose isomerase, extracted from bacteria.

(a) The commercial production of high fructose corn syrup uses immobilised glucose isomerase.

Fig. 3.1 shows the effect of pH on the activity of immobilised glucose isomerase compared to glucose isomerase free in solution.

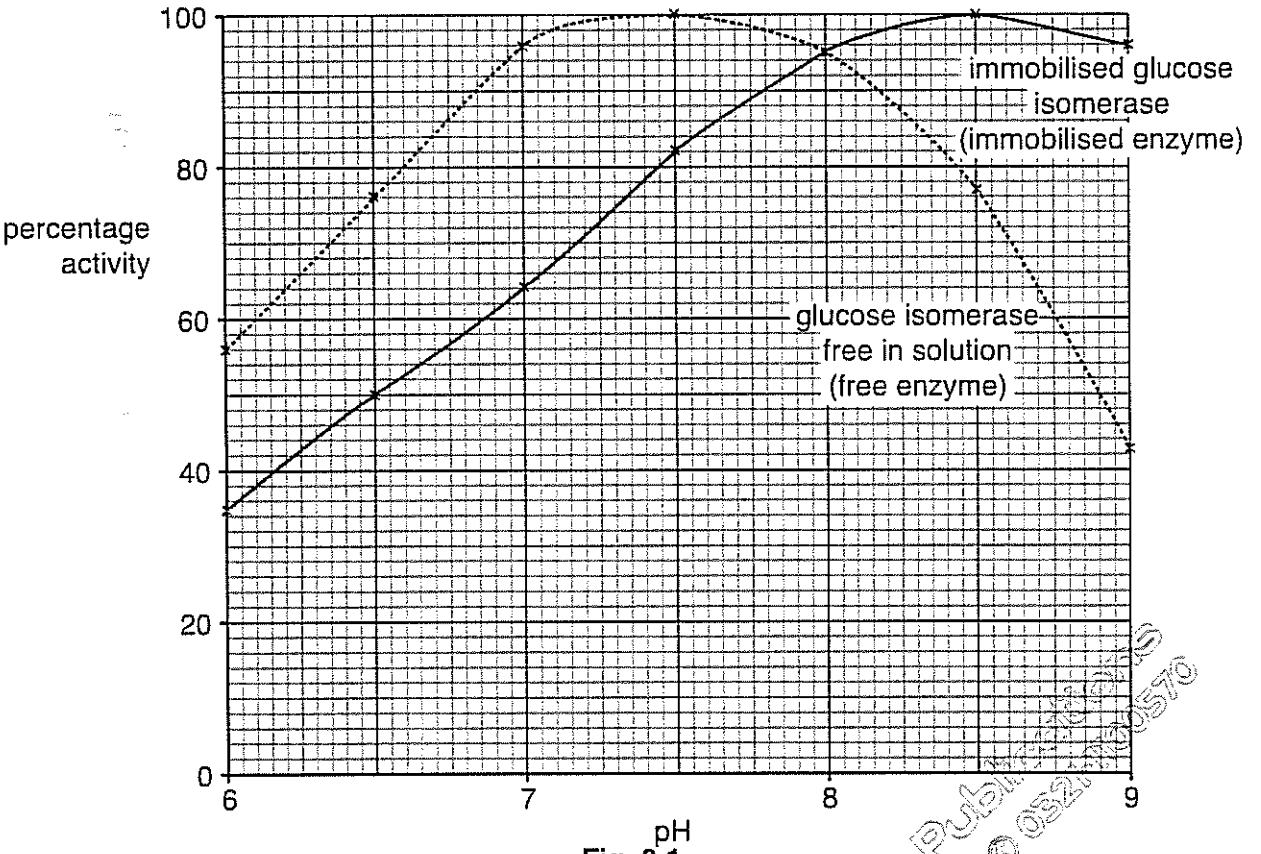


Fig. 3.1

With reference to Fig. 3.1, describe the differences shown between the immobilised enzyme and the free enzyme as pH changes.

.....

.....

..... [3]

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21. O/N 16/P21/Q3/b,c,d,e

(a) Lysozyme hydrolyses the β-1,4 glycosidic bonds present in compounds found in bacterial cell walls.

(i) State what is meant by the term *hydrolysis*.

..... [1]

(ii) Suggest the type of biological molecule which is the substrate for lysozyme.

..... [1]

(iii) Lysozyme uses the induced fit mechanism.
Explain the mode of action of an enzyme that uses the induced fit mechanism.

.....

.....

.....

..... [4]

(b) In human tears and saliva, lysozyme acts as an extracellular enzyme.
State what is meant by the term *extracellular*.

..... [1]

(c) Fig. 3.2 shows the results of an investigation into the effect of substrate concentration on the rate of reaction catalysed by lysozyme.

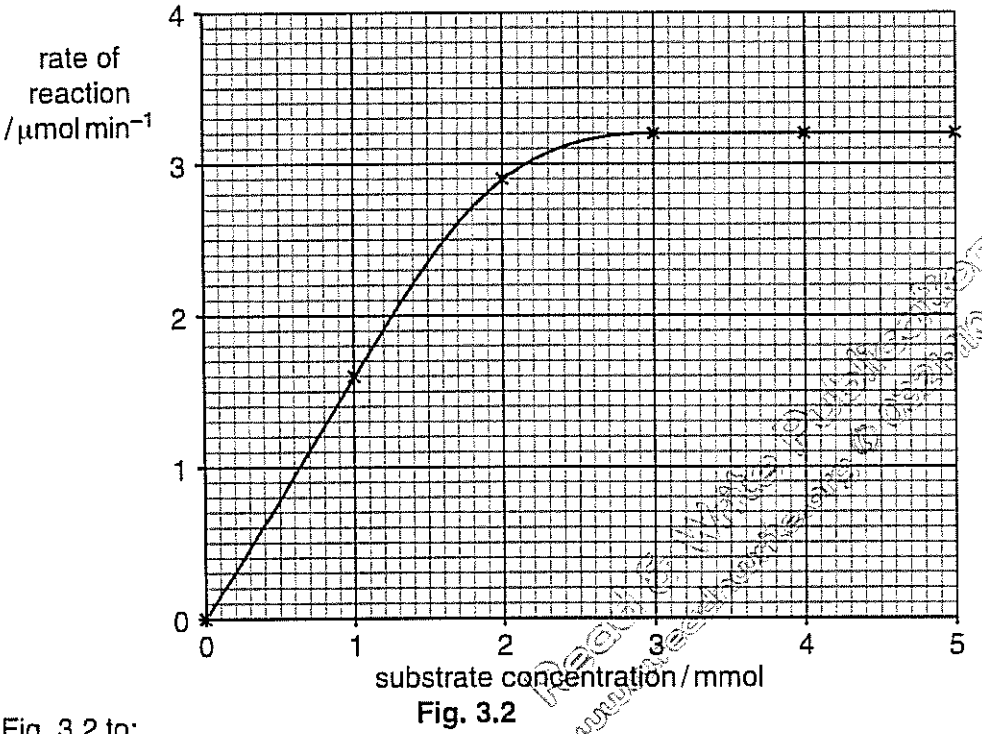


Fig. 3.2

Use Fig. 3.2 to:

(i) state the lowest substrate concentration to give the maximum rate of reaction, V_{max}

..... [1]

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(ii) determine the Michaelis-Menten constant, K_m.

K_m = ...[1]

(d) The investigation was repeated in the presence of a competitive inhibitor of lysozyme. Draw a curve **on Fig. 3.2** to show the expected results. [2]

22. O/N 16/P23/Q2/a

(a) Explain how enzymes lower the activation energy needed to allow reactions to proceed.

.....

..... [2]

23. M/J 16/P22/Q1

Statements **A** to **E** are about the structure and functioning of enzymes.
State the correct term to match each of the statements **A** to **E**.

A The energy level, lowered by enzyme action, that needs to be overcome by reactants in order for products to be formed.

.....

B The mechanism of enzyme action that relies on the active site being partially flexible and changing shape in order to bind the substrate.

.....

C The term to describe a protein, such as an enzyme, with a tertiary or quaternary structure that results in an approximately spherical shape.

.....

D The term for enzymes that function outside cells.

.....

E The concentration of substrate that enables an enzyme to achieve half the maximum rate of reaction.

..... [5]

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24. M/J 16/P23/Q2

Trypsin is a protease enzyme found in the digestive system.

Fig. 2.1 shows how the substrate concentration affects the rate of reaction of trypsin.

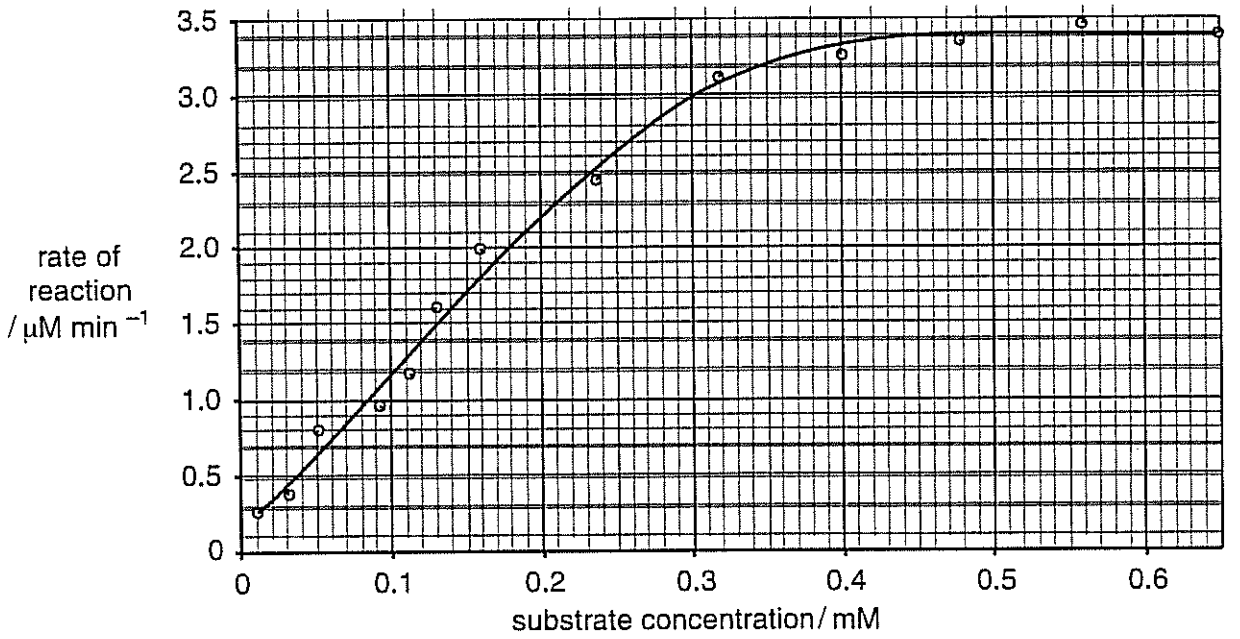


Fig. 2.1

(a) Use Fig. 2.1 to:

(i) determine V_{max} for trypsin

..... [1]

(ii) calculate K_m for trypsin.
Show your working.

..... [2]

(b) Describe **and** explain the shape of the curve in Fig. 2.1.

.....

.....

.....

.....[4]

(c) Trypsin is composed of one polypeptide chain of 223 amino acids.
The active site of trypsin contains three amino acids which catalyse a hydrolysis reaction.
These three amino acids occupy the following positions in the primary structure of trypsin:

- histidine, position 57
- aspartate, position 102
- serine, position 195.

(i) In the functioning enzyme, these three amino acids are close together in the active site.

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Explain how the structure of the protein makes this possible.

.....

.....

..... [3]

(ii) When trypsin acts on a substrate, another substance is required as a reactant.
Name this other substance.

..... [1]

25. O/N 15/P22/Q2/c

(a) The synthesis and release of elastase enzymes by macrophages and neutrophils is an important feature in the development and progression of emphysema. Elastase causes the breakdown of the protein elastin, the main component of elastic fibres.

(i) Explain what is meant by an enzyme.

.....

..... [2]

(ii) Elastase has an active site with a specific shape. The mode of action of this enzyme supports the lock and key hypothesis.

Explain the mode of action of elastase.

You may use the space below to draw a diagram or diagrams to help your answer.

.....

.....

..... [3]

26. O/N 15/P23/Q3/a,d,e

The enzyme catalase is found in many plant and animal tissues.
The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism. The reaction is:

$$2H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2H_2O$$

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *Anopheles gambiae*, an important vector of malaria. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.

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The results are shown in Fig. 3.1.

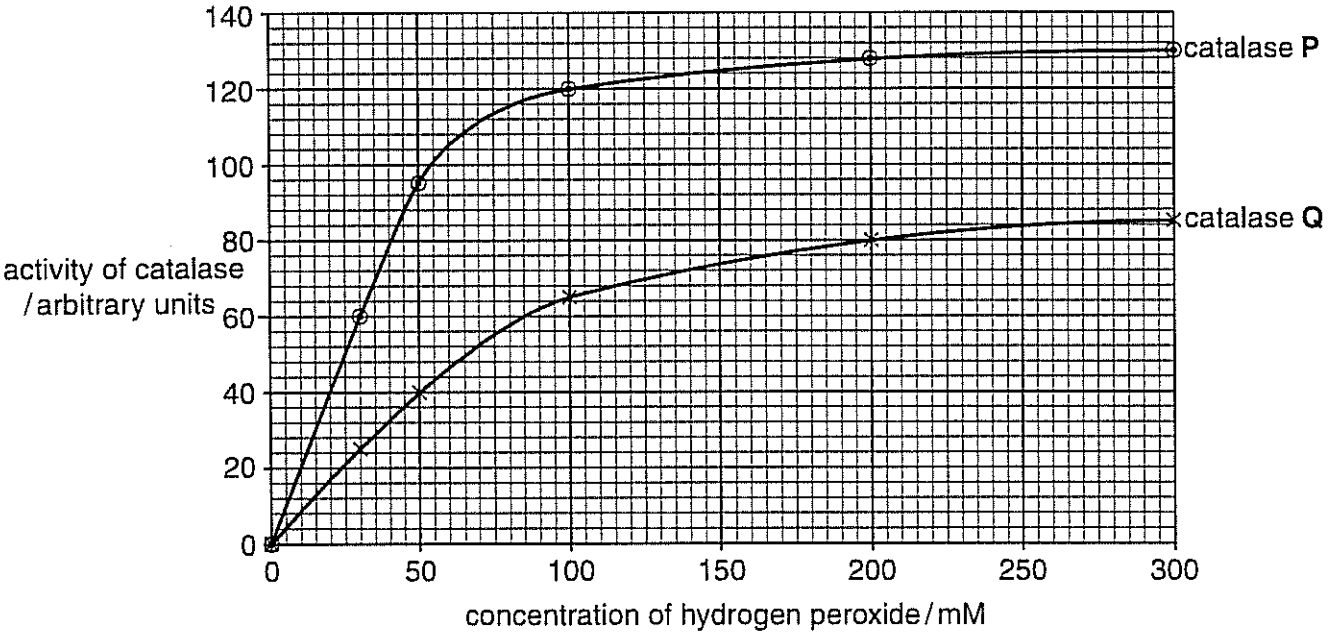


Fig. 3.1

(a) With reference to Fig. 3.1, describe **and** explain the effect of increasing the concentration of hydrogen peroxide on the activity of catalase **P**.

.....

.....

.....

.....

..... [5]

(b) Metal ions can act as a non-competitive inhibitor of catalase.
Explain how copper ions can act as a non-competitive inhibitor.

.....

..... [2]

(c) Enzyme inhibitors can also inhibit carrier proteins in cell surface membranes.
Explain why carrier proteins are required in cell surface membranes.

.....

..... [2]

27. M/J 15/P22/Q4

Many microorganisms can digest cellulose by using a group of enzymes collectively known as cellulases. Cellobiose is the disaccharide produced during cellulose digestion.
The cellulase known as β-glucosidase completes the digestion of cellulose by hydrolysing the cellobiose molecule to produce two β-glucose molecules.

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(a) Draw the ring structure of one β-glucose molecule in the space provided.

[2]

(b) β-glucosidase was extracted from two different bacteria, *Agrobacterium tumefaciens* and *Thermotoga maritima*.

Fig. 4.1 shows the results of an investigation into the effect of temperature between 0 °C and 100 °C, on the activity of each enzyme.

- **L** represents the lowest temperature at which activity of each enzyme was detected.
- **H** represents the highest temperature at which activity of each enzyme was detected.

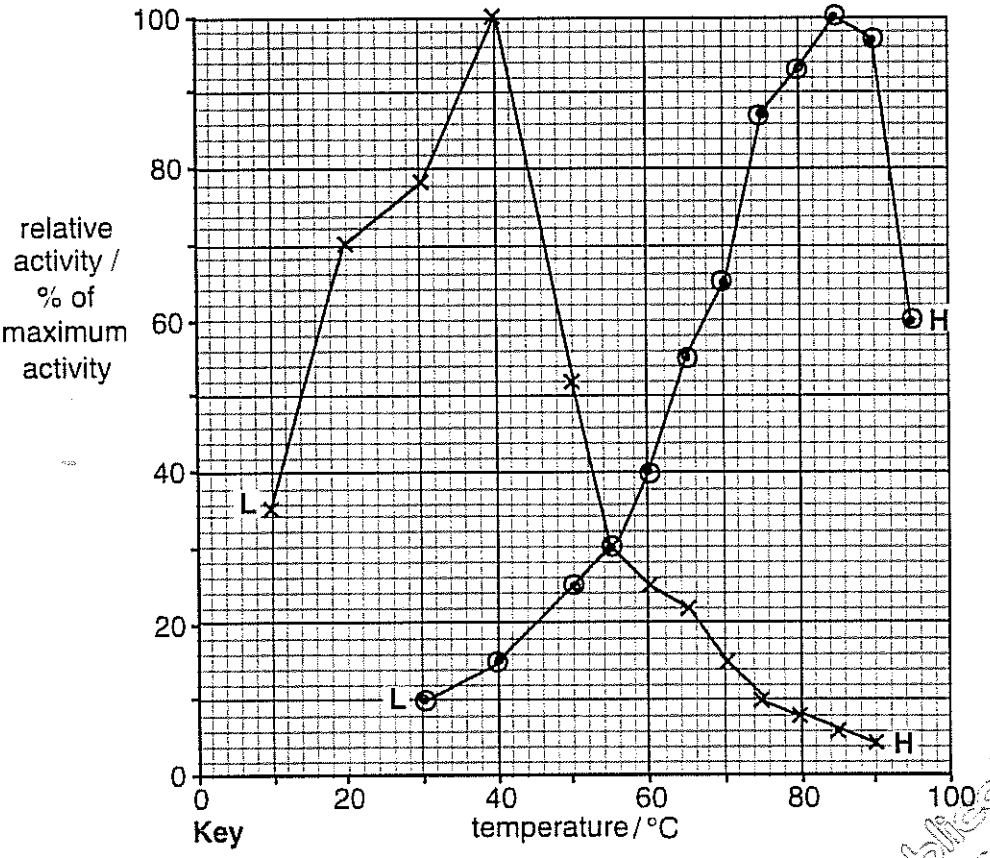


Fig. 4.1

(i) With reference to Fig. 4.1, describe the **differences** in the results for the two enzymes, **A** and **T**.

.....

.....

.....

..... [4]

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(ii) Both enzyme **A** and enzyme **T** act on cellobiose. They have a similar, but not identical, primary structure.

Suggest how similarities **and** differences in the primary structure of the two enzymes could help to explain the results obtained in the investigation.

.....

.....

.....

..... [4]

28. M/J 15/P21/Q4

(a) Fig. 4.1 shows two ways in which enzymes interact with their substrates.

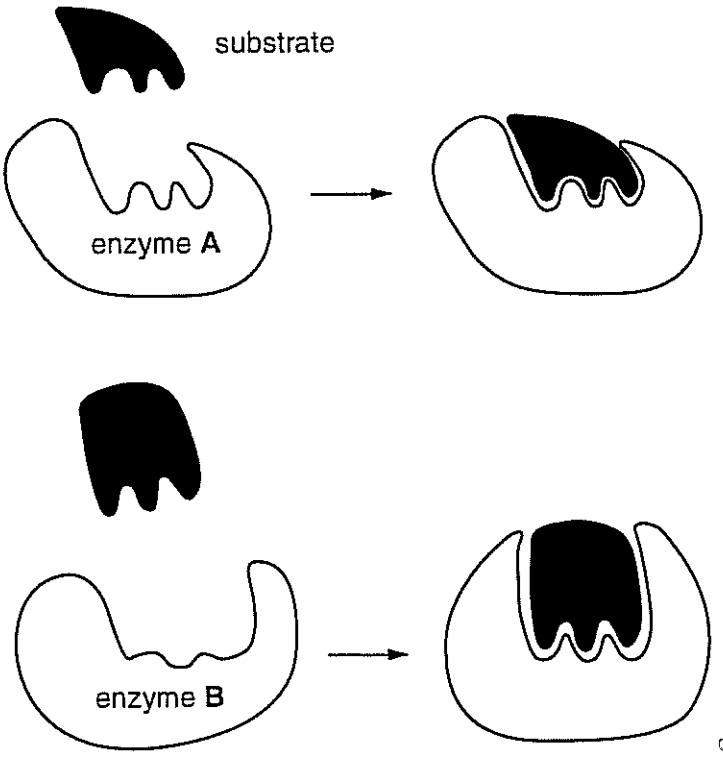


Fig. 4.1

Explain the difference between the two ways in which enzymes interact with their substrates as shown in Fig. 4.1.

.....

.....

..... [3]

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(b) Carbonic anhydrase is an enzyme that is found in blood, liver and kidneys. Fig. 4.2 shows a molecular model of this enzyme.



Fig. 4.2

(i) With reference to Fig. 4.2 and the parts labelled **P** and **Q**, explain the term *secondary structure*.

.....

.....

..... [3]

(ii) Describe the role of carbonic anhydrase in the blood.

.....

.....

.....

..... [4]

29. O/N 14/P23/Q4

Fig. 4.1 is a computer-generated image of the enzyme hexokinase binding with its substrate, glucose. The product of the enzyme-catalysed reaction is glucose-6-phosphate.

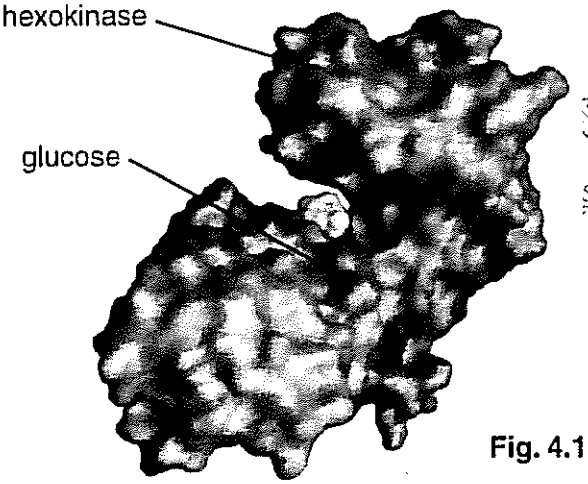


Fig. 4.1

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(a) Hexokinase binds with glucose using the induced fit mechanism.
Describe how an enzyme-substrate complex forms by this mechanism.

.....

.....

..... [3]

(b) Suggest how enzymes which use the induced fit mechanism can be less affected by competitive inhibitors than those which use the lock and key mechanism.

.....

..... [2]

(c) When a solution of the enzyme hexokinase is heated to 45 °C for 10 minutes, the quantity of product formed decreases by 50% compared to a sample kept between 30 °C and 40 °C.
Explain this result.

.....

.....

..... [3]

Glucose can enter cells by active transport or facilitated diffusion.
Glucose-6-phosphate is a charged, polar molecule and cannot move out of cells.

(d) (i) State two **differences** between active transport and facilitated diffusion.

1. .....

2. ..... [2]

(ii) Suggest why glucose-6-phosphate cannot move out of cells.

.....

..... [2]

30. O/N 13/P22/Q2

Keratin and chitin are two important biological molecules. Keratin is found in hair, fur and skin. Chitin is a modified polysaccharide found in a number of different organisms, for example in fungal cell walls and the hard outer skeletons of insects.

(a) Features of chitin and keratin are shown in the boxes in Fig. 2.1.

example:

Keratin and chitin are insoluble in water
cellulose triglyceride amylopectin collagen

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Keratin and chitin have structural functions	Keratin is a fibrous protein
The monomers of chitin are β-1,4 linked	Keratin and chitin contain nitrogen

Fig. 2.1

Write, in each box, the biological molecules from the list below that have the same feature.

Each box may contain one, or more than one, biological molecule. The first box has been completed as an example.

amylopectin
cellulose
collagen
haemoglobin
mRNA
triglyceride

[5]

(b) Chitin and the products of chitin hydrolysis have many useful medical and environmental applications. Chitinase enzymes can be used commercially to hydrolyse chitin. Enzyme stability and activity are important considerations in technological applications of chitinase.

Fig. 2.2 is a graph showing the effects of temperature on chitinase extracted from a soil bacterium.

The relative activity of the enzyme was measured at different temperatures, with 100% representing maximum enzyme activity.

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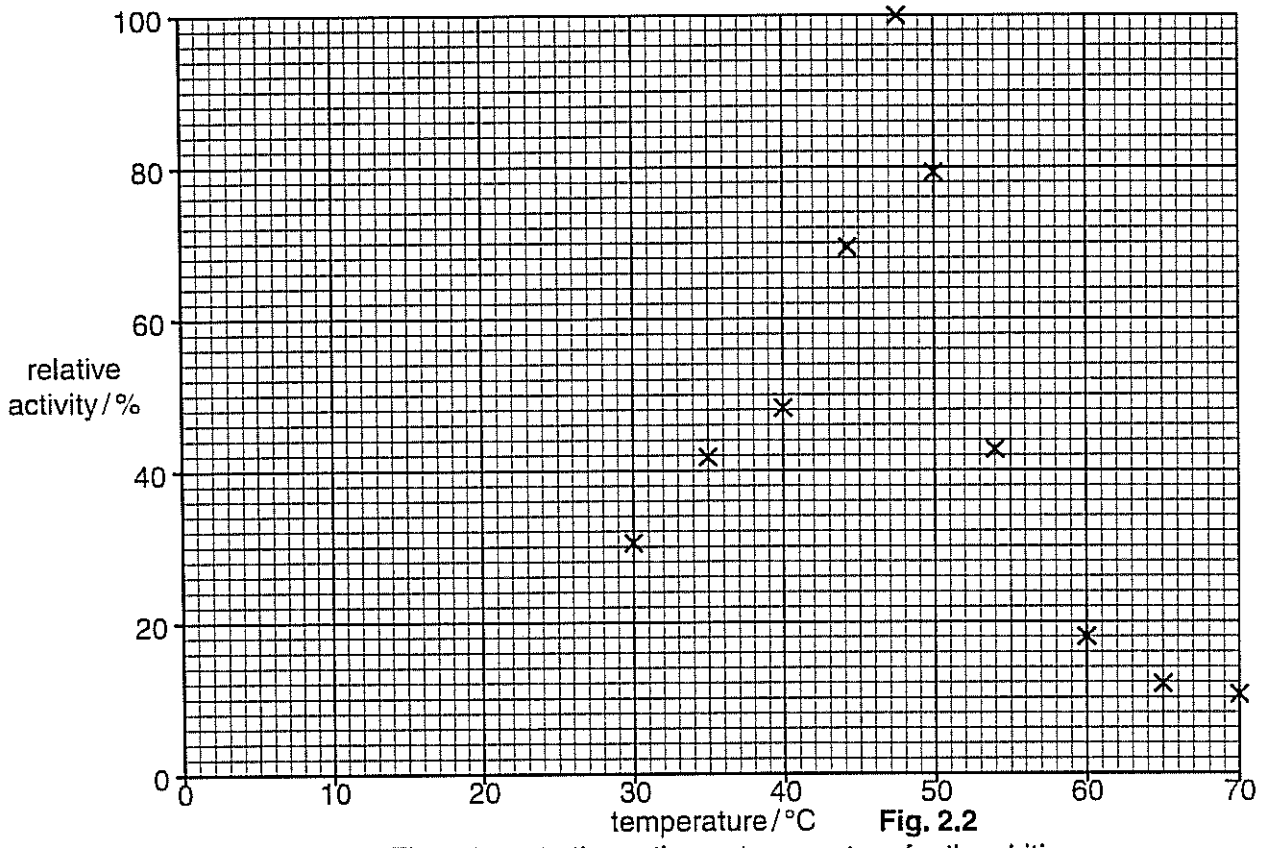


Fig. 2.2

(i) With reference to Fig. 2.2, state the optimum temperature for the chitinase enzyme.

..... [1]

Fig. 2.3 is a graph showing how temperature affects the stability of chitinase. The activity of the enzyme was measured over a time period of 72 hours at each of five different temperatures.

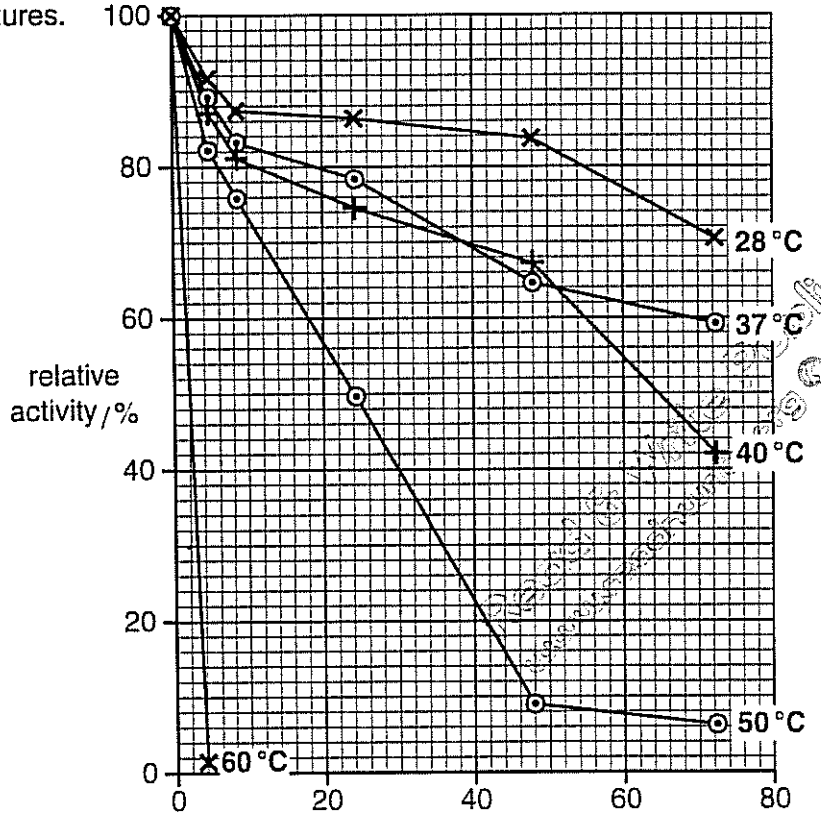


Fig. 2.3

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(ii) With reference to Fig. 2.2 and Fig. 2.3, describe **and** discuss the effect of temperature on chitinase activity **and** stability.

.....

.....

.....

.....

..... [5]

31. M/J 13/P22/Q4/d,e

(a) Freezing temperatures can also completely stop enzyme activity by causing the molecules to undergo 'cold denaturation'. Enzyme activity is not recovered when temperatures are increased to a normal working temperature range.

(i) Explain the mode of action of enzymes.

.....

.....

..... [3]

(ii) Suggest how the molecular structure of the enzyme changes during 'cold denaturation'.

.....

..... [2]

(b) Cryoprotectants, such as trehalose, are of particular interest in their application to preserving cells, tissues or organisms for future use.

An investigation was carried out to find the protective effect given by different concentrations of two cryoprotectants, trehalose and glycerol, on a respiratory enzyme.

The enzyme was subjected to a freezing temperature and then returned to its optimum temperature. The activity of the enzyme was measured at its optimum temperature.

Fig. 4.2 is a graph showing the results of the investigation.

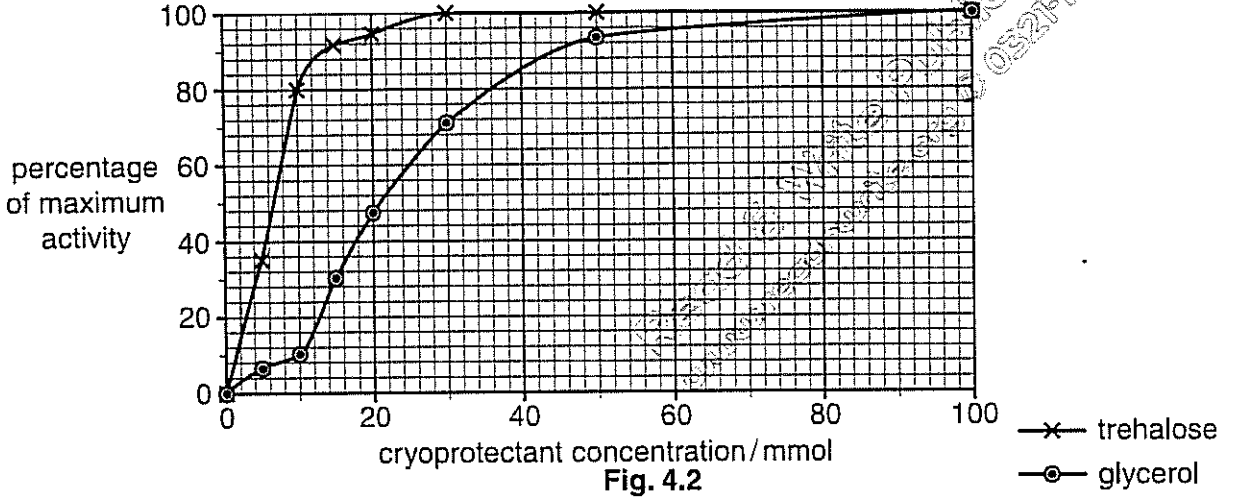


Fig. 4.2

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With reference to Fig. 4.2, **describe** the results of the investigation.

.....

.....

.....

..... [4]

32. M/J 13/P23/Q4

The enzyme, catechol oxidase, causes a brown colour to develop when slices of many fruits, such as apples, are exposed to air.

The enzyme catalyses the following reaction:

$$\text{catechol} + \text{oxygen} \xrightarrow{\text{catechol oxidase}} \text{quinone} + \text{water}$$

Quinone is then immediately further oxidized in air to a brown-coloured substance. Catechol and quinone are colourless.

A student investigated the rate of this reaction under different conditions.

(a) State how the student could follow the progress of this reaction.

..... [1]

In the first investigation, the student measured the initial rate of the reaction in varying concentrations of catechol. The results are shown in Fig. 4.1.

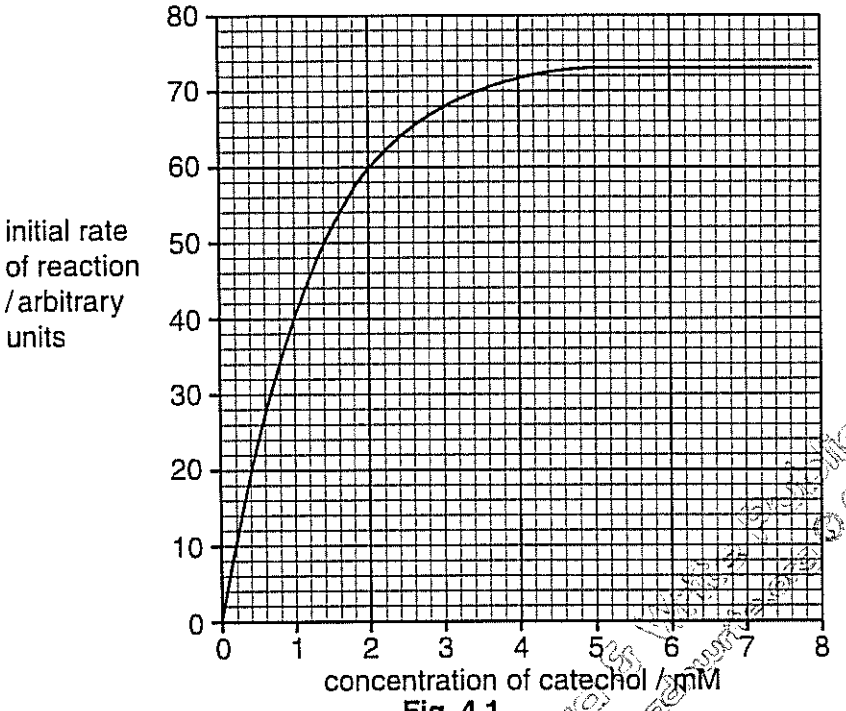


Fig. 4.1

(b) Explain the results shown in Fig. 4.1.

.....

.....

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.....

.....

..... [5]

(c) In a second investigation, the student repeated the experiment, but this time added a competitive inhibitor, para-hydroxybenzoic acid (PHBA), to each reaction mixture.

(i) Sketch **on Fig. 4.1** the results that would be obtained for this second investigation. [2]

(ii) Explain the effect that PHBA will have on the action of phenoloxidase.

.....

..... [2]

(d) Lemon juice contains citric acid. Adding even a small amount of diluted lemon juice to apple slices slows the appearance of the brown colour.
Suggest an explanation for this observation.

.....

..... [2]

33. M/J 12/P21/Q4

Penicillin is an antibiotic that interferes with the synthesis of cell walls in bacteria. Even before penicillin became widely available in the 1940s, the enzyme penicillinase which breaks down penicillin had been isolated. This enzyme is now found in many bacteria and gives them resistance to penicillin.
Fig. 4.1 is a ribbon model of the structure of the enzyme penicillinase. The arrow indicates the active site of the enzyme.



Fig. 4.1

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(a) Explain why the shape of the active site of an enzyme, such as penicillinase, is important.

.....

.....

..... [3]

(b) With reference to Fig. 4.1, identify the aspects of protein structure that are shown and those that are **not** shown.

aspects of protein structure shown

.....

.....

aspects of protein structure not shown

.....

..... [3]

Fig. 4.2 shows the changes in energy during the progress of an uncatalysed reaction.

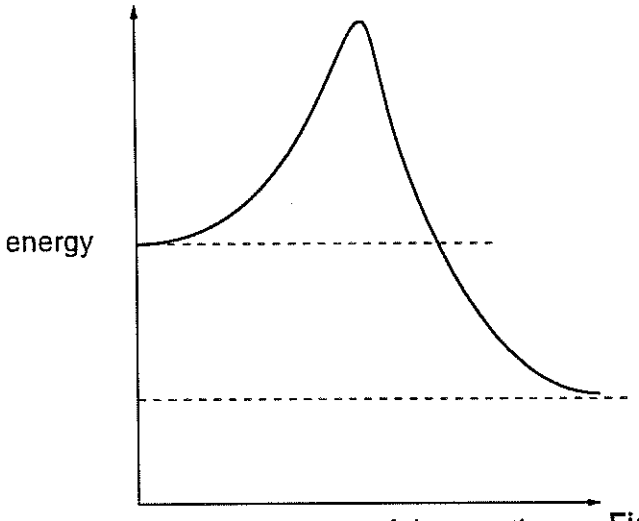


Fig. 4.2

(c) (i) Draw on Fig. 4.2 a curve to show changes in energy during the progress of the same reaction when catalysed by an enzyme. [2]

(ii) State the term given to the energy level that must be overcome before a reaction can progress.

..... [1]

(d) Antibiotic resistance is a serious worldwide problem.
Suggest how antibiotics can be used effectively to avoid the development of widespread resistance in bacteria.

.....

..... [2]

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Answers Section

1. M/J 22/P21/Q3

(a) **1** active site, shape / tertiary structure ;
2 complementary to, substrate(s) / (intracellular) protein / ATP ;

(b) *any **three** from:*
1 at low(er) concentrations / AW, of, substrate / ATP, lower rate of activity with GNF-5 ;
2 as substrate concentration increases, effect of GNF-5 decreases ;
3 maximum rate of reaction / V_{max} / described, is the same ;
4 Michaelis-Menten constant / K_m, is higher with inhibitor ; ora
accept comparative data quotes to support answers
for ATP concentration, must use μmol dm^{-3} at least once

(c) (i) *without inhibitor, activity of T315L*
*any **one** from:*
1 no activity at 0.1 μmol dm^{-3} (ATP) ;
2 maximum rate of reaction / V_{max}, is reached / AW, (for T315L) at a higher concentration (of ATP) ;
3 Michaelis-Menten constant / K_m, is higher (for T315L) ; ora
accept comparative data quotes to support answers
for ATP concentration, must use μmol dm^{-3} at least once

(ii) *with inhibitor, activity of T315L*
*any **two** from:*
1 activity does not reach TKR, maximum rate of reaction / V_{max} ;
2 *idea that* drug / GNF-5, acts as a non-competitive inhibitor of T315L ;
3 drug / GNF-5, has less of an effect at low concentrations on activity (of enzyme / T315L) ; ora
accept comparative data quotes to support answers [8]

2. O/N 21/P23/Q2

(a) *any **two** from:*
anything within range 0.6 to 0.8 ;
μmol dm^{-3} min^{-1} / μmol per dm^3 per min ;
A μmol per dm^3 / min *or* μmol dm^{-3} / min

(b) (i) *ignore any explanation*
*any **two** from:*
1 initial rate will be, lower / slower ;
2 takes longer to reach the, plateau / end concentration / 10 μmol dm^{-3} ;
A longer to complete the reaction / maximum concentration
3 *idea that* the final / end, concentration of product will be the same / 10 μmol dm^{-3} ;
I refs to the shape of the graph

(ii) *ignore any explanation*
*any **two** from:*
1 initial rate will be, higher / faster ;
2 shorter time to reach, / plateau / end concentration / 10 μmol dm^{-3} ;
A shorter time to complete the reaction / maximum concentration
3 *idea that* the final / end, concentration of product will be, the same / 10 μmol dm^{-3} ;
I *ref. to* the shape of the graph

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(c) *any **two** from:*
1 allows a (valid) comparison of the, activities / AW, of the enzymes ;
2 initial rate is the fastest rate ;
3 *idea that* if rate is calculated over a longer period of time than the linear part of the curve the rate will vary ;
4 not limited by substrate concentration / substrate is in excess ;
A 'no limiting factors' if substrate not mentioned
5 not influenced by (increase in concentration of) product ; [8]

3. M/J 21/P22/Q5/c,d

(a) *accept substrate for cellulose and enzyme for cellulase*
allow use of extracted data to support a response to confirm awarding a mark
1 correct description ; *overall trend or more detailed break down*
e.g. as, cellulose / substrate, concentration increases, rate of reaction increases
or
as, cellulose / substrate, concentration increases, steep increase in rate of reaction then, less steep increase / (begins to) plateau
I 'rate of reaction is fast and then slows down'
needs ref. to rate of reaction, describing 'gradient of curve' is not enough

plus any two from
2 increasing cellulose concentration increases number of, collisions between enzyme and subtrate / enzyme-subtrate complexes / ESCs ;
A collisions between active site and substrate
A *idea of* increased chances of cellulose binding to active site
3 at low cellulose concentrations, (many) active sites, available / not all used / not saturated ;
4 at higher cellulose concentrations, active sites becoming saturated / most active sites occupied / most active sites not available / AW ;
A actives sites are, saturated / occupied
5 named limiting factor(s), qualified ;
e.g. at low(er) cellulose concentrations, cellulose concentration limiting / enzyme concentration not limiting
A idea of, not enough cellulose / enzyme in excess
as cellulose concentration increases, change from cellulose concentration limiting to enzyme concentration as limiting factor
at higher cellulose concentrations, enzyme concentration limiting / cellulose concentration not limiting
A idea of, cellulose in excess / not enough enzyme / enzyme working at its fastest rate / active sites not emptying quickly enough for substrate available

(b) (i) *mark to max 2 if microorganisms are considered to be enzyme inhibitors*
lower K_m for pectinase, any two from
ultrasound
increases affinity of enzyme for substrate ;
makes shape of active site more complementary ;
makes (position of) active site more accessible (to substrate) ;
A makes it easier for substrate to enter (active site)
breaks up pectin, aggregates / AW, to expose more substrate for binding ;
higher Vmax for xylanase, any two from
ultrasound
increases rate of, collision between enzyme and substrate / more enzyme-substrate complexes per unit time **I** more ESC form *needs idea of increased rate*

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increases rate of catalysis after binding ;
may change substrate for easier hydrolysis ;
may lower, more than normal, activation energy required for reaction ; **A** described, e.g. increased ability to, break / form bonds

(ii) yes (as all have) increased, catalytic efficiency / productivity / V_{max} /K_m ;
A manipulated data for increased catalytic efficiency
any <u>two</u> from pectin 24.5 / 25%
cellulase 17.25 / 17%
xylanase 16.8 / 17% [7]

4. M/J 21/P21/Q4

(a) *idea* of *shape needs to be in the answer for mp2 and mp4* **I** *'substrate changes shape'*
any three from
1 active site is not (fully) complementary to substrate ;
2 active site, changes shape / moulds around, to fit the substrate ;
A conformational change for shape change
3 <u>enzyme-substrate complex / ESC</u>, forms ;
4 active site returns to original shape on release of product ;
5 AVP ;
e.g. change of shape (to give complementary fit) lowers activation energy / puts strain on bonds / AW ref. to binding site / catalytic site (of active site)

(b) (i) *A peroxidase for enzyme*
any three from
rate of reaction increases as substrate concentration increases to 0.33–0.35 mmol dm^{-3}
1 (up to 0.33 to 0.35 mmol dm^{-3}) some active sites are not occupied ;
2 more collisions between, enzyme / active site, and substrate molecules ;
A more collisions lead to increase in formation of enzyme-substrate complexes
rate of reaction remains constant above 0.33–0.35 mmol dm^{-3}
3 all active sites, occupied / saturated ;
4 correct reference to limiting factor for slope ; **A** limits / limiting
e.g. at low substrate concentrations, substrate concentration limiting / enzyme concentration not limiting
5 correct reference to limiting factor for plateau ; **A** limits / limiting
e.g. at high substrate concentrations, enzyme concentration limiting / substrate concentration not limiting

(ii) *idea that* determined V_{max} / maximum rate / *ref. to* 5.6 (µmol min^{-1}) ;
A if V_{max} shown on graph
K_m is the substrate concentration at half the V_{max} ;

(c) *any three from*
in respiring tissue
1 (carbonic anhydrase) catalyses the reaction between water and carbon dioxide in, red (blood) cells / erythrocytes
2 to form carbonic acid, which dissociates to form HCO_3^- and H^+ ;
A from equation **A** use of word ion(s)
3 HCO_3^-, moves / passes / diffuses (through membrane proteins from red blood cells) into plasma ;
4 (activity of enzyme) maintains (steep) concentration gradient for diffusion of carbon dioxide into red blood cells ;
5 *idea that* so helps to remove large quantities of carbon dioxide ;

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in lungs

6 (carbonic anhydrase) converts HCO_3^- back into carbon dioxide so can be, excreted / removed / exhaled ; if described earlier **A** catalyses reverse reaction so carbon dioxide can be, excreted / AW [11]

5. O/N 20/P22/Q5

(a) fructose ; **I** α or β

(b) *any **two** from:*
formation of enzyme-substrate complex / substrate fits into active site ;
A substrate binds to active site
(so) reactants held close together (e.g. for bond formation) ;
lowers, activation energy / energy of activation ; **A** Ea / Ae
can award annotated on a sketch
detail ; e.g. transfer of electrons
strain on bonds
alternative pathway
holds substrate in a way that the bonds needed to be broken are exposed

(c) **I** *ref. to* denaturation, either mp2 **or** mp10 can be awarded
*any **four** from:*
immobilised
1 higher optimum temperature ; AW e.g. peak / max activity / 100% activity ;
2 74 / 75 / 76°C, v, 56 / 57 / 58 / 59°C ;
A one correct value and calculation e.g. 17°C lower
3 *idea that* greater range of pH with, higher activity / greater stability ; AW
allow use of comparative data at one pH value to support if answer unclear
4 *idea that* if pH changes, less effect on enzyme activity ;
A resists changes in pH
5 *ref. to* more active at, higher temperatures / temperatures above 68°C ;
A more thermostable / less effect on enzyme at higher temperatures
A free enzyme not active above 70°C
allow use of comparative data at one temperature to support if answer unclear
6 one advantage of immobilised ; **e.g.** reusable
- less / no, contamination of product (by enzyme)
- easier, downstream processing / separation of enzyme from product
- longer shelf-life useful if enzyme, difficult to obtain **A** *ref. to* cost effective
- can use in continuous processes so more productive
- suggestion that (can carry out process at) lower pH (more acid conditions and) may be more effective against microorganisms

free enzyme
7 higher activity, at lower temperatures / between 35°C to 68°C ;
in context of a range, quoting one temperature not enough
8 two temperatures, comparative values for both enzymes to support mp7 ;
9 optimum temperature lower so cheaper maintaining that temperature ; AW
A lower temperatures cost efficient to maintain and enzyme works well / AW
10 (values of optimum) 74 / 75 / 76°C, v, 56 / 57 / 58 / 59°C ;
A calculation, e.g. 17°C lower
11 lower optimum temperature still high enough to kill microorganisms ; [7]

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6. O/N 20/P21/Q2/b

(a) (i) macromolecule and extracellular enzyme ;

(ii) 4 (hours) ;

(iii) *any **four** from:*

1 triglyceride hydrolysis / action of lipase, produces fatty acids ;
2 decrease in pH / described, because of production of (fatty) acids ;
3 steepest rate of (pH) decrease at start because, substrate / triglyceride, concentration highest ;
4 rate of pH decrease / AW, slows because decrease in rate of formation of fatty acids ;
5 rate of pH decrease /AW, slows because enzymes, not at optimum / begin to denature ;
6 rate of pH decrease slows because,
substrate / triglyceride, being used up
or
substrate concentration becomes a limiting factor / AW ;
7 *ref. to* plateau at 18 hours / at pH 6.1, enzymes are denatured ;
8 *ref. to* plateau at 18 hours / at pH 6.1, as all the, triglyceride / substrate, has been, hydrolysed / AW ;
9 optimum pH for lipase activity, is pH 8 / alkaline conditions / at the start ;
10 AVP ; e.g. *ref. to* tertiary structure of lipase

(iv) *any **two** from:*
(initial) decrease in pH would be more rapid ;
plateau would be reached earlier ; AW
plateau would be at the same pH (as the previous experiment) ; [8]

7. O/N 20/P23/Q5/c,d

(a) *induced fit*

1 active site changes shape ;
A active site moulds round substrate
A 'active site changes to fit the substrate (more closely)'
2 (so) active site becomes (fully) complementary shape to collagen ;

any four from

3 formation of, enzyme-substrate complex / ESC ;
4 lowering of activation energy ;
5 breakage of peptide bond ;
6 active site returns to, pre-ESC / original, shape **and** can be reused ;
7 AVP ;
e.g. *ref. to*, binding site / catalytic site (of active site)
e.g. suggestion of how activation energy lowered, e.g. strain put on bond / alternative pathway

(b) *description*

1 general description of effect of pH on activity ;
e.g. as pH increases the activity increases and then decreases
e.g. as pH increases activity reaches a peak
e.g. use of data with unit for relative activity to describe increase and decrease (see next page)
2 2 optimum pH is 7 ;

explanation
*any **three** from:*

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3 partial denaturation in, acid **and** alkaline conditions / AW ;
A 'starts to denature' as alternative to partial denaturation
small changes either side of optimum

4 (ionisable) R-groups in, active / catalytic, site affected ;
large changes either side of optimum

5 hydrogen bonds / ionic bonds, break / disrupted ;

6 active site (shape) / (enzyme) tertiary structure, changes, so substrate / collagen, no longer fits into active site / fewer ESC complexes formed;
A fits less well *in context of partial denaturation*

7 AVP ; e.g. detail of R groups [9]

8. M/J 20/P22/Q5/b(iii)

(a) (i) max three if describing breakdown of sucrose
allow points from diagrams
any four from
induced fit shape of, substrates / UDP and glucose, not (fully) complementary to shape of active site (of sucrose synthase);lock and key shape of, substrates / UDP and glucose, complementary to shape of active site (of sucrose synthase);allow ecf if no ref. to shape
induced fit active site flexible / moulds around, substrates / UDP and glucose ; AW
lock and key active site does not change shape / is not flexible / AW ;
induced fit (active site moulds around so) idea of provides better fit / fully complementary;
lock and key substrate fits into active site ; [4]

9. M/J 20/P21/Q3

(a) (i) *one mark for units*
one mark per column

	V_{max} $\mu mol\ min^{-1}$	K_m $mmol\ dm^{-3}$;
J	60	0.2
K	50 ;	0.2 ;

(ii) *K compared with J*
max 3 from mp4–mp8
any four from:
1. rate of reaction is lower at all substrate concentrations ;
2. *ref. to* greater difference as substrate concentration increases ;
3. rate of reactions for **J** and **K** compared at two substrate concentrations to support mp1 or mp2 or
manipulated data at two substrate concentrations to support mp2 ;
4. less efficient / acts more slowly / AW ;
5. active site is still binding substrate ;
6. *idea that* active site is less effective at catalysing reaction
7. *or*
enzyme has lower affinity for substrate ;
8. (replaced / changed) amino acid is important in, shape / structure, of active site ;
9. AVP ; e.g. how the mutation may have changed interaction between substrate and, active / catalytic, site e.g.ref.to hydrogen bonding/transfer of electrons

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(b) each polypeptide shows primary, secondary and tertiary structure ;
A description of levels of structure
both (forms of G6PD / enzyme) composed of more than one polypeptide (so have quaternary structure) ; [9]

10. M/J 20/P23/Q4/e,f

(a) (i) *any two from*
(higher K_m enzyme)
has a lower affinity for its substrate ; **A** binds substrate less easily
needs a higher concentration of substrate to reach, V_{max} / maximum activity / ½ V_{max} ;
less likely to be saturated with substrate ;
variations in substrate have greater effect on rate of reaction ;

(ii) *any two from*
in the vacuole ; A in lysosome
qualified ;
e.g. has, acidic / low pH, environment
contains, acid hydrolases / enzymes that require low pH
non-regulatory trehalase needs acidic conditions for optimum activity
cytosol has neutral pH so likely to be location of regulatory trehalase (and enzymes are in different locations) if in cytosol then this would mean low pH and other enzymes, would (partially) denature / work below optimum as acid conditions required, will be in area protected from rest of cell and vacuole has the tonoplast as barrier
A lysosomes are membrane bound

(iii) yes because they both work, within the cell / inside the cell ;

(b) *any three from*
likely to be regulatory trehalase / unlikely to be non-regulatory trehalase
nearer to optimum of regulatory trehalase (of S. cerevisiae) ; ora
pH 6.5 / 6.6 nearer to pH 7.0 (than to pH 5.0 of non-regulatory trehalase) ;
no / (very) low, activity at pH 4.5
or
greater activity at pH 7 than pH 4.5(–5.0) ;
alternative
suggestion that enzyme could be a different form of trehalase ;
because has different optimum pH to both regulatory and non-regulatory ;
pH 6.5 / 6.6, rather than pH 7.0 or pH 5.0 ;
general
(so) likely to act in the cytosol with, neutral pH / pH7 ;
unlikely to be found in vacuole / lysosome, with low / acid, pH ; [8]

11. M/J 19/P22/Q6

(a) (i) *any two from:*
correct ref. to time ;
correct ref. to volume of oxygen ; **A** gas for oxygen
A volume of water displaced by oxygen
A measuring height of water level (decreasing)
A cm^3 instead of volume
AVP ; subtract volume of gas displaced by H_2O_2 addition

(ii) *any two from:*
greater surface area (over which catalase released) ;
greater number of cells, damaged / cut open, to release catalase ;
higher concentration of, catalase / enzyme ; **A** more, catalase / enzyme
A more active sites available

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must be linked to idea of more enzyme (i.e. must get mp 2 or 3)
so, higher rate of reaction / more enzyme-substrate complexes / more oxygen released ; AW

(b) increase to optimum and steeper decrease ;
A if curve does not touch one or both axes [5]

12. M/J 19/P21/Q3

(a) (i) *any two from:*
(Neutrase® breaks down / hydrolyses) protein to, peptides / amino acids / smaller molecules ; A idea of increase insolubility
during the reaction / AW, more light passes through / more light is transmitted / less light is absorbed ;
idea that 100 s is long enough to see the progress of the reactions ;
I 'the rate of reaction can be calculated'
I 'allow time for reaction to complete'

(ii) *accept* ***ora*** *where appropriate*
1 copper sulfate, decreases / AW, the activity of Neutrase (*ref. to* **A** or **B**) ;
2 0.01 (mol dm^{-3}) / low concentration, $CuSO_4$ has less of an effect than, 0.05 (mol dm^{-3}) / high concentration (ref. to and **B**) ;
3 potassium sulfate has, little / no, effect on activity (*ref. to* **C**) ;
4 data quote to show absorbance for two different lines at the same time ;
one time and two absorbance readings from different lines on the graph with the unit for time used once anywhere in answer, allow 'at the end' for 100 s
5 copper sulfate is an inhibitor of Neutrase ;
6 potassium sulfate is not an inhibitor ; **A** 'less of...'
7 copper sulfate binds to Neutrase ; **A** anywhere
8 substrate cannot enter active site / ESCs do not form (so protein not hydrolysed) ; **A** fewer ESCs

(b) *higher productivity / higher yield and fewer costs because*
enzyme can be re-used ;
enzyme can be easily recovered ;
downstream processing is easier ;
product, not / less, contaminated ; **A** less purification needed
longer shelf-life of enzyme ;
reduces product inhibition ;
enzyme is, more stable / less likely to denature *or* described ;
A thermostable / can work at high temperatures
A in context of change in pH
'can withstand changes in temperature' [9]

13. O/N 18/P21/Q2

(a) glycosidic ; **I** any qualification of glycosidic, e.g. β,1–4

(b) (i) hydrolysis ;

(ii) *any two from*
(lactose) lowers the water potential (in the lumen of the intestine) / AW ;
reduces the water potential gradient (between the intestine and the blood) ;
osmosis occurs ; (must be in the correct context)

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(c) (i) *any two from*
pack more beads into the column ;
slows the passage of milk through the column ;
more time for enzyme to be exposed to substrate ;
(small beads have a) larger surface area to volume ratio ;
rate of reaction will be faster / AW ;
A faster reactions
will take less time to collect results (at each temperature) ;
fast(er), rate of diffusion of, substrate / product ;

(ii) *any three from*
both have same activity between 0 and 20 °C ;
A described with values from **Fig. 2.2**
between 20 °C and 40 °C, the activity of **F** increases more steeply than **I** ;
F, has a lower optimum temperature / peaks at a lower temperature / AW, than **I** ;
A optimum temperature, **F** is 40 °C v **I** is 50 °C
at 70 °C, no activity for **F** but there is activity for **I** ;
A 4% for **I** and 0% for **F**
A denatured for 0%
above the optimum temperature **I** has a steeper decrease of activity ;
I is active over a greater range of temperature (than F); [9]

14. M/J 18/P21/Q3

(a) *four from:*
activity increases and decreases / activity peaks, for both ;
A both have maximum activity / optimum temperature, at 60 °C
activity is 76% at 40 °C for both ;
(overall) activity decreases more steeply for free enzyme after, optimum / maximum / 60 °C ;
A ora
at 80 °C free enzyme is inactive / (fully) denatured / 0%, but immobilised enzyme, is still active / is partially denatured/27%; for immobilised enzyme, activity is higher (than free enzyme) at all temperatures above 60°C ;

(b) *two from:*
(alginate / immobilisation), is protective / has stabilising effect ;
A enzyme, less / not, exposed (to solution)
hydroxide ions do not penetrate the alginate beads ;
shape of active site (of immobilised enzyme) is, less / not, disrupted / AW ;
A active site is (more) complementary to substrate
A few(er) active sites are, altered / changed
few(er) bond(s) within (immobilised) enzyme break ;
A hydrogen / ionic
R peptide / disulfide
at pH 8 immobilised enzyme is not fully denatured ;
A pH 7 / 7.5

(c) explanation must match variable stated
standardised variable
concentration / volume, of, enzyme / substrate, solution ;
explanation for standardised variable
idea that:
concentration / volume, of, enzyme / substrate, influences the probability of collisions between enzyme and substarte molecules / formation of enzyme/substrate complexes ;
A number of / frequency of, collisions between substrate and enzyme

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or
standardised variable
use the same method for determining enzyme activity ;
e.g. time when samples are taken
explanation for standardised variable 3
ref. to how enzyme activity is measured by conversion of substrate to product ;

(d) *two from:*
1 (may be able to) obtain more product (per unit time) ;
2 can use higher temperatures (to obtain more product) / still active at higher temperatures ; **A** thermostable
3 does not denature (as easily as free) if temperatures increase / AW ;
4 immobilised enzyme can be reused / immobilised enzyme can be recovered ;
5 enzyme does not contaminate product ;
A no effect on quality of product, e.g. taste
6 less, purification (of product) / downstream processing, needed ;
A idea that downstream processing less, complex / difficult
7 longer shelf-life of enzyme / AW ; **A** durability
8 AVP ; e.g. allows continuous production (rather than batch)
some enzymes are difficult to extract

I ref. to cost / cost effective unqualified
R reduces effect of end product inhibition [10]

15. M/J 18/P23/Q5

(a) (i) *three from:*
1 papain higher optimum temperature than ficin / ora
or
temperature is higher for papain for percentage of maximum activity of 100
A 100% activity / maximum activity / peak of activity
or
(100% of maximum activity) papain 60 °C v ficin 45 °C ;
2 papain (overall) less steep increase / AW, (to peak) / ora ;
3 papain steeper decline / AW (after peak) / ora ;
for mp 2 and 3 allow ecf for a ref. to time, e.g. rapidly / slowly
4 papain lower activity at all temperatures between 20 °C and, 54 °C / 55 °C ;
5 papain higher activity at all temperatures above, 54 °C / 55 °C ;
6 ref. to ficin more active over a greater range of temperatures ;
A ref. to activity at temperatures around 100% maximum
7 comparative, extracted / manipulated, data to support mp, 2–6 ;

(ii) ficin, as higher activity at 37 °C / body temperature ;

(b) *one from:*
(may be able to) obtain more product (per unit time) ;
A can use in a continuous system
(may be) more, thermostable / tolerant to pH changes / AW ;
A idea that enzyme less likely to denature
product, not / less, contaminated with enzyme ;
A less downstream processing
longer shelf-life / AW ;
enzyme, easier to recover / can be reused ;
AVP ; e.g. ficin may be, costly / difficult, to extract

(c) (i) extracellular (enzyme) ;

(ii) *any one valid example:*
e.g.
collagen / elastin ; [7]

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16. O/N 17/P22/Q3/a,b,c,d

(a) intracellular (enzyme) ; **R** interacellular

(b) (i) 8.5 mmol dm ^{3} ;; **A** 8–8.7 *max 1 if no units*
allow one mark if only half V_{max} stated half V_{max} = 0.5 (au)

(ii) *two from*
(K_m is the) affinity, of enzyme for its substrate ;
G / low K_m enzyme, has a, high(er) affinity for its substrate (than **H**) ; **ora**
A binds more easily *note that if the term 'affinity' is used, then this is also mp1*
G / low K_m enzyme, needs a lower concentration of substrate to reach, V_{max} / maximum activity / ½ V_{max} (than, **H** / enzyme with high K_m) ; **ora**
G / low K_m enzyme more likely to be saturated with substrate ;
(so) variations in substrate have less effect on rate of reaction (for **G**) ;

(c) lysosomes ; *treat as neutral Golgi vesicles* **R** lysozyme **R** if any other organelle named

(d) *any one relevant e.g.*
leakage (of substances) through/damage to, (mitochondrial) membranes **A** *ref. to* fewer cristae
or
impaired uptake of substances through transport proteins / AW
or
no / impaired, ATP production / aerobic respiration / oxidative phosphorylation
or
no / low, protein / enzyme, synthesis (from mitochondrial ribosomes)
or
change to, number / distribution / presence, of membrane proteins
or
no mitochondrial replication occurring ; [7]

17. O/N 17/P21/Q4/d,e,f

(a) *four from*
1 both, increase and decrease / peak ;
2 both active, over range of temperature tested / between 20 to 55°C ;
3 free enzyme lower, optimum temperature / temperature for maximum activity ; **ora**
4 (free) 37°C v (immobilised optimum) 46°C;
5 free enzyme higher, maximum activity / activity at optimum temperature ; **ora**
6 (free) 8.2 / 8.3, a.u. v 7.5 a.u. ;
7 between 20°C and 39°C the activity of free is higher ; **ora**
8 between 39°C and 55°C the activity of free is lower ; **ora**
if mp 7 and 8 not gained, allow 1 mark for free activity higher at lower temperatures and lower at higher temperatures (than *immobilised) ora*
9 comparative data to support mp 7 or 8 ; **A** comparison at one temperature (stated or use of numerical data)
10 AVP ; e.g. both have same activity at 39°C, similar activity between 20°C and 30°C

(b) substrate concentration that gives half V_{max} / AW ;
A description of how to use a graph to derive (must refer to substrate concentration)

(c) *two from* *look for ora throughout*
free / low(er) K_m, has higher affinity for substrate ;
free needs a lower concentration of substrate to reach V_{max} / maximum activity / ½ V_{max} ;
takes lower substrate concentration to saturate active sites in free ;
free active site more, likely to be saturated with substrate / accessible ;
active site (may be) distorted by immobilising ;
ref. to substrate passing through matrix when immobilised ;
ref. to some product retained within matrix ; [7]

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18. M/J 17/P22/Q2

(a) addition of water shown ; **A** H_2O
fatty acid(s) and glycerol ;

(b) *positive result*
emulsion ; **I** on top / throughout
A milky (layer) / cloudy (suspension) / opaque / white droplets
R precipitate
ref. to mixing with / dissolving in / adding / adding to, alcohol / ethanol ;
R *if incorrect substance added to alcohol, e.g. fatty acids, then allow ecf*
then, add / add to, water ;
max 1 for method if heated or added additional chemicals
max 1 if wrong sequence or all contents into one test tube at once
no marks if both of above (wrong sequence and heated)
accept other valid methods

(c) **1** increase (pH2) to pH7, decrease from pH7 (to pH10.5) ;
A trend described as increase then decrease **or**
optimum / peak / maximum activity / 99% / 100% (relative) activity, at pH7 ;

2 steep(er) decrease from, pH7 / optimum, (to pH10.5) ;
in context of steepness of increase from pH2–7

3 detail either side of optimum (pH2–7 **or** pH7–10.5) ;
pH2–7
less steep (increase) pH5–pH7 / little difference between pH5 and 6
/ steepest increase between pH2–4
or
pH 7–10.5
steeper decrease between pH 7 and 7.5 / less steep decrease between pH 7.5 and 10.5

4 activity, pH2–7 / below 7, higher than activity, after pH8 ;
A in, alkaline / basic, pH / conditions
A enzyme works better in acidic and neutral conditions ora
A enzyme works better in acidic than, alkaline / basic, conditions ora

5 enzyme active throughout the pH range ;

6 data / manipulated data, (to support above mps) ;
needs comparison values, pH and, percentage activity / %

7 *ref. to* partial denaturation at higher pH ; **A** starts to denature

(d) **(i)** *suggestion of changed conditions for immobilised compared to free e.g.*
(immobilised) support material / AW, affects enzyme action ;
support material is charged ;
idea that free has greater exposure to hydrogen ions **or**
immobilised has protection from hydrogen ions ;
idea that immobilised has changed ability to catalyse ;
immobilised has (slightly) altered active site ; **R** *ref. to* denaturation
I changes to tertiary structure
support material causes change to, external / substrate, solution ;

(ii) can be re-used ;
can be easily recovered ;
easier downstream processing ;
product, not / less, contaminated ;
longer shelf life of enzyme ;
more stable ;
can use higher temperatures (owing to protective matrix) ;
more productive ;
less time-consuming ;
cost alone is not enough

[11]

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19. M/J 17/P21/Q2

(a) half V_{max} / AW, = 7 (µmol dm^{-3} min^{-1}) / take half of V_{max} of 14 (µmol dm^{-3} min^{-1}) ;
A description of using the graph to find ½ V_{max} without reference to figures
read (substrate concentration) from *x*-axis / AW ;
alternative
plot 1 / [S] = x

(b) ***allow*** *phosphate group(s) / organic compound for substrate*
if affinity not used, accept idea of ability to form ESC
check for **ora**
I *ref. to* competitive inhibition

1 enzyme **B** has a lower affinity for its substrate (than enzyme **A**)
or
the higher the K_m the lower the affinity of the enzyme for its substrate ;
R if substrate has affinity for the enzyme

2 enzyme **B** needs a higher concentration of substrate to reach, V_{max} / ½V_{max} / K_m (than enzyme **A**) ;

3 AVP ; e.g.
enzyme **B** forms fewer ESC in the same unit of time
enzyme **B** active site is a less good fit for substrate
idea that in normal cell enzyme **A** is saturated (with substrate) so works at a constant rate
variations in substrate concentration will have less effect on the rate of formation of product by enzyme **A**
I *ref. to* turnover number(s)

(c) *marks can be taken from a sketch graph*

1 competitive inhibitor, occupies / competes with substrate for / AW, active site (of the enzyme) ;

2 reduces frequency of collisions (with substrate) / fewer ESCs form ;
R no ESCs form

3 reduces reaction rate at low substrate concentrations ;

4 *idea that* curve with inhibitor is to the right of the curve without inhibitor ;

5 at high substrate concentration/with increasing substrate concentration,the inhibitor has,no / less, effect ;
A *idea that* substrate outcompetes inhibitor at high substrate concentration

6 therefore V_{max} is the same as it is determined by the enzyme concentration / AW ;
A explanation in terms of active sites, saturated / fully occupied

7 *idea of* intercept to curve gives a higher value for K_m ; [8]

20. O/N 16/P22/Q3/c

(a) *accept 'glucose isomerase' for 'enzyme'*
accept '100 percent activity' for 'maximum activity'
accept (initial) rate of reaction for activity
penalise once if 'pH' and/or percentage activity (or %) not stated
three from

1 maximum / peak of, activity, at lower pH for free enzyme ora
or
free enzyme lower optimum pH ora
or
free enzyme pH 7.4 / 7.5 / 7.6 v immobilised pH 8.5 ;

2 free enzyme has higher / AW activity, at pH, 6 / 6.5 / 7 / 7.5 ; **A** up to pH 8
ora for immobilised (lower up to pH 8) *
or
free enzyme has higher activity over greater range of pH** (between pH 6–9) ;

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3 data to support mp 2 ; *any one pH and comparative activity
** needs two pHs and comparative activities
A manipulated data

4 free enzyme has lower activity, pH 8 to pH 9 ; **A** after pH 8.0
ora for immobilised (higher after pH 8)

5 data to support mp 4 ; *any one pH and comparative activity / manipulated data*
increase to max activity

6 free enzyme has (slightly) steeper increase in activity as pH increases to pH 7 ; ora

7 data to support mp 6 ;

allow ecf to 2 max if free and immobilised the wrong way round but all statements are correct [3]

21. O/N 16/P21/Q3/b,c,d,e

(a) (i) breaking a (covalent) bond with addition of water ;

(ii) peptidoglycan / murein ; **A** carbohydrate / polysaccharide / amino sugar

(iii) *four from*
substrate shape not (exactly) complementary to active site shape / AW ;
active site (partially) flexible / changes shape slightly, when substrate, enters / binds ;
(so) active site and substrate, now complementary / better fit ;
(allows) formation of enzyme-substrate complex ; **A** ES complex / ESC
AVP ; e.g. role of R-groups in active site interacting with substrate
lowers, activation energy / E_A, so products form

(b) outside cells ; *can be in a general context or in context of enzymes*

(c) (i) 2.9 mmol ; **A** 2.75–3.0 mmol

(ii) 1 mmol ;

(d) single graph line with lower gradient ;
reaches or approaches plateau ; [11]

22. O/N 16/P23/Q2/a

(a) *two from*

1 provide an alternative pathway ;
2 brings reactants close together (in active site / to form ESC) ;
3 put a strain on the reactant(s) ;
4 so bonds, break / form, more easily ;
5 transfer of, charges / groups ;
6 AVP ; e.g. involvement of R groups [2]

23. M/J 16/P22/Q1

(a) A activation energy / energy of activation ;

B induced fit ; **A** induced fit, model / hypothesis / theory / mechanism

C globular ;

D extracellular ;

E Michaelis-Menten constant ; **A** K_m [5]

24. M/J 16/P23/Q2

(a) (i) 3.4 μM min^{-1} ; **A** 3.4 μM / min

(ii) 0.15 mM ;; **A** ecf from **(a) (i)**
allow 1 mark if no units given

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if answer incorrect allow one mark for evidence of ½ V_{max}
3.4 / 2 = 1.7

(b) *max 3 if no attempt at description (D) with explanation (E)*
at lower substrate concentrations
1 *(D)* rate of reaction proportional to substrate concentration ; AW
2 *(D)* up to 0.25 mM ; **A** range 0.25–0.30 mM
3 *(E)* not all active sites occupied ;
A few, enzyme-substrate complexes / ES complexes / ESC
A more active site occupied as substrate concentration increases
4 *(E)* substrate concentration is limiting ;
at higher substrate concentrations
5 *(D)* less steep increase in rate (from 0.25 mM) ;
6 *(D)* further increase in substrate concentration gives, no further increase / plateau / levelling out, in rate ; **A** rate remains at 3.4 μM min^{-1}
7 *(D)* greater than / at, 0.45 mM ; **A** 0.46 / 0.47, mM
8 *(E)* enzyme concentration is limiting ; **A** idea that some other factor is limiting
9 *(E)* all active sites occupied / AW ;
10 *(E)* **A** *for mp3 / mp6* description in terms of enzyme-substrate collisions in context ;

(c) (i) folding / coiling, (of polypeptide chain) ;
tertiary structure ;
(held in position by) *ref. to* R group interactions ;
A two or more bond types in context
brings distant, amino acids / parts of the chain, close ; AW
(ii) water ; **A** H_2O [11]

25. O/N 15/P22/Q2/c

(a) (i) biological catalyst / described ;
e.g. biological molecule / protein that, increases the rate of / catalyses
speeds up, a reaction
molecule that, increases the rate of / speeds up / catalyses, metabolic / biological / cell(ular) reaction
one of:
globular protein ;
remains unchanged (at end of reaction) / not used up (in reaction) ;
lowers the activation energy (of a reaction) ;

(ii) *points can be gained from diagrams if not contradicted in written answer*
1 (shape of) substrate / elastin, complementary to (shape of) active site ;
R matching / same
A description e.g. substrate fits (into) active site
diagram – label active site + substrate (shapes must be complementary)
2 lock is, enzyme / elastase / active site, and key is, substrate / elastin ;
3 formation of, enzyme-substrate complex / ES complex / ESC ;
A successful collision between enzyme and substrate
A substrate, binds / AW, at / to, the active site
diagram – ESC no label required if following on from mp1
4 peptide fragments / peptides / products, released / formed ; **A** amino acids
diagram – allow without label if sequence clear and products shown
following points need to be annotated if shown on diagram
5 hydrogen / temporary, bonds form between, enzyme / active site, and substrate ;

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6 detail of how Ea lowered ; *term Ea not required and points can be general*
strain on (peptide) bond
electron transfers
reactants held close for bond forming (i.e. water joining) [5]

26. O/N 15/P23/Q3/a,d,e

(a) *description*

1 activity / rate, increases to a, maximum / plateau ;
A 'levels off' / remains constant / reaches V_{max}

2 increase in, activity / rate, slows ;

3 data quote with units to support any correct statement ;
e.g. mp 1128–132 au at 250–300 mM
e.g. mp 2 0 to 120 au between 0 and 100 mM, 120–128 au between 100 and 200 mM
A au for arbitrary units

explanation
at low / increasing, concentration of hydrogen peroxide

4 substrate / hydrogen peroxide, (concentration) is limiting (factor) ;

5 active sites, unoccupied (low concentration) / become more occupied (increasing concentration) ;
R active side *(penalise once)*

6 (low concentration) few collisions between enzyme and substrate / few ESC formed
or
(increasing concentration) more collisions between enzyme and substrate / increasing ESC formed ;

at high (activity slows) / higher (plateau) concentration of hydrogen peroxide

7 enzyme / catalase, concentration / AW, becomes / is, limiting (factor) ;

8 maximum number of enzyme-substrate complexes formed ;
A ES complexes / ESCs

9 (all) active sites, saturated / (always) occupied ; **A ora**

(b) bind to, allosteric site / site other than active site ;
causes change in (shape of) active site ;
A changes shape in active site (so) substrate cannot bind (to enzyme / active site) / enzyme-substrate complex cannot form ;

(c) needed for, <u>facilitated</u> diffusion / active transport ;
A description of active transport e.g. moving, molecules / ions, against a concentration gradient
ref. to (some) substances are, water soluble / polar / hydrophilic / ionic / charged ;
I large cannot pass through, phospholipid bilayer / hydrophobic core ; [9]

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27. M/J 15/P22/Q4

(a) either diagram A or B below (or more detailed – e.g. all carbons and all bonds shown in diagram A) ;;
A CH_30 for CH_2OH
I incorrectly numbered carbons

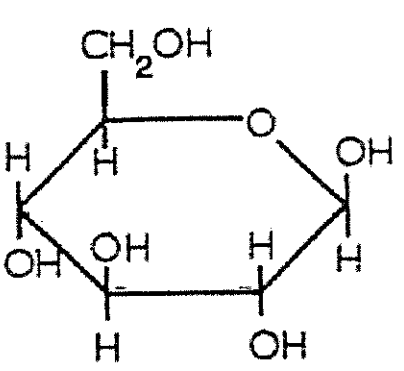


diagram A

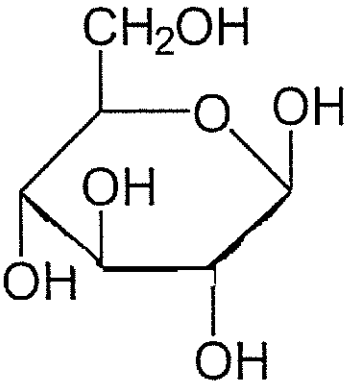


diagram B

if incorrect (e.g. If one or more H missing from the ring in diagram A ***or*** *if an H added to diagram B ring) allow one mark if*:

- hexose ring with oxygen shown in correct position and
- CH_2OH group in correct position and

OH groups of ring in correct position.

(b) (i) accept *T. maritima* or **T** and *A.tumefaciens* or **A** throughout for the β-glucosidases
accept ***T*** *if stated as* ***B*** *(as long as* ***A*** *is clearly mentioned)*
if only ***A*** *or* ***T*** *stated, look for comparative phrase*
compare optimum temperatures

1 optimum temperature, **A** lower (than **T**) / **T** higher (than **A**) ;
A maximum activity **A** is at a lower temperature

2 40 °C(**A**) v 85° C(**T**) / **A** lower by 45 °C ;

3 one difference in shape of curve before or after optimum ;
e.g. after optimum, **T** does not have the less steep decrease after the initial steep decrease (unlike **A**)
before optimum, steepest increase for **A** is at the lower temperatures, (unlike **T**)
compare activity below and above 55 °C

4 below 55 °C, **A** has a higher activity / above 55 °C **A** has a lower activity, (than **T**) ;
ora
A has a higher activity at low(er) temperatures and a lower activity at high(er) temperatures ora

5 comparative data to support mp 4 ;
compare temperature ranges of activity

6 temperature range for activity is greater for **A** ; ora

7 (**A**) spans 80 °C v (**T**) spans 65 °C ; **A** (**A**) 10–90 °C v (**T**) 30–95 °C
compare ***L*** *for both*

8 **A** has a lower, **L** / lowest temperature for (detectable) activity **or** ora
L is 20 °C lower for **A** ; **A** 10 °C (**A**) v 30 °C (**T**) ;

9 (at **L**), A (relative) activity = 35%, **T** = 10% ;
compare ***H*** *for both*

10 **T** has a higher, **H** / highest temperature for detectable activity **or** ora
H is 5 °C higher for **T** ; **A** 95° (**T**) v 90 °C (**A**) ;

11 (at **H**) (relative) activity = 4%, **T** = 60% ;

if mp 10 data given to support mp 1, then CON = no marks for mp 1 or 10

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(ii) 1 primary structure, dictates, folding of the polypeptide chain / tertiary structure ;
A idea that differences in primary structure leads to differences in, secondary / tertiary, structure
A in terms of folding to give the active site
similarity
2 same / (very) similar, (shape of) active site ;
3 active site (shape) is complementary to / AW, substrate / cellobiose ; **R** matches
A ES complex forms
differences
4 differences in, side-chain / R-group, interactions / AW ;
5 qualified ; e.g. differences in, numbers / types, of bonds
differences in bonding to give different stabilities
R different bonds without further qualification
R peptide bond
6 suggestion for thermal stability of **T** ; e.g. more bonds / more of a named bond type
7 suggestion of how active site may work in different ways ;
e.g. at lower temperatures, **T** induced fit mechanism may mean active site does not mould fully round substrate [10]

28. M/J 15/P21/Q4

(a) enzyme **A** uses 'lock and key' **and** enzyme **B** uses induced fit ;
A enzymes work by 'lock and key' and induced fit
enzyme **A** / lock and key, (shape of) active site is complementary / AW, to (shape of) substrate (molecule) ;
enzyme **B** / induced fit, has an active site that, moulds around / AW, the substrate ;

(b) (i) 1 **P** is β-pleated sheet, **Q** is α-helix ;
accept if P and Q are identified by a description
2 determined by, coiling / folding / sequence, of amino acids / polypeptide ;
A primary structure for sequence of amino acids
3 stabilised / held / AW, by hydrogen bonds ;
4 between C = O and H–N (of peptide bonds) ;
A carbonyl / carboxyl group, and, amine / amino group
5 ref to, parallel / anti-parallel, nature of β-pleated sheet ;

(ii) 1 catalyses reaction between carbon dioxide and water to form carbonic acid ;
A correct, formulae / equation
2 very fast reaction ;
3 in (cytoplasm of) red blood cell / erythrocyte ;
4 (so there are) hydrogen ions / protons, and hydrogencarbonate ions ;
5 hydrogen ions promotes oxyhaemoglobin dissociation / AW ;
e.g. reduces affinity of haemoglobin for oxygen / (oxy)haemoglobin gives up oxygen more readily
6 increases supply of oxygen to (respiring) tissues ;
7 carbon dioxide is transported as hydrogencarbonate ions ;
8 in the plasma ; **A** carbon dioxide diffuses from red blood cell to plasma
9 AVP ; e.g.
carbonic anhydrase catalyses reverse reaction in the lungs
ref to hydrogencarbonate ions as buffer in plasma (as a consequence of reaction)
R buffering action of haemoglobin in red blood cells [10]

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29. O/N 14/P23/Q4

(a) **1** glucose / substrate, is not complementary / is partially complementary, to active site ;

2 enzyme / active site, changes shape / moulds around / fits around, when substrate, enters / binds ; **R** if substrate / glucose changes

3 stronger binding of substrate to active site ;

4 further detail ; e.g. becomes complementary to / fits more tightly to, glucose / substrate
interaction of, functional groups / R–groups / side-chains
formation of (named) bond but not disulfide *or* peptide bond

(b) **1** (competitive) inhibitor has, same / similar, shape to substrate ;

2 inhibitor does not induce the same change in, 3D shape / tertiary structure / active site (as the substrate) ;

3 (so inhibitor) less likely to bind (successfully) in active site ;

4 *idea that* because it does not have same functional groups (in same positions) / AW ;

5 in lock and key the inhibitor, fits directly into / is complementary to / binds to, active site ;

(c) enzymes / hexokinase, denatured ;
all enzymes molecules are partially denatured / some enzyme molecules are denatured ;
changes / disrupts / loss of (specific shape / structure) active site ;
A no longer complementary to, glucose / substrate
breakage of, ionic / hydrogen, bonds ; **R** disulfide / peptide bonds
idea that loss of structure makes E–S complex formation more difficult / fewer E–S complexes are formed / substrate does not fit into active site ;

(d) **(i)** *accept* ***ora***
active transport requires, ATP / energy (whereas facilitated diffusion does not) ;
active transport moves substances against the concentration gradient (whereas facilitated diffusion moves substances down the concentration gradient) ;
active transport uses only carrier proteins (whereas facilitated diffusion uses both carrier and channel proteins) ;
A active transport can involve cotransport but facilitated diffusion does not

(ii) too large / too big ; **R** 'it is a big molecule' unqualified
polar / charged, so cannot pass through hydrophobic region of membrane ;
A fatty acid tails for hydrophobic
no, specific / AW, protein, in membrane / carrier / channel ;
e.g. AW = no protein for G–6–P
AVP ; e.g. gated channels are closed [12]

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30. O/N 13/P22/Q2

(a)

Keratin and chitin have structural functions	*Keratin is a fibrous protein*
cellulose ; collagen ; *allow only one incorrect molecule to be listed for max 1*	collagen ; *no marks if other molecules given*

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The monomers of chitin have β-1,4 linkages between them cellulose ; *no marks if other molecules given*	*Keratin and chitin contain nitrogen* collagen / haemoglobin ; *1st mark* mRNA ; *2nd mark* *allow only one incorrect molecule to be listed for max 1*

(b) (i) 47.5 °C ;

(ii) *accept activity for relative activity throughout*
accept manipulated data quotes and penalise once for, incorrect / no, units
Fig. 2.2 (relative activity of enzyme at different temperatures)

1 as temperature increases, activity increases up to, optimum / 47.5 °C (*allow ecf from* **(i)**, then decreases ;
A peaks (*for increase then decrease)*

2 activity increases from 30 °C to 47.5 °C, then decreases to 70 °C ; *also mp 1*
or
increase or decrease, described with comparative data (*activity and temperature compared with another activity and temperature*)

3 at higher temperatures (compared to most others) enzyme still active ;

4 high optimum temperature (compared to most other enzymes) ;

Fig. 2.3 (stability over time for enzyme maintained at different temperatures)

5 enzyme becomes less stable over time ;
A activity decreases over time
A description if at least two temperatures described

6 data quote to support ; *activity at two times for any one temperature*
if time 0 or 'start', then assume 100% relative activity
if 100%, assume time 0

7 (over the time period) the lower the temperature, the more stable the enzyme ; ora
A enzyme has higher activity at the lower temperatures
A stated temperatures (at least two) to illustrate the point
e.g. 28 °C higher activity than 40 °C throughout
A 28 °C, highest activity / enzyme most stable (throughout)

8 data quote to support ; *temperatures and (relative) activity (with one time)*
discussion points

9 AVP ; ;

10 *e.g. Fig 2.2*
reason for increasing activity up to optimum / decrease after optimum
e.g. ref. collisions, kinetic energy increase e.g. denaturation at 60–70 °C
R denaturation at 50 °C (but **A** denaturation begins)
suggested reason for higher optimum temperature e.g. more bonds
Fig. 2.3
(suggests that) more molecules become, denatured / inactive, as time progresses
greater stability / higher activity, at 40 °C than 37 °C between 40–50 hours
Fig. 2.2 and 2.3
optimum temperature for activity not most stable temperature
steep decrease in stability at 60 °C in a short time as (nearly complete) denaturation occurs *allow once only*
commercial application e.g. if hydrolysis occurs over a longer time period, better to use a lower temperature than optimum [11]

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31. M/J 13/P22/Q4/d,e

(a) (i) **1** active site has, specific / particular, shape ;

2 complementary to substrate ; **A** substrate fits into active site

3 ref. to (some enzymes) induced fit mechanism ; **A** described

4 formation of enzyme-substrate complex ; AW

5 lowering, activation energy / Ea ; **A** detail of how activation energy lowered
e.g substrates held close together for bond formation
facilitates transfer of electrons
places strain on bond(s) to be broken

(ii) 1 loss of tertiary structure / hydrogen bonds broken / ionic bonds broken ;
R if include disulfide or peptide bonds

2 changes shape / substrate unable to fit, active site; **A** enzyme changes shape so alters active site

3 loss of / AW, globular structure ;

4 hydrophobic groups to outside of molecule ;

5 hydrophilic groups no longer interact with water / AW ;

(b) *penalise once for no units*

1 with no cryoprotectant, enzyme (remains), inactive / AW ;
A at 0 mmol of cryoprotectant, 0% (of maximum) activity

2 for both, increasing concentration increases % (enzyme) activity recovered ;
A comparative data quote with ref. to increase *need units*

3 trehalose, steeper curve / AW, up to 10 mmol (cryoprotectant) ; ora **R** rapid

4 at all concentrations (below 90 mmol), trehalose has higher percentage of (maximum enzyme) activity

5 comparative data quote to support either mps 3 or 4 ;
for mp 3 trehalose from 0 to 80% and glycerol from 0 to 10%

6 both cryoprotectants can produce,100% / maximum, (enzyme,activity / recovery) ;

7 trehalose produces, 100% (enzyme) activity / full (enzyme) recovery at,
lower concentrations than glycerol / 30 mmol
compared to, 90-100 (mmol) ; *this is also mp 6*

8 trehalose more effective than glycerol (up to 90 – 95 mmol cryoprotectant) ;
A trehalose is a better cryoprotectant (than glycerol) [9]

32. M/J 13/P23/Q4

(a) any one valid ;
e.g.(first) appearance of (brown) colour
use of, colour standards/colour charts
use of colorimeter
time-lapse photography/ video

(b) *allow catechol for substrate throughout*
rate of reaction 0 au, no substrate to act on / AW ;
at substrate concentrations lower than 5mM
substrate (concentration) is limiting (factor in rate of reaction) ;
presence of free active sites/ enzyme is in excess ;
few collisions between enzyme and substrate ;
rate increases with substrate concentration as more active sites can be occupied/ E-S complexes can form ;
one data quote to support response
V_{max} reached/rate becomes maximum, at 4.5–5 mM substrate concentration;
rate constant/levels out/AW, from 4.5–5 mmol substrate concentration ;

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at substrate concentrations greater than 5 mM
enzyme (concentration) becomes limiting (factor) ;
all active sites, saturated / occupied ;
(so) further increase in substrate concentation does not increase rate ;

(c) (i) curve always lower than that with no inhibitor ; *must be similar shape*
curve reaches the maximum ; **A** curve heading to maximum

(ii) PHBA / inhibitor, similar shape to, substrate / catechol ;
(so) binds to active site ;
blocks access to substrate / fewer (successful) enzyme-substrate collisions ;
reduces rate of, reaction / conversion of substrate to product ;
AVP ;
e.g. inhibitor has a greater effect on rate at lower substrate concentrations
V_{max} reached at higher substrate concentrations
inhibitor forms same interactions with R-groups in active site

(d) enzymes work in a limited pH range / either side of optimum pH rate decreases ;
(acid so) presence of H^+ ions, partially denatures / denatures (some), enzymes ;
further detail ; e.g. ref. to breaking ionic or hyrdrogen bonds
change of active site shape means substrate can no longer fit ;
AVP ; e.g. ref. to antioxidant effect of, lemon juice / citric acid / vitamin C [12]

33. M/J 12/P21/Q4

(a) *this can be answered in the context of penicillinase*
1 complementary shape ;
2 substrate, fits into / enters / binds to / with, active site ;
A enzyme-substrate complex / ESC
3 ref. to specificity ;
4 lock and key / induced fit ; **A** description of induced fit
5 ref. to temporary bonds form with, active site / R groups (of amino acid residues) ;

(b) *shown to max 2*
secondary structure ;
α / alpha, helix ; **R** 'helix' / helical structure unqualified by alpha
β pleated sheet ;
tertiary structure / folding ; **ignore** 3D shape or structure
globular ;
not shown to max 2
amino acids / primary structure / sequence of amino acids ;
(types of) R groups ;
bonds / named bonds ; **A** peptide
quaternary structure ;
prosthetic group ;

(c) (i) one lower peak inside line than uncatalysed ;
start and finish at, dotted lines / same energy levels as uncatalysed ;

(ii) activation (energy) / (energy of) activation ;

(d) 1 do not prescribe for viral diseases ;
2 only use when necessary / do not overprescribe ;
3 only available on prescription / not available 'over the counter' ;
4 people must, complete the course / take as instructed
R take a long course
5 test to find out which is most appropriate antibiotic to use ;
A use most, appropriate / effective, antibiotics
A use narrow-spectrum antibiotics
6 details of sensitivity test ;
7 rotate / AW, antibiotics / use in combination ; **R** use many antibiotics
8 do not use same antibiotics for humans and animals ; [11]

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Unit 4

CELL MEMBRANES AND TRANSPORT

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

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Syllabus

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Unit 4: Cell Membranes and Transport

1. M/J 22/P22/Q1

Epithelial cells in the small intestine have cell structures known as microvilli. The microvilli of these cells are found only on the surface that borders the gut lumen.

Fig. 1.1 shows images of microvilli of intestinal epithelial cells. These images have been obtained using a scanning electron microscope and a transmission electron microscope.

Fig. 1.1**A** is at a different magnification to Fig. 1.1**B**.

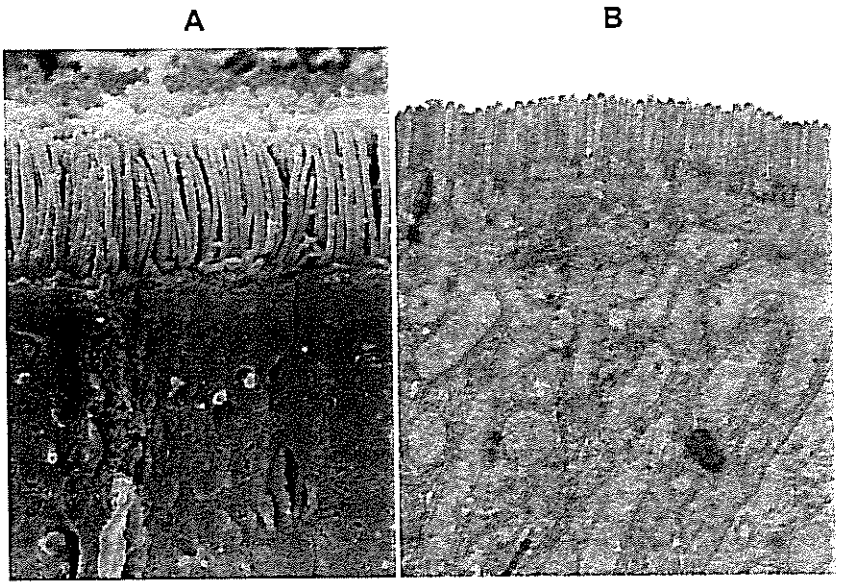


Fig. 1.1

(a) With reference to Fig. 1.1, state how it is possible to distinguish between a scanning electron micrograph and a transmission electron micrograph.

..... [1]

(b) The approximate length of a microvillus is 1 μm.

Outline the method you would use to estimate the magnifications of the images shown in Fig. 1.1.

.....

..... [2]

(c) One role of an intestinal epithelial cell is the absorption of glucose from the gut lumen into the circulatory system. This involves different membrane transport proteins.

The events occurring in an intestinal epithelial cell during the absorption of glucose are summarised in Fig. 1.2.

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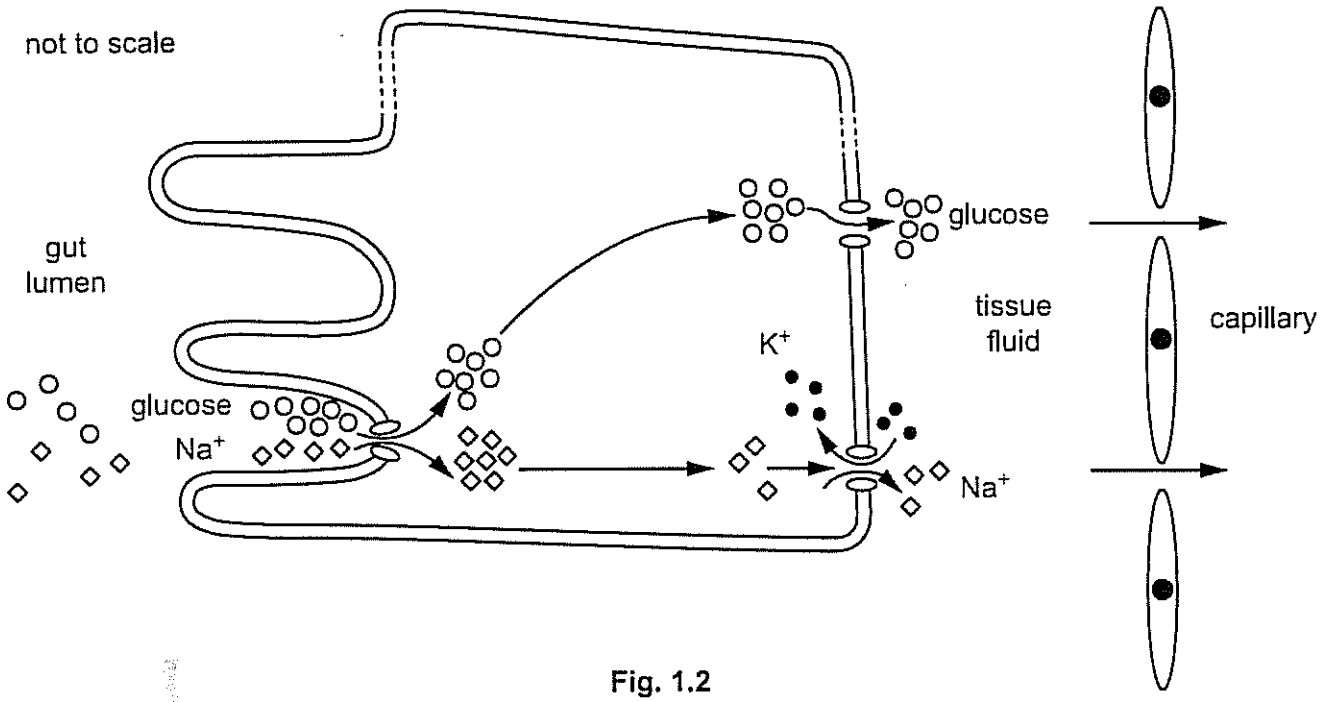


Fig. 1.2

- Sodium ions (Na^+) are removed from the cell by active transport through a transport protein known as a sodium-potassium (Na^+/K^+) pump.
- This decreases the concentration of Na^+ in the cell compared to the gut lumen.
- Glucose molecules are cotransported with Na^+ into the cell from the gut lumen.
- Glucose molecules are transported out of the cell into the tissue fluid down a concentration gradient.

(i) Active transport involves water-soluble substances, such as Na^+ and K^+, and the use of ATP to provide the energy needed for their transport through carrier proteins.

Outline **other** features of active transport.

.....

..... [2]

(ii) Glucose molecules enter the cell through a membrane protein.

Suggest why glucose molecules need to be cotransported with Na^+ when it enters the cell through the membrane protein.

.....

..... [2]

(iii) Explain how microvilli increase the uptake of glucose into an intestinal epithelial cell.

.....

..... [2]

(d) Stem cells are also located in the wall of the small intestine. These cells divide by mitosis continuously.

Suggest **and** explain the importance of mitosis by stem cells in the small intestine.

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.....

.....

.....

..... [4]

2. **M/J 22/P23/Q3**
Hakea spp. are xerophytic plants native to Australia. The leaves of *Hakea* have adaptations for a xerophytic mode of life.

(a) Fig. 3.1 is a photomicrograph of a transverse section of part of a leaf of *H. laurina*.

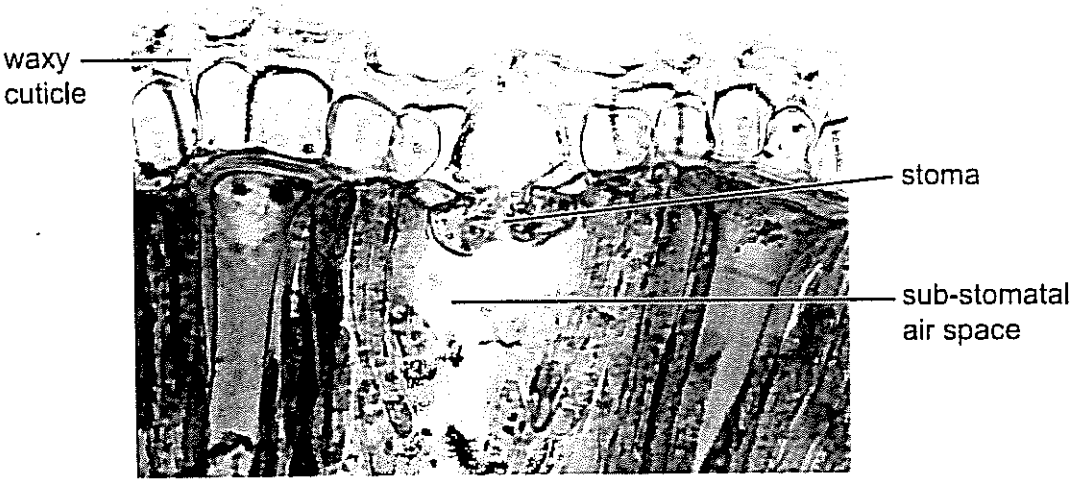


Fig. 3.1

Describe the xerophytic features of the waxy cuticle and the stoma shown in Fig. 3.1 **and** explain how these features adapt the plant to a xerophytic mode of life.

.....

.....

..... [3]

(b) When the availability of phosphate ions and other soil nutrients is limited, a number of changes occur in the roots of *Hakea* spp.:

- Regions of meristematic tissue are active for a few days.
- Root clusters are formed. A root cluster is a dense arrangement of tiny side roots known as rootlets.
- Most of the epidermal cells of the rootlets are root hair cells.
- Rootlets release compounds into the soil that make phosphates and other mineral ions more soluble for uptake.
- Uptake of phosphate ions and the absorption of water from the soil increases.

(i) Meristem cells have a similar role to stem cells in animals.
Suggest how meristematic tissue activity leads to the formation of root clusters.

.....

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.....

..... [3]

(ii) Organic anions (negatively charged organic compounds) are released into the soil by rootlets. The concentration of these organic anions can become higher in the soil solution than in the rootlet cells.

Suggest **and** explain how the concentration of organic anions in the soil solution can become higher than in the rootlet cells.

.....

.....

..... [3]

(iii) Explain how the formation of root clusters can lead to an increase in the uptake of phosphate ions and absorption of water from the soil solution.

.....

..... [2]

3. M/J 22/P23/Q5

Arachidonic acid is a fatty acid that is a common component of phospholipids.

Phospholipids can be used as a source of arachidonic acid when it is metabolised within cells in an enzyme-catalysed pathway known as the cyclooxygenase (COX) pathway.

The final products of the COX pathway can be different in different cell types, causing a range of responses. In some cells, the products are involved in the inflammatory response, which is a response by the body to infection. In other cells, cell division is stimulated.

Fig. 5.1 shows the **first reaction** in the COX pathway. This reaction is catalysed by an enzyme known as COX-2.

$$\text{arachidonic acid + oxygen} \xrightarrow{\text{COX-2}} \text{prostaglandin-H}_2$$

Fig. 5.1

(a) The enzymes involved in the COX pathway are located in the membrane of rough endoplasmic reticulum.

Suggest the advantages to the cell of enzyme pathways being located in cell membranes, rather than in the cytosol of the cell (fluid portion of cytoplasm).

.....

..... [2]

(b) During an inflammatory response, compounds produced by the COX pathway cause an increased sensitivity to pain.

Some anti-inflammatory drugs are reversible competitive inhibitors of COX-2.

Fig. 5.2 shows how increasing arachidonic acid concentration affects COX-2 activity.

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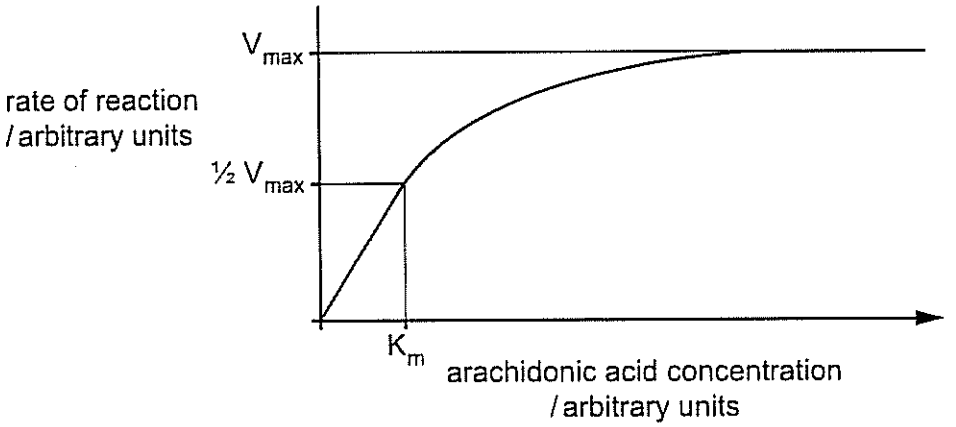


Fig. 5.2

(i) Sketch on Fig. 5.2 the curve obtained if an anti-inflammatory drug, which is a **competitive** inhibitor, is present with arachidonic acid. [1]

(ii) Complete the statements to show whether the maximum rate of reaction (V_{max}) and the Michaelis-Menten constant (K_m) of COX-2 **increases**, **decreases**, or **stays the same** in the presence of a competitive inhibitor.

In the presence of a competitive inhibitor:

V_{max} of COX-2 .....

K_m of COX-2 ..... . [2]

(c) COX-2 is composed of two identical polypeptides. The enzyme is produced when a gene, *PTGS2*, located on chromosome 1, is switched on and transcription begins.

(i) Using gene *PTGS2* and enzyme COX-2 as examples, explain what is meant by a gene.

.....

..... [2]

(ii) Some mutations in *PTGS2* lead to an increased rate of transcription. These mutations have been linked to an increased risk of certain types of cancer.

Suggest why mutations in *PTGS2* may increase the risk of cancer.

.....

..... [2]

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(d) Fig. 5.3 shows the molecular structure of arachidonic acid. Not all hydrogen atoms are shown.

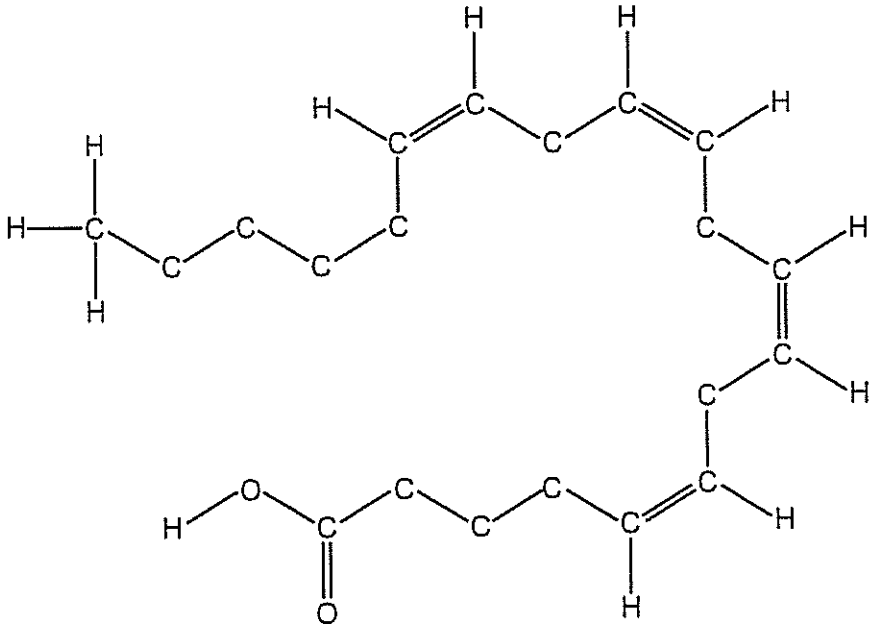


Fig. 5.3

With reference to Fig. 5.3, explain why increasing the proportion of phospholipids with arachidonic acid in a cell will increase the fluidity of the cell surface membrane of the cell.

.....

.....

..... [3]

4. O/N 21/P22/Q1/b

(a) One role of the cell surface membrane of bacterial cells and plant cells is the transport of substances into and out of cells.
Explain how membrane carrier proteins and membrane channel proteins are involved in the transport of substances into and out of cells.

.....

.....

..... [3]

5. O/N 21/P21/Q2/b

(a) (i) The cell surface membranes of the respiring cells have a role in regulating the exchange of substances between the cells of the body and the blood.
Draw a diagram in the space below to show the arrangement of phospholipid molecules in the cell surface membrane.

[2]

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(ii) Cholesterol is a molecule found in the cell surface membrane.
Describe **one** role of cholesterol in the cell surface membrane.

..... [1]

6. O/N 21/P23/Q4

In thale cress, *Arabidopsis thaliana*, most of the stomata are on the lower surface of the leaves. Fig. 4.1 is a diagram of an open stoma and two guard cells. Some of the cellulose fibres in the cell wall of the guard cells are shown.

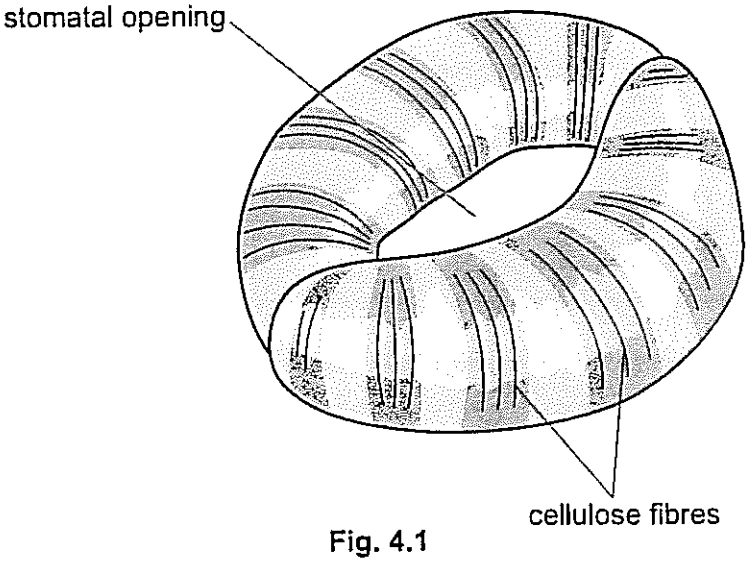


Fig. 4.1

(a) The cellulose fibres shown in Fig. 4.1 are composed of bundles of cellulose microfibrils.
Explain how molecules of cellulose are arranged into a microfibril.

.....

..... [2]

(b) The width of stomatal openings in *A. thaliana* is regulated by movement of ions. These ions move through channel proteins in the cell surface membranes of the guard cells.

(i) Draw a diagram to show part of a cell surface membrane with a channel protein.
Label your diagram.

[3]

(ii) Explain why channel proteins are needed for the movement of ions into and out of cells.

.....

..... [2]

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(c) The outward movement of ions from guard cells causes stomata to close.
A variety of *A. thaliana* does **not** have channel proteins for the outward movement of ions in the cell surface membranes of the guard cells.
Suggest **and** explain the effect of **not** having these channel proteins on transpiration.

.....

.....

..... [3]

7. M/J 21/P22/Q3/b,c,d,e
In mammals, some cell signalling molecules are steroid (lipid) hormones. These hormones are transported in the bloodstream to reach capillary networks.
At a capillary network, hormones pass out of the blood into tissue fluid.
Hormone **S** is a steroid hormone involved in cell signalling.
Fig. 3.2 shows the sequence of events that occurs when hormone **S** enters a target cell.

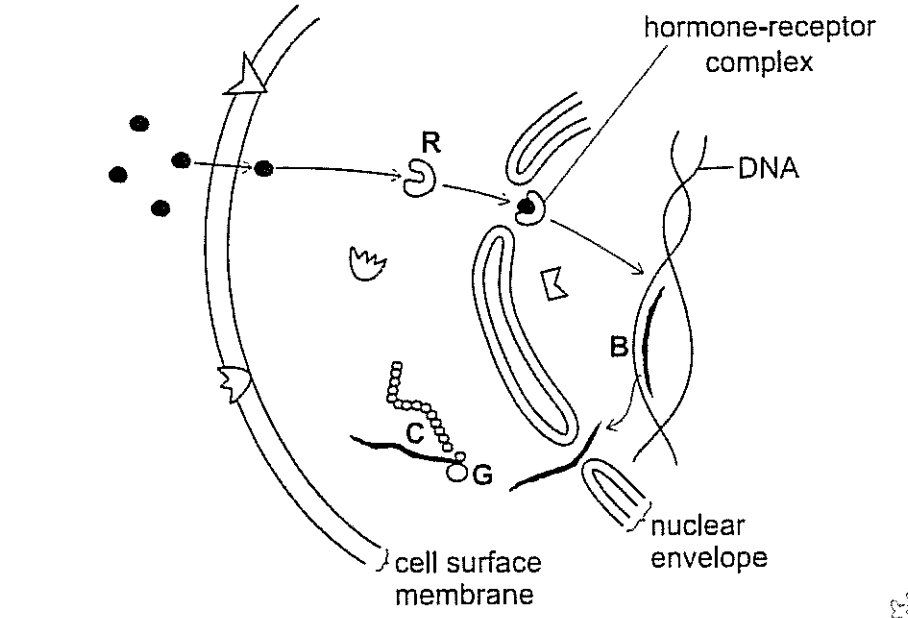


Fig. 3.2

(a) Explain why hormone **S**, shown in Fig. 3.2, does not need to pass through a transport protein to enter the cytoplasm of the target cell.

.....

..... [2]

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(b) The target cell can respond to other cell signalling molecules in addition to hormone **S**. The cell has receptors in the cell surface membrane, in the cytoplasm and in the nucleus.

Explain why hormone **S** binds only with receptor **R** in the cytoplasm and **not** with the other receptors shown in Fig. 3.2.

..... [1]

(c) The hormone-receptor complex shown in Fig. 3.2 enters the nucleus and binds to DNA. This switches on a gene coding for a polypeptide that is synthesised in the cytoplasm.

(i) Name the structure through which the hormone-receptor complex enters the nucleus.

..... [1]

(ii) Name the processes occurring at **B** and **C**.

B .....

C ..... [2]

(iii) Name structure **G**.

..... [1]

(d) Cell signalling by hormone **S** results in the production of a functioning globular protein molecule composed of three identical polypeptide chains.

After the synthesis of these polypeptides, changes need to occur to form the functioning globular protein molecule.

Outline the changes that need to occur to form the functioning globular protein molecule.

.....

.....

.....

..... [4]

8. M/J 21/P22/Q5/a,b

Fig. 5.1 is a transmission electron micrograph showing parts of two plant cells. The function of the middle lamella is cell-to-cell adhesion. The middle lamella is composed of a polysaccharide known as pectin.

Pectin interacts with the polysaccharides cellulose and hemicellulose in the cell walls of the plant cells so that the cell walls are held close together, as shown in Fig. 5.1.

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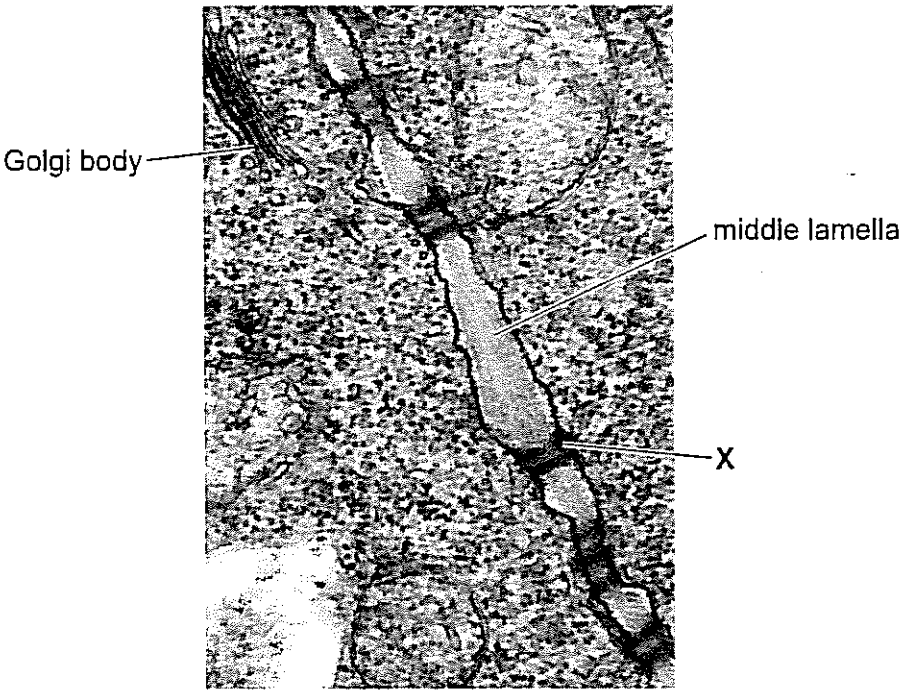


Fig. 5.1

(a) Cell structure **X** in Fig. 5.1 is a cytoplasmic channel with strands of cytoplasm passing through the cell walls of the two cells.

Name cell structure **X and** state **one** function of this cell structure.

name .....

function ..... [2]

(b) Researchers have discovered that pectin is synthesised within the Golgi body. Golgi vesicles containing pectin are moved to the cell surface membrane for release.

(i) Suggest why researchers would **not** have investigated ribosomes as being the possible location for the synthesis of pectin.

..... [1]

(ii) Name the mechanism that is used to transport pectin out of the cell.

..... [1]

9. M/J 21/P21/Q3

Visking tubing can be used to investigate the properties of cell membranes.

A student carried out an experiment to investigate osmosis using Visking tubing. An outline of the investigation is shown in Fig. 3.1.

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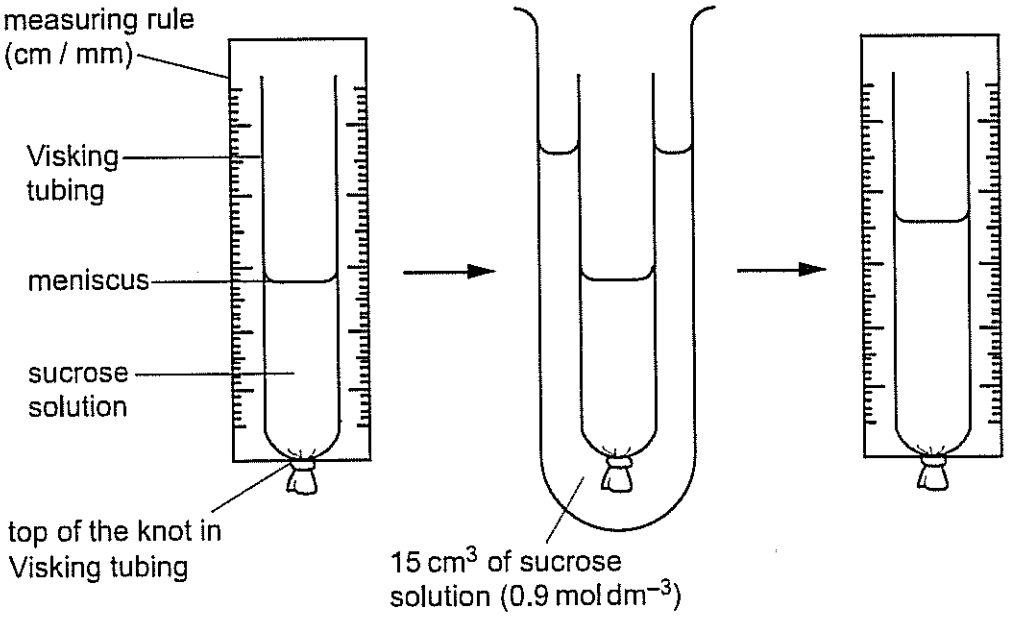


Fig. 3.1

- Six pieces of Visking tubing were filled with 10 cm^3 of different concentrations of sucrose solution: 0.0, 0.4, 0.8, 1.2, 1.6 and 2.0 mol dm^{-3}.
- The height of the meniscus of each solution in the Visking tubing was measured.
- The pieces of Visking tubing were put into test-tubes containing 15 cm^3 of 0.9 mol dm^{-3} sucrose solution.
- After 20 minutes, the pieces of Visking tubing were removed from the test-tubes and the height of the meniscus in each was measured.

The results are shown in Table 3.1.

Table 3.1

concentration of sucrose solution inside Visking tubing / mol dm^{-3}	difference in height of meniscus after 20 minutes / mm
0.0	–12
0.4	–4
0.8	–2
1.2	+1
1.6	+6
2.0	+11

(a) The Visking tubing used by the student was **not** permeable to sucrose.
Explain the results shown in Table 3.1.

.....

.....

..... [3]

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(b) When red blood cells are placed in water they are destroyed by bursting.

The student also investigated how red blood cells are affected by immersion in solutions of sodium chloride of different concentration. Blood samples of the same volume were added to solutions of sodium chloride in separate test-tubes.

After 10 minutes, the student took 0.1 cm^3 of the blood samples from the test-tubes and estimated the percentage of red blood cells that had burst in each blood sample.

Fig. 3.2 shows the student's results.

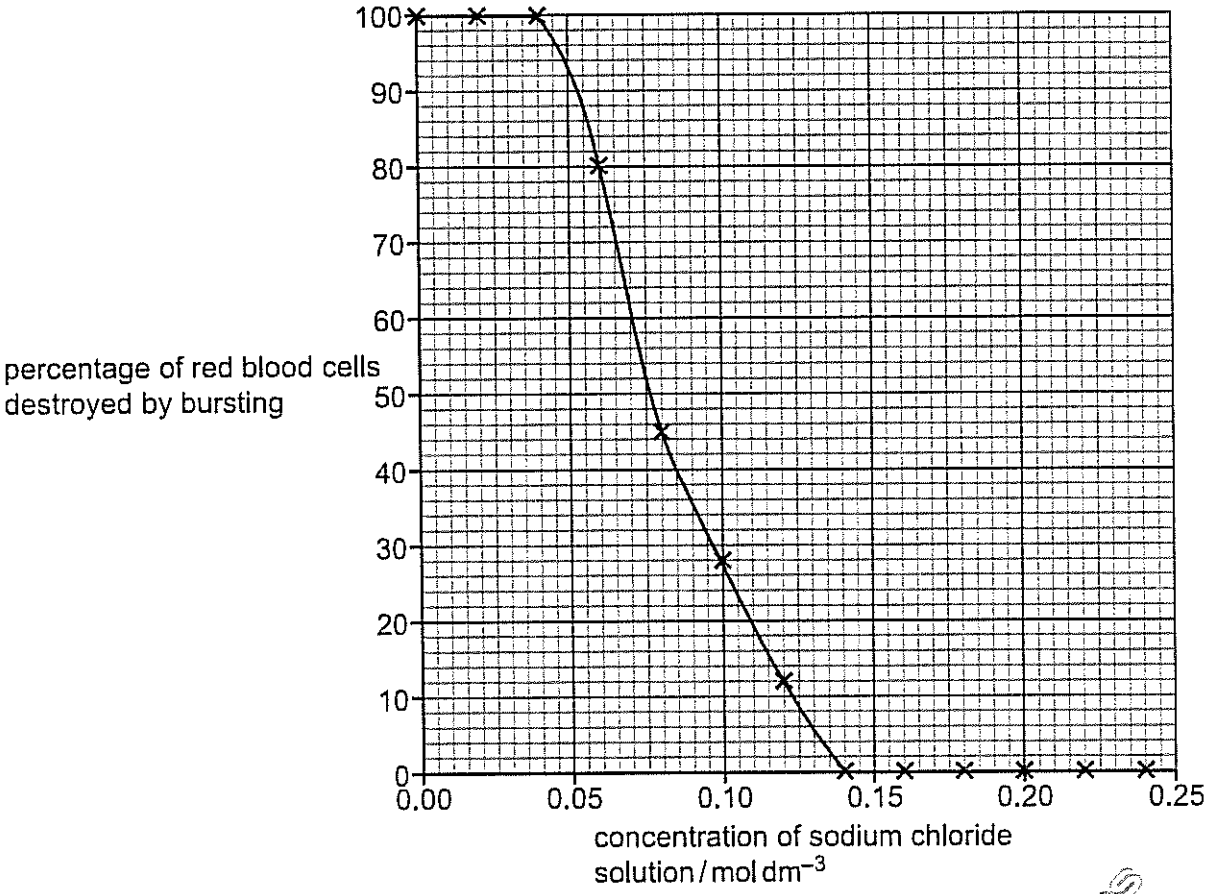


Fig. 3.2

Describe **and** explain the effects on red blood cells of immersion in different concentrations of sodium chloride as shown in Fig. 3.2.

.....

.....

.....

..... [4]

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10. M/J 21/P21/Q6

Lysosomes are cell structures that contain enzymes known as acid hydrolases.

Fig. 6.1 shows some processes that occur in animal cells.

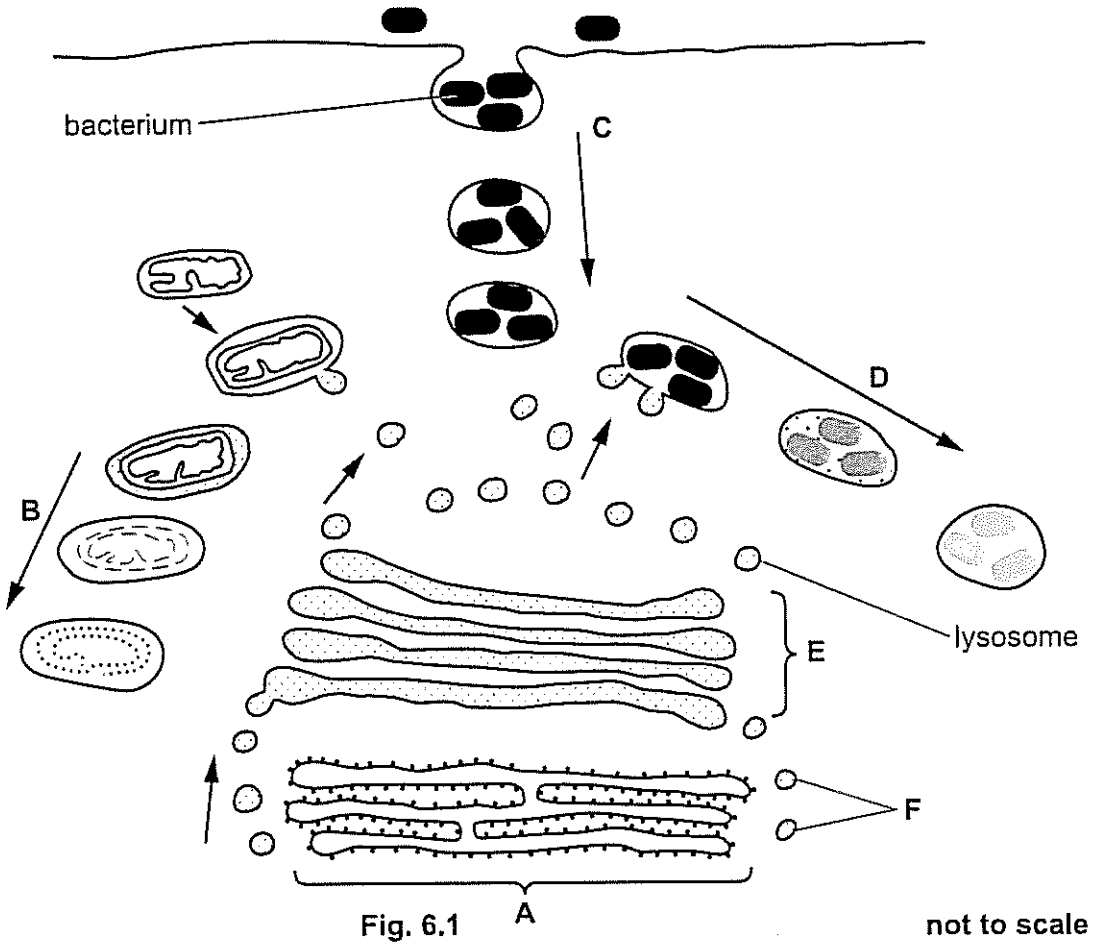


Fig. 6.1 not to scale

(a) Name the cell structures labelled **A** and **E**.

A .....

E ..... [2]

(b) State the function of the structures labelled **F**.

..... [1]

(c) Name the process by which bacteria are taken into the cell at **C**.

..... [1]

(d) With reference to the processes occurring at **B** and at **D** in Fig. 6.1, outline the role of acid hydrolases in lysosomes.

.....

.....

..... [3]

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(e) Carrier proteins in the membranes of lysosomes maintain a lower pH than the surrounding cytoplasm by moving hydrogen ions.

Suggest how the carrier proteins maintain the lower pH within the lysosomes.

.....

..... [2]

11. M/J 21/P23/Q1

The Golgi body, rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER) form part of the internal membrane system of a cell. The membranes have a fluid mosaic structure.

Fig. 1.1 is a transmission electron micrograph of one area of a liver cell showing a region with RER and a region with SER. Mitochondria are also visible in the image.

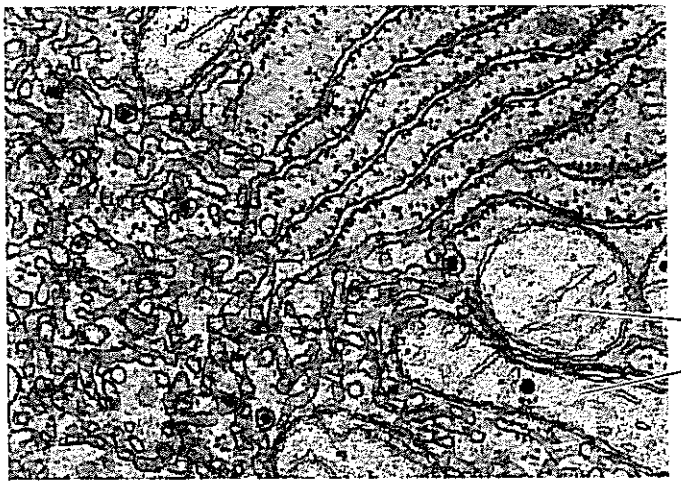


Fig. 1.1

(a) Describe the differences in structure **and** function between RER and SER.

.....

.....

..... [3]

(b) Phospholipids are one of the main components of membranes.

Describe the structure of a phospholipid molecule.

.....

..... [2]

(c) One function of a Golgi body is to package molecules into Golgi vesicles.

(i) A Golgi body and Golgi vesicles are **not** visible in Fig. 1.1.

Describe the features, **other than** the presence of Golgi vesicles, that would help you identify a Golgi body in a transmission electron micrograph of another area of the same liver cell.

.....

..... [2]

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(ii) Some Golgi vesicles contain secretory proteins for release from the cell.
Describe the sequence of events that occurs following the packaging of a secretory protein into a Golgi vesicle to its release from the cell.

.....

.....

..... [3]

(iii) Some Golgi vesicles contain glycoproteins or glycolipids to be added to the cell surface membrane.
Outline the role of **glycolipids** in the cell surface membrane.

.....[1]

12. M/J 20/P23/Q6

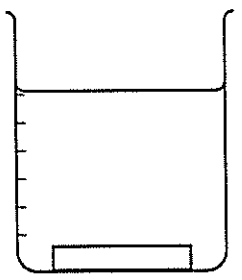
A student carried out an investigation to estimate the water potential of potato tissue. The main steps in the procedure and in the analysis of results are outlined in Fig. 6.1.

beaker	concentration of sucrose solution / mol dm^{-3}
1	0.0
2	0.1
3	0.2
4	0.3
5	0.4
6	0.5

Six different concentrations of sucrose solution were prepared and an equal volume of each was placed in a labelled beaker.



Six equal-sized blocks of potato tissue were cut out of the same potato, blotted dry and weighed.



One potato block was immersed in the solution in each beaker for 30 minutes.

After this time, the block was removed, blotted dry and reweighed.

The experiment was repeated twice.

The mean percentage change in mass of potato tissue was calculated for each concentration of sucrose used.

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A graph was drawn of mean percentage change in the mass of potato tissue against concentration of sucrose.

Fig. 6.1

(a) Explain why the different concentrations of sucrose result in different mean percentage changes in mass of potato tissue.

.....

.....

..... [3]

(b) State how the graph is used to estimate the water potential of the potato tissue.

..... [1]

13. O/N 19/P22/Q3/a,b

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

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(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.

.....

..... [2]

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

.....

.....

..... [3]

14. O/N 19/P21/Q3

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.

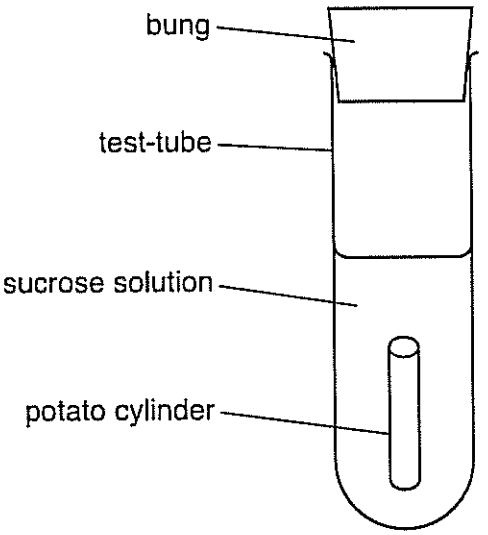


Fig. 3.1

- 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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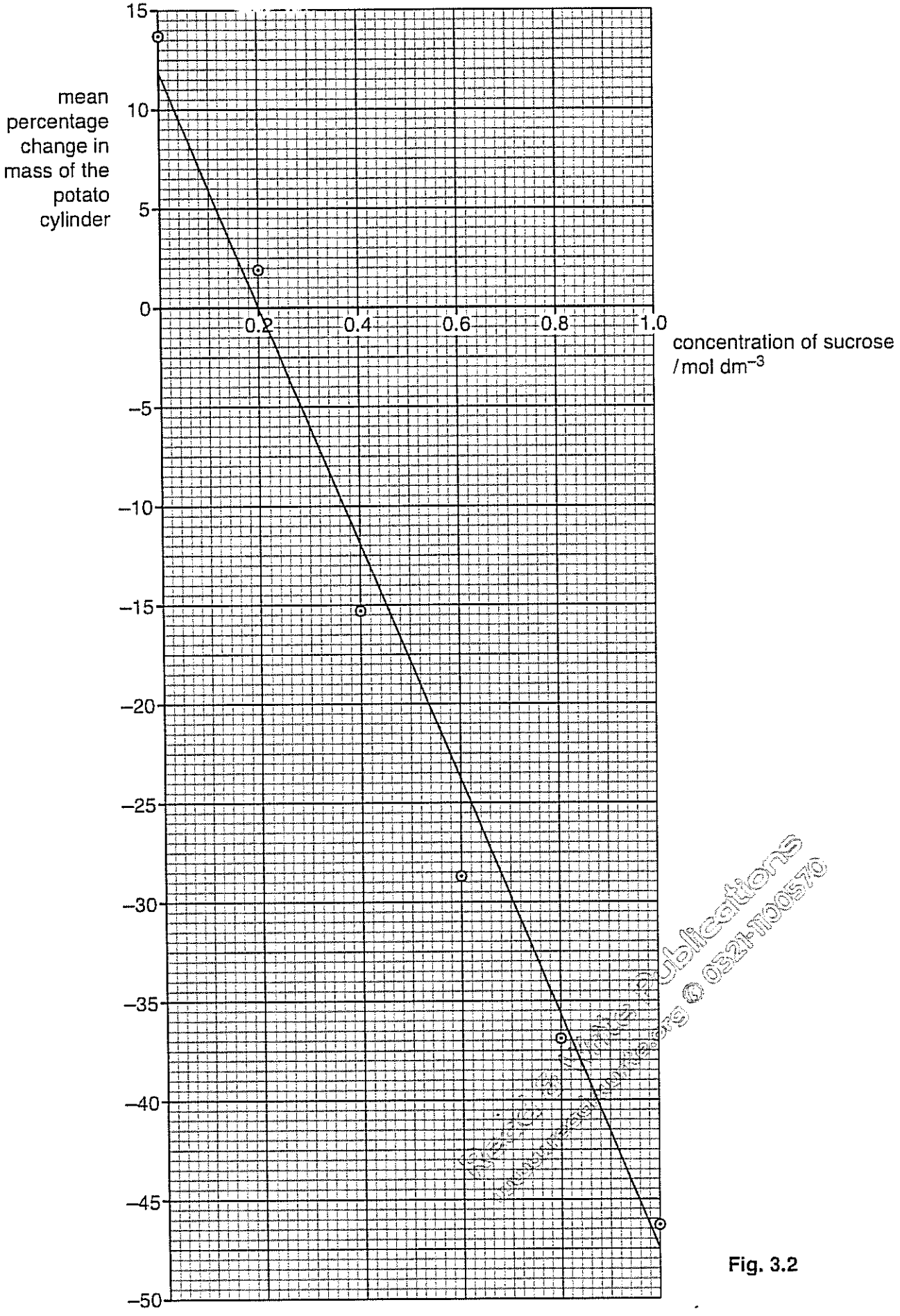


Fig. 3.2

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

.....

.....

..... [3]

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

.....

.....

..... [3]

15. O/N 19/P21/Q5/b(ii),c

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

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.

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

.....

.....

..... [4]

(b) 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.

.....

.....

..... [3]

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16. O/N 19/P23/Q6

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

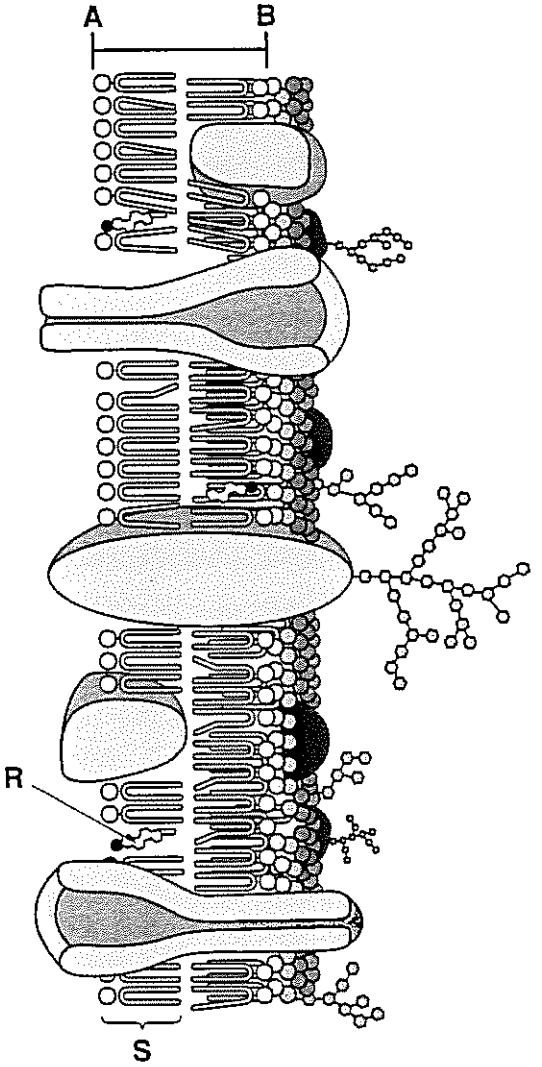


Fig. 6.1

(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]

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

component R

name .....

role .....

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component ***S***

name .....

role ..... [4]

17. M/J 19/P21/Q2

Linoleic acid is an unsaturated fatty acid that is found in some triglycerides and some phospholipids.

Phospholipids are components of cell membranes.

Fig. 2.1 shows a molecule of linoleic acid.

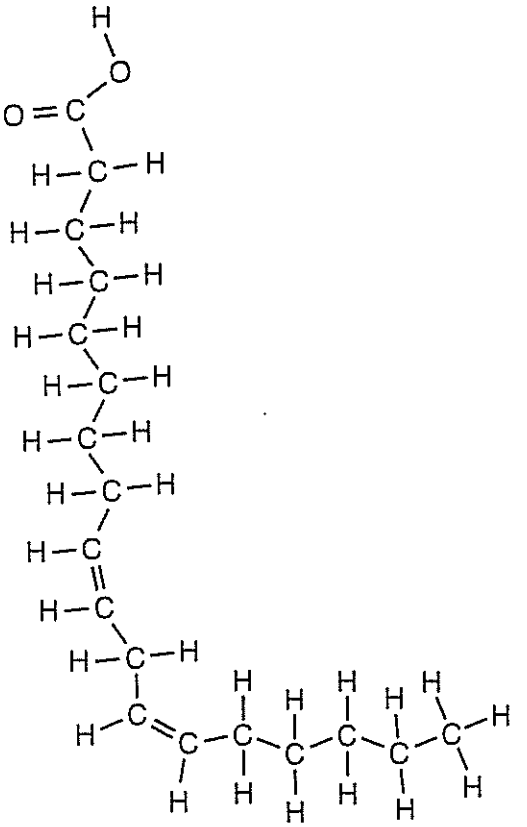


Fig. 2.1

(a) The composition of cell membranes of plants changes in response to changes in temperature.

At the start of the cold season there is an increase in the proportion of phospholipids with unsaturated fatty acids in the chickpea, *Cicer arietinum*. Chickpea plants that do not make this change do not survive.

Suggest how the increase in the proportion of phospholipids with unsaturated fatty acids helps plants, such as chickpea, survive decreases in temperature.

.....

..... [2]

(b) (i) State why triglycerides and phospholipids **cannot** be described as polymers.

..... [1]

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(ii) State two **differences** in the **structure** of triglycerides and phospholipids.

1 .....

2 ..... [2]

(c) Platelets metabolise linoleic acid to produce a molecule known as thromboxane.

Thromboxane is released by platelets when blood loss occurs. Thromboxane acts on smooth muscle cells in the walls of arteries. This causes arteries to constrict, which reduces blood flow.

Explain why the constriction of arteries following blood loss is an example of cell signalling.

.....

.....

.....

..... [4]

18. M/J 19/P23/Q5

(a) Fig. 5.1 is a photomicrograph of human blood cells that have been placed in a solution of sodium chloride.

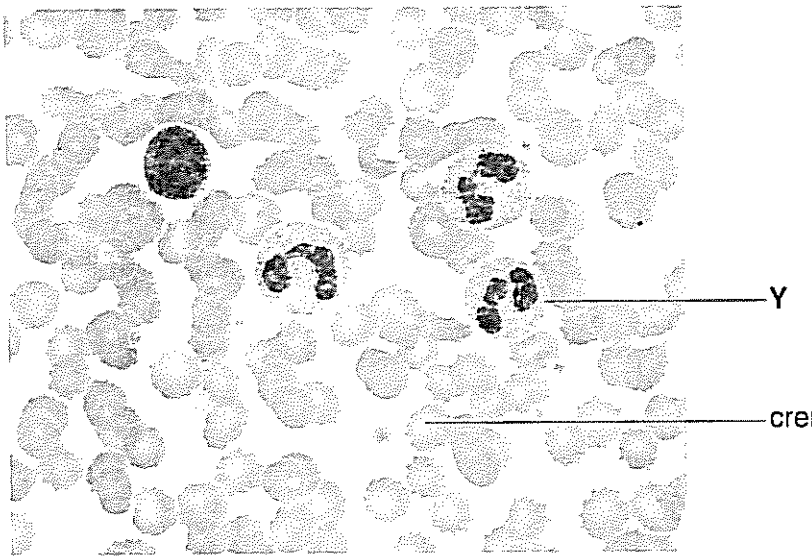


Fig. 5.1

(i) State the function of the cell labelled **Y**.

..... [1]

(ii) The red blood cell labelled in Fig. 5.1 is described as crenated because it has an abnormal, shrivelled appearance.

Explain how this red blood cell has become crenated.

.....

..... [2]

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(b) Researchers studied the effect of altitude on the red blood cell count of humans. They recorded the red blood cell count of healthy adults from populations living at four different altitudes in a mountainous region.

The results are shown in Table 5.1.

Table 5.1

population	altitude of population / m above sea level	mean red blood cell count / number of cells $\times 10^6$ mm^{-3}
A	695	4.50
B	1676	5.14
C	2003	5.04
D	2118	5.11

(i) Calculate the percentage increase in mean red blood cell count between population **A** and population **D**.

.....%[1]

(ii) Describe and suggest explanations for the data shown in Table 5.1.

.....

.....

.....

..... [4]

(c) Carbonic anhydrase is an enzyme found in red blood cells which has an important role in the transport of respiratory gases.

Explain why a non-competitive inhibitor of carbonic anhydrase will reduce the supply of oxygen to actively respiring tissues.

.....

..... [2]

19. O/N 18/P23/Q4/c

(a) The activity of the SAN is controlled by the nervous system. Noradrenaline is released by nerve cells in the SAN.

Fig. 4.1 shows the role of noradrenaline in causing calcium ions (Ca^{2+}) to enter a cell in the SAN.

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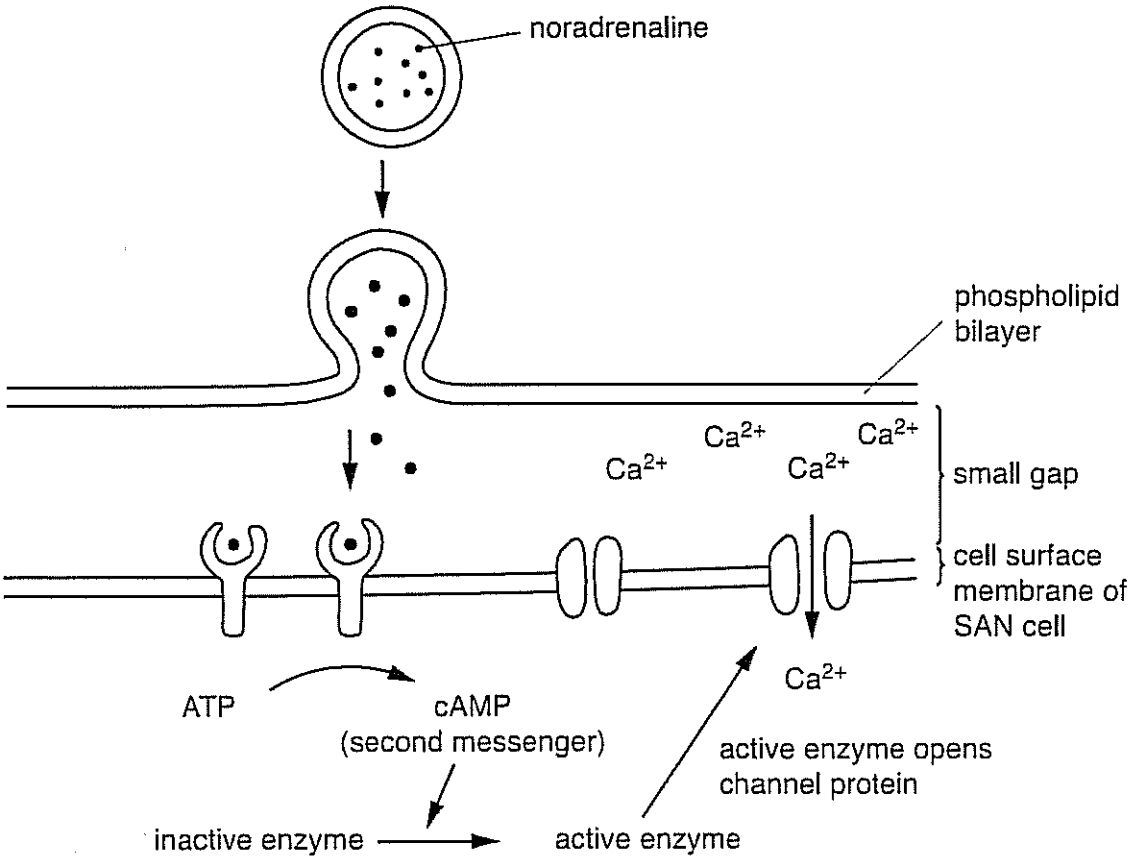


Fig. 4.1

With reference to Fig. 4.1, outline the process of cell signalling.

.....

.....

.....

..... [4]

20. M/J 18/P22/Q3/b,c(i)

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*.

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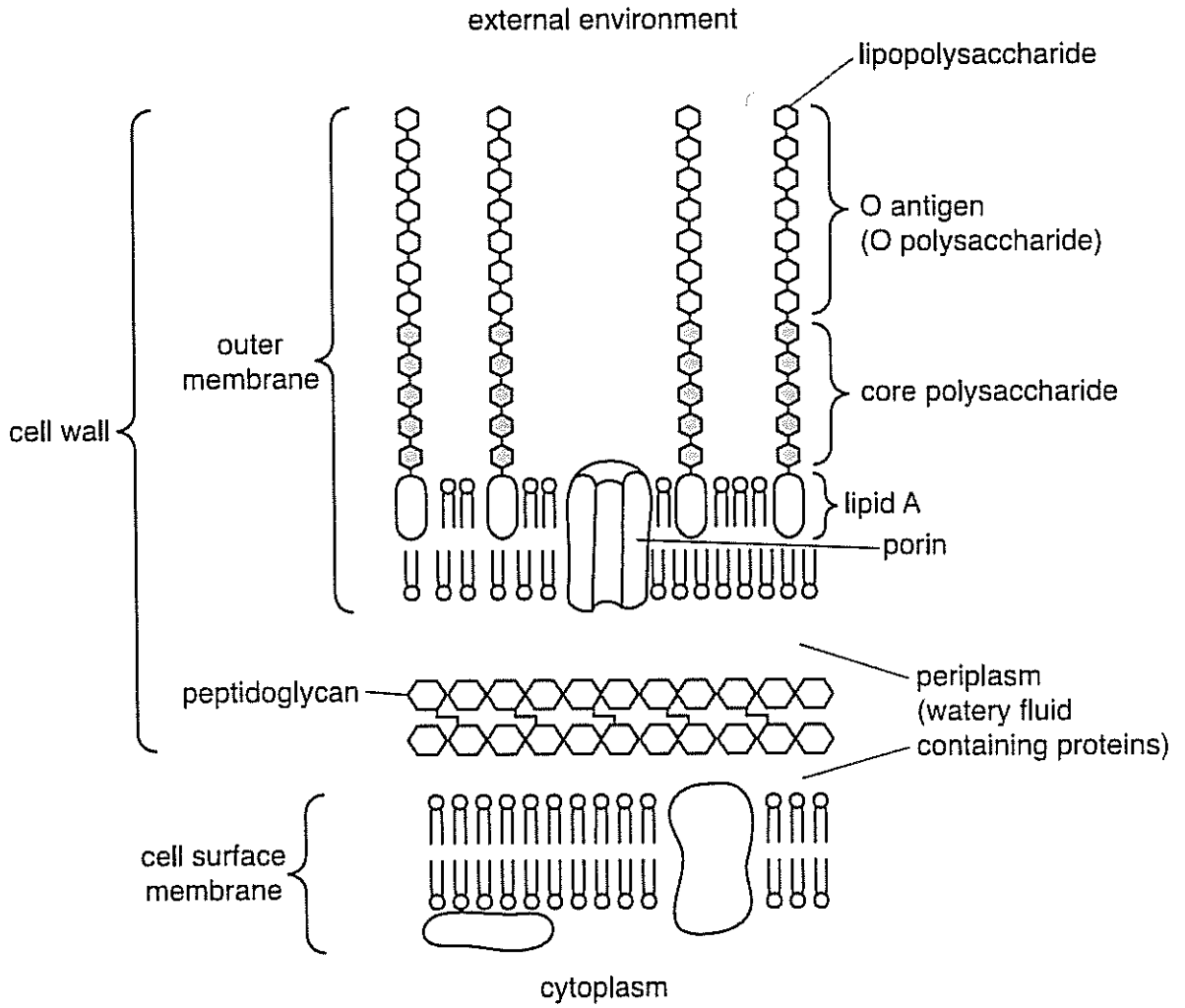


Fig. 3.1

(a) 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.

.....

.....

.....

..... [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.

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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.

.....

..... [2]

(b) 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.*

.....

..... [2]

21. M/J 18/P21/Q6/d

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.*

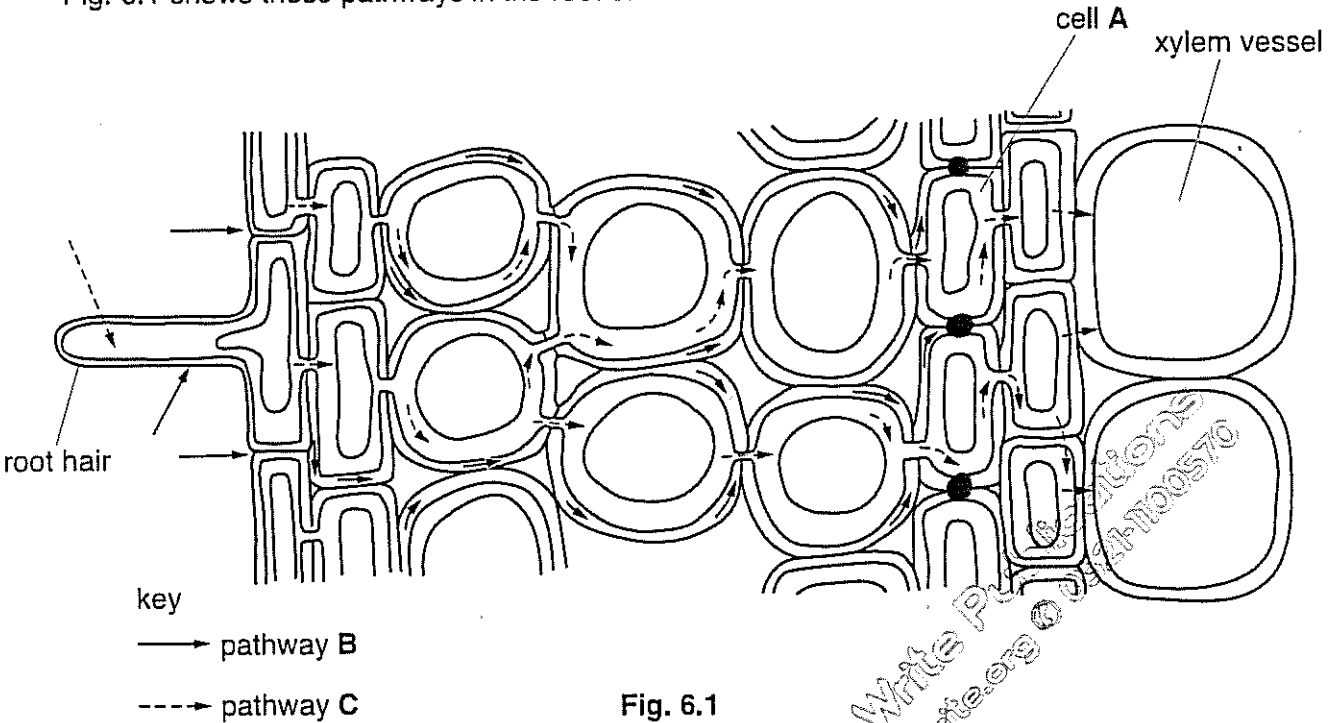


Fig. 6.1

(a) 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 .....

2 ..... [2]

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22. M/J 18/P23/Q2

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.

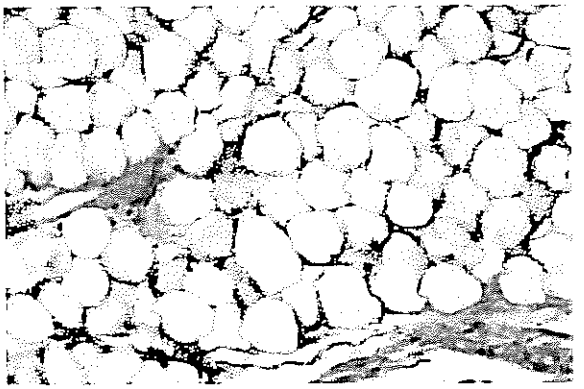


Fig. 2.1

(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.

.....

..... [2]

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

triglyceride $\rightleftharpoons^{\text{lipase}}$ fatty acids + glycerol

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.

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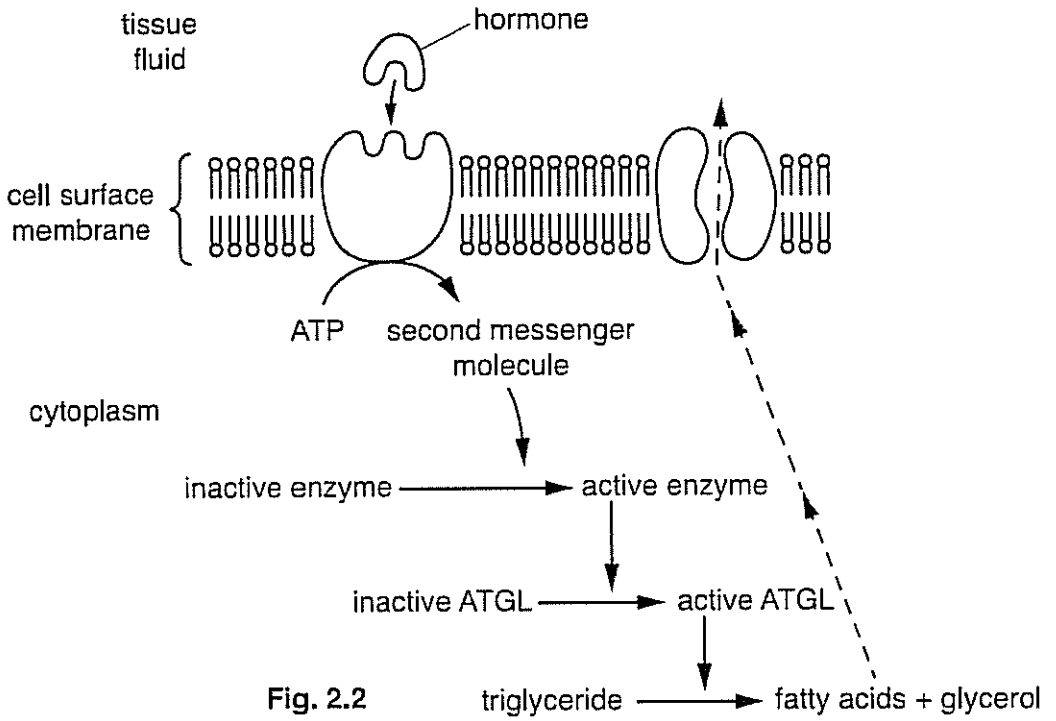


Fig. 2.2

(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.

.....

.....

..... [3]

(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.

.....

.....

.....

.....[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]

23. O/N 17/P21/Q4/b,c

Fig. 4.1 shows the structure of the R groups of three amino acids, aspartate (Asp), glutamine (Gln) and isoleucine (Ile).

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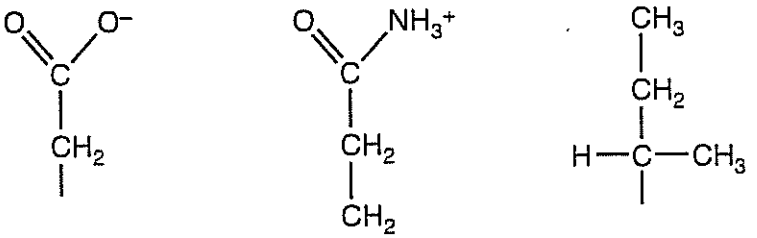


Fig. 4.1

(a) Many proteins that contain the amino acids shown in Fig. 4.1 are globular.
Describe how the three R groups in Fig. 4.1 can contribute to the globular structure of a protein.

.....

.....

.....

..... [4]

(b) An example of a globular protein is the enzyme starch phosphorylase. This enzyme catalyses the conversion of starch to glucose-1-phosphate.
Name the type of bond that is broken when starch is converted to glucose-1-phosphate.

..... [1]

24. O/N 17/P21/Q5/d

(a) (i) The structure of the cell surface membrane is described as a fluid mosaic.
Explain what is meant by the term *fluid mosaic.*

.....

..... [2]

(ii) Outline the roles of the cell surface membrane.

.....

.....

.....

..... [4]

25. M/J 17/P21/Q5/a

Sugar molecules enter cells through transport proteins.

(a) Explain why transport proteins are required for the movement of sugar molecules, such as glucose and fructose, into cells.

.....

..... [2]

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26. M/J 17/P23/Q4/c

(a) Some glycoproteins in cell surface membranes function as transport proteins.
State two **other** functions of glycoproteins in cell surface membranes.

1 .....

2 ..... [2]

27. O/N 16/P22/Q2/a

Phloem sap containing sucrose is transported in phloem sieve tubes from the source to the sink.

(a) A student carried out an experiment using Visking tubing to investigate osmosis. The student prepared a sucrose solution to represent phloem sap at the source. This was put into Visking tubing that was tied at one end, so that the tubing was approximately 75% full.
The rest of the procedure is summarised in Fig. 2.1. The tubing was removed after 20 minutes, dried and re-weighed.

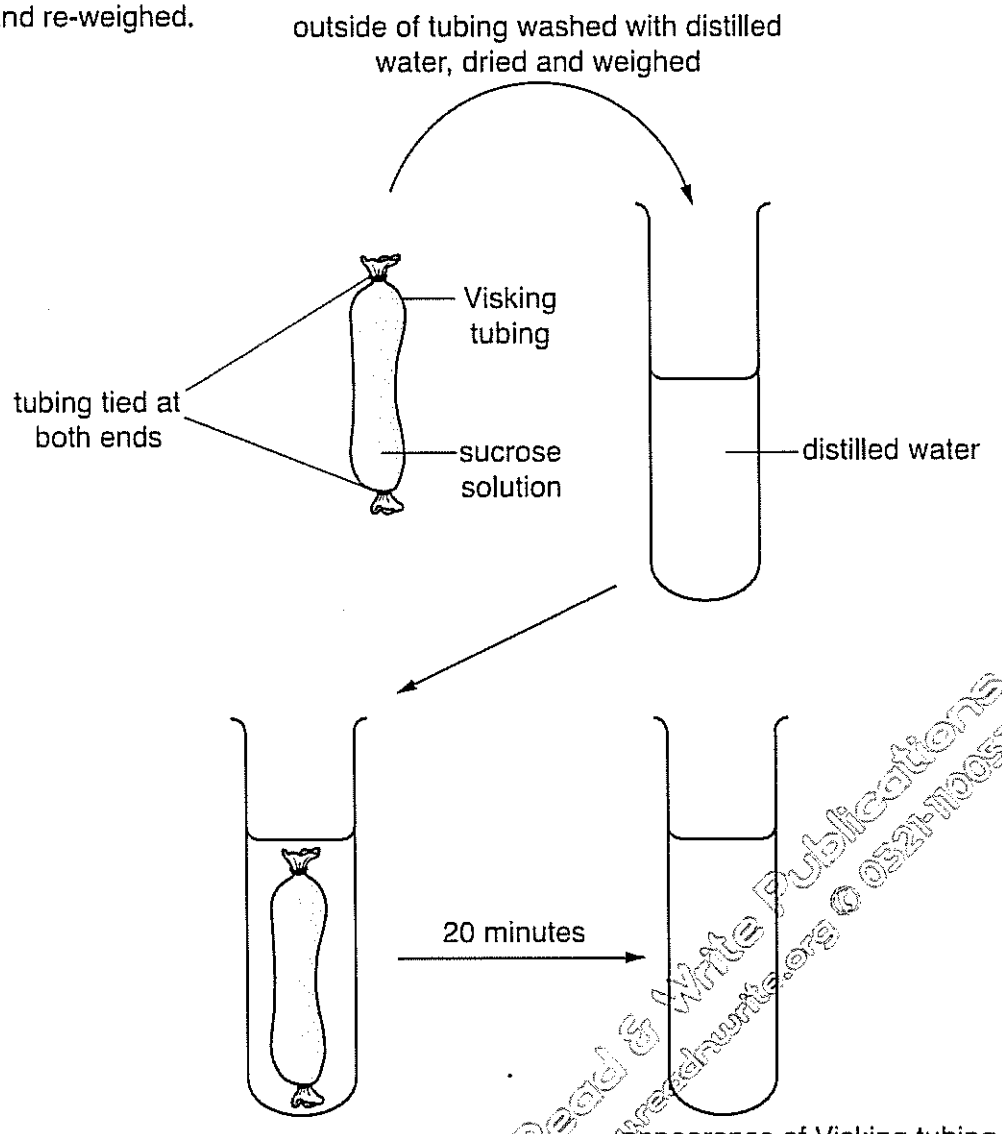


Fig. 2.1

(i) Complete Fig. 2.1 to show the appearance of the Visking tubing inside the test-tube after 20 minutes. [1]

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(ii) State, **with reasons**, whether there would be a change in the mass of the Visking tubing containing the sucrose solution after 20 minutes.

.....

.....

.....[3]

28. O/N 16/P21/Q1/d

(a) Sodium ions cross cell surface membranes using facilitated diffusion or active transport. Explain why sodium ions cross cell surface membranes by these mechanisms and **not** by simple diffusion.

.....

.....

..... [3]

29. M/J 16/P21/Q6

Fig. 6.1 shows an incomplete diagram of the fluid mosaic model of membrane structure. The diagram shows the cell surface membrane of a eukaryotic cell.

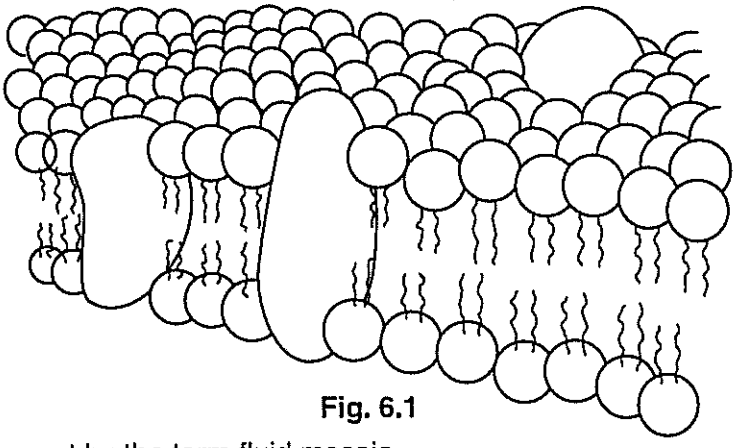


Fig. 6.1

(a) State what is meant by the term fluid mosaic.

.....

..... [2]

(b) State the thickness of a cell surface membrane.

.....[1]

(c) List four features of cell surface membranes of eukaryotic cells that are **not** visible in Fig. 6.1.

1 .....

2 .....

3 .....

4 ..... [4]

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30. O/N 15/P22/Q4

(a) Table 4.1 describes three examples of substances moving into or out of cells.

Complete Table 4.1 by identifying the transport mechanism involved for each example.

Table 4.1

example	transport mechanism involved
uptake of magnesium ions from a lower concentration in the soil solution to a higher concentration in the cytoplasm of a root hair cell	
release of antibodies from an active B-lymphocyte (plasma cell)	
movement of sucrose from a companion cell into a phloem sieve tube element via plasmodesmata	

[3]

(b) Oxygen moves into and out of red blood cells. Fig. 4.1 shows an oxygen dissociation curve for adult human haemoglobin.

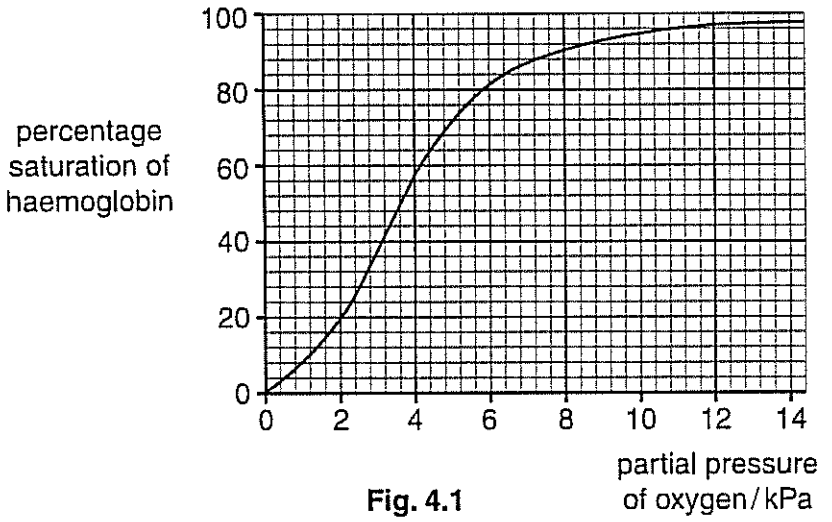


Fig. 4.1

The steepest part of the curve is between 2.6 kPa and 4.2 kPa.

Explain the importance of this for respiring tissues.

.....

..... [2]

31. O/N 15/P21/Q2

Fig. 2.1 is a diagram of the structure of a protein channel for ions in a cell surface membrane.

Fig. 2.1a shows the channel when open and Fig. 2.1b shows the same channel when closed.

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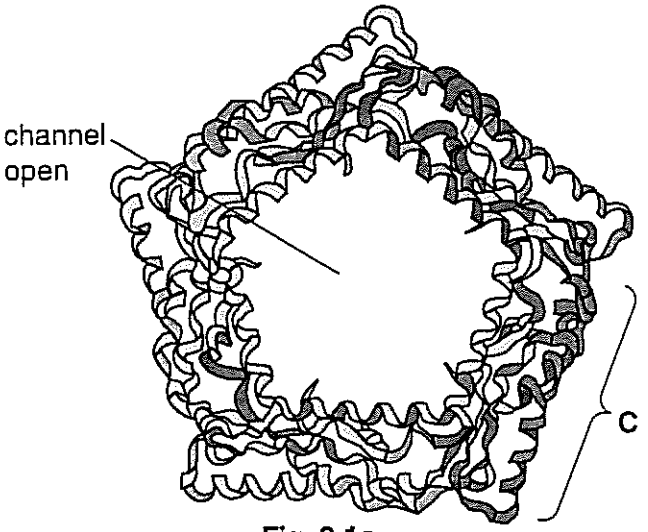


Fig. 2.1a

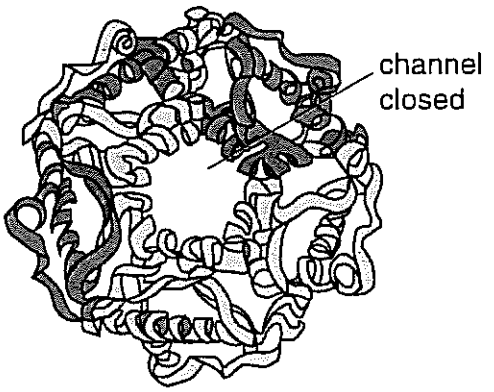


Fig. 2.1 b

(a) (i) Name the process by which ions pass across the membrane using channel proteins.

..... [1]

(ii) Explain why a channel protein is needed for ions to pass across a cell membrane.

.....

..... [2]

(b) The channel protein in Fig. 2.1 is made from five identical polypeptide chains.

(i) Name the level of protein structure which is present when five polypeptide chains form the protein.

..... [1]

(ii) The part labelled **C** in Fig. 2.1 is another level of protein structure.
Name this level.

..... [1]

(c) Channel proteins are examples of transmembrane proteins. The polypeptides are held together and also interact with phospholipids in the membrane.
Suggest how the polypeptides are held together **and** suggest how they interact with phospholipids.

.....

.....

..... [3]

32. O/N 15/P23/Q3/f

The enzyme catalase is found in many plant and animal tissues.
The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism. The reaction is:

$$2H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2H_2O$$

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A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *Anopheles gambiae*, an important vector of malaria. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.
The results are shown in Fig. 3.1.

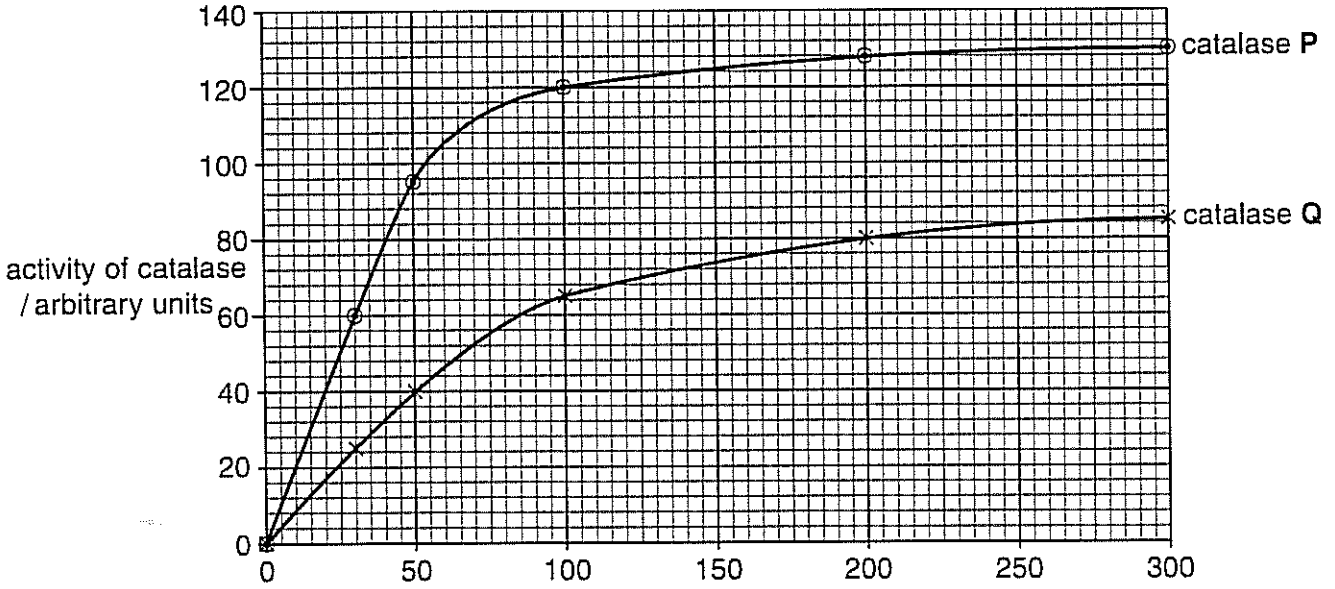


Fig. 3.1

(a) Describe three roles of cell surface membranes, **other than** the transport of substances into and out of cells.

1. .....

2. .....

3. ..... [3]

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33. M/J 15/P21/Q5/b

(a) Cells in the pancreas secrete enzymes, such as amylase and trypsin, into a duct.
The enzymes are packaged in vesicles so that they can be exported from these cells as shown in Fig. 5.2.

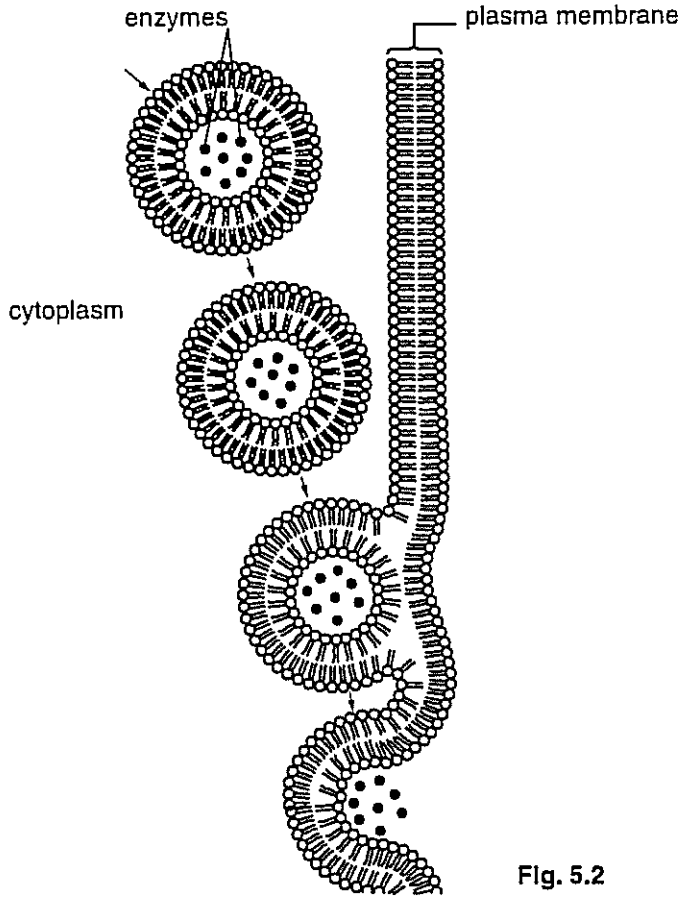


Fig. 5.2

With reference to Fig. 5.2, explain how enzymes that are secreted by cells in the pancreas are packaged into vesicles and exported.

.....

.....

..... [4]

34. M/J 15/P23/Q1

The cell surface membrane has a fluid mosaic structure.

(a) Describe what is meant by the term *fluid mosaic.*

.....

..... [2]

(b) In 1934, the biologists Davson and Danielli published their suggestion for the structure of the cell surface membrane, as shown in Fig. 1.1.

They suggested that the membrane was a phospholipid bilayer with a layer of hydrophilic protein on both surfaces.

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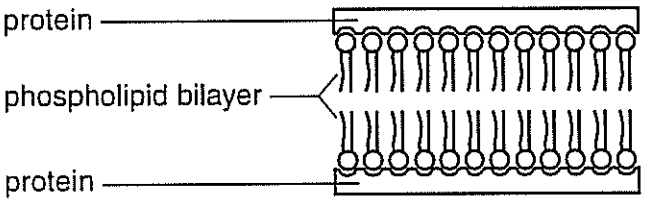


Fig 1.1

State **one** way in which the Davson-Danielli structure is similar to the fluid mosaic structure **and one** way in which it differs from the fluid mosaic model.

similarity

..... [1]

difference

..... [1]

(c) One way in which substances can cross cell membranes is by active transport.
Describe the mechanism of active transport.

.....

.....

..... [3]

(d) High temperature can damage cell membranes. One factor contributing to this damage is the denaturation of membrane proteins.
Describe how proteins become denatured at high temperature **and** explain how this could lead to damaging cell membranes.

.....

.....

..... [3]

35. M/J 14/P23/Q3/a,b

The enzyme glutamyl-tRNA reductase (GluTR) is present in many bacteria to make a product which is essential to their survival.

GluTR acts on the substrate glutamyl-tRNA, which is composed of the amino acid glutamic acid attached to a tRNA.

Fig. 3.1 shows the structure of glutamyl-tRNA and another compound called glutamycin.

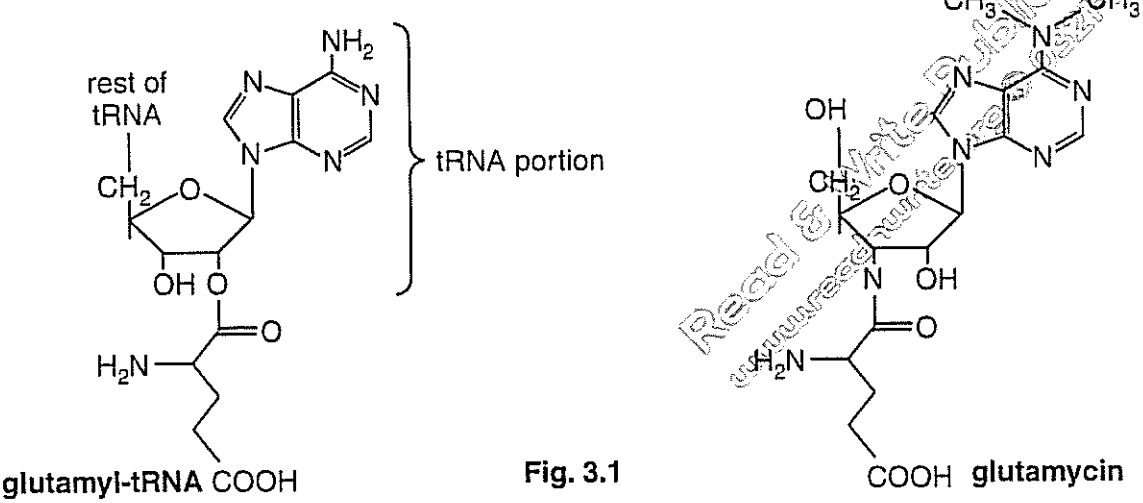


Fig. 3.1

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(a) Explain how glutamycin can act as an inhibitor for the enzyme GluTR.

.....

.....

.....

..... [4]

(b) The bacteria take in glutamic acid by active transport.
Describe the process of active transport.

.....

.....

..... [3]

36. O/N 13/P21/Q2/c

(a) Some pea plants were grown with their roots in a solution of mineral ions. The solution was kept aerated for three days.
The concentrations of five ions in the solution and in the root tissue were determined after the three days. The results are shown in Table 2.2.

Table 2.2

ion	concentration / mmol dm^{-3}	
	surrounding solution	root tissue
potassium (K^+)	1.0	75.0
magnesium (Mg^{2+})	0.3	3.5
calcium (Ca^{2+})	1.0	2.0
phosphate (PO_4^{3-})	1.0	21.1
sulfate (SO_4^{2-})	0.3	19.7

With reference to Table 2.2, suggest how cell surface membranes of root cells are responsible for the concentrations of ions in the roots compared to the surrounding solution.

.....

.....

.....

.....

..... [5]

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37. O/N 13/P21/Q4

Cholesterol is synthesised in the smooth endoplasmic reticulum (SER) in liver cells by a series of enzyme-catalysed reactions.

Within the SER, molecules of cholesterol and triglycerides are surrounded by proteins and phospholipids to form lipoproteins. These lipoprotein particles enter the Golgi apparatus where they are packaged into vesicles and pass to the blood.

Fig. 4.1 is an electron micrograph of part of a liver cell showing lipoprotein particles within the Golgi apparatus.

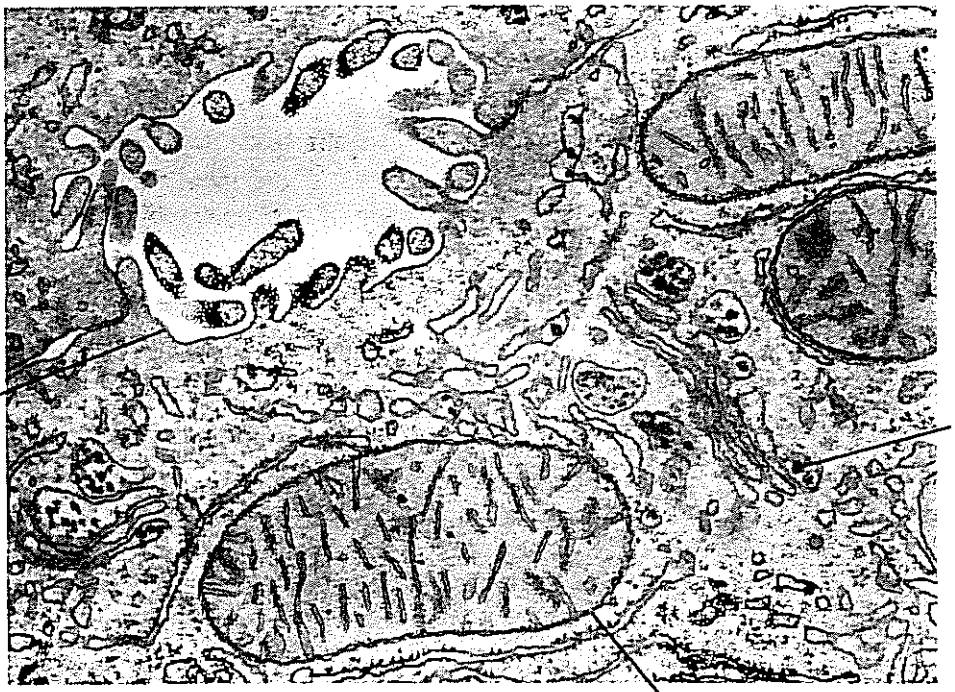


Fig. 4.1

(a) Name structure **T** in Fig. 4.1 and state its role in liver cells.

.....

.....

..... [3]

(b) (i) Suggest why cholesterol is packaged into lipoproteins before release from liver cells into the blood.

..... [1]

(ii) Explain why cells of the body need to be supplied with cholesterol.

.....

..... [2]

(c) Cholesterol is also packaged into vesicles by the SER and then secreted from the cell into small fluid-filled spaces between the liver cells. These spaces form ducts that drain into the gall bladder to form bile.

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Suggest how cholesterol is secreted into ducts, such as the duct in Fig. 4.1.

.....

..... [2]

(d) State **one** function of the Golgi apparatus **other than** the packaging of substances into vesicles for transport.

..... [1]

38. O/N 13/P23/Q5/c

(a) Digested material in animals is absorbed using both facilitated diffusion and active transport.

State two similarities **and** two differences between facilitated diffusion and active transport.

similarities:

1. .....

2. .....

differences:

1. .....

2. ..... [4]

39. M/J 13/P22/Q4/c

In some organisms, trehalose is used as an energy store and gives protection against the harmful effects of very low temperatures. Trehalose is sometimes referred to as a cryoprotectant, allowing organisms to survive in freezing conditions.

Freezing temperatures can damage the cell surface membrane and membranes within the cell.

(a) Explain the importance of the cell surface membrane to cells.

.....

.....

..... [3]

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40. M/J 13/P21/Q5

Fig. 5.1 shows a section of a cell surface membrane.

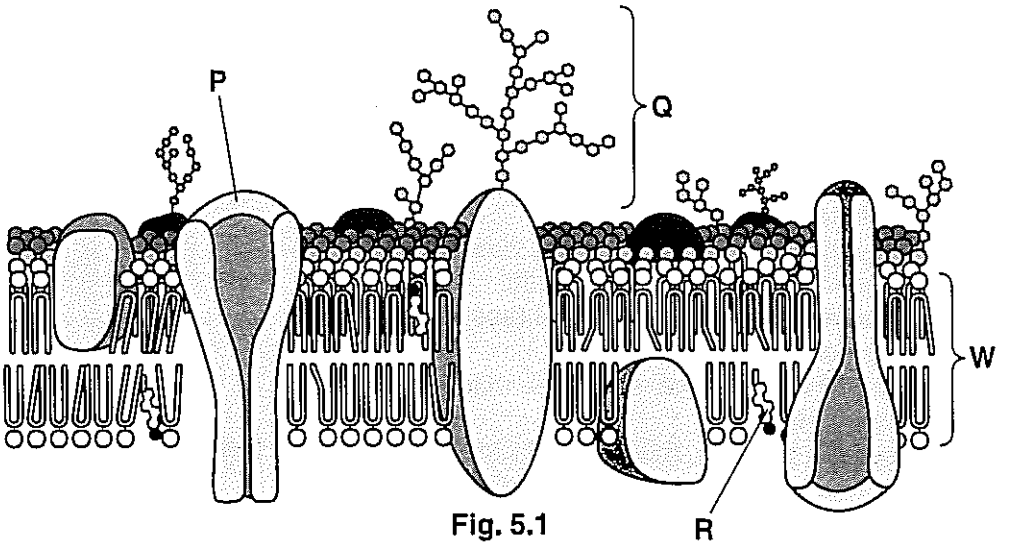


Fig. 5.1

(a) State the functions of structures **P**, **Q** and **R**.

P .....

Q .....

R ..... [3]

(b) Circle the width of the membrane shown as **W** in Fig. 5.1.

17.0 μm 1.7 μm 0.7 μm 70.0 nm 17.0 nm 7.0 nm 0.7 nm [1]

(c) Membranes, such as the cell surface membrane, are described as having a fluid mosaic structure.

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

.....

..... [2]

(d) Aquaporins are membrane channel proteins in plant and animal cells. They permit the movement of water across membranes. Explain why they are necessary.

.....

.....

..... [3]

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Answers Section

1. M/J 22/P22/Q1

(a) **I** *ref. to* resolution

*any **one** from:*

Fig. 1.1**A** is scanning (EM), qualified ;

e.g. shows, surface / contour / 3-D, views

shows (only the), the outer / external, view (of microvilli)

idea of good focus with different depths

does not have stated feature of TEM (see mp2)

Fig. 1.1**B** is transmission (EM), qualified ;

e.g. showing, 2D / flat, views (of, microvilli / mitochondria)

image in one plane

showing section through, mitochondria / microvilli / cell **I** thin

shows, internal view of cell / contents of cell / AW

does not have stated feature of SEM (see mp1)

scanning (EM) stated plus feature
<u>and</u>
transmission (EM) stated plus feature
; if Fig. 1.1, **A** / **B** not identified

(b) *any **two** from: max 1 if stating to measure one of the sides of the figure*

(for each image) measure a number of microvilli and calculate a mean ;

same units for actual and measured images / example given ;

e.g. *if microvillus measurement is in mm*

convert, microvillus measured length to μm / actual length to mm

R if extra detail given is incorrect e.g. <u>divide</u> by 1000 for mm to μm

divide, microvillus / image, length by, actual length / AW / 1(μm) ;

A *idea that* /

(c) (i) *any **two** from:*

(movement of substances) against concentration gradient / from low(er) to high(er) concentration ; (protein has) binding site(s) ;

specific ; **A** description e.g. shape complementary to shape of substance

can be in context of protein or binding site

ref. to (binding causes protein), conformational change / change of shape ;

(ii) *any **two** from:*

1 glucose is moving against a (concentration) gradient ; AW e.g. low to high

2 movement powered by inward movement of Na^+ ; AW

3 Na^+ movement (into cell from gut lumen) down an electrochemical gradient **or** down a (Na^+), concentration / diffusion, gradient
or by facilitated diffusion, gradient;
A diffusion if response includes *ref. to* the cotransport protein / cotranporter

4 AVP ;
e.g. *idea that*, cotransport needed so that <u>all</u> glucose will be removed from gut lumen ora facilitated diffusion of glucose will only be to equilibrium/AW
cotransporter has (specific) binding site for glucose
I cotransporter has a complementary shape
idea that there is no specific active uptake protein for glucose

(iii) increases / larger / large, surface area (over which glucose can enter cell per unit time) ; **A** increases / higher / high ,SA:V

idea of (so) more, transport / carrier / cotransport, proteins

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A more cotransporters
or
more proteins, located in membrane / AW ; **R** pump proteins
A *idea of* more space / places, where proteins can transport glucose

(d) *any **four** from:*

suggestion max 3	explanation
1 to replace, old / dead / damaged / injured, cells **or** to, repair / replace, damaged tissue ; **I** repair cells **I** replace old tissues	6 *idea of* <u>function</u> in context of mp1 or 2 or 3; e.g. repair allows tissues to function specialisation / differentiation, allows, cells / tissue,to function genetically identical so cells can function as a tissue *look for other approaches e.g.* *'replace damaged cells that no longer function'* is mp1 and mp6
2 cells are produced that can, differentiate / become specialised (into intestinal cells); **I** multipotent / AW **R** if, stated / strongly implied that, <u>all</u> cells produced by mitosis become specialised	7 detail of function (intestines) ; e.g. absorption (of, glucose / nutrients) production of digestive enzymes pass absorbed, nutrients / AW, to blood **I** nutrition
3 produce cells that are genetically identical ; **A** clones **A** identical / same, DNA / genetic material / genetic information	
4 growth ; **R** growth of cells	8 idea of development during, infancy/childhood;
5 renew / replenish / restore number of / AW, stem cells ; **I** increase in stem cells	9 for, continued production / constant supply / AW, of intestinal cells **or** so that number of stem cells doesn't decrease;

[13]

2. M/J 22/P23/Q3

(a) *any **three** from:*
decreases / reduces, transpiration ; **A** lower transpiration rate
accept in the correct context once only
counts towards max two
I evaporation
max two for cuticle
thick (waxy) cuticle ;
increased waterproof layer ;
increased (diffusion) distance for <u>water vapour</u> / less <u>water vapour</u> lost ;
in context of cuticular transpiration
max two for stoma
sunken stoma ; **A** stoma in depression / AW
moist / humid, air collects in area near to external environment ; AW
decreases water potential gradient ;

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in context of between sub-stomatal air space or area above stoma and external environment
alternative acceptable statement for the transpiration mark
reduces diffusion of water vapour (out) via the stoma ;

(b) (i) *any **three** from:*
(many) mitotic cell cycles / mitoses ; AW
ref. to division of (meri)stem cell also produces more (meri)stem cells ;
formation of rootlets by mitosis is, growth / increase in number of cells ;
idea of producing large number of cells
R cell growth
differentiation / specialisation ;
in context of the new cells formed by stem cell division

(ii) *any **three** from:*
active transport occurring ;
(pumped / moved, out) against the(ir) concentration gradient ;
(move out through), carrier / pump, protein ; **R** channel protein
using, ATP / energy ; **A** have ATPase activity
AVP ; e.g. membrane impermeable to entry of anions
suggestion that move out by exocytosis *allow ATP mp if also stated*;

(iii) *any **two** from:*
increased surface area ;
(because, many / more) root hairs / root hair cells ;
increase in, carrier proteins / channel proteins (for ion uptake) ;
A transport proteins / aquaporins (for water)
R channel proteins
AVP ; increase in water uptake osmotically to follow ion uptake / AW ; [11]

3. M/J 22/P23/Q5

(a) *any **two** from:*
ref. to can organise / order, enzymes / events, in pathway ;
consequence in terms of distance ;
e.g. product of one reaction is close to next enzyme (where it acts as substrate)
enzyme (more likely to be) closer to substrate
distance between enzymes shorter
I short distance / less distance to travel, unqualified
(so) increases chance of successful collisions between substrate and enzymes ;
increased rate of formation of final product
or
decrease time for ES complex to occur ;
idea that products can pass to either side of the membrane ;
all reactions, localised / occur in the same location (within the cell) ;
AVP ; e.g. membrane provides a source of arachidonic acid
I phospholipid

(b) (i) (similar shaped) curve to the right of main curve and reaches V_{max} ;
A increasing to reach V_{max}

(ii) stays the same ;
increases ;

(c) (i) the gene / PTGS2, is a sequence of nucleotides, that forms part of a DNA molecule / AW / on chromosome 1 ;
A bases

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codes for (the production of) a, polypeptide / enzyme / COX-2 ;
A protein **I** codes for an amino acid
max one if no example used

(ii) *any **two** from:*
more, product / compounds, produced that stimulate mitosis ;
increased, DNA replication / cell division / mitosis ;
I *ref. to* cancer cells replicating
idea that, may lead to / increases chance of / AW, (other) mutations ;
mutations can result in oncogenes ;
AVP ; e.g.
idea that proof checking capacity impaired / increased chance of errors

(d) *any **three** from:*
phospholipids may be, used in / added to, the (cell surface) membrane ;
arachidonic acid, is unsaturated / polyunsaturated ;
has, C=C / (carbon-carbon) double bonds ;
allow ecf if stated as saturated
unsaturated fatty acid tails, have kinks / not linear / AW ;
A double bonds produce, kinks / AW
increased distance between, phospholipids / other fatty acid tails ;
A phospholipids cannot pack closely together
less hydrophobic interactions between phospholipid (molecules) ; [12]

4. **O/N 21/P22/Q1/b**
(a) *any **three** from:*
A particles *for substances* **I** *ref. to* size
1 for transport of ions <u>and</u>, hydrophilic / polar, molecules / substances AW
or
for transport of substances that cannot pass (directly) across the (phospholipid) bilayer / hydrophobic core ; AW
R if implied that all substances cannot cross the bilayer
I substances, bypass / do not need, to cross the bilayer
2 carrier proteins for active transport and facilitated diffusion <u>and</u> channel proteins for facilitated diffusion;
3 further detail carrier protein ; **I** water-filled / hydrophilic interior
e.g. have specific binding sites
are specific in, molecule / ion / named example, transported AW
carry out conformational change (following binding) / AW
use, ATP / energy active transport)
moves substances against the concentration gradient / AW (active transport)
moves substances down the concentration gradient / AW (facilitated diffusion) *accept once in mp3 or 4*
I moves substances by diffusion
4 further detail channel protein ;
e.g. hydrophilic / water-filled, pore / channel **A** hydrophilic lining
some, ion channels / proteins channels for ions, are selective (for size and charge)
(most) channel proteins are not selective
aquaporins for passage of (larger quantities of) water
some, are gated / voltage-gated
moves substances down the concentration gradient / AW [3]

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5. O/N 21/P21/Q2/b

(a) (i) bilayer drawn with heads pointed outwards and tails pointed inwards ;
phospholipid drawn with one (phosphate) head and two fatty acid tails ;

(ii) *any **one** from:*
cholesterol, maintains / regulates, the fluidity of the membrane ;
A reduces fluidity at high temperature / increases the fluidity at low temperatures
maintains / regulates, (mechanical) stability of the membrane / AW;
prevents entry of hydrophilic substances / AW / ions ; [3]

6. O/N 21/P23/Q4

(a) *any **two** from:*
cellulose molecules

1 straight (chains) / linear / unbranched ;
2 arranged in parallel ;
3 hydrogen bonds between (cellulose) molecules ;
4 any detail, e.g. between H of –OH groups and –O of –OH groups ;
A between -OH groups
5 AVP ;
e.g. cellulose molecules have, staggered / overlapping, ends
I overlapping microfibrils

(b) (i) *any **three** from:*

1 two layers of phospholipid ;
2 label for, phospholipids / phospholipid bilayer ;
3 channel protein across whole bilayer with <u>hole through middle</u> + label ; ecf if a monolayer shown or no phospholipids drawn
4 any additional feature + label ;
e.g. hydrophilic heads / hydrophobic tails / cholesterol / other named protein (e.g. glycoprotein)

(ii) *any **two** from:*

1 to allow <u>facilitated diffusion</u> ;
R active transport
2 ions are, charged / hydrophilic ;
3 cannot pass through, hydrophobic core / phospholipid bilayer ;
A ora – channel proteins provide a, hydrophilic / water-filled, pathway (through the membrane) / AW
A channel proteins are lined by polar R groups
A ions are repelled by, hydrophobic core / phospholipid bilayer

(c) *any **three** from:*

1 transpiration (rate), will not decrease to a low level / remains the same (if conditions remain the same) / remain the
same at night / increases if (named) condition(s) change / AW;
2 <u>water vapour</u> continues to <u>diffuse out</u> (from intercellular air spaces) ;
3 (because) stomata, cannot close / remain open ;
4 guard cells do not lose turgidity ;
5 because no outward flow of water (from guard cells) ;
6 by osmosis / down water potential gradient (from guard cells) ;
7 AVP ;
e.g. *ref. to* more likely to wilt
rates of gaseous exchange remain the same [10]

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7. M/J 21/P22/Q3/b,c,d,e

(a) *any two from:*

1 can cross / AW, hydrophobic core (of bilayer) / phospholipid bilayer
or
can pass through gaps between, fatty acid tails / phospholipids ;

2 is, hydrophobic /lipid-soluble / non-polar / not ionic / not charged
or
not, hydrophilic / water-soluble / polar / ionic / charged ;

3 small size ;

(b) **Reject** if hormone S or receptor **R** described as an antigen or enzyme
complementary (shape) to / only fits into / specificity for (binding to),
R / receptor ;

(c) **(i)** nuclear pore ; **A** nuclear pores

(ii) **B** = transcription ;
C = translation ;

(iii) (80S) ribosome ; **I** 70S

(d) *any four from*

1 (formation of), secondary / 2° / second level, structure with, alpha-helix / α-helix / beta-pleated sheet(s) / β-pleated sheet(s) ;
A β-conformation for β-pleated sheet
I incorrect detail of bonds

2 folding / coiling, to form tertiary / 3° / third level, structure ;
A *ref. to* 3D structure as alternative to, folding / coiling
A secondary structure, folds / coils, to form tertiary structure
R alpha helix / beta-pleated sheet, coils / folds

3 *two of* hydrogen bonds / ionic or electrostatic bonds / disulfide bonds or bridges / hydrophobic interactions ;
I peptide bonds *as part of a list that contains two correct bond types*
these must be in context of tertiary structure

4 (formation of), quaternary / 4° / fourth level structure ;
A description e.g. polypeptides held together by, interactions / hydrogen bonds / ionic bonds / disulfide bonds
R if peptide bonds included

5 (globular protein) has hydrophilic, amino acids / R-groups / side chains, to, outside / AW ;
ora hydrophobic, amino acids / R-groups / side chains, towards centre / AW

6 example of other post-translational modification ;
e.g. removal, methionine / met
addition sugar group / glycosylation
addition phosphate group / phosphorylation
addition prosthetic group [11]

8. M/J 21/P22/Q5/a,b

(a) plasmodesma ;

plus any one from
R if stated as apoplast

1 allows / AW, symplast, pathway / movement ;

2 allows transport of / AW, water / sucrose / sugars / amino acids / organic substances / ions / mineral salts (**A**

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minerals) / lipids / assimilates / hormones / cell signalling molecules ; *in context of* between cells
I substance unqualified
I osmosis of water if in a longer list where other substances are named correctly
R osmosis of water *if this is the only item noted*

3 cell to cell / AW, communication / signalling ; A cell communication

(b) (i) *any one from*
(only) polypeptides / proteins, synthesised at ribosomes ;
carbohydrates / polysaccharides, not synthesised at ribosomes ;
enzymes, for synthesis / required, not located at ribosomes ;

(ii) exocytosis ; [4]

9. M/J 21/P21/Q3

(a) *any three from*

1 *differences in height show that*
concentrations of sucrose, 0, 0.4 and 0.8 (mol dm^{-3})
or ⩽ / less than, 0.8 / 0.9, water moves out of Visking tubing ;
A one of 0, 0.4 or 0.8 R sucrose moving

2 concentrations of sucrose 1.2, 1.6, 2.0 (mol dm^{-3}) *or* ⩾
/ more than, 0.9 /1.2, water moves into Visking tubing ;
A one of 1.2, 1.6 or 2.0 R sucrose moving

3 *ref. to* net water movement ;
if water enters Visking tubing – **A ora** *for water leaving*

4 external solution has higher water potential (than contents of Visking tubing) ;
A high water potential to low water potential

5 water moves, down, water potential / Ψ, gradient ;

(b) *mark whole question to a max of four marks*
descriptions

1 at concentrations, less than / ⩽, 0.04 mol dm^{-3} all cells, burst / AW ;

2 at concentrations between 0.04 and 0.14 mol dm^{-3} decreasing percentage of cells burst / AW ; A use of percentages

3 at concentrations, greater than / ⩾, 0.14 mol dm^{-3} no cells, burst / AW ;

explanations to max 3

4 in low concentrations / ⩽ 0.04, of sodium chloride water moves into cells down water potential gradient / from high Ψ to low Ψ ;

5 cells increase in, volume / size / internal pressure ;

6 *either*
cell membranes are not strong enough to withstand increase in volume / pressure
or
red blood cells burst because they have no cell wall ;

7 between 0.04 and 0.14 (mol dm^{-3}) water potential gradient into cells, decreases / becomes less steep / AW ;

8 above 0.14 (mol dm^{-3}) / in high concentrations, water potential inside cells is the same or higher than the sodium chloride solution ;

9 at high concentration / ⩾ 0.14, water leaves cells / cells shrink / cells shrivel / cells show crenation ; [7]

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10. M/J 21/P21/Q6

(a) **A** rough endoplasmic reticulum ;
E Golgi, body / apparatus / complex ;

(b) transport from, (R)ER / ribosomes, to Golgi ; **A** from **A** to **E**
A transport from Golgi to, cell surface membrane / phagosome
A separate, acid hydrolases / enzymes, from, rest of cell / AW

(c) phagocytosis / endocytosis ;

(d) *any three from*
1 break down / digest / destroy, bacteria / pathogen(s) ;
2 break down / digest / destroy, (worn out / defective / AW), organelles / named organelle (in animal cell); **A** autophagy
3 catalyse / speed up, hydrolysis ;
4 any **two** named substrates ;
e.g. (any named) polysaccharides / proteins / (phospho)lipids / (named) nucleic acids
5 *idea that* recycle / reuse, biological molecules within cell ;
6 (macrophage / phagocyte) cut up to present antigen ;

(e) moves / pump(s), hydrogen ions / protons, into the lysosome against concentration gradient ;
active transport / uses ATP / energy from respiration / ref to conformational change of carrier ;
R if a ref to facilitated diffusion [9]

11. M/J 21/P23/Q1

(a) *structure max 2 marks*
1 RER has ribosomes **R** *if context is within lumen*
or
SER does not have ribosomes ;
2 RER, flattened sacs / cisternae, and SER tubular ; AW
3 RER continuous with, (external) nuclear membrane ; **ora**
I near to nuclear membrane
R continuous with internal nuclear membrane
4 *ref. to* RER, more regular / layered, arrangement
or
SER more irregular / disorganised, arrangement ;

function
5 RER produces / transports, proteins / glycoproteins ; **A** polypeptides
A examples of post-translational modification
6 SER produces, lipids / cholesterol / steroids ; **A** stores
I produces hormones

(b) *any two from*
ref. to phosphate (group) and two fatty acid, chains / tails / residues ;
A two hydrocarbon chains
correct *ref. to* attachment, phosphate / fatty acids, to glycerol ;
AVP ; e.g. *ref. to* ester bond
ref. to additional group e.g. choline-containing
ref. to, saturated / unsaturated, (fatty acid tails)
award marks from an annotated diagram

(c) (i) flattened sacs / cisternae ;
stack / layered / described ;
any one from
idea that each cisterna in stack is, separate / not interconnected ;
smooth (outer surface) / no ribosomes ;

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close to, nucleus / RER ;
single membrane ;
AVP ; e.g. two distinct faces
ref. to swollen ends to cisternae

(ii) *ignore events occurring before vesicle formation*
any three from
vesicle moves to, cell surface / cell (surface) membrane ;
A plasma membrane
movement of vesicle via, cytoskeleton / microtubules ;
vesicle fuses with (cell surface) membrane (and protein released) ; AW
e.g. vesicle makes contact with membrane and becomes part of it
I attaches to / binds to
exocytosis ; **I** bulk transport / excreted / secreted
allow in context of release only or movement from Golgi and release

(iii) *any one relevant e.g.*
acts as (self-)antigen / recognition site / cellular recognition / receptor / membrane stability / cell adhesion ; **I** involved in cell signalling [11]

12. M/J 20/P23/Q6

(a) *any three from*
idea that water moves down a water potential gradient / from a high to low water potential / AW ; sucrose solutions produce differences in water potential inside the cell and externally
or
different concentrations of external sucrose solution produces different gradients of water potential ;
high concentration of, sucrose / solutes, is, lower / more negative, water potential ; ora
loss of water by osmosis out of potato cells lowers mass of block ; ora for gain of mass
no net gain or loss means water potential inside and out are equal ;

(b) concentration where the, curve / line, crosses the *x*-axis (and use a reference table)
or
the concentration at which there is zero percentage change in mass (and use a reference table); [4]

13. O/N 19/P22/Q3/a,b

(a) *any two from:*
1 higher / better, resolution
A higher resolving power
I clearer resolution
or
greater ability to distinguish between two points / AW ;
*ignore wavelength values if stated as wavelength but **R** if stated as resolution values*

2 *ref. to* resolution values ;
e.g. able to see points closer together than 200 nm (range 100–300 nm)
can see, points up to 0.5 nm (0.0005 µm) apart (range 0.2–1.0 nm)
can see structures larger than 0.5 nm

3 thinner sections can be obtained ;
A idea that complete image will be in better focus

4 able to see, ribosomes / membranes / detail within organelles ;

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(b) *any three from:*

1 (shape of) red blood cell is biconcave *accept biconcave from a diagram*
or
(shape of) erythroblast is, cuboidal / spherical / not biconcave / irregular / AW ;

2 red blood cell has no nucleus / erythroblast has nucleus ;

3 erythroblast has, mitochondria / organelles / named organelles
or
red blood cell has no, mitochondria / organelles / named organelles ;

4 red blood cell has more haemoglobin / erythroblast has less haemoglobin ;
I *ref. to* haem
statement only about erythroblast:
A erythroblast has no haemoglobin
statement only about rbc: must say <u>more</u> haemoglobin
statement with both:
A red blood cell has haemoglobin, erythroblast has no haemoglobin

5 AVP ; e.g. erythroblast, is larger / basophilic
red blood cell is more flexible [5]

14. O/N 19/P21/Q3

(a) between 0 – 0.2 mol dm^{-3} the mass of the potato increases
or
between 0.2 – 1.0 mol dm^{-3} the mass of the potato decreases ;
no change in mass at 0.2 mol dm^{-3} ;
from approximately 0.2 mol dm^{-3} increasing concentration gives a greater decrease ;
comparative data quote including two concentrations and two percentage changes ;
units for concentration of sucrose and reference to percentage change in mass must appear once to award this point

(b) *three from*
decrease in mass because
water (molecules) leave the cells ;
by osmosis ;
down a water potential gradient / from higher water potential to lower water potential
or
solution has a more negative water potential than the potato tissue ;
ref. to plasmolysis / loss of turgidity ; [6]

15. O/N 19/P21/Q5/b(ii),c

(a) (i) *three from*
active site of enzyme **Y** is, not (fully) complementary / partially complementary ;
active site, moulds to fit / becomes fully complementary to, cell signalling molecule ;
enzyme-substrate complex forms ; **A** ESC forms
ref. to interaction between substrate and R groups of enzyme amino acids ;
lowers activation energy ;
products leave the active site ;
enzyme molecule unchanged / able to be re-used ;
AVP ; e.g. detail of how activation energy is lowered

(b) *three from*
I *statements about locating or diagnosis of disease*
specific / targeted, therapy / treatment ; AW **A** only affects, one cell type in the body / B lymphocytes bind to / recognition of, receptors / antigens / CD20, on cell surface (of diseased cells) ; **A** in context of B lymphocytes or diseased cells

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monoclonal antibodies, are not recognised as foreign / do not trigger an immune response ; **A** *ref. to* humanisation of antibodies example of presence of monoclonal antibody stimulating the immune system / AW ; *in context of examples given* **A** stimulates phagocytosis / activates B-cells

attach, radioactive substance / drug (to treat / kill, B lymphocytes / diseased cells) ; *must be in context* [6]

16. O/N 19/P23/Q6

(a) (i) nanometres / nm ;

(ii) **A ora** throughout
(presence of) carbohydrate / sugar, chains / residues, on, (glyco)proteins / (glyco)lipids ;
A there are no sugar chains on the inner surface
A (presence of) glycoproteins / glycolipids (on external surface)
A (presence of) cell surface antigens / receptors (on external surface)
A (presence of) glycocalyx

(b) **R**
1 cholesterol ;
one from
2 maintains / regulates, fluidity of, membrane / phospholipid bilayer
or
at low temperatures, maintain / increase fluidity / prevents close packing
A prevents hydrophobic 'tails' interacting at low temperatures
or
at high temperatures, stabilises the membrane / decreases fluidity ;
3 prevents passage (across membrane) of, hydrophilic / polar, substances ;
S
4 phospholipid (monolayer) ; **R** phospholipid bilayer
one from
5 forms a bilayer ;
6 (bilayer is a) barrier to, water soluble molecules / polar molecules / ions ;
ora not a barrier to lipid soluble molecules / allows lipid soluble molecules to cross **membrances A** non-polar / AW
7 (bilayer is a) non-polar barrier between cytoplasm and (aqueous) surroundings ;
8 hydrophilic 'head' forms hydrogen bonds with water ; [6]

17. M/J 19/P21/Q2

(a) *any two from:*
('kinks') prevents close packing of, phospholipids / membrane components, (at low temperature) ;
keeps / maintains, fluidity ; **A** increases
A ora - prevents becoming too rigid
idea of preventing damage to membranes by preventing freezing ;
maintains movement of (named) substances across membranes ;
A any named example of movement across membrane
R increases
AVP ; e.g. maintains movement of proteins within membrane

(b) (i) *idea that triglycerides and phospholipids*
are not composed of, monomers / repeating (sub-)units ;

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(ii) *any two from:*
phospholipids have
two fatty acids (residues / tails) not three ;
A hydrocarbon chains / aliphatic chains
A one less fatty acid (residue / tail) **A** ora
two ester bonds rather than three ;
a phosphate (group / head) ; **A** ora **R** 'phosphate not glycerol'
AVP ;
e.g. may have a (named) additional group, such as choline / AW
e.g. triglycerides do not have nitrogen / phospholipids may have nitrogen

(c) *any four from:*
1 thromboxane is a (cell) signalling molecule ;
A 'thromboxane acts as a signal' **I** 'messenger' / hormone
2 released into / circulates in / AW, blood / plasma ;
3 (smooth) muscle, cell / tissue, is target ;
4 thromboxane binds to receptors ;
5 *ref. to* thromboxane is complementary to receptor ;
6 (specific) response is smooth muscle (cell) contraction ;
R smooth muscle constricts
7 AVP ; e.g. detail of change, such as activating G proteins / secondary messenger / enzyme cascade / chain of reactions / AW [9]

18. M/J 19/P23/Q5

(a) (i) phagocytosis (of, dead cells / pathogens / AW) ;
A endocytosis of pathogens

(ii) (sodium chloride) solution has lower water potential (than cytoplasm) ; ora
A Ψ *for water potential*
water, leaves / AW, cell by osmosis ;

(b) (i) 13.56 ; **A** 13.6 / 14

(ii) *allow (red) blood cell count for mean red blood cell count*
allow ***ora***
any four from:
1 description of data ; e.g.
lowest mean red blood cell count for, (population) **A** / lowest altitude
(populations) **B**, **C** and **D** / all other altitudes, have a higher mean red blood cell count **than A** / 695m altitude
(population) **B** has highest mean red blood cell count
(population) **B** has higher mean red blood cell count than **C** and **D**
*physiological explanation population **A** compared to **B/C/D***
2 decrease in partial pressure of oxygen in the atmosphere with increase in altitude / AW
or
lower partial pressure of / less, oxygen in, inhaled air / lungs / alveoli AW
3 *ref. to* haemoglobin ;
e.g. lower saturation of haemoglobin with oxygen (in lungs)
lower affinity of haemoglobin for oxygen (in lungs)
more haemoglobin required to carry sufficient oxygen to tissues
4 suggestion of increase in count at 1676 m and above ;
e.g. rate of production of red blood cells increases
higher erythropoietin (EPO) levels
ref. to changed proportion of plasma to red blood cells / plasma volume decreases
5 little difference between **B**, **C** and **D** / AW ;

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6 differences in altitude are not great / AW ; *in context of* ***B, C, D***

7 *ref. to* genetic differences / adaptation to environment ;
allow if general statement includes population ***A***

8 AVP ; e.g. *ref. to* differences in demographics

(c) less haemoglobinic acid is formed / fewer hydrogen ions to bind to haemoglobin (to cause dissociation of oxygen);
any one from:
binds to allosteric site / site other than active site (of enzyme), qualified ;
e.g. causes change in shape of active site
substrate cannot bind to active site
fewer / no, enzyme-substrate / ES, complex formation
prevents / reduces / AW, carbonic acid / H_2CO_3, formation / AW ; A fewer hydrogen ions produced from carbonic acid dissociation [10]

19. O/N 18/P23/Q4/c

(a) *any four from*

1 noradrenaline is, signalling, molecule / compound ;
A noradrenaline is the signal
I noradrenaline is a (neuro)transmitter

2 SAN cell is the target cell ;

3 noradrenaline / signalling molecule, binds to (cell surface) receptors (of target cell) ;
A 'fits'
R 'receptor cells'

4 receptors are specific to noradrenaline ;
A *ref.* to complementary (shapes)

5 *ref.* to formation of cAMP / second messenger *or* activating enzyme ;

6 response is the opening of channel proteins (so calcium ions enter) ; [4]

20. M/J 18/P22/Q3/b,c(i)

(a) (i) ATP not required ; **A** (metabolic) energy not required

(ii) *four from:*

1 channel protein ; **A** pore protein / has a pore / has a channel

2 channel / pore, can form from polypeptides
or
(protein) has quaternary structure ;

3 hydrophilic R-groups, on amino acids lining channel / face inwards (towards channel) ;
A hydrophilic, lining / channel
A water-filled, channel / AW
A idea that passage is through hydrophilic region of protein

4 allows facilitated diffusion ; **A** diffusion alone if in context of through the protein but **R** if via phospholipid bilayer

5 increases permeability for, movement of water / osmosis ;
I faster

6 no (specific) binding sites / (channel) not specific / not selective / allows more than one type of substance through / AW;

7 globular ;

8 AVP ; e.g. ref. to hydrophobic part of protein, faces / interacts with, hydrophobic, region / core / fatty acid tails
ref. to hydrophilic parts of, protein / polypeptide, extend into, external environment / periplasm / aqueous regions / AW

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(iii) *two from:*
translation, cannot / does not, begin / occur
or
polypeptide / protein, synthesis, cannot occur / decreases ;
I ompF not made
A chain of amino acids
R transcription does not occur so translation does not occur
R if in context of mutation or enzyme inhibition
mRNA cannot attach to, ribosome / small subunit / ribosomal subunit ;
(first) tRNA (with UAC anticodon) / tRNA carrying met, cannot bind (to START codon) ;

(b) (i) (composed of) many / chain of / polymer of / AW, monosaccharides / sugar monomers / sugar units ;
A glucose, molecules / residues
A more than two / many sugars
further detail ; e.g. carbohydrate
may be, branched / unbranched *in context of polysaccharide*
macromolecule *in context of polysaccharide*
glycosidic bonds *in context of between sugar monomers*
(sugar monomers) joined by condensation reactions [9]

21. M/J 18/P21/Q6/d

(a) *assume answer is about facilitated diffusion unless told otherwise – accept* ***ora*** *for active transport*
two from:
movement is, down a concentration gradient ;
passive / ATP not required / (metabolic) energy not required ;
carrier and channel proteins are involved ; [2]

22. M/J 18/P23/Q2

(a) *too small to see*
35 μm is 0.035 mm (smaller than 0.05 mm)
or
0.05 mm is 50 μm (larger than 35 μm) ;

(b) *in context of light microscope*
two from:
1 resolution / resolving power, poor / not high enough / AW ;
2 ability to distinguish between two points not high enough / AW ;
3 ref. to limit of resolution ;
e.g. organelles smaller than, 0.2 μm / 200 nm, not visible
A organelles smaller than 200 nm (accept range 100–300 nm)
4 organelle too small to interfere with light waves ;
A wavelength of light too long
I organelles are small

(c) (i) ester ;

(ii) <u>facilitated diffusion</u> ;
plus two from:
(diffusion) through (membrane), transport / channel / carrier, protein ; **A** pore
I transmembrane / integral, protein
high to low concentration **or** down, concentration / diffusion, gradient ;
passive ; **A** no, ATP / (metabolic) energy, required
if active transport incorrectly stated allow ecf

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through (membrane), transport / carrier, protein ; **R** channel protein
low to high concentration / against a concentration gradient / requires ATP / requires (metabolic) energy ;

(iii) *four from:*
1 ref. to hormones, released into / arrive at adipocyte in, blood stream ;
A released by another, cell / tissue (elsewhere in the body)
2 hormone is, (chemical) signal / signalling molecule / messenger molecule ;
3 (adipocyte is) target cell ; **A** (adipose is) target tissue
4 (hormone) binds to / AW, receptor ;
in context of on cell surface membrane of adipocyte
5 ref.to receptor (shape) complementary to hormone ;
A specific receptor for hormone
6 (binding) triggers / stimulates, reactions within the cell ;
A cascade of reactions
I binding causes a reaction to occur
7 cell signalling results in a response, qualified ;
e.g. triglyceride breakdown
fatty acids (and glycerol) produced
fatty acids leave, the cell / via transport protein

(d) any one valid suggestion:
e.g.
do not have mitochondria / mitochondria required (to produce ATP) ;
do not have nucleus (so no mRNA produced) ;
no mRNA for enzyme synthesis ;
(required) enzymes not present ;
impermeable to fatty acids / AW ;
have lost / do not have, the required organelles ; [12]

23. O/N 17/P21/Q4/b,c

(a) *four from*
Asp and Gln R groups, hydrophilic / AW, and Ile R group, hydrophobic / AW ;
ref. to R group interactions and, folding / coiling, of polypeptide chain (to give globular structure);
ref. to (charged / polar R groups) forming, ionic / hydrogen, bonds ;
(amino acids with), hydrophobic / non-polar, R groups, on the inside / AW ; **A** hydrophobic amino acids
(amino acids with), hydrophilic / charged / polar, groups on outside / AW ; **A** hydrophilic amino acids
detail ; e.g. ionic R groups can interact with water, hydrogen bonds form with water
ref. to promotes stability / helps to maintain globular structure ;
in context of interaction with water/ formation of (compact) hydrophobic core

(b) glycosidic; [5]

24. O/N 17/P21/Q5/d

(a) (i) *fluid*
idea of phospholipid (and protein) molecules, move about / diffuse (within their monolayer);
mosaic
protein (molecules), interspersed / scattered / AW ; **A** different / AW, proteins ;

(ii) *any four from*
1 barrier between cytoplasm and, external environment / AW ; e.g. tissue fluid
A protects, organelles from damage / from pathogens, **I** keeps cell contents in /

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membrane surrounds the organelles
2 cell signalling
or
has receptors for, cell signalling substance / hormone / neurotransmitter / AW
3 cell recognition / acts as cell surface antigen ;
4 cell-to-cell adhesion ;
5 site for, enzymes / catalysing reactions ;
6 anchoring the cytoskeleton / AW ;
7 selection of substances that enter or leave a cell ; AW
8 formation of hydrogen bonds with water for stability ;
9 AVP ; e.g. *ref. to*, changing shape of cell / flexibility of cells e.g. phagocytosis [6]

25. M/J 17/P21/Q5/a
(a) sugar (molecules) / glucose / fructose, is polar / is water soluble / not lipid soluble / hydrophilic ; cannot pass through, (phospho)lipid bilayer / hydrophobic core / fatty acid 'tails' / hydrocarbon 'tails' ; **A** non-polar regions [2]

26. M/J 17/P23/Q4/c
(a) receptor(s) / cell signalling ;
cell recognition / antigens ;
cell adhesion ;
form H-bonds with water to stabilise membrane ;
enzyme ;
AVP ; e.g. *ref. to* role in antigen presentation / MHC [2]

27. O/N 16/P22/Q2/a
(a) **(i)** tubing drawn more swollen ;
(ii) *three from*
1 (mass) increased / AW ;
2 water in by osmosis ; **A** diffuse in by osmosis
if direction of water movement is out in mp2, allow ecf for mp 3
3 lower / more negative, water potential / Ψ (inside tubing) ; ora
A down the water potential gradient / from high to low water potential / from less negative to more negative water potential
R across
R water moves from a high water potential gradient to a low water potential gradient
I *ref. to*, solute / osmotic, potential
I water moves down the concentration gradient
4 sucrose too large to leave (tubing) / pores too small for sucrose to leave ;
5 (Visking tubing) partially permeable membrane ; **A** selectively-permeable [4]

28. O/N 16/P21/Q1/d
(a) *three from*
(sodium ions are) charged / hydrophilic ; **I** *ref. to* size / polar
cannot pass through hydrophobic, core / interior (of phospholipid bilayer) ;
(so) must pass through, transport proteins / carrier proteins / channel proteins *(facilitated diffusion)* ;
ref. to hydrophilic (amino acids lining) channels ;
ref. to active transport only way to move sodium ions against concentration gradient / AW ; [3]

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29. M/J 16/P21/Q6

(a) *fluid*
phospholipids (and proteins), move / AW ;

mosaic
proteins / glycoproteins, scattered / AW (in the phospholipid bilayer) ;
A different types of proteins
I pattern unqualified

(b) 7 nm ; **A** any size or range within 6 nm and 10 nm
A 7 nanometres

(c) cholesterol ;
unsaturated fatty acids ; **A** phospholipid tails
carbohydrate chains added to protein(s) / glycoproteins ;
A oligosaccharides *for carbohydrate chains*
carbohydrate chains added to lipids / glycolipids ;
glycocalyx ;
channel protein(s) / AW ; **A** aquaporin(s) ;
carrier proteins / AW ;
peripheral / extrinsic, proteins ;
attachment to, cytoskeleton / microfilaments ;
receptor(s) ;
antigen(s) ;
AVP ; [7]

30. O/N 15/P22/Q4

(a) *ignore descriptions or further qualification*
no marks for each box if other mechanisms given
active transport ; **A** active uptake
exocytosis ; **I** bulk transport / secretion
diffusion ; **I** passive / simple **R** facilitated diffusion

(b) **I** *ref. to* small increase in partial pressure causes more oxygen to associate
A pp / pressure, for partial pressures
1 this is the range of (partial) pressures occurring in respiring tissues ;
A (partial) pressures in respiring tissues are low
2 (for a) small / 1.6 kPa, decrease in partial pressure ;
3 (so) allows, large quantity of / more, oxygen to, be released / dissociate ;
A oxygen dissociates more, easily / readily
4 affinity of haemoglobin to oxygen decreases ;
in context of, as oxygen is released / as partial pressure decreases
5 data to support ; e.g. 60–62% to 28–30% / 30–32% difference [5]

31. O/N 15/P21/Q2

(a) **(i)** facilitated diffusion ;
(ii) ions are, charged / water-soluble ; **A** hydrophilic
unable to pass, through hydrophobic core / hydrophobic (fatty acid) tails of, phospholipid bilayer / phospholipids(s) ;
(channel of) protein lined with amino acids with, hydrophilic / polar, R groups / side chains ; **A** hydrophilic channels

(b) **(i)** quaternary / 4°, (structure) ;
(ii) secondary structure ; **A** alpha / α, helix

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(c) *bonds must be named in the correct context of maintaining 4° structure and interactions with phospholipids*
polypeptides held together
bonds between, R groups / side chains ;
two named bond types ; *from*
ionic
hydrogen
hydrophobic interactions
disulfide
van der Waal's forces
I peptide bond
polypeptides interact with phospholipids
(regions with) hydrophilic / charged / polar (R groups / side chains, of) amino acids interact with, phosphate / hydrophilic head , of phosholipid ;
(regions with) hydrophobic / non-polar (R groups / side chains, of) amino acids interact with, fatty acid / hydrocarbon / hydrophobic, tails / chains ;
further detail of named bond ; [8]

32. O/N 15/P23/Q3/f

(a) 1 barrier between cell cytoplasm and, external environment / AW ; e.g. tissue fluid
R barrier unqualified
R 'keeps cell contents in'
R 'membrane surrounds the organelles'
R barrier for water soluble substances
2 receptor for, hormone / neurotransmitter / cell signalling substance / AW ;
A signal receptor
3 cell recognition / acts as cell surface antigen ;
4 cell-to-cell adhesion ;
5 site for, enzymes / catalysing reactions ;
6 anchoring the cytoskeleton / AW ;
7 selection of substances that enter or leave a cell ;
R controls / regulates substances that enter cell
8 formation of hydrogen bonds with water for stability ;
9 AVP ; e.g. *ref. to*, changing shape of cell / flexibility of cells e.g. phagocytosis [3]

33. M/J 15/P21/Q5/b

(a) *answer may be phrased in the context of amylase / trypsin*
ignore anything before Golgi, e.g. shuttle vesicles from RER
1 vesicles, form from / 'pinch off', Golgi (apparatus / body / complex) ;
2 vesicles moves, through cytoplasm / to cell (surface) *or* plasma membrane ;
3 role of cytoskeleton / microtubules in movement of vesicles ;
4 energy / ATP, is required (movement of vesicles / fusion with membrane) ;
5 vesicle fuses with / AW, cell (surface) / plasma, membrane ;
I bind / attach **A** join / merge / becomes part of
6 exocytosis / vesicle 'opens up' so that enzyme molecules are released ;
7 ref to fluid nature of, membranes / phospholipid bilayer, that makes this possible ; [4]

34. M/J 15/P23/Q1

(a) phospholipid (and protein) molecules, move about / diffuse / AW ;
protein (molecules), scattered / AW ; **A** different proteins present

(b) *similarity to max 1*
(contains) phospholipid (bilayer); **A** detail of orientation of phospholipid
(contains) protein ; **A** lipid bilayer

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difference (look for ora)
(Davson Danielli) layer(s) of protein / protein only on outside ;
(fluid mosaic) ref. to proteins, in different locations discrete / different types / named or described ;
(fluid mosaic) presence of cholesterol (molecules) ;

(c) 1 requirement for, energy / ATP ; **R** ATP energy
2 uses, carrier / transport, protein ; **A** pump
3 conformational change (of carrier protein) ; AW
4 moving against a concentration gradient ; **A** low to high concentration
5 specific, binding site ; **A** ref. to specificity to substance moved across
to max 2

(d) 1 loss of, tertiary structure / quaternary structure / secondary structure ;
A loss of shape of active site *in correct context*
2 loss of globular, shape / structure / form ;
3 breakage of, ionic / hydrogen / hydrophobic, bonds / interactions ;
to max 2
4 loss of function of (membrane) proteins ;
5/6 detail ; ;
e.g. transport of, polar molecules / ions, impaired AW
loss of cell to cell adhesion
unable to receive cell signals
loss of enzyme function
7 ref. to membranes, become leaky / lose partially permeable nature ;
A cannot regulate, entry / exit, substances
8 disrupt interaction between protein and phospholipid bilayer / described ; [10]

35. M/J 14/P23/Q3/a,b

(a) *allow mps 1, 5 and 6 if non-competitive or both described*
1 (glutamycin) similar shape to, substrate / glutamyl-tRNA ;
2 competes with substrate / competitive inhibition ;
3 (glutamycin) binds to / fits into / enters, active site ;
4 (glutamycin) complementary (shape) to active site ;
5 (so) substrate / glutamyl-tRNA, cannot, enter / bind ;
A no / few, ES complexes
A prevents formation of ES complexes
A glutamyl-tRNA forms enzyme inhibitor complex
6 slows the rate of reaction / **AW** ;
7 *ref. to* increasing concentration of inhibitor has greater effect on inhibition;

(b) transport is against the concentration gradient / **AW** ;
requirement of, energy / ATP ;
use of, membrane / carrier / transport / pump, protein ;
R channel / pore, protein
ref. to conformational change (of pump protein) ;
ref. to specificity ; [7]

36. O/N 13/P21/Q2/c

(a) 1 concentration of all the ions is greater in the root tissue than in the solution ; ora
A roots
2 comparative data quote ;
according to these data
3 (so) ions will not diffuse into the root tissue ;
A if (facilitated) diffusion only, initially / till equilibrium reached

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4 (so) active transport ; **A** active, uptake / pumping **I** facilitated diffusion
5 use ATP ; **A** energy
R ATP energy
6 move ions, against concentration gradient / from low to high concentration;
A diffusion gradient
7 use, membrane / integral / intrinsic / transmembrane / transport / carrier, proteins ;
R channel proteins
8 are specific / have specific binding sites ;
9 involve, conformational / shape, change ;
10 comparative data quote to suggest that some ions are pumped more than others ;
e.g. steepest gradients for K^+ and SO_4^-
11 phospholipid bilayer / hydrophobic core (of cell surface membrane) is impermeable to ions ;
12 so ions cannot diffuse out / (membrane) proteins only allow inward flow of ions ;
13 AVP ; e.g. suggestion of differing numbers of specific membrane proteins to explain observation of mp 10 [5]

37. O/N 13/P21/Q4

(a) 1 mitochondrion ; **A** mitochondria
A outer mitochondrial membrane
2 produces / synthesises / AW, ATP ; **A** release / supply, ATP / energy
R produces energy
R ATP energy
or
for outer mitochondrial membrane allows exit of (synthesised) ATP to cell
3 example of use of ATP in liver cells ;
e.g. for synthesis of, cholesterol / glycogen / protein / biological molecules / polymers / AW
intracellular movement of vesicles
exocytosis / endocytosis / bulk transport
active transport

(b) **(i)** lipoproteins are soluble ;
cholesterol is not water-soluble ;
cholesterol surrounded by / lipoproteins have, phospholipid heads / proteins, that are hydrophilic ; AW
allows transport in blood ;

(ii) *cholesterol needed for*
making / components of, membranes ;
membrane stability ;
regulating the fluidity of, membranes / phospholipid bilayer ;
production of, steroid hormones / named steroid hormone ;
AVP ; e.g. helps prevent entry of, ions / polar molecules

(c) vesicles travel to cell surface membrane ; **A** travels through cytoplasm towards space between cells
exocytosis ;
vesicle / membrane, fusion (with cell surface membrane) ;
contents / cholesterol, released ;

(d) glycosylation / adding sugar molecules to proteins / making glycoproteins ;
A modifying proteins
phosphorylating proteins ;
cutting / folding, proteins ;

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assembly of polypeptides into proteins (with quaternary structure) ;
AVP ; e.g. lipid synthesis
ref. lysosome formation [8]

38. O/N 13/P23/Q5/c

(a) *one mark per line*
similarities
use, membrane / integral / intrinsic / transmembrane / transport / carrier, proteins ;
R channel proteins
are specific / have specific binding site ;
involve conformational / shape, change of protein ;
(movement of (named)), ions / polar molecules / water soluble molecules / hydrophilic molecules / lipid insoluble molecules ;
I large molecules **A** charged
(movement) across membranes / into *or* out of the cell ;
differences ***A*** *ora*
facilitated diffusion is (movement from), high(er) to low(er) concentration / down concentration gradient ; ora **A** diffusion gradient
I 'along a concentration gradient'
facilitated diffusion, is passive process / does not require energy *and / or* ATP (from the cell) ;
R ATP energy
R the cell makes energy for active transport [4]

39. M/J 13/P22/Q4/c

(a) **1** *idea of* separation / barrier / AW, from surroundings / external environment ;
2 regulates / controls / AW, entry / exit, substances / named substances ;
3 enables recognition of self (antigens)/cell recognition/avoids cell destruction/act as antigens / AW ;
4 allows binding of / receptors for, hormones/signal molecules/neurotransmitters /antigens;
5 cell to cell adhesion ;
6 location for enzymes / multi-enzyme systems / enzyme pathways ;
7 AVP ; e.g. idea of flexibility (for some cells,
ref. glycoproteins / glycolipids, form H bonds with water for stability [3]

40. M/J 13/P21/Q5

(a) **P –** moves, polar substances / hydrophilic molecules / ions, through membrane / in or out (of cells) ;
A facilitated diffusion / active transport / described
Q – receptor / recognition site / cell recognition / binding site ;
A cell adhesion / 'receives' named signal
A stabilises membrane (as forms hydrogen bonds with water)
R – regulates / AW, fluidity of, membrane / (phospholipid) bilayer ;
A contributes to hydrophobic layer / impermeability to ions

(b) 7.0 nm ;

(c) *fluid*
idea of phospholipid (and protein) molecules, move about / diffuse (within their monolayer) ;
mosaic to max 1
protein (molecules), interspersed / scattered / not a complete layer / AW ;
different / AW, proteins (molecules) ;

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(d) **1** water molecules are polar ;
R hydrophilic / charged

2 *idea that* few polar molecules pass through the phospholipid (bilayer) ;
ora for non-polar molecules
A none pass / repelled

3 core of membrane / phospholipid tails, are hydrophobic ;
A hydrophobic core

4 channels (through aquaporins), are hydrophilic ;
A core of channel proteins / described as R-groups of amino acids

5 (aquaporins) increase permeability of membrane to water ;

6 example ;
e.g. root hairs small intestine epithelium nephron

7 role of water in a cell ;
e.g. solvent / reactant / reaction medium / turgidity *or* support in plant cell
ignore references to osmosis / bursting / crenation / regulation [9]

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Unit 5

THE MITOTIC CELL CYCLE

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

Editorial Board

Syllabus

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Unit 5: The Mitotic Cell Cycle

1. **O/N 21/P22/Q1/d**
   (a) Fig. 1.2 shows plant cells in a root tip where cell division by mitosis is taking place.

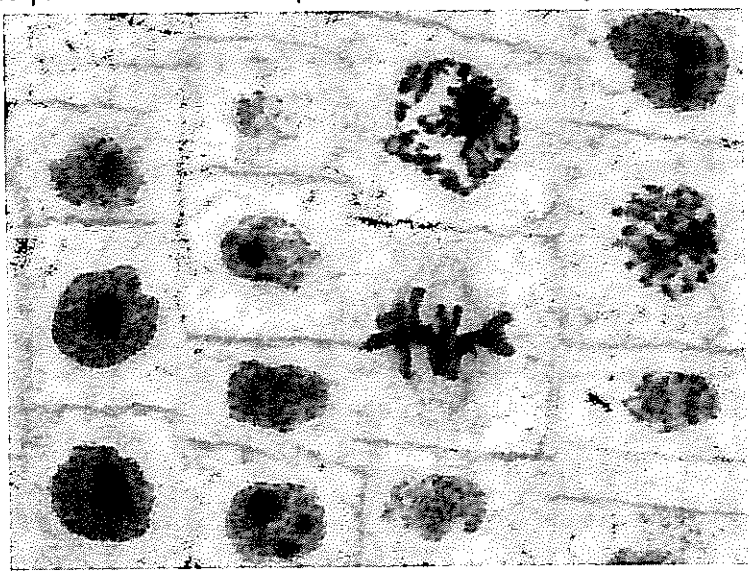


Fig. 1.2

Identify **two** cells in Fig. 1.2 that are in different stages of mitosis.
Draw a label line to each cell and add the name of the stage of **mitosis** that is shown by the cell. [2]

2. **O/N 21/P21/Q4**
   (a) Fig. 4.1 is a drawing made by a student of a plant cell, showing one of the stages of mitosis.

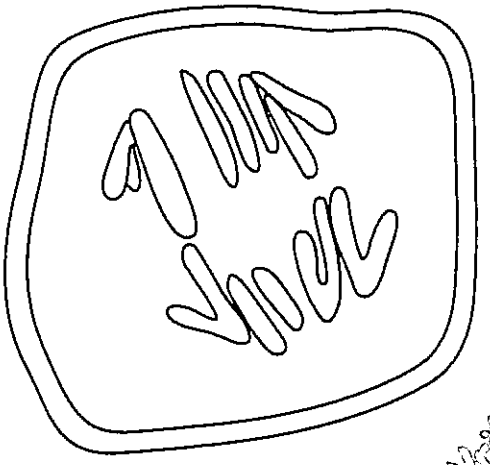


Fig. 4.1

(i) Describe the role of the spindle during this stage of mitosis.

.....

..... [2]

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(ii) The chromosomes are composed of DNA.
Describe the structure of a monomer of a DNA molecule.

.....

..... [2]

(b) Telomeres are located at the ends of each chromosome.
Telomeres progressively shorten each time a healthy human cell divides, until the cell is no longer able to divide.
Stem cells have an enzyme called telomerase that prevents the telomeres shortening during the cell cycle.

(i) Suggest why telomerase activity is important in stem cells.

.....

..... [2]

(ii) Suggest why tumour cells produce high concentrations of telomerase.

..... [1]

(iii) Scientists have researched the possibility of treating cancer by inhibiting the action of telomerase.

One method that has been studied involves inserting small, single-stranded DNA into cancer cells. These sections of DNA have a base sequence that is complementary to a section of the mRNA transcribed from the gene coding for telomerase.

Explain how inserting small, single-stranded DNA could prevent **translation** of the mRNA to produce telomerase.

.....

.....

..... [3]

3. **O/N 21/P23/Q6/d**

(a) Name the stage of the cell cycle during which DNA **and** proteins are synthesised.

..... [1]

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4. M/J 21/P22/Q1

(a) Fig. 1.1 is a photomicrograph of a region of eukaryotic tissue. Some of the cells are in stages of mitosis.

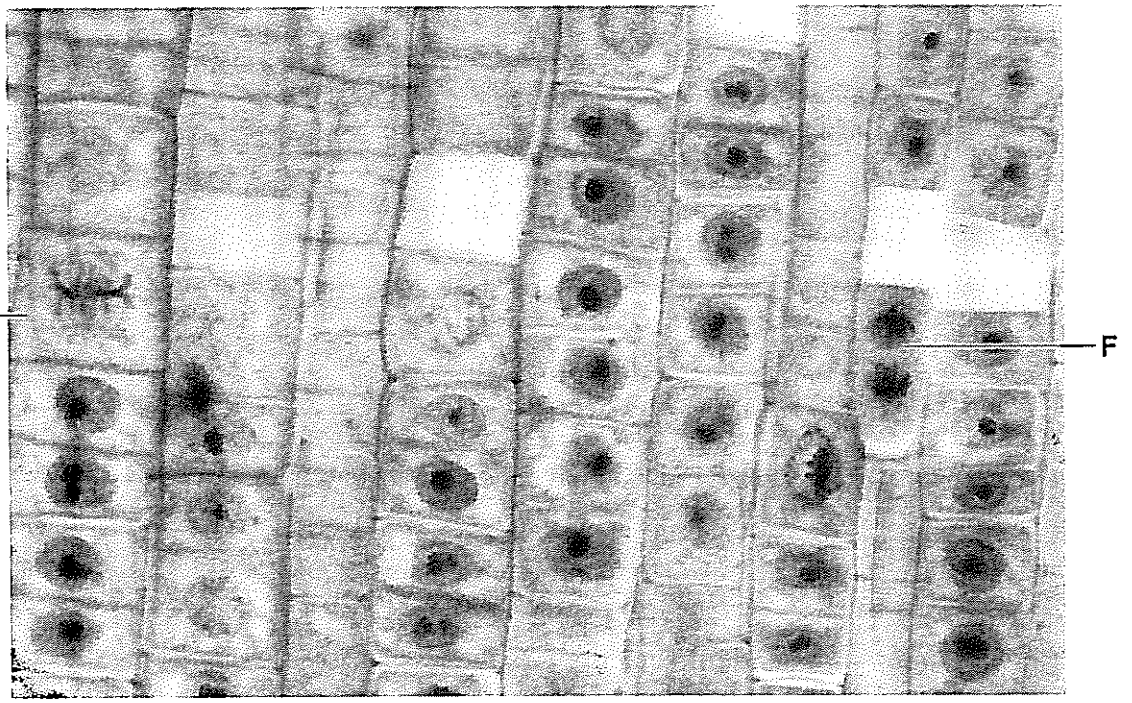


Fig. 1.1

(i) Identify which stage of mitosis is shown in cell **E** and in cell **F** in Fig. 1.1.

E .....

F ..... [2]

(ii) Microtubules are present within the cells that are in stages of mitosis, but these are not visible in Fig. 1.1.

State the function of microtubules in mitosis.

..... [1]

(iii) State, with a reason, whether Fig. 1.1 shows a region of animal or plant tissue.

..... [1]

(b) Semi-conservative replication of DNA occurs during interphase, before mitosis begins.

Write the correct term in the spaces provided to complete each of statements **A** to **D**.

A The DNA double helix unwinds and is separated into two template strands when ..... bonds holding the two strands together are broken.

B One of the template strands of DNA is copied in fragments. The enzyme ..... is required to join the fragments together to form a continuous strand of DNA.

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C Complementary DNA nucleotides are added to the template strands, catalysed by the enzyme ..... .

D ..... are regions of repeating nucleotide sequences at the ends of chromosomes that allow the continued replication of DNA, without the loss of genes. [4]

5. M/J 21/P23/Q6

The best time to obtain a clear image of chromosomes during a mitotic cell cycle is during the metaphase stage.

Fig. 6.1 is a scanning electron micrograph of a group of human chromosomes at metaphase.

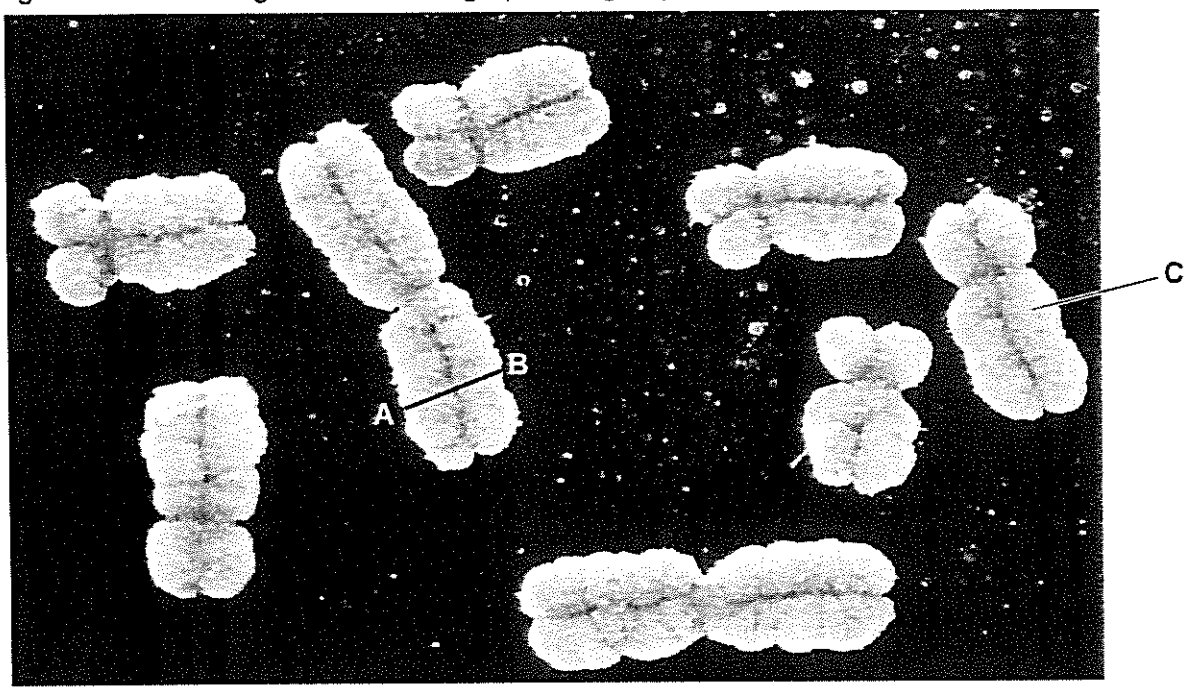


Fig. 6.1

(a) The group of chromosomes shown in Fig. 6.1 is magnified many times.
The actual width of the human chromosome between **A**—**B** is 1400 nm.
Calculate the magnification of the scanning electron micrograph shown in Fig. 6.1.

magnification × ..... [2]

(b) Draw chromosome **C** in Fig. 6.1 in the space provided.
Label your drawing to show the structure of the chromosome.

[4]

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(c) Suggest why the metaphase stage is the best time during a mitotic cell cycle to obtain a clear image of chromosomes.

..... [1]

(d) Name the stage of mitosis that immediately follows metaphase.

..... [1]

6. O/N 20/P22/Q4/b

(a) The transition from the activated B-lymphocyte to the fully mature plasma cell requires a number of mitotic cell cycles to occur. This process, which is known as clonal expansion, results in a large number of genetically identical plasma cells.
Fig. 4.2 describes events, **A** to **F**, that occur during the mitotic cell cycle of the B-lymphocyte.

A centrioles replicate
B DNA polymerase catalyses the formation of phosphodiester bonds
C condensation of chromosomes
D nuclear envelope reassembles around each set of daughter chromosomes
E centromeres move towards poles
F chromosomes line up at spindle equator

Fig. 4.2

Table 4.1 lists the stages occurring during one cell cycle of the B-lymphocyte. These stages are not in the correct order.

Table 4.1

stage of cell cycle	correct letter from Fig. 4.2
G_2 phase	
metaphase	F
cytokinesis	
prophase	
S phase	
anaphase	
G_1 phase	
telophase	

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Complete Table 4.1 by writing the letter of the event described in Fig. 4.2 that correctly matches the stage of the cell cycle listed.

Leave a **blank space** if there is **no** matching description for the stage in the list. Use each letter **once** only.

One of the letters in Table 4.1 has already been added for you. [5]

7. O/N 20/P21/Q1

(a) Fig. 1.1 is a diagram of a human chromosome at a stage in mitosis.

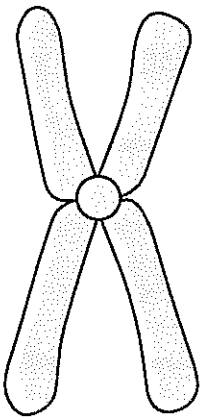


Fig. 1.1

(i) The paragraph describes the structure of the chromosome shown in Fig. 1.1.

Complete the paragraph using the most appropriate term in each space provided.

The chromosome shown in Fig. 1.1 has two genetically identical ..... joined at a ..... . The chromosome is composed of two DNA molecules, each wrapped around proteins known as ..... proteins. [3]

(ii) State **one** stage during mitosis when the chromosome would appear as shown in Fig. 1.1.

..... [1]

(iii) Suggest the role of ATP in the process of mitosis.

.....

..... [2]

(b) Prokaryotes divide by a process known as binary fission.
Fig. 1.2 shows some of the stages in binary fission.

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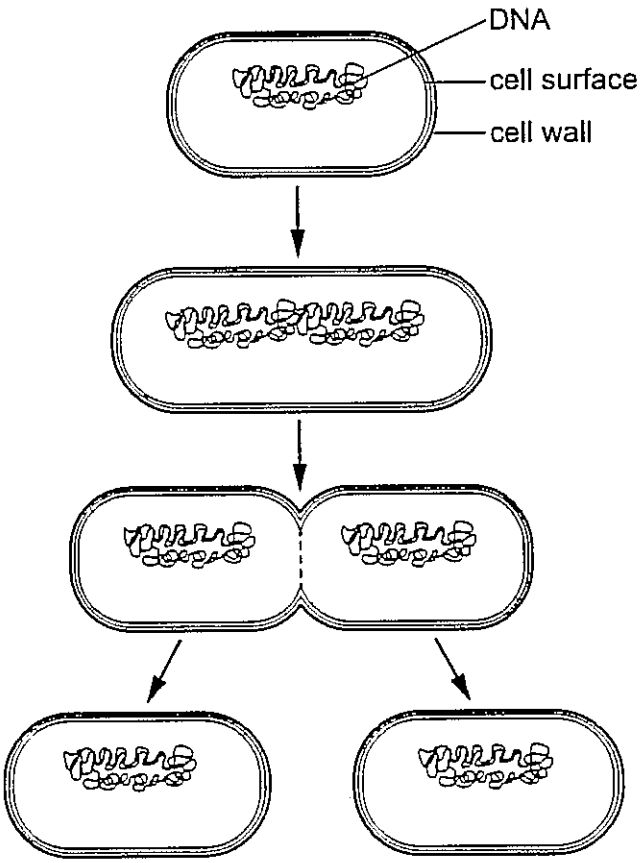


Fig. 1.2

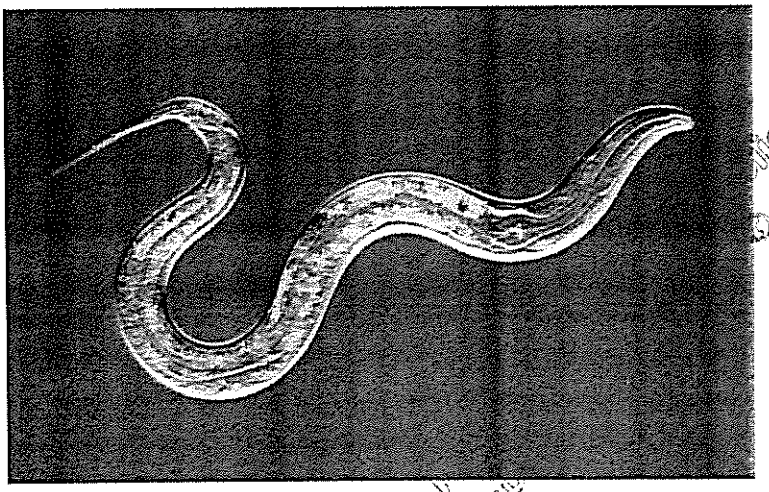
With reference to Fig. 1.2, identify **two** events that occur during binary fission that do **not** occur during mitosis in human cells.

.....

..... [2]

8. O/N 20/P23/Q3

Fig. 3.1 shows the nematode worm, *Caenorhabditis elegans*.



magnification ×250

Fig. 3.1

Stem cells of *C. elegans* have been studied.

Fig. 3.2 shows the change in mass of DNA per nucleus in a stem cell during one cell cycle.

1 pg = 1×10^{-12} g

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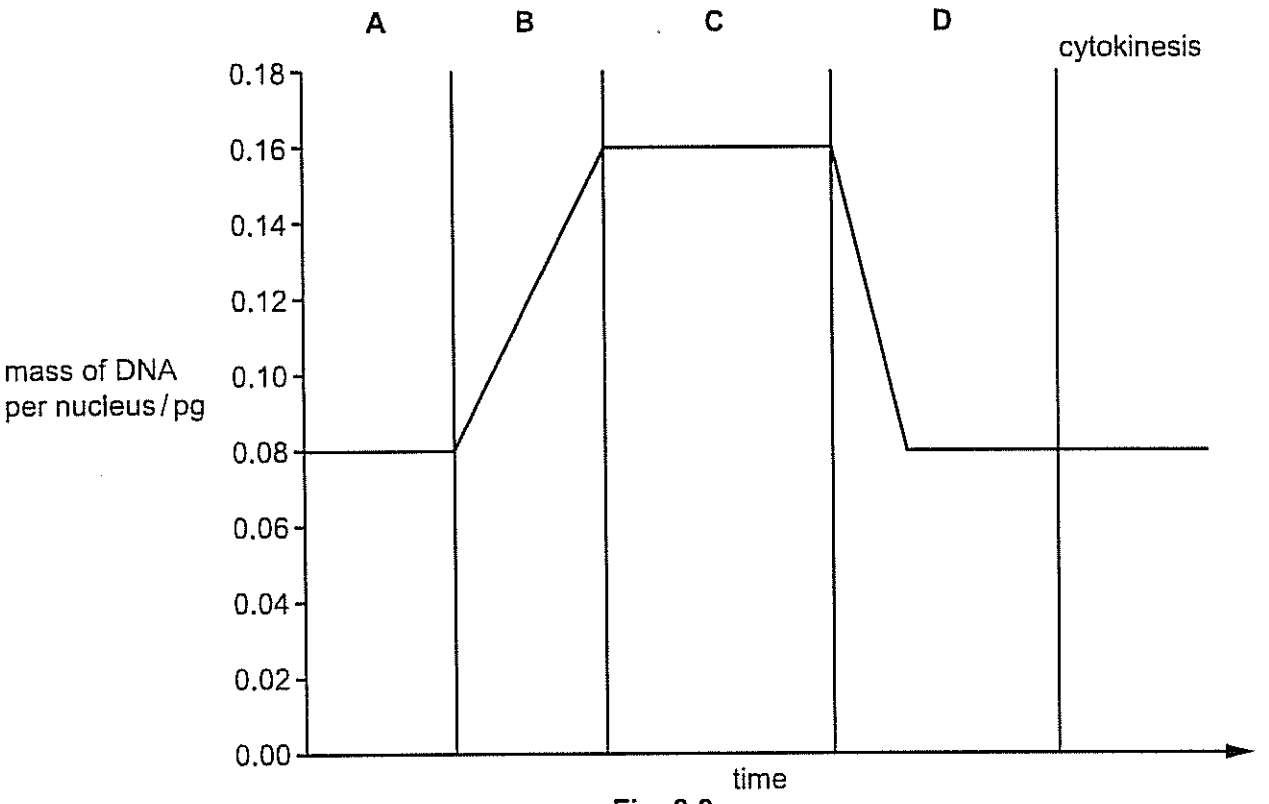


Fig. 3.2

(a) (i) State the phases of interphase shown by **A** and **B** in Fig. 3.2.

A .....

B ..... [2]

(ii) State the stage of mitosis shown by **D** in Fig. 3.2.

..... [1]

(iii) Outline what happens in a cell in preparation for cytokinesis.

.....

..... [2]

(iv) A stem cell of a female *C. elegans* has 12 chromosomes.
Complete Table 3.1 to show the number of nuclei within the stem cell in stages **A**, **B** and **D** of the cell cycle shown in Fig. 3.2 **and** the number of chromosomes in each nucleus during these stages.

Table 3.1

	stage of the cell cycle		
	A	**B**	**D**
number of nuclei within the stem cell			
number of chromosomes in each nucleus			

[2]

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(b) Young nematodes have stem cells throughout the body.
Fig. 3.3 summarises three cell cycles of one of these stem cells.

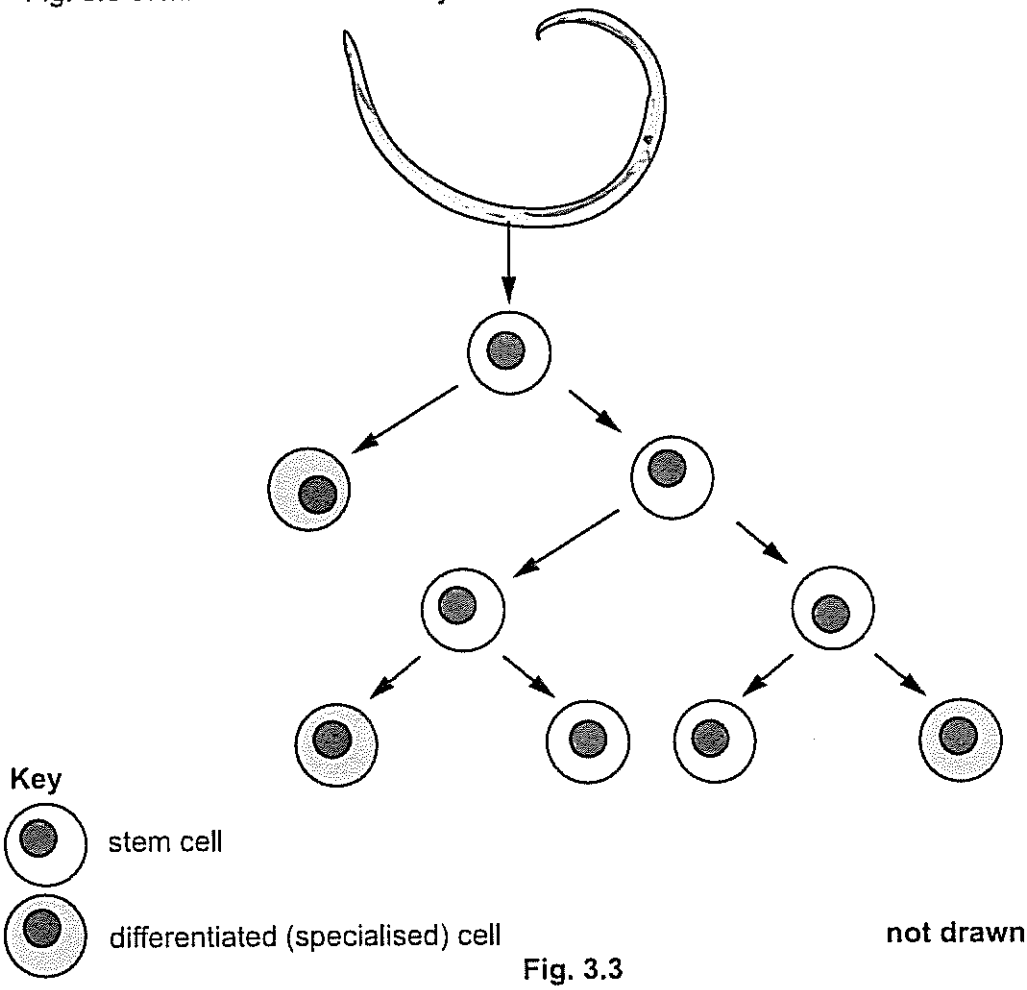


Fig. 3.3

With reference to Fig. 3.3, outline the role of stem cells in animals.

.....

.....

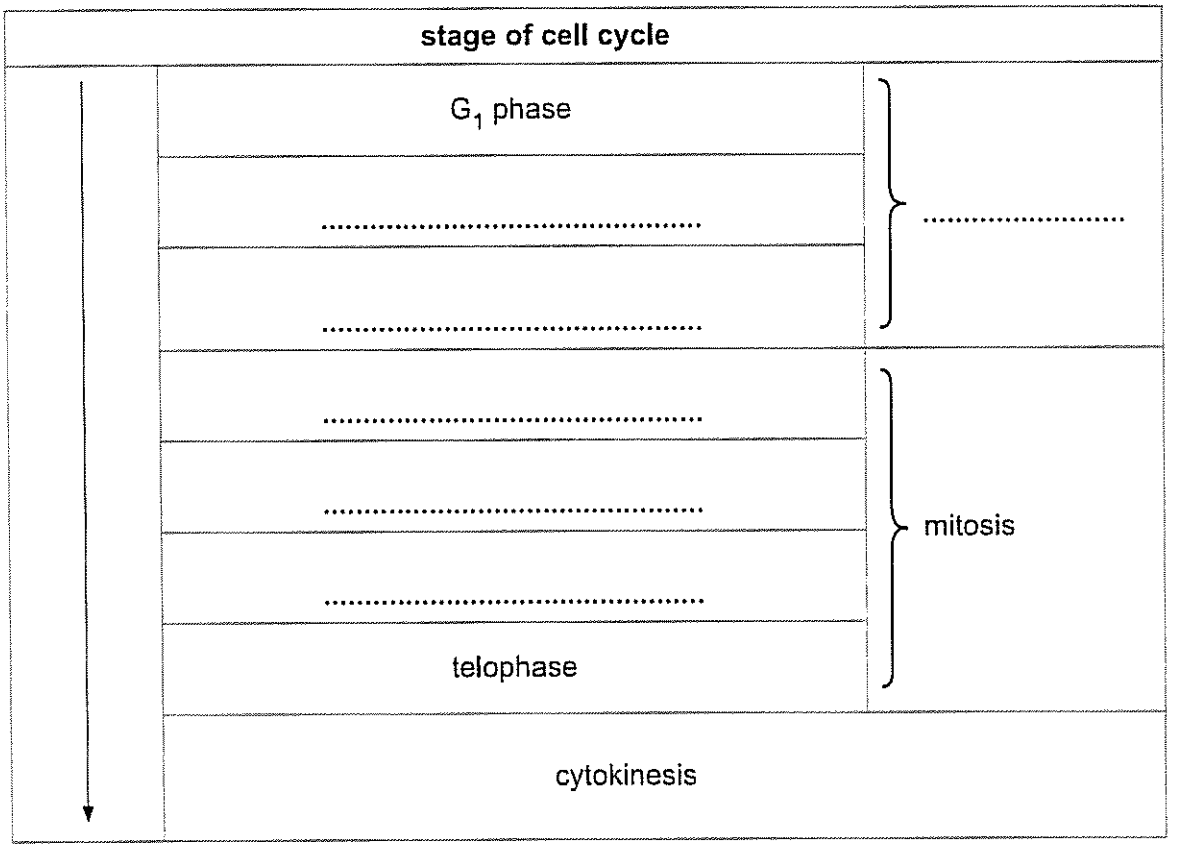
..... [3]

9. M/J 20/P22/Q6/a,b
The mitotic cell cycle in dividing cells is very carefully controlled.
(a) Complete Table 6.1 to show the correct order of stages in the mitotic cell cycle.
Some of the stages have been completed for you.

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Table 6.1



[3]

At various points during the mitotic cell cycle, checks are made. A cell goes through cell death (apoptosis) if errors occur that cannot be repaired. This makes sure that the daughter cells produced are genetically identical to each other and to the original cell.
Drugs have been developed that can inhibit the mitotic cell cycle and cause the cell to carry out apoptosis. These drugs are used in the treatment of cancer.

(b) Vincristine and 5-fluorouracil are chemical compounds that act as cell cycle inhibitors and can lead to apoptosis.

- Vincristine binds to spindle microtubules and prevents the spindle from carrying out its function.
- 5-fluorouracil prevents the synthesis of thymine nucleotides.

Complete Table 6.2 to show which event in the cell cycle will occur when Vincristine or 5-fluorouracil are added to healthy dividing cells at the start of the interphase stage of the cell cycle.
Place a tick (✓) if the event will occur or a cross (✗) if the event will **not** occur.
All boxes in the table should be completed.

Table 6.2

event in cell cycle / compound	S-phase completes	cell enters prophase of mitosis	chromosomes line up at spindle equator	sister chromatids move towards opposite poles
Vincristine				
5-fluorouracil				

[2]

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10. M/J 20/P21/Q2

Fig. 2.1 shows some stages of the cell cycle in the meristematic tissue in the root tip of a plant. Three of these stages, **P**, **Q** and **R**, are identified in Table 2.1.

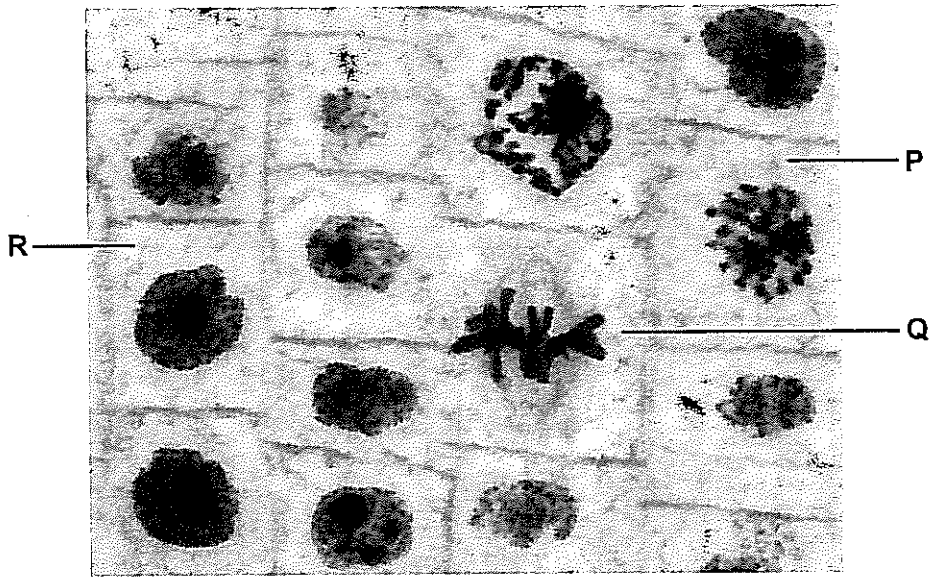


Fig. 2.1

(a) Complete Table 2.1 by stating **one** feature, **visible in Fig. 2.1**, that is used to identify each stage.

Table 2.1

cell	stage of cell cycle	reason
P	prophase of mitosis	
Q	metaphase of mitosis	
R	interphase	

[3]

(b) (i) Draw a labelled diagram to show **one** chromosome at metaphase of mitosis.

On the chromosome you have drawn add labels to show:

- the position of a telomere
- a chromatid
- the centromere.

[4]

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(ii) State the type of protein that is associated with DNA in chromosomes.

..... [1]

(iii) Describe how the spindle is involved during the process of mitosis.

.....

.....

..... [3]

11. M/J 20/P23/Q5

Blood cells are formed from tissue stem cells in the bone marrow. These bone marrow stem cells go through a number of mitotic cell cycles to form the fully functioning blood cell.

Fig. 5.1 shows the three main stages of the cell cycle.

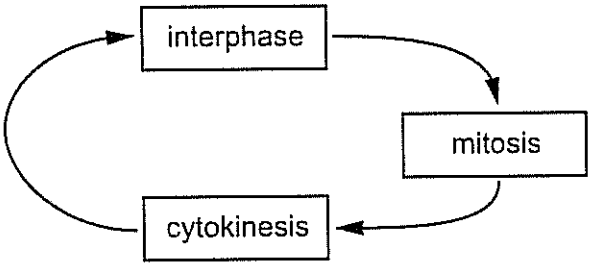


Fig. 5.1

The activity of genes changes during the mitotic cell cycle.

When genes are being expressed, the cell produces many messenger RNA (mRNA) molecules and ATP molecules.

(a) Explain what is meant by a gene.

.....

..... [2]

(b) Name the main stage of the cell cycle in Fig. 5.1 during which most mRNA and ATP is formed.

..... [1]

(c) Fig. 5.2 is an incomplete diagram of an ATP molecule.

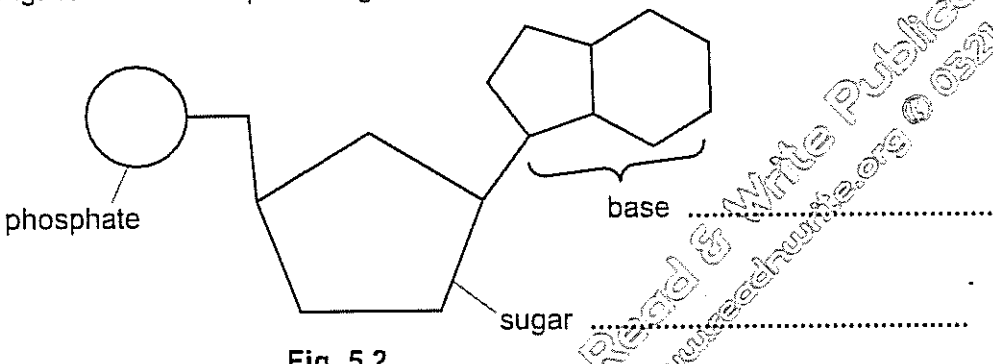


Fig. 5.2

(i) On Fig. 5.2:

- complete the diagram of the ATP molecule
- write the name of the base in the space provided
- write the name of the sugar in the space provided. [3]

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(ii) The base shown in Fig. 5.2 has a double ring structure.
State the term for a base that has a double ring structure.

..... [1]

(d) Suggest **and** explain the role of mitosis in the formation of blood cells by the bone marrow stem cells.

.....

.....

..... [3]

12. O/N 19/P22/Q6

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.

.....

..... [2]

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

..... [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]

(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.

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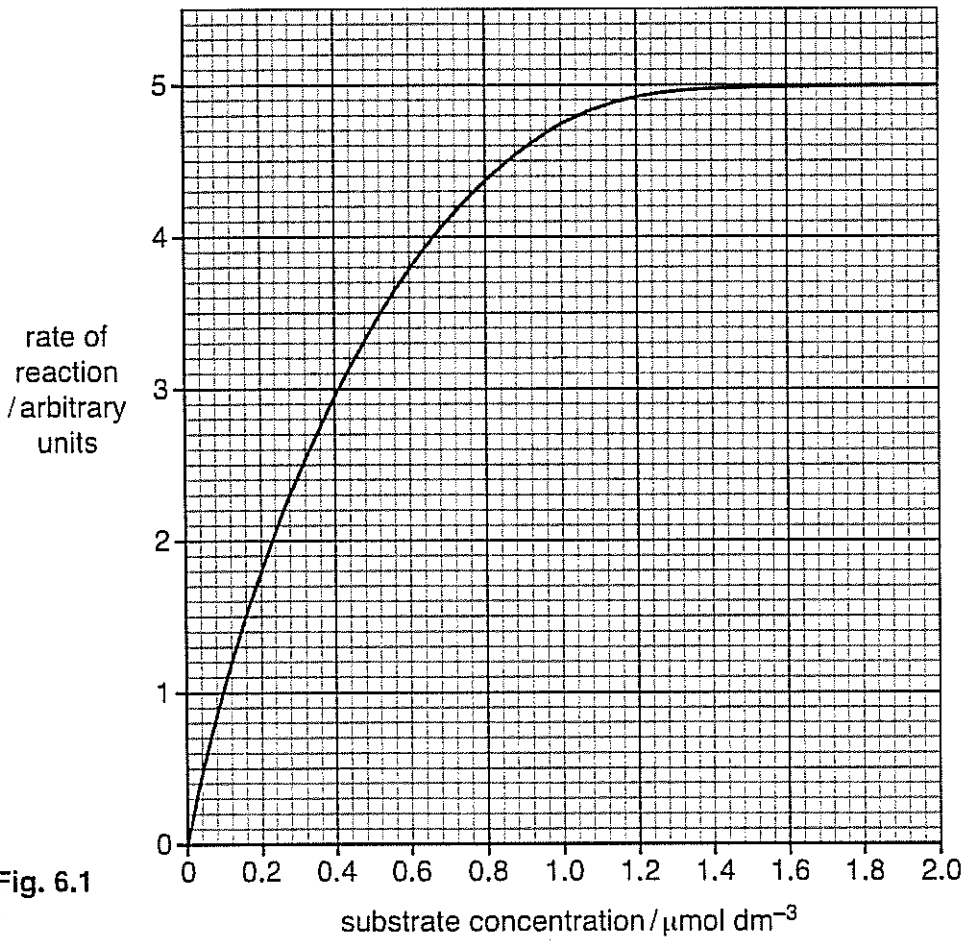


Fig. 6.1

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}.

.....

..... [2]

13. O/N 19/P21/Q6

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

.....

.....

..... [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.

..... [1]

(ii) Floxuridine prevents thymine nucleotides being produced.
Explain why floxuridine does **not** affect transcription.

..... [1]

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

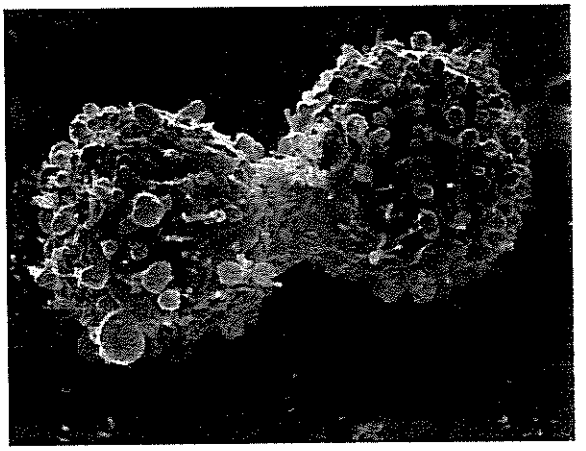


Fig. 6.1

(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.

.....

.....

..... [3]

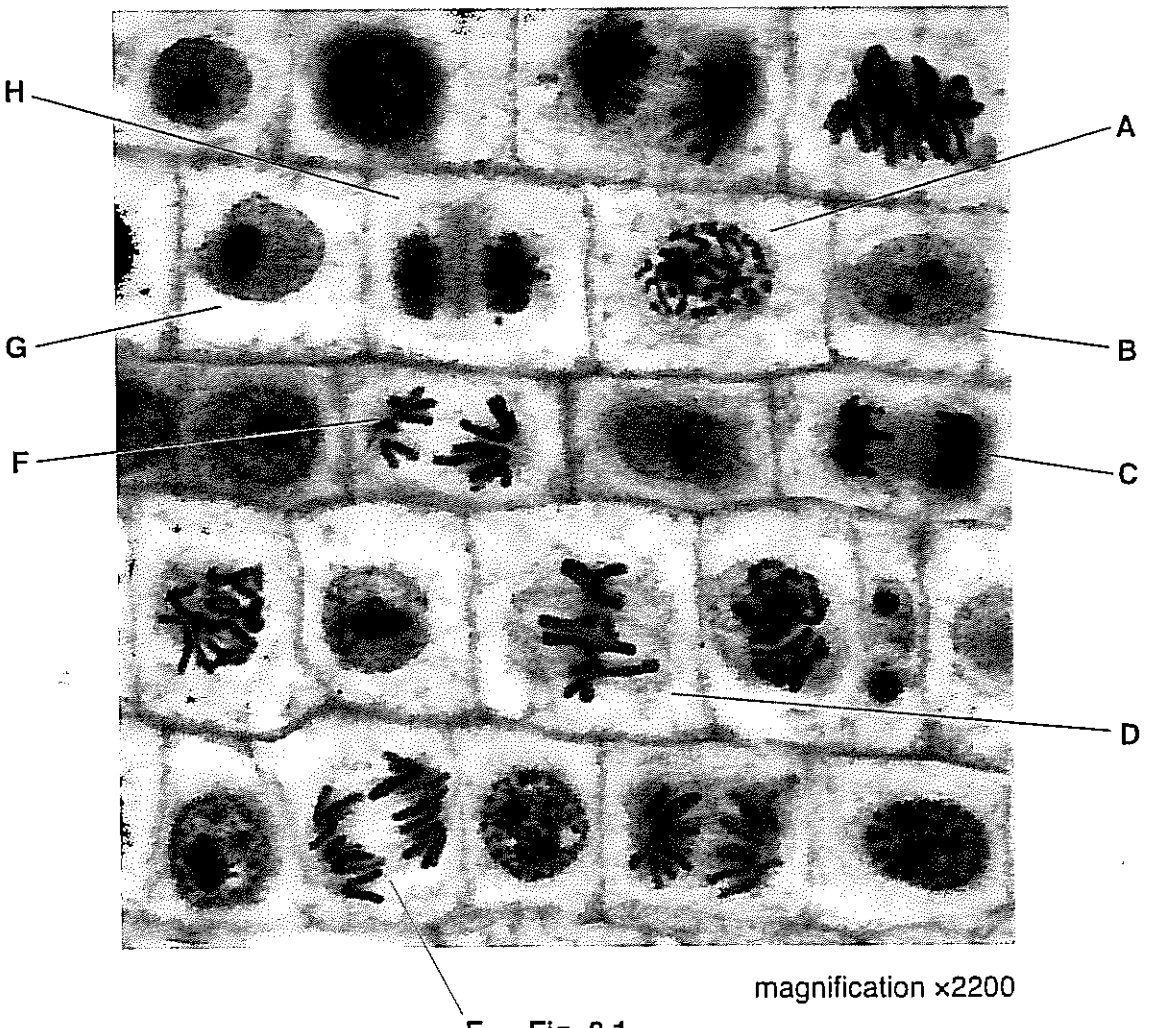
14. O/N 19/P23/Q2

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*.

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magnification ×2200

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

(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.

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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 = ... %

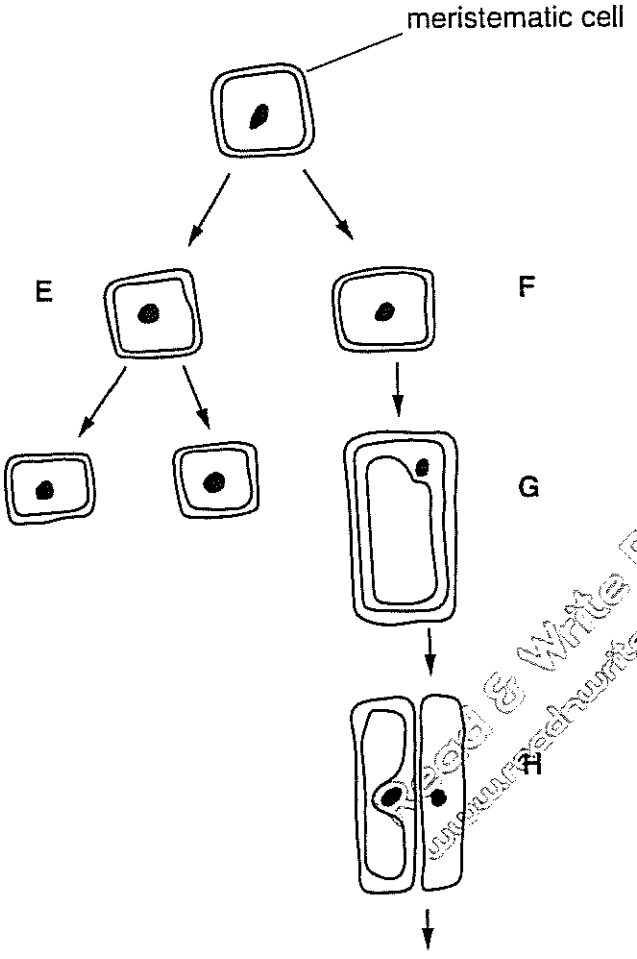
mean length of time in anaphase = ... min [2]

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

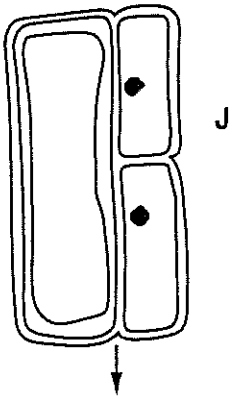
..... [1]

15. M/J 19/P21/Q4/a,b

Meristematic tissue is found in the growing regions of plants, such as shoot tips. Meristematic cells have a similar role to stem cells in animals.
Fig. 4.1 shows some of the stages in the formation of a mature phloem sieve tube element and companion cells from a meristematic cell.



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mature sieve tube element
and companion cells

Fig. 4.1

(a) Cells **E** and **F** in Fig. 4.1 are daughter cells produced when the meristematic cell divides in the shoot tip.
Explain why it is important that one of the daughter cells (cell **E**) is a meristematic cell.

..... [1]

(b) Complete Table 4.1 to describe the changes that are shown in Fig. 4.1 between stages:
- **F** and **G**
- **G** and **H**
- **H** and **J**.

Table 4.1

stages	description
F and **G**	
G and **H**	
H and **J**	

[3]

16. O/N 18/P22/Q3

The response of the human body to tissue damage depends on the types of tissues involved. Epithelial tissue, liver tissue and cardiac muscle tissue each respond differently to damage.

- Epithelial tissue of the gas exchange system contains stem cells.
- Liver tissue contains cells in a non-dividing state that can enter a cell cycle when stimulated.
- Cardiac muscle tissue contains cells that cannot divide at all. Damage is permanent and is associated with scar tissue formation.

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(a) Explain the importance of mitosis in the repair of damaged tissue.

.....

..... [2]

(b) Explain why stem cells are important in tissue repair.

.....

..... [2]

(c) Following liver tissue damage, chemicals are produced and released into the circulation. These chemicals are able to stimulate the liver cells to help tissue repair.

Explain how this is an example of cell signalling.

.....

.....

..... [3]

17. O/N 18/P23/Q6

(a) As part of a study of the mitotic cell cycle, a student made stained sections of a root tip of onion, *Allium cepa*, and observed them with a light microscope.

The student made drawings of six of the cells, **A** to **F**, using the high power of the microscope, as shown in Fig. 6.1.

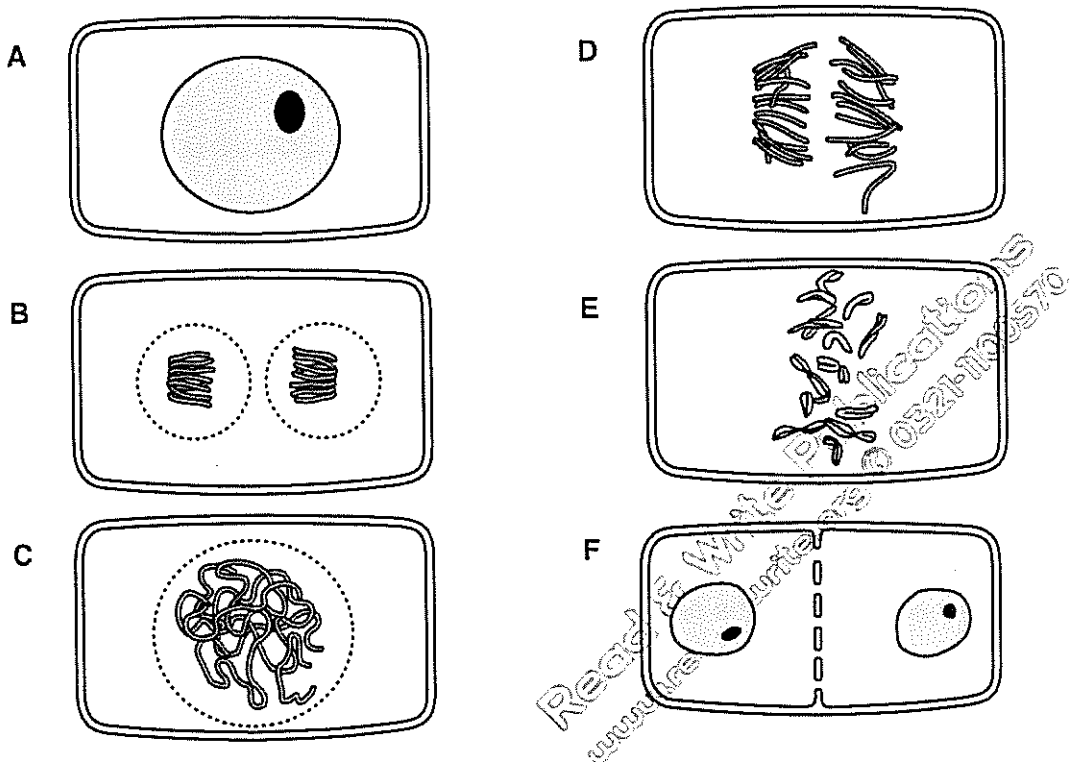


Fig. 6.1

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(i) Complete Table 6.1 to show the sequence of stages in the mitotic cell cycle, using the letters, **A** to **F**, as shown in Fig. 6.1.

Table 6.1

sequence of stages	cell
1	**A**
2	
3	
4	
5	
6	

[1]

(ii) Table 6.2 shows some events that occur during the mitotic cell cycle in *A. cepa*. Complete Table 6.2 by naming the stage of the cell cycle when each event occurs.

Table 6.2

event in the cell cycle	name of the stage in the cell cycle
DNA replication	
division of centromeres	
condensation of chromatin	
contraction of spindle fibres	
organisation of chromosomes at the equator	metaphase

[4]

(b) Explain the importance of mitosis in the immune response.

.....

.....

..... [3]

18. M/J 18/P22/Q4

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

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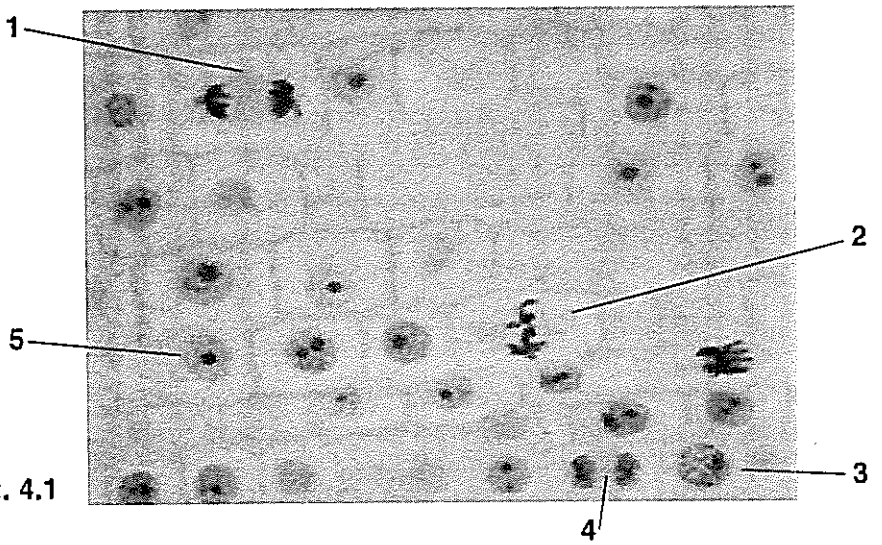


Fig. 4.1

(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**.

.....

..... [2]

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

..... [1]

19. M/J 18/P23/Q1
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.

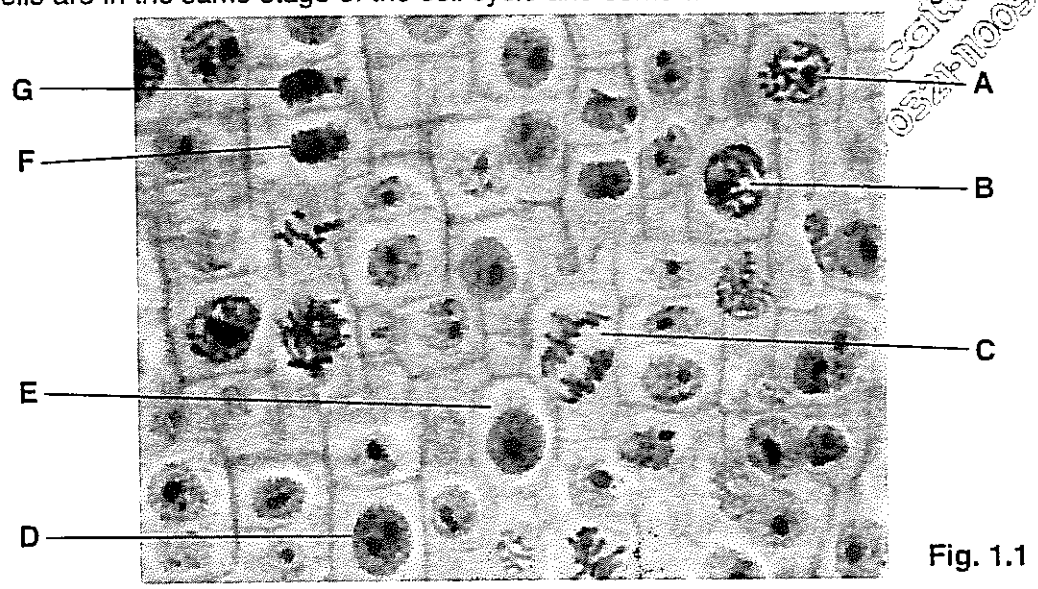


Fig. 1.1

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(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.

.....

..... [2]

20. O/N 17/P22/Q1

The root apical meristem is a region of undifferentiated cells in the root tips of plants. Mitosis occurs in this region.

(a) Fig. 1.1 is an image of the root tip of *Allium* as observed using a microscope with a low-power objective lens.

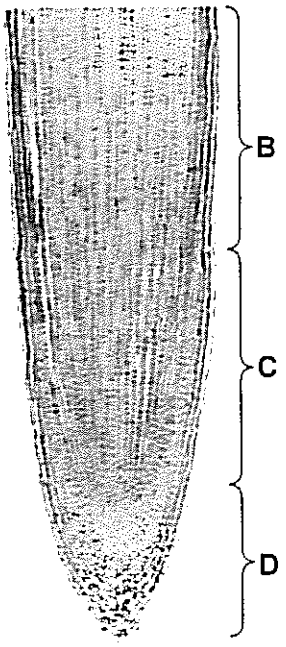


Fig. 1.1

State which region, **B**, **C**, or **D**, should be chosen in order to observe the highest proportion of cells in stages of mitosis.

..... [1]

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(b) (i) Draw a labelled diagram to show the structure of a chromosome at late prophase of mitosis.

[3]

(ii) Describe the behaviour of the nuclear envelope during mitosis.

.....

..... [2]

21. O/N 17/P21/Q1

Fig. 1.1 is a photomicrograph of plant cells showing stages in cell division.

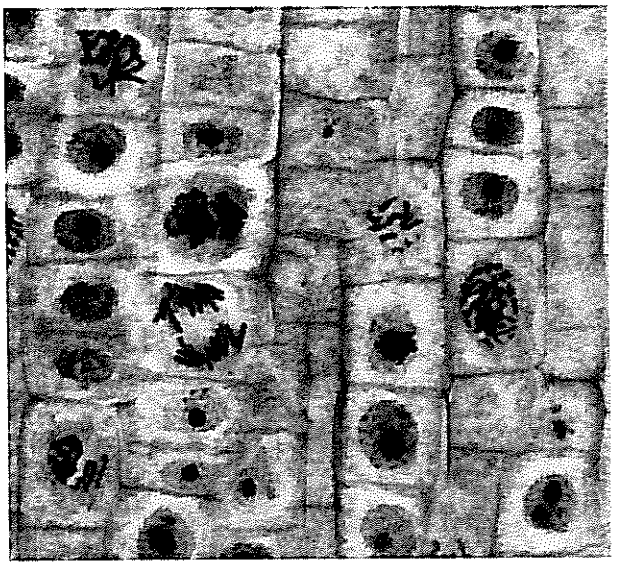


Fig. 1.1

(a) On Fig. 1.1, draw a circle around a cell in anaphase. [1]

(b) Suggest the advantages of using a light microscope, rather than an electron microscope, to study cell division.

.....

.....[2]

(c) Mitosis is important in producing more cells for plant growth.
Describe **three other** ways in which mitosis is important in plants.

.....

.....

..... [3]

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22. O/N 17/P23/Q6

Extracellular growth factors are involved in the control of cell cycles in some mammalian cells. One of these growth factors is epidermal growth factor (EGF).

Fig. 6.1 shows the events that occur when EGF is present at the surfaces of two cells, **A** and **B**.

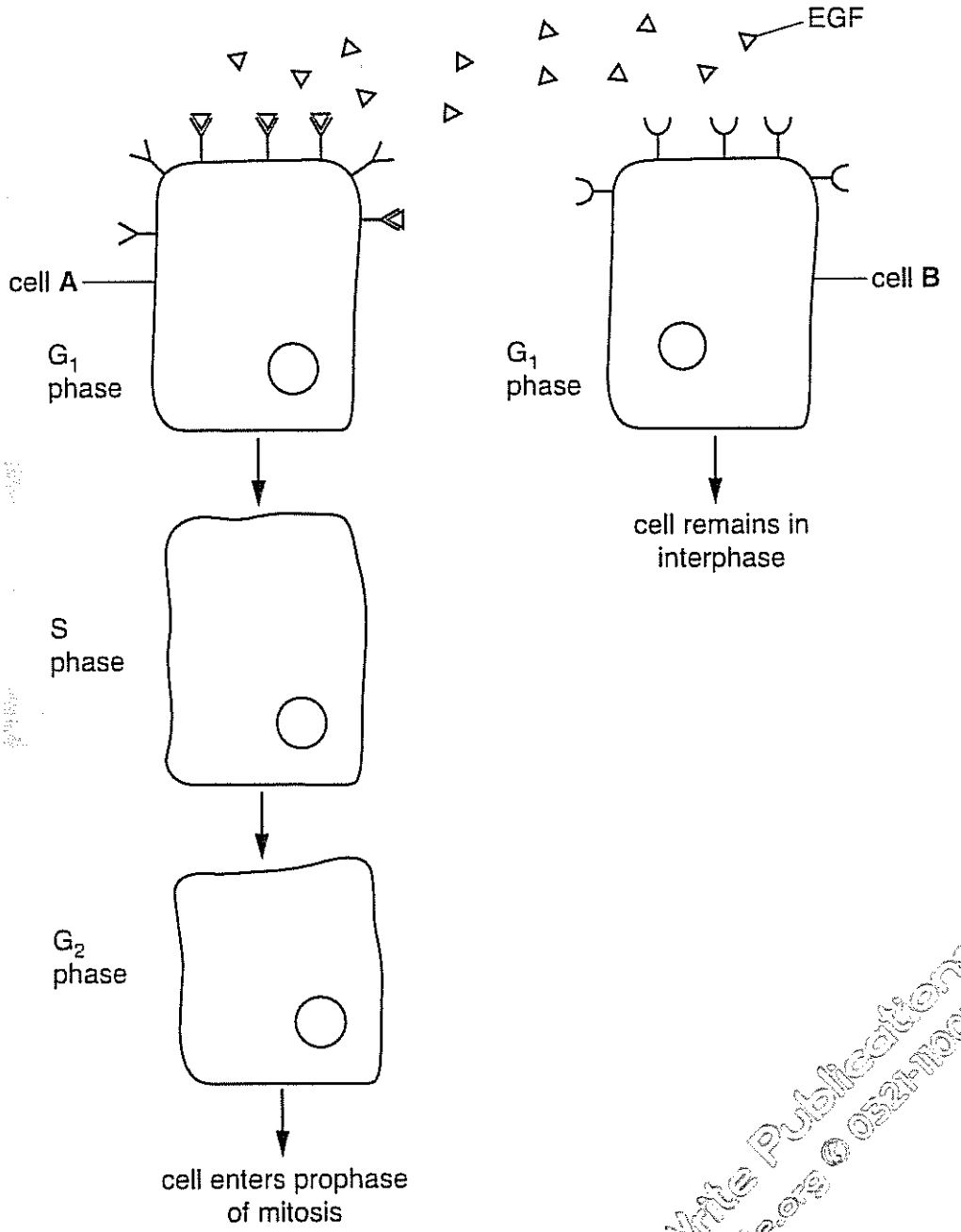


Fig. 6.1

(a) Explain why cell **A** in Fig. 6.1 responds to EGF, but cell **B** does not.

.....

.....[2]

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(b) In the cell cycle, more mRNA is produced in the G_1 phase than during mitosis.
Suggest why this is so.

..... [1]

(c) DNA is replicated during the S phase of the cell cycle. EGF is one of many factors that stimulate the change from the G_1 phase to the S phase.
State the substances used to synthesise DNA during the S phase.

.....

.....

..... [3]

(d) Fig. 6.2 is a drawing of chromosome 1 from rice, *Oryza sativa*, during metaphase of mitosis.

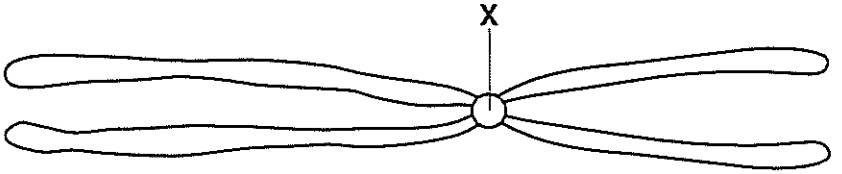


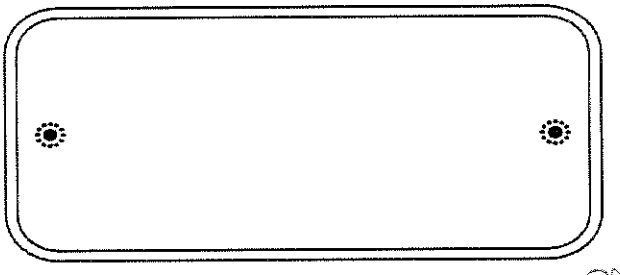
Fig. 6.2

(i) State the name and function of the region of the chromosome labelled **X**.

name .....

function ..... [2]

(ii) In the outline of the cell below, draw the chromosome from Fig. 6.2 as it would appear in anaphase of mitosis.



[2]

23. M/J 17/P22/Q4/a
Meristematic tissue is found in the growing regions of plants, such as root tips.

(a) Fig. 4.1 summarises a cell cycle for a meristematic cell in the root tip. The two phases of this cell cycle are shown:

- interphase, which is divided into the G_1, S and G_2 stages
- cell division, which is divided into stages 1–5.

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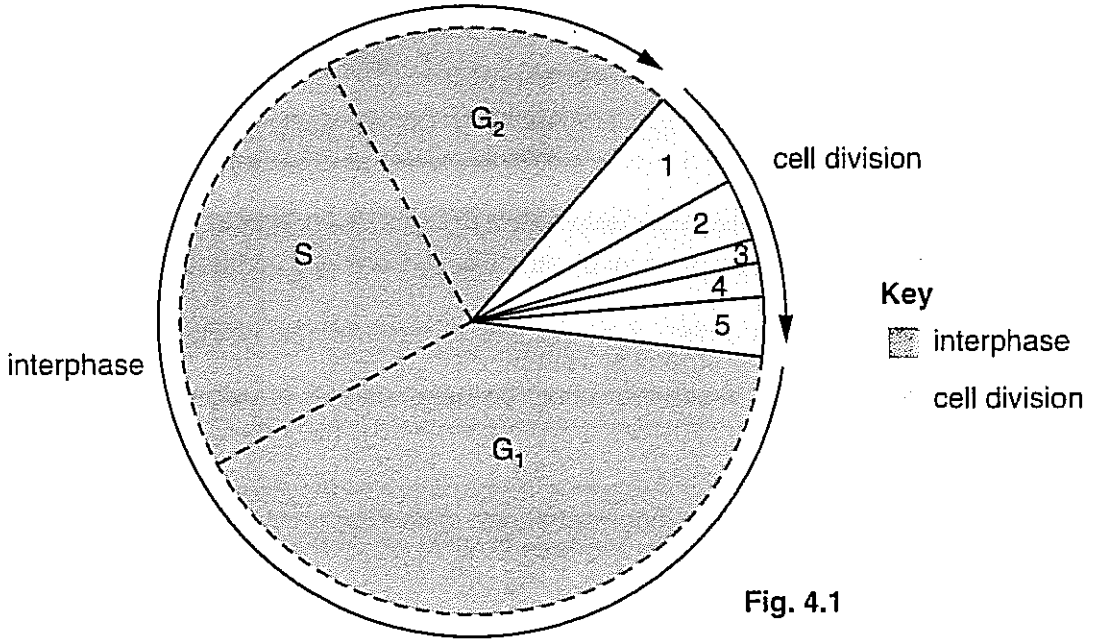


Fig. 4.1

(i) In Fig. 4.1, stage 2 is metaphase.
The stages shown in Fig. 4.1 are listed below. Draw a circle around the stage in the cell cycle that is cytokinesis **and** describe what happens in this stage in the root tip meristematic cell.

1 2 3 4 5 G_1 S G_2

.....

.....

..... [3]

(ii) The stages shown in Fig. 4.1 are listed below. Draw a circle around the stage in the cell cycle in which the semi-conservative replication of DNA occurs **and** state what is meant by semi-conservative replication.

1 2 3 4 5 G_1 S G_2

.....

.....

.....[3]

24. M/J 17/P23/Q5

(a) Describe the process of DNA replication.

.....

.....

.....

.....

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..... [5]

(b) State the name of the part of the chromosome that prevents the loss of genes during DNA replication.

..... [1]

(c) During DNA replication, the use of an incorrect base in the newly synthesised strand can lead to a mutation.

(i) A transversion event is where a pyrimidine is used in the newly synthesised strand instead of a purine, or the other way round.
Name the **two** possible bases that could be used instead of cytosine in a transversion event.

..... [1]

(ii) A transition event is where an incorrect purine is used or an incorrect pyrimidine is used. Suggest why transversion events are **less** likely to occur than transition events.

.....

..... [2]

(d) Outline how mutations can cause healthy cells to become tumour cells.

.....

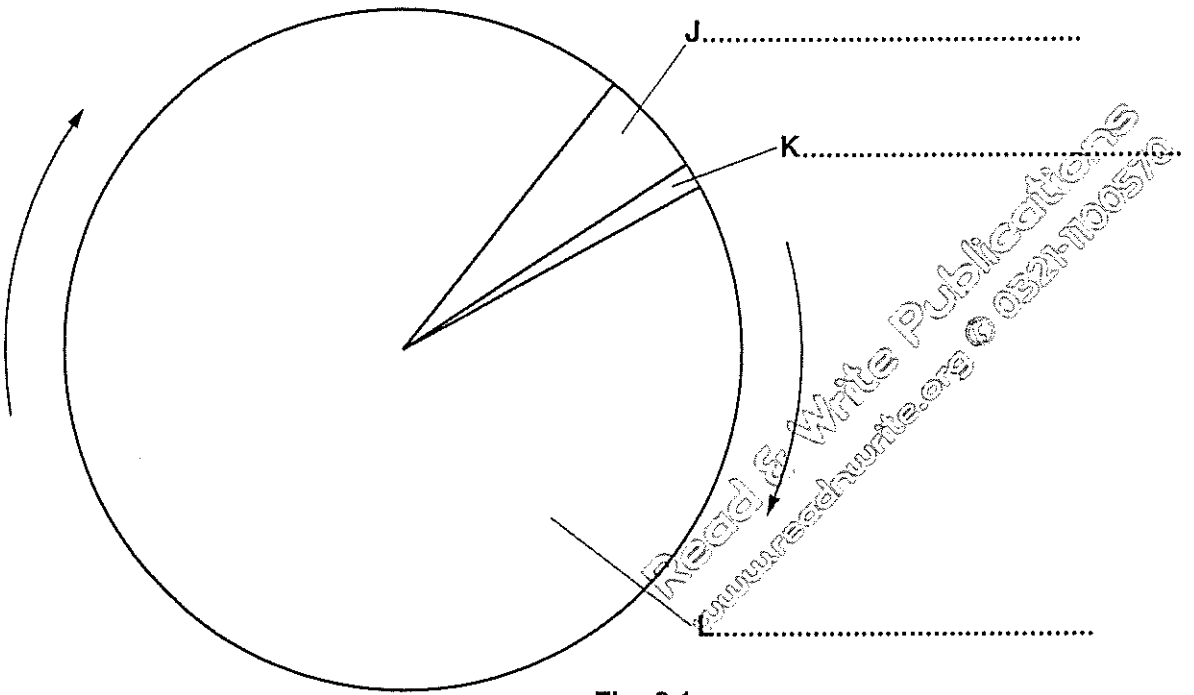
.....

..... [3]

25. O/N 16/P22/Q6/a

(a) Fig. 6.1 represents one complete cell cycle for a eukaryotic cell.

(i) Complete Fig. 6.1 by naming the stages represented by **J**, **K** and **L**.



[3]

Fig. 6.1

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(ii) Name the stage in the cell cycle in which semi-conservative replication of DNA occurs.

..... [1]

26. O/N 16/P21/Q1/c

Fig. 1.1 is a transmission electron micrograph of part of an animal cell.

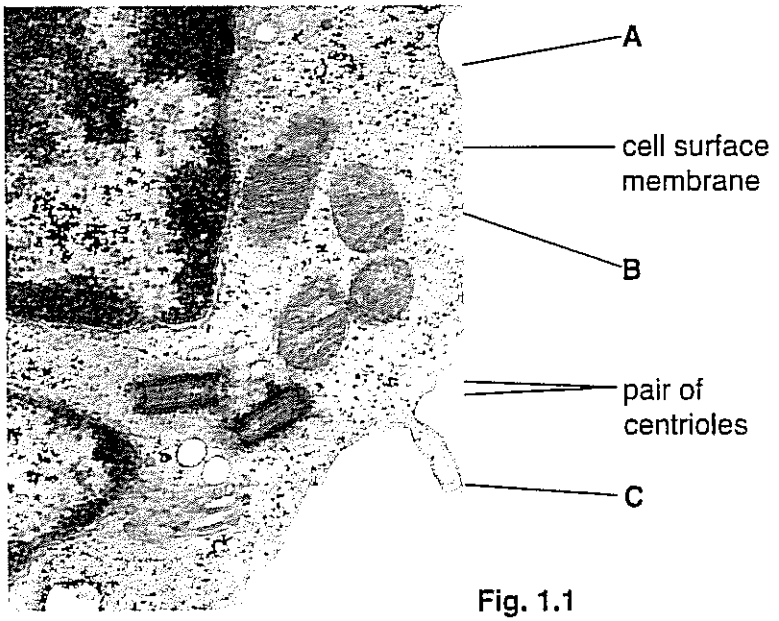


Fig. 1.1

(a) Cells such as that in Fig. 1.1 can divide by mitosis.
Describe the role of centrioles in mitosis.

.....

..... [2]

27. M/J 16/P22/Q5

Fig. 5.1 shows plant cells in stages of mitosis.



Fig. 5.1

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(a) Individual chromosomes cannot be seen in the cell at the start of prophase. Changes to the chromatin occur so that by late prophase chromosomes are clearly visible.

(i) Outline what occurs during early prophase so that chromosomes become visible in late prophase.

..... [1]

(ii) Describe the structure of the chromosome in late prophase.

.....

.....

..... [3]

(b) State **two** differences between the chromosome at metaphase and the chromosome at late anaphase.

.....

..... [2]

(c) One of the functions of a plant hormone known as cytokinin is to act as a cell signalling molecule and promote cytokinesis.

Suggest how cytokinin acts as a cell signalling molecule.

.....

.....

..... [3]

28. M/J 16/P21/Q5/a

(a) Fig. 5.1 is a diagram of part of an animal cell in a stage of mitosis.

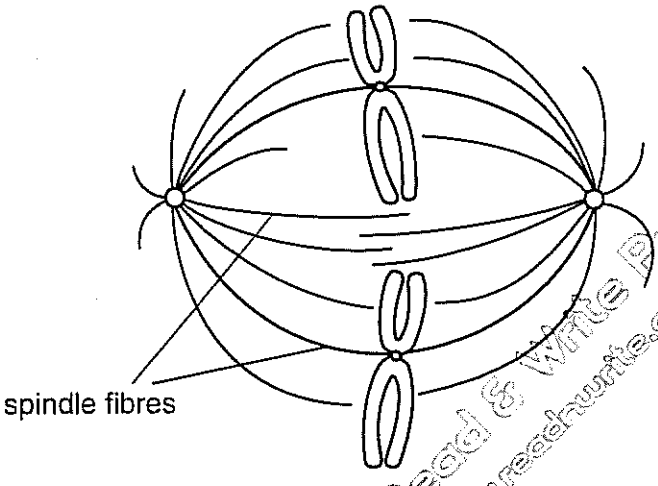


Fig. 5.1

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(i) Draw a diagram in the space below to show the stage of mitosis that follows the stage in Fig. 5.1.

[3]

(ii) Describe the roles of the spindle fibres during mitosis.

.....

..... [2]

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29. O/N 15/P22/Q3

The photomicrographs in Fig. 3.1 show stages of the mitotic cell cycle occurring in the root tip of the onion, *Allium sp.* They are all of the same magnification. Stages **A** to **C** are in the correct sequence and stages **K** to **N** are **not** in the correct sequence.

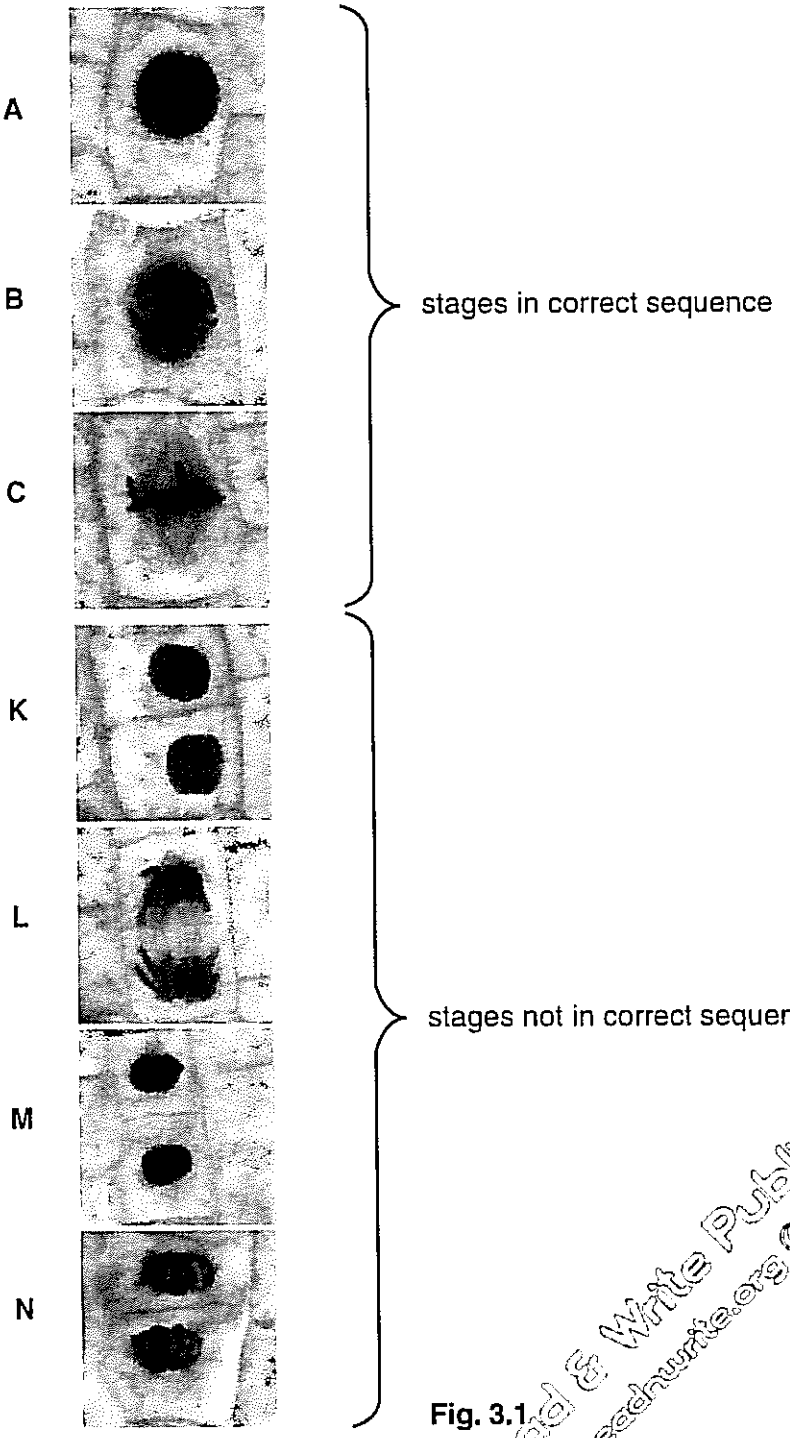


Fig. 3.1

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(a) Name stages **A** and **C**.

A .....

C ..... [1]

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(b) Put stages **K** to **N** in the correct sequence, starting with the stage that immediately follows stage **C**.

C ⟶ ..... ⟶ ..... ⟶ ..... ⟶ ..... [1]

(c) Explain how the behaviour of the chromosomes and spindle during stage **L** in Fig. 3.1 ensures that the two daughter cells will be genetically identical.

.....

.....

..... [3]

30. O/N 15/P21/Q3

Fig. 3.1 is a light micrograph of cells in the root tip of the garlic plant *Allium sativum*. It has a diploid number (2n) of 16.

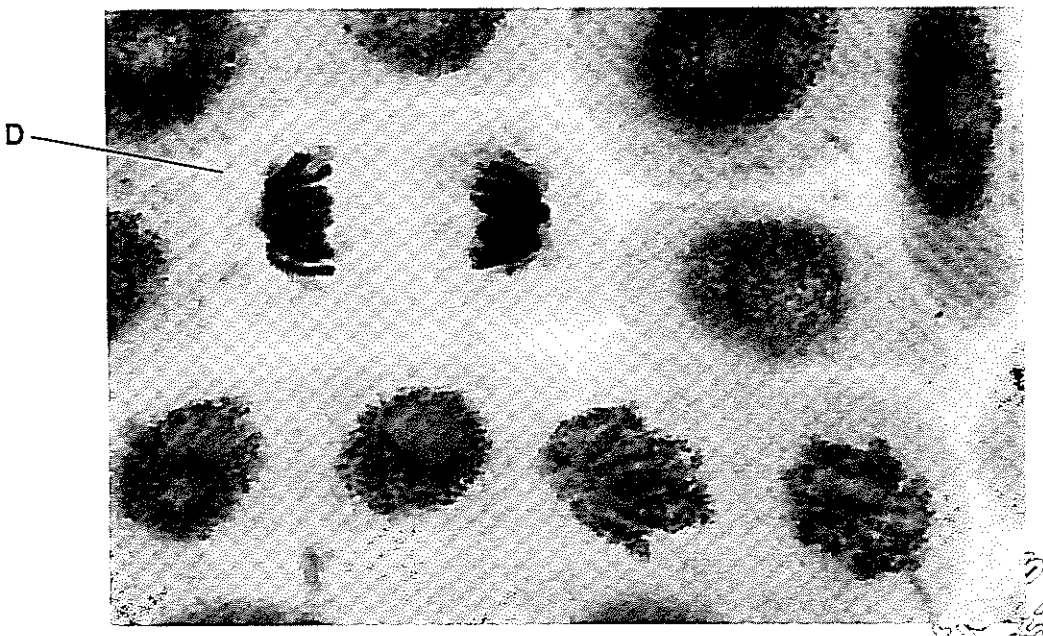


Fig. 3.1

(a) Name the stage of mitosis shown in cell **D**.

..... [1]

(b) Explain why mitosis occurs in a plant such as *A. sativum*.

.....

..... [2]

(c) **(i)** State the haploid number of *A. sativum*.

..... [1]

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(ii) Explain why a plant such as *A. sativum* produces haploid cells.

.....

.....

..... [3]

(d) DNA replication must occur before cell division.
Describe the process of DNA replication.

.....

.....

.....

.....

..... [5]

31. M/J 15/P21/Q1

A student investigated growth in the roots of broad bean, *Vicia faba*. The student cut sections of the root tip of this plant and viewed them with a light microscope.

Fig. 1.1 is a photomicrograph of one of the sections. The cell labelled **D** is in interphase.

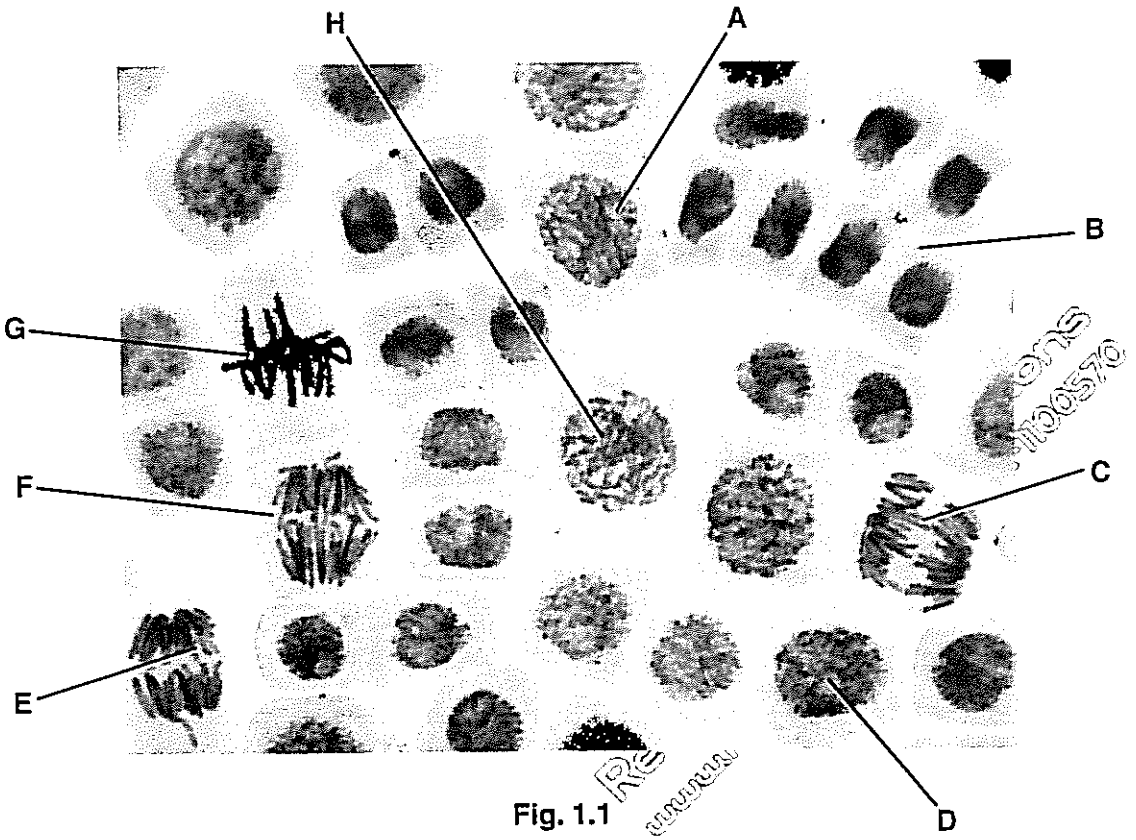


Fig. 1.1

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(a) Complete the table below by:

- naming the stages of mitosis in the correct sequence following interphase
- identifying **one** example from the cells labelled **A** to **H** that is in each stage of mitosis that you have named.

stage of mitosis	label from Fig. 1.1

[5]

(b) In animal cells, centrioles are responsible for assembling microtubules to make the spindle at the beginning of mitosis.
Describe the role of the spindle during mitosis.

.....

..... [2]

(c) State two roles of mitosis in plants and animals **other than growth.**

1 .....

2 ..... [2]

(d) *V. faba* is a legume. Roots of legumes often have swellings at intervals known as nodules. Cells within the nodules contain nitrogen-fixing bacteria.

(i) Explain the role of nitrogen fixation in the nitrogen cycle.

.....

..... [2]

(ii) Farmers in some parts of the world grow legume crops together with cereal crops in the same field. This is known as intercropping.

Explain how intercropping results in an increase in the yield of the cereals when the legumes die.

.....

.....

..... [3]

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32. O/N 14/P22/Q6

Agrobacterium tumefaciens is a bacterium that can enter plants through wounds and cause a disease known as crown gall disease.

The bacterium attaches to the surface of cells and inserts a small circular DNA molecule, known as a plasmid, into the cell. Some of the genes on the plasmid code for proteins that cause changes in the plant cell and result in the formation of a plant tumour, or gall.

(a) Outline the changes that occur during tumour formation.

.....

.....

.....

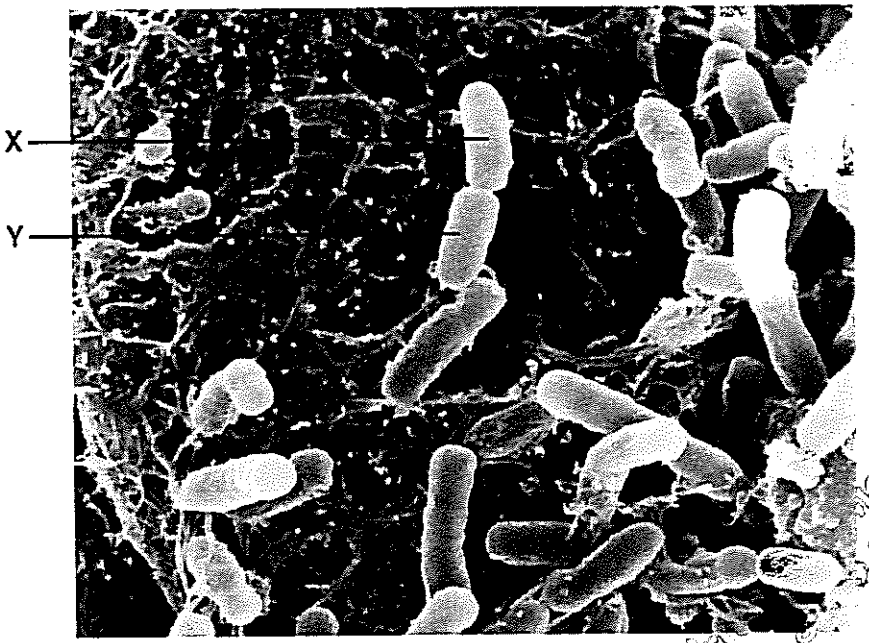
..... [4]

(b) Bacteria that enter the stem through a wound can reach the root of the plant to cause damage. Suggest how the bacteria are able to reach the root of the plant.

..... [1]

(c) Fig. 6.1 shows *A. tumefaciens* on the surface of cells of a tobacco plant, *Nicotiana plumbaginifolia*.

The cells **X** and **Y** are newly formed cells.



magnification ×11500

Fig. 6.1

Calculate the actual length of cell **X** in micrometres.
Show your working.

answer ..... μm [2]

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33. O/N 14/P21/Q4

(a) A student cut thin sections of a root tip of *Allium cepa* and stained them to show chromosomes. A photomicrograph of part of one of these sections is shown in Fig. 4.1.

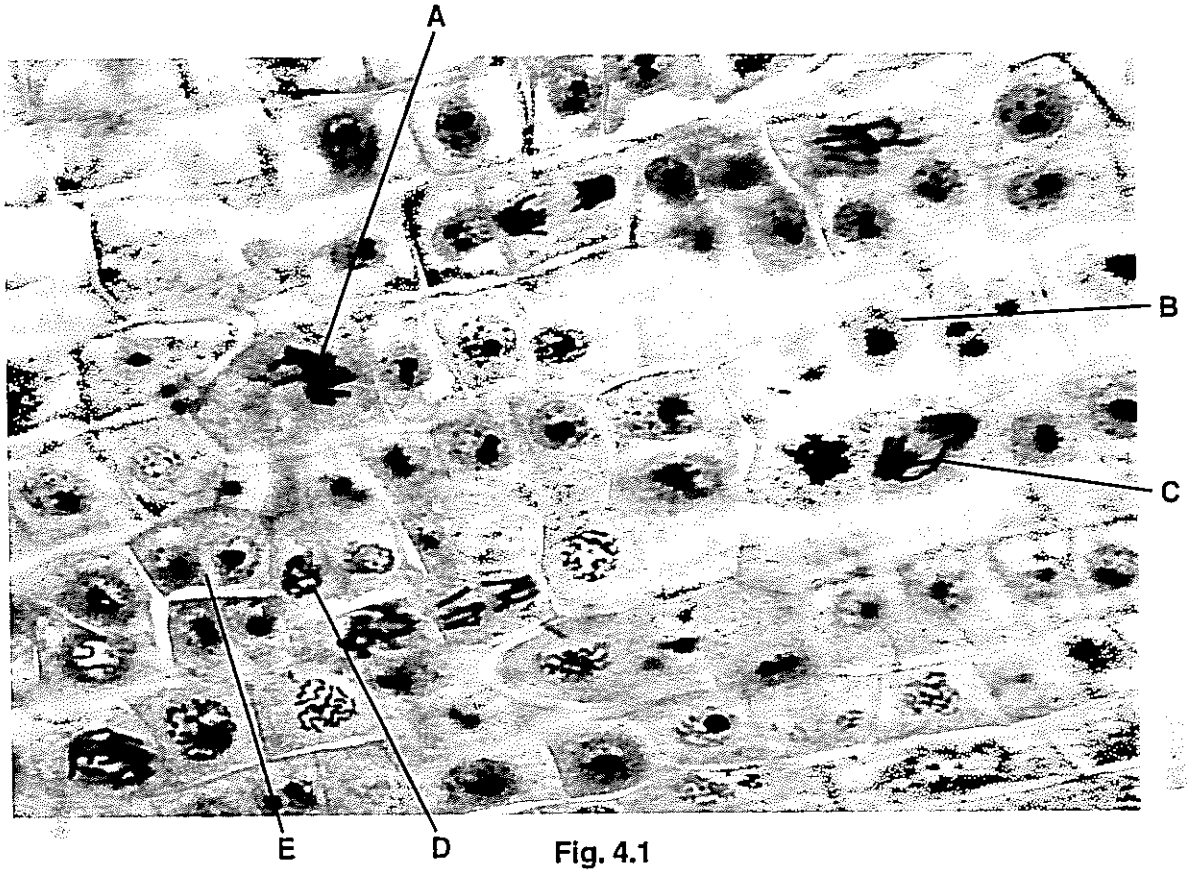


Fig. 4.1

Table 4.1 shows the behaviour of chromosomes and the changes that occur to the nuclear envelope during a mitotic cell cycle in the root tip of *A. cepa*.
Complete Table 4.1.

Table 4.1

name of stage	cell in Fig. 4.1	behaviour of chromosomes	nuclear envelope
	B	chromosomes uncoiled, may be replicating	intact
prophase			intact, but then breaks down
metaphase			not present
anaphase		chromosomes / chromatids, moving to opposite poles	
telophase		chromosomes uncoiling	

[5]

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(b) Explain why the growth of roots, such as those of *A. cepa*, involves mitosis and **not** meiosis.

.....

.....

..... [3]

(c) State two processes, **other than growth**, in which mitosis is involved.

1. .....

2. ..... [2]

34. O/N 14/P23/Q1

Fig. 1.1 is a photomicrograph of plant root cells near the growing tip. Some of the cells are undergoing mitosis.

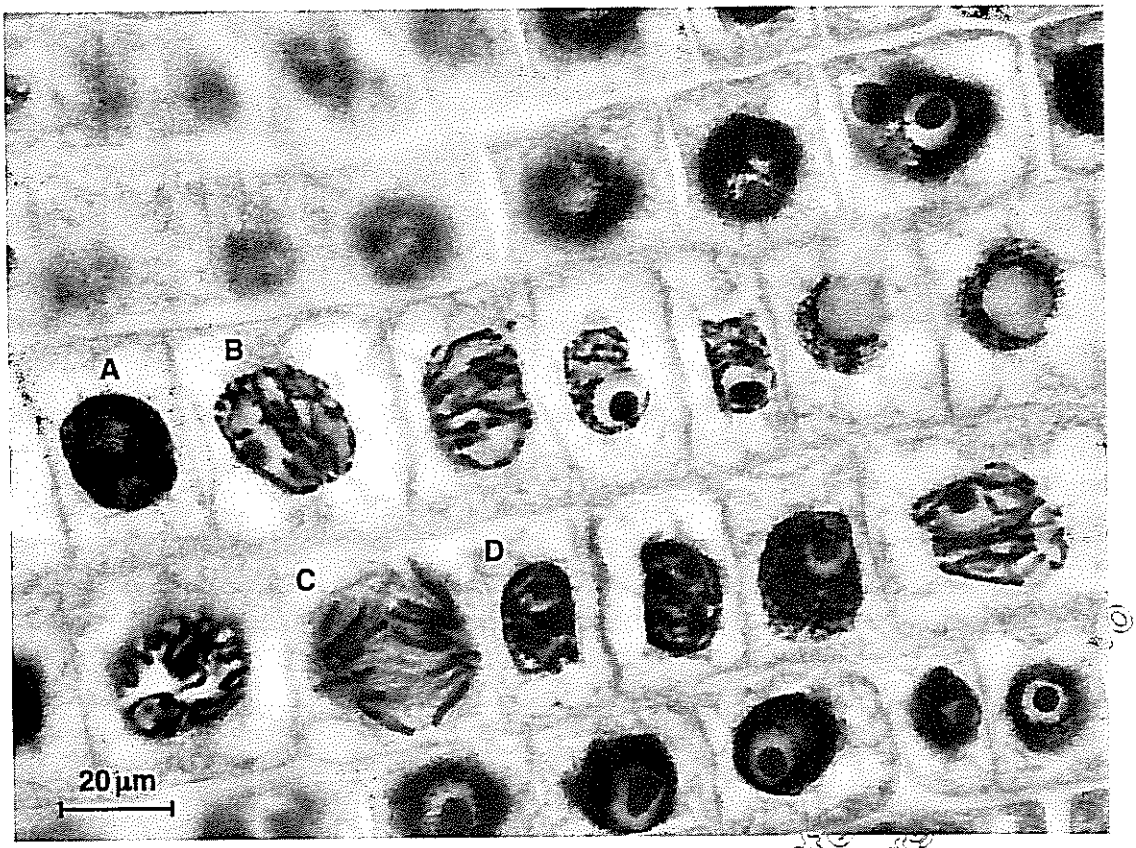


Fig. 1.1

(a) State **one** feature, visible in Fig. 1.1, which indicates that the section is taken from plant tissue and not animal tissue.

.....[1]

(b) State the letter, **A** to **D**, of the cell in Fig. 1.1 which is in:

(i) prophase .....

(ii) anaphase. ..... [2]

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(c) Describe two events occurring in cell **B**.

1. .....

2. ..... [2]

(d) **(i)** Describe the role of mitosis in a growing plant root tip.

.....

..... [2]

(ii) Mutations can sometimes occur in cells which are rapidly dividing.
Outline how a mutation can cause an altered polypeptide to be produced.

.....

.....[2]

(e) Calculate the magnification of Fig. 1.1.
Show your working and give your answer to the nearest whole number.

magnification × ..... [2]

35. O/N 13/P22/Q1/d

(a) The inner lining of arteries and veins is composed of a layer of epithelial cells supported by a layer of elastic and connective tissue. The epithelial cells are capable of cell division by mitosis.

(i) State the role of mitosis in cell division of epithelial cells.

.....

..... [2]

(ii) Explain why the epithelial cells undergo mitosis and **not** meiosis.

.....

..... [2]

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36. O/N 13/P21/Q1

Fig. 1.1 shows a cell of a female fruit fly, *Drosophila melanogaster*, during a stage of mitosis.

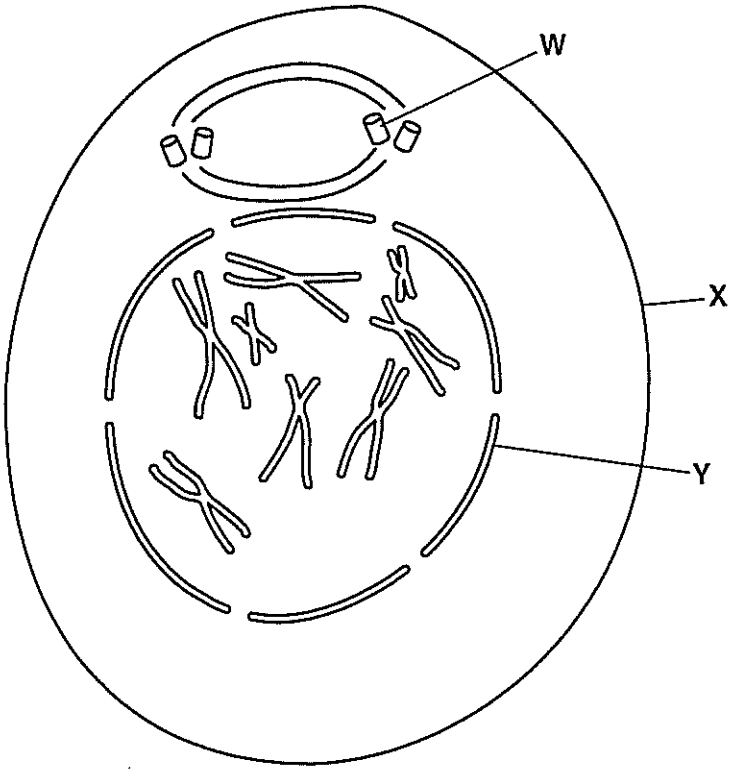


Fig. 1.1

(a) (i) Name the stage of mitosis shown in Fig. 1.1.

..... [1]

(ii) Shade a pair of homologous chromosomes. [1]

(iii) Name the structure labelled **W** and state its function.

.....

..... [2]

(b) State what happens to structure **X** and to structure **Y** between the stage shown in Fig. 1.1 and the end of cell division.

.....

.....

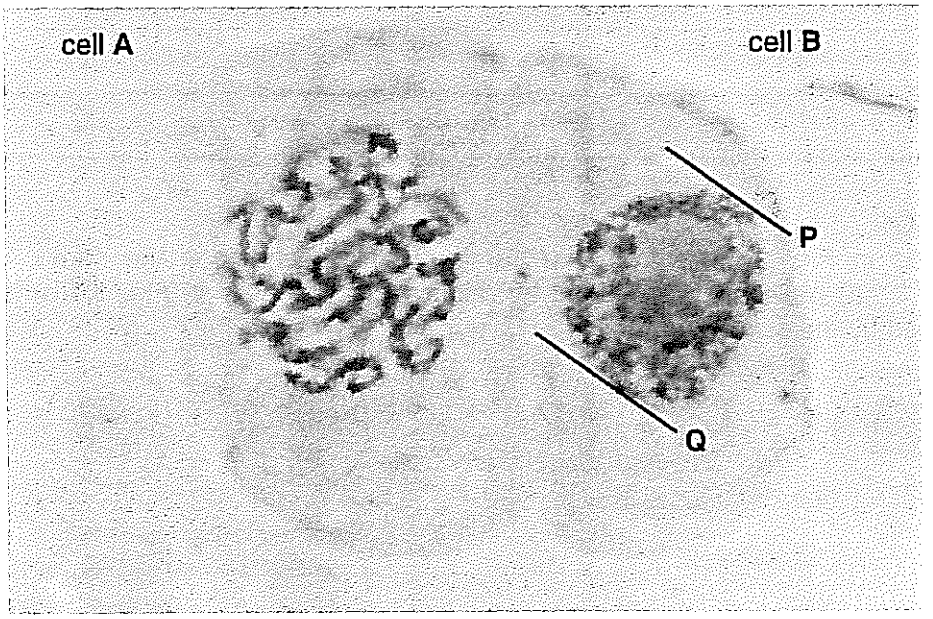
..... [3]

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37. O/N 13/P23/Q3

Fig. 3.1 is a photomicrograph of two animal cells, **A** and **B**, at different stages of the mitotic cell cycle.



magnification ×5000

Fig. 3.1

(a) (i) For each cell, state the name of the stage of the cell cycle shown in Fig. 3.1.

cell **A** .....

cell **B** ..... [2]

(ii) Describe the events that occur during the stage of the cell cycle named for cell **A** in **(a)(i)**.

.....

.....

.....

..... [4]

(b) The magnification of Fig. 3.1 is ×5000.
Calculate the diameter of the nucleus of cell **B** between lines **P** and **Q**.
Show your working and give your answer to the nearest micrometre (μm).

answer ..... μm [2]

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(c) State the advantages of light microscopy, rather than electron microscopy, for studies of the cell cycle.

.....

.....

..... [3]

38. M/J 13/P22/Q1

(a) The cells in Fig. 1.1 are from the same organism and look the same. The cells in Fig. 1.1(a) have been produced by mitosis and the cells in Fig. 1.1(b) have been produced by meiosis.

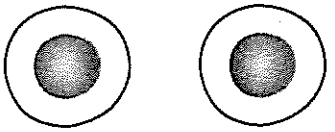


Fig. 1.1(a)

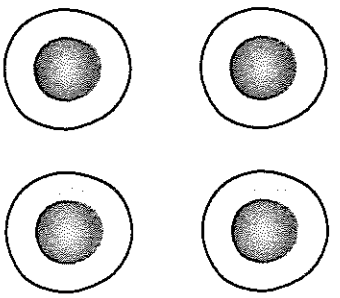


Fig. 1.1(b)

(i) Complete the table to show two differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis.

mitosis	meiosis

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[2]

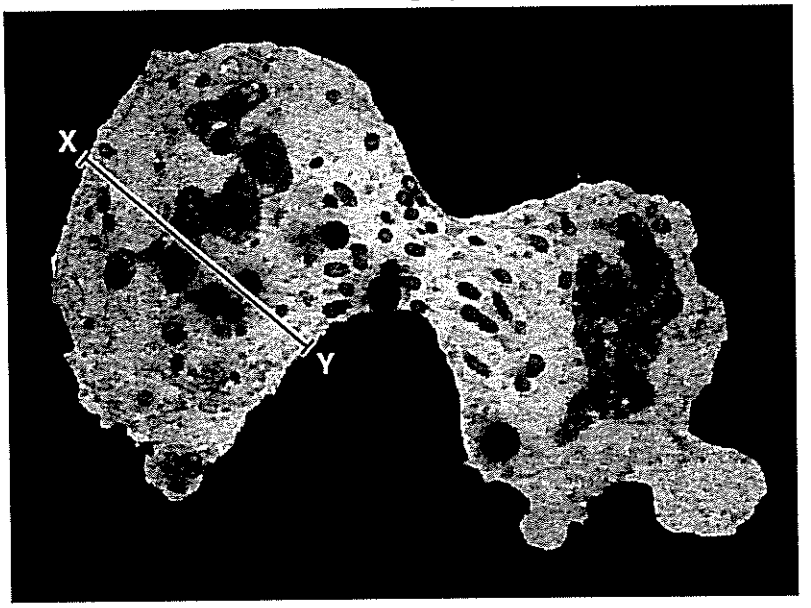
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(ii) Explain why the organism produces cells by meiosis.

.....

..... [2]

(b) Fig. 1.2 is a transmission electron micrograph of a dividing cancer cell.



magnification x 3000

Fig. 1.2

(i) Calculate the actual width of the cell shown in Fig. 1.2 at **X-Y**.
Show your working and give your answer to the nearest micrometre (μm).

answer ..... μm [2]

(ii) The cancer cell shown in Fig. 1.2 has more mitochondria and rough endoplasmic reticula (RER) compared to the non-cancerous cell from which it originated.
Suggest why this is so.

.....

..... [2]

39. M/J 13/P21/Q6

(a) Explain how uncontrolled cell division can result in cancer.

.....

.....

..... [3]

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(b) Describe the experimental evidence that shows that smoking causes lung cancer.

.....

.....

..... [3]

(c) Fig. 6.1 shows the changes in mortality rates for lung cancer in five countries between 1950 and 2006 for males.

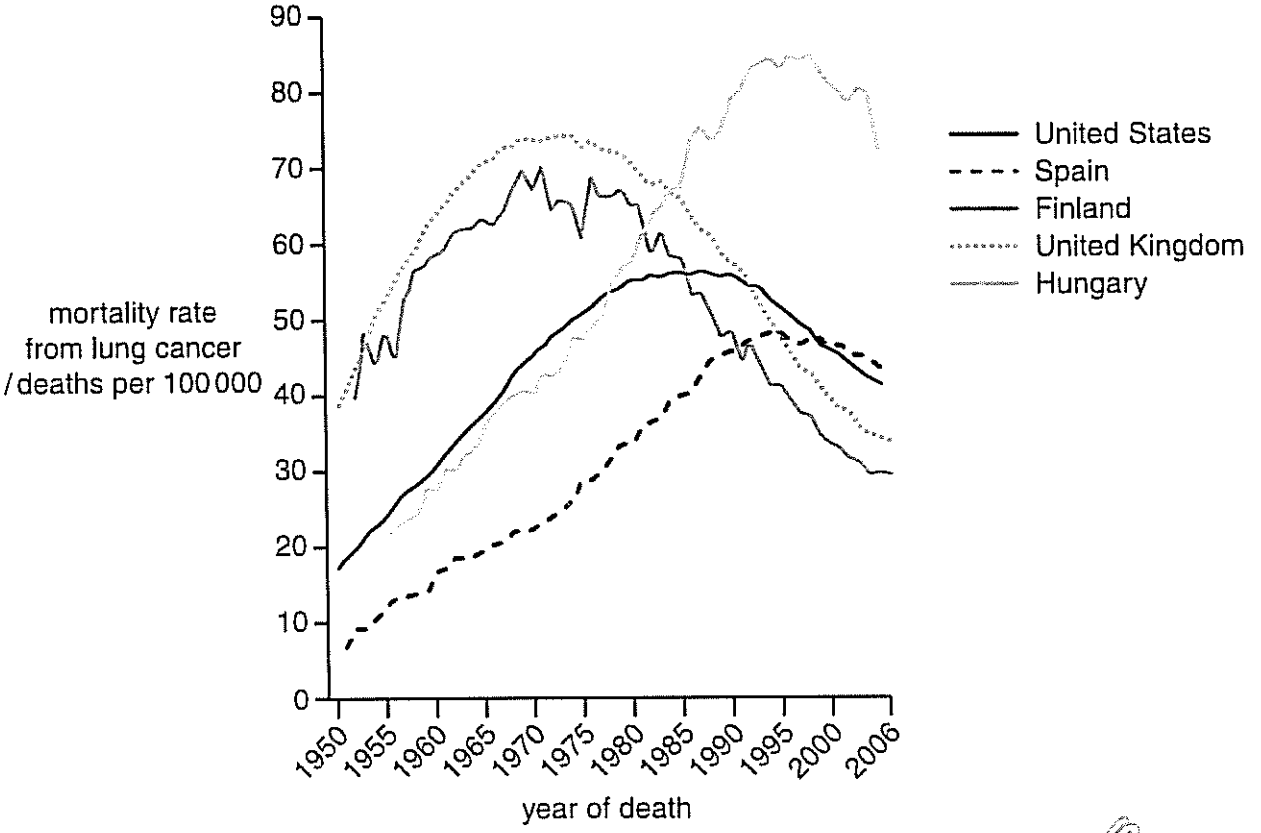


Fig. 6.1

With reference to Fig. 6.1, describe the similarities **and** differences in the trends in mortality rates in the countries shown.

.....

.....

..... [3]

40. M/J 13/P23/Q5

(a) Explain the importance of mitosis in multicellular organisms.

.....

.....

..... [3]

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A protein, mitosis-promoting factor (MPF), has been identified in cells. MPF is a globular protein made from two polypeptide chains.

(b) Place a tick (✓) in the box next to the type, or types, of protein structure shown by MPF.

primary ☐

secondary ☐

tertiary ☐

quaternary ☐ [1]

The presence of MPF is known to cause prophase to start.

(c) Describe the changes that occur during prophase in an animal cell.

.....

.....

.....

..... [4]

(d) MPF normally begins to break down and stops functioning during anaphase. Suggest the possible consequences of MPF **not** breaking down.

.....

.....

..... [3]

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Answers Section

1. **O/N 21/P22/Q1/d**
   (a) metaphase label to metaphase cell ;
   prophase label to one of the prophase cells ; [2]

2. **O/N 21/P21/Q4**
   (a) (i) *any **two** from:*
   microtubules / spindle (fibres), are attached to, centromere / kinetochore ;
   (spindle) fibres, contract / shorten / retract ; **A** microtubules disassemble / AW
   move / pull, (sister) chromatids / (daughter) chromosomes, to opposite poles ;
   (ii) deoxyribose and phosphate and base ;
   further detail
   one from
   diagram / description, of phosphate group and base attached to deoxyribose ;
   one correctly named base or A,T C and G ;
   (b) (i) *any **two** from:*
   allow DNA replication to continue ;
   idea that stem cell to, self renew / keep dividing ;
   idea that stem cells differentiate into (named) specialised cells ;
   idea that mitosis produces cells for, cell replacement / tissue repair ;
   (maintains telomeres, so) prevents the loss of genes ;
   (ii) *any **one** from:*
   (high level of telomerase activity) allows ,continuous / uncontrolled, mitosis / cell division ;
   idea of allowing shorter cell cycle ;
   (iii) *any **three** from:*
   DNA binds to (complementary section of) mRNA / hydrogen bonds form between the complementary base (of DNA and RNA) ;
   mRNA cannot bind to the ribosome ;
   ribosome cannot, move along the mRNA ;
   consequence e.g. no sites for tRNA to bind / tRNA cannot bring attached amino acid ;
   tRNA anticodons cannot form hydrogen bonds with mRNA codons ;
   AVP ; e.g. *idea that* DNA enters nucleus to bind and mRNA then too large to leave via nuclear pores [10]

3. **O/N 21/P23/Q6/d**
   (a) interphase / S (phase) / synthesis (phase) ;
   A S1 / S2
   R if 'interphase + G1 / G2' or 'S + G1 / G2' [1]

4. **M/J 21/P22/Q1**
   (a) (i) **E** = metaphase ;
   F = anaphase ; **I** early / mid / late
   R more than one stage given for either **E** or **F**
   (ii) *any one from*
   (assemble) to form / become part of / AW, spindle fibres / spindle ;
   attach to, centromere ; **A** kinetochore *for centromere*
   A form (part of) kinetochore
   A to connect, chromatid / chromosome, to, spindle / spindle fibres
   I to connect, chromosome / centromere, to centrosome
   example of allowing movement of, chromosomes / chromatids ; e.g.
   A to, pull chromosomes / orientate chromosomes, at equator
   A to pull (sister) chromatids apart (at anaphase)

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A to move, (sister) chromatids / daughter chromosomes, to poles

(iii) must state 'plant' to gain mark
I vacuoles / large permanent vacuole / vague ref. to shape
any one from
cell walls present;
uniform / regular, shape of cells ;
no, cleavage furrow / pinching in of cytoplasm (in cells at cytokinesis) ;
cell plate present (in late telophase / cytokinesis, stages) ;

(b) **R** *any answers where a choice is given*
A hydrogen ;
B (DNA) ligase ;
C DNA polymerase ; **R** RNA polymerase
I roman numerals, e.g. DNA polymerase I
D telomeres ; [8]

5. **M/J 21/P23/Q6**
(a) correct working ; e.g. 14 000 000 ÷ 1400 (**A–B** = 13 to 15 mm)
(x) 9286 / 9642 / **10 000** / 10 357 / 10 714 ;
incorrect conversions used in working or incorrect measured value of **A–B** *can be awarded the answer mark as ecf– the working must show use of dividing by 1400 (or incorrect conversions of 1400)*
(b) *any four from*
two chromatids drawn with, non-metacentric centromere / chromosome arms unequal length ; (sister) chromatid ;
centromere ; *allow as a constriction*
telomere ; *must be labelled at / towards the end*
AVP ; e.g. four telomeres labelled **or** telomere sectioned off at each chromatid end and one labelled DNA and histones
/ allele *must be shown as a section*
(c) **R** homologous chromosomes
any one from
most condensed state ; AW **I** chromosomes, are condensing / condense
chromosomes (all) in one, plane / focus ;
A *idea of* all at the equator (so clearly visible)
I line up. horizontally / vertically
(d) anaphase ; [8]

6. **O/N 20/P22/Q4/b**
(a) if letter used in more than one row, **R** these rows
correct interphase knowledge G2 = **A**, S = **B**, G1= **blank** ;
cytokinesis **blank** ;
prophase **C** ;
anaphase **E** ;
telophase **D** ; [5]

7. **O/N 20/P21/Q1**
(a) (i) (sister) chromatids ;
centromere ;
histone ;
(ii) prophase / metaphase ; **I** late / early **A** prometaphase
(iii) **I** *ref. to* replication or cytokinesis
any ***two*** *from:*
provides energy ;

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movement of centrioles to poles ;
spindle formation / organisation of microtubules (for spindle) ;
movement of chromosomes to the, spindle equator / AW ;
separation of, (daughter) chromosomes / (sister) chromatids, to opposite poles (of the cell) / during anaphase ; AW AVP ; e.g. (for) condensation / AW, of, chromatin / chromosomes

(b) *assume reference to binary fission unless stated otherwise*
*any **two** from:*
DNA replication ; **A** *idea* of, doubling / duplicating, DNA
cell, elongation / gets longer ; **A** cell increases in size
cell wall formation ;
(includes) cytokinesis / described ;
max 1 if two ideas correct describing events that only occur in mitosis [8]

8. **O/N 20/P23/Q3**
(a) (i) **A** – G1 / gap 1 ;
B – S / synthesis ; **A** DNA replication **I** S1 / S2 / replication unqualified
(ii) telophase ;
(iii) *any **two** from:*
increase in cytoplasm / increase in number of (named) organelle(s), during interphase ; **A** synthesis of organelles **I** cell growth
(re)formation of nuclear envelope ;
nuclear envelope, forms around each group of chromosomes ;
A nuclear membrane as an **ECF** if used for mp2
(movement of) organelles to be shared between two daughter cells ;
spindle, disassembles / breaks down / degrades / disappears / AW ;
cleavage furrow forms ;
A cytoplasm / cell membrane, pinches in / constricts / infolds AVP ;
e.g. (actin) microfilaments / microtubules, form contractile ring / AW, around equator of cell / beneath cell surface membrane
A cytoskeleton for microtubules / microfilaments
(iv) *one mark per row*

	stages of cell cycle		
	A	**B**	**D**
number of nuclei within the stem cell	1	1	2 ;
number of chromosomes ineach nucleus	12	12	12 ;

(b) **1** stem cells) continue to divide / divide repeatedly (by mitosis) ;
A at least one daughter cell, retains ability to divide / is a stem cell / **A** 'repeated mitosis' / **A** 'to produce more stem cells'
*any **two** from mps 2-5:*
to produce cells
2 for growth ;
3 for repair of tissues ; **R** repair of cells
4 for replacement of, worn out / old / dead, cells ;
A damaged cells if repair of tissues not given

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5 to differentiate for formation of, tissues / organs ;
A specialised cells for forming, tissue / organs

and:

6 AVP ; e.g. *ref. to* potency of stem cells (multipotent or pluripotent) [10]

9. M/J 20/P22/Q6/a,b

(a)

Stage of cell cycle	
(G_1 phase)	interphase ;
S phase	
G_2 phase ;	
prophase	(mitosis)
metaphase	
anaphase ;	
(telophase)	
(cytokinesis)	

one mark for interphase
one mark for S phase and G_2 phase in correct sequence
one mark for prophase, metaphase and anaphase in correct sequence

(b) Vincristine: ✓ ✓ x x ;
5-fluorouracil : x x x x ; [5]

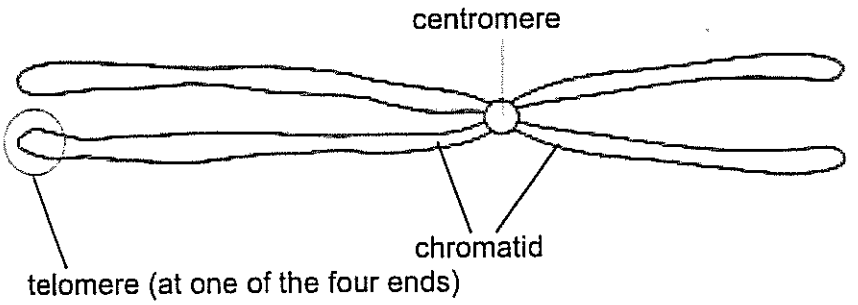
10. M/J 20/P21/Q2

(a) **P** – chromosomes, arranged randomly / AW
or
idea that chromosomes present but not (yet) visible as consisting of two sister chromatids (joined by centromere);
A description related to idea of chromosomes becoming visible / chromatin condensing
Q – chromosomes are, arranged / aligned / AW, at the, (cell / spindle) equator / metaphase plate ;
A equatorial plate
R – no chromosomes visible / nucleolus is present / chromatin not condensed / euchromatin present ;

(b) (i) *drawing*
two chromatids of identical length joined at the centromere ;
labels
chromatid ; *one label line is sufficient* **R** if second line drawn to arm of sister chromatid
centromere ;
telomere ;

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(ii) histone(s) ; **A** highly basic (protein)

(iii) *accept spindle fibres / microtubules as alternative to spindle*
max 2 if stages are named and are incorrect
any three from:
(prophase) attachment to centromere of each chromosome ;
A *ref. to* kinetochore *in correct context*
(prophase) arranging / orientating / AW, chromosomes at the, equator / metaphase plate / AW ;
A *ref. to* metaphase in correct context
(anaphase) centromere division / separation of sister chromatids ;
(anaphase) pulling, chromatids / daughter chromosomes, apart / towards poles ;
(because) spindle fibres contract / (as) lengths of microtubules decreases / microtubules are disassembled ;
(elongates in telophase to) push, poles / nuclei, apart ; [11]

11. M/J 20/P23/Q5

(a) *any two from*
sequence of DNA nucleotides ;
forms part of a DNA molecule / length of DNA / AW ;
coding for a polypeptide ; **A** protein

(b) interphase ; **I** phases of interphase

(c) (i) two phosphates added to existing phosphate ;
base = adenine ;
sugar = ribose ;

(ii) purine ;

(d) *any three from*
to produce, many / AW, new blood cells ;
idea that large numbers are required to, transport oxygen / maintain immune system ;
produce genetically identical cells ;
loss of genetic material may not allow function / cells maintain function / cells are able to function ;
replacement of, old / damaged / dead, cells ;
AVP ; e.g. to maintain healthy numbers of cells
red blood cells have short life [10]

12. O/N 19/P22/Q6

(a) **I** maintains length of chromosomes / prevents chromosome shortening
any two from:
permit continued replication ;
prevent loss of genes ;
I prevents gene damage genetic material is neutral
A genetic / coded, information *for genes*
A information on DNA
A protein coding regions of DNA
A exons

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protect ends of chromosomes from being, degraded / AW ;
AVP ;
e.g. prevents ends of chromosomes from being attached to each other
not mistaken for a break in DNA that needs repairing

(b) *Idea that,* mitosis / cell cycle / (DNA) replication / (cell) division, occurs in both cell types (continuously / regularly / AW) ;
R uncontrolled mitosis
R meiosis

(c) induced fit ;

(d) *allow low(er) rate for 0.2 μmol dm^{-3} and high(er) rate for 1.6 μmol dm^{-3}*
any two from:
comparison in terms of active site(s) ;
e.g. (low rate) active sites, not all occupied / spare / not all saturated
or
(high rate) active sites all occupied / no spare active sites / active sites saturated bod 'active sites are limited'
comparison in terms of enzyme-substrate complexes formed (per unit time)
e.g. (low rate) few(er) ES complexes formed
or
(high rate) many / more, ES complexes formed ;
A (low rate) few(er) collisions between enzyme and substrate ora
(low rate) substrate concentration limiting factor
or
(high rate) limiting factor is, enzyme concentration / not substrate concentration; [6]

13. O/N 19/P21/Q6

(a) *three from*
joins a nucleotide to extending, polynucleotide / strand ;
(only allows) complementary base pairing ;
forms phosphodiester bonds (between nucleotides) / forms the sugar phosphate backbone ;
proofreading the new strand ;
repairs any mismatched base pairs ;

(b) (i) stops, cell cycle / mitosis / cell division / cell replication / AW ;

(ii) thymine only present in DNA / no thymine in RNA ;
uracil (nucleotide) replaces thymine (nucleotide) in transcription ;

(c) (i) cytokinesis ;

(ii) *three from*
tobacco smoke / tar, contains (named) carcinogens ;
cause, damage to DNA / mutations ;
detail ; e.g. proto-oncogenes to oncogenes / tumour suppressor genes switch off (in) epithelial cells in the, trachea / bronchus / gas exchange system / lungs ;
uncontrolled, mitosis / cell division ;
AVP ; e.g. forms a mass of undifferentiated cells / AW
cells do not respond to signals [9]

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14. O/N 19/P23/Q2

(a)

name	one example of cell from 2.1
interphase	B / G
prophase	A
metaphase	D
anaphase	E / F / C
telophase	C / H **R** C *if stated for anaphase*

all five correct = 3 marks
three or four correct = 2 marks
one or two correct = 1 mark

(b) (29 as a percentage of 5000 =) 0.58 (%) ; **A** 0.6 (%)
(0.0058 × 720 minutes =) 4 (min) / 4.2 / 4.18 / 4.176 ; *allow ecf*

(c) *mark first answer*
one from
1 cell plate forms (across equator of cell) ;
2 cell wall / cellulose, laid down ; **A** cell wall forms (between the two)
3 cytoplasm divided (into two) ;
R cytoplasm, constricts / pinches in
I 'separates into two daughter cells'
I events at late telophase
4 *idea that* organelles shared out ;
5 AVP ; detail of cell plate formation
e.g. *ref. to* vesicles transported to equator / involvement of cytoskeletal structures / *ref. to* phragmoplast [6]

15. M/J 19/P21/Q4/a,b

(a) *any one from:*
idea that to provide cells that can, differentiate / divide ;
for (continued) growth of the, shoot tip / (named) tissues ;
I 'to produce more meristematic cells'

(b) *one mark per row*

stages	description
F and **G**	cell, elongates / enlarges / grows **and**, a vacuole forms / makes a tonoplast ;
G and **H**	cell divides (longitudinally) **and** one of the cells has a vacuole ;
H and **J**	developing sieve tube cell, elongates / enlarges / grows **and** loses its nucleus **or** one (developing companion) cell divides (transversely) to form (two) companion cells ; **A** companion cell divides

[4]

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16. O/N 18/P22/Q3

(a) *any two from*

1 (division that) produces, new / daughter, cells **A** produces more cells
or
(so) replaces, damaged / lost / dead, cells ;

2 new / daughter, cells, genetically identical ;
A *ref. to* clone if correct context
A genetic information not lost
I same number of chromosomes

3 (all) new cells can retain function ; AW

(b) *any two from*

1 cell cycle continuous / continually divide / AW ;

2 (produce cells that) can, differentiate / specialise / described ;
A multipotent / pluripotent **I** totipotent
divide to produce a cell that can divide and a cell that differentiates = 2 marks

3 can produce, cells / tissue, that can still function (as before) ;

(c) *any three from*

1 chemicals (released) are cell signalling, molecules / compounds ;

2 liver cells, are target cells ;
A liver tissue for liver cells

3 binding of, chemicals / cell signalling molecules, to receptors (of liver cells) ;
R receptor cells

4 *ref. to* specificity (of receptors) / chemicals complementary to receptors ;
*if **R** above, then allow ecf for idea of complementary*

5 (specific) response is, cell enters the cell cycle / mitosis / cell division ;
A DNA replication

6 AVP ; e.g. *idea of* communication between cells
suggestion of detail following binding, e.g. second messenger activated / enzyme cascade / signal transduction phosphorylation events / enzyme activation
I cascade of reactions [7]

17. O/N 18/P23/Q6

(a) (i) [A] C E D B F ;

(ii) **I** early and late except where indicated

event in the cell cycle	name of the stage in the cell cycle
DNA replication	interphase / S phase ;
division of centromeres	anaphase ; **R** late anaphase
condensation of chromatin	prophase ;
contraction of spindle fibres	anaphase ;
organisation of chromosomes at the equator	metaphase

(b) **I** antibodies have receptors

any three from

1 clones / AW, of B/T cells consist of very few cells ;
AW = types of / specific / groups of

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2 (mitosis occurs) during clonal expansion ;
3 many, B cells / plasma cells, to make antibodies ;
4 many, T-helper / T_h, cells to secrete, cytokines / lymphokines / interleukins ;
5 many, T-killer cells / T-cytotoxic cells, to kill, infected cells / cancer cells ;
6 memory cells are produced for, secondary response / faster response (when antigen encountered again) ;
A during a secondary infection (implying of the same pathogen)
7 need to make genetically identical cells ; [8]

18. M/J 18/P22/Q4

(a) 1 / 4 ;
3 ;
5 ;

(b) *two from:*
centromere (of each chromosome) divides ;
A sister chromatids separated at the centromere
spindle fibres, contract / shorten ; A spindle contracts
(sister / identical) chromatids / daughter chromosomes, pulled / move, to opposite poles ;
A (sister) chromatids separated
I chromosomes are at opposite poles
centromeres, leading (towards poles) / AW ; A ref. to V-shape / diagram

(c) *one from:*
not sectioned to include (nucleus) ;
did not take up the stain / not stained (correctly) / AW ;
AVP ; e.g. cells may be dead I destroyed / eliminated / AW [6]

19. M/J 18/P23/Q1

(a) (nucleus of cell) D has two nucleoli v E has one nucleolus ;

(b) A = (early / mid) prophase ; R late
B = (mid / late) prophase ; R early
C = anaphase ;

(c) I name of stage
two from:
ref. to (daughter) chromosomes at poles ;
A (sister) chromatids at poles
R chromatids move to poles
A two separate groups of (daughter) chromosomes
A two nuclei form (enclosing chromosomes)
I there are two nuclei
in context of at each pole
nuclear envelope reassembles (around chromosomes) ;
A nuclear membranes reassemble
nucleolus reappears / nucleoli reappear ;
(daughter) chromosomes, become diffuse / become long and thin / decondense / uncoil
A become chromatin
I disappears
spindle, disassembles / AW ; [6]

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20. O/N 17/P22/Q1

(a) **C** ;

R if more than one area given

(b) (i) *three from*

two chromatids drawn ; *must be connected at some point*

(sister) chromatid label to correct structure ;

centromere label to correct structure ; **A** kinetochore

telomere label to end of chromatid ;

DNA and histone (proteins) label to chromatid ;

(ii) *two from*

disassembles / breaks down / disintegrates / AW, at, prophase ; **A** prometaphase

re-forms / re-assembles / AW, after anaphase / at telophase ;

if mp 1 and 2 not gained, one mark can be awarded for knowledge of disassembles and then reassembles

detail ;

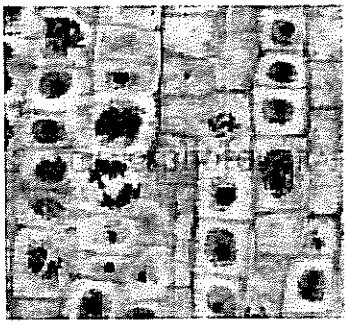
e.g.

breakdown into vesicles

re-forms from vesicles / vesicles fuse to form new membranes

re-forms around both sets of (daughter) chromosomes [6]

21. O/N 17/P21/Q1

(a) 

;

(b) *two from*

can observe living, specimens / cells ;

(so) the process of mitosis can be seen happening / AW ; **R**

easier to see mitosis happening **I** to study cell division

ease of use, qualified ; e.g. no need for heavy metal staining,

preparation of specimen less time-consuming

I *ref. to* colour **I** portable

(c) *three from*

production of genetically identical cells ;

asexual reproduction ;

repair of damaged tissue ; **A** replace damaged cells **R** repair damaged cells

replace, dead / worn out / old / non-functioning, cells ;

gamete production *in context* ; [6]

22. O/N 17/P23/Q6

(a) EGF binds to receptor(s) on cell **A** ; **ora**

A has receptor for, EGF / cell signaling compound

A EGF does not bind to receptor on **B**

idea of complementary / specific ; **ora**

R antigen to antibody

I active site

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(b) *accept* ***ora***
one from
more, proteins / polypeptides, are made ;
proteins are required for growth / to provide (named) protein for DNA synthesis / proteins are required for organelles / AW ;
A S phase for DNA synthesis
during mitosis DNA is highly condensed ;

(c) *three from*
ATP ;
(activated / free / DNA) nucleotides ;
R in context of transcription
DNA polymerase ;
(DNA) ligase ;
AVP ; e.g. topoisomerase / gyrase helicase

(d) (i) centromere ; **A** kinetochore
one from
holds / joins / AW, (sister) chromatids together ;
attach to spindle

(ii) *max 1 if more than one chromosome shown*
two from
separate chromatids that are identical in shape ;
one arm larger than the other on both separate chromatids ;
V-shaped chromatids with centromeres pointing towards the poles ; [10]

23. M/J 17/P22/Q4/a

(a) (i) 1 circle round **5** ;
to max 2 but 4 cells produced = max 1 out of 2
I details of telophase leading to cytokinesis
2 cell plate forms (across equator of cell) **or** cell wall / cellulose, laid down ; **A** cell wall forms (between the two)
3 (so) cytoplasm divided (into two) ;
R cytoplasm constricts / pinches in / cleavage furrow forms / cleavage forms *(i.e. referring to animal cell)*
4 AVP ; detail of cell plate formation e.g. *ref. to* vesicles transported to equator / involvement of cytoskeletal structures *idea that* organelles shared out

(ii) circle round **S** ;
synthesis of two identical DNA, molecules / double helices (from one) ;
each new molecule consists of one, original / parental, strand, and one, new / newly synthesised, strand ; AW
A daughter *for newly synthesised* [6]

24. M/J 17/P23/Q5

(a) 1 DNA (double helix) unwinds ; **A** uncoils **I** unzips **R** DNA strand unwinds
2 hydrogen bonds break between, base pairs / bases / strands ;
3 both strands used as templates ;
4 catalysed by / AW, DNA polymerase ;
5 *ref. to* (free) activated nucleotides / AW ;
6 complementary (DNA) nucleotides added ; **R** RNA nucleotides
A described in terms of complementary base pairing
7 step-by-step / sequentially / AW ;
8 *idea that* process continues, along whole DNA molecule ;
9 replication bubbles / described

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or
ref. to Okazaki fragments ;

10 replication is semi-conservative / each newly formed molecule contains one original and one newly synthesised strand

11 AVP ; e.g. *ref. to* repair / proofreading
ref. to, helicase / ligase *in correct context*

(b) telomere(s) ;

(c) (i) adenine and guanine ;

(ii) *idea that* purines and pyrimidines are different sizes / two rings and one ring ;
purine normally bonds with pyrimidine (to maintain DNA double strand width) ;
idea that two purines or two pyrimidines will distort the double helix width (in a transversion event) ; **ora**
AVP ; e.g. (transversion event) more likely to be detected by the repair mechanism **ora**

(d) *idea that* mutation occurs for a gene controlling cell division ;
detail ; e.g. proto-oncogene to oncogene
tumour suppressor gene switched off ;
ref. to disruption of cell cycle / shortened interphase ;
(results in) uncontrolled cell division ; **I** uncontrolled growth
other detail of result of mutation ; e.g.
divide indefinitely / no programmed cell death
do not respond to signals to stop dividing
loss of, specialisation / function [12]

25. O/N 16/P22/Q6/a

(a) (i) J = mitosis ; **A** mitotic division **I** nuclear division **R** mitotic cell division
K = cytokinesis; **A** cytoplasmic, division / cleavage **I** cell division
L = interphase;

(ii) interphase ; **A** S-phase / synthesis phase / late interphase **R** early interphase [4]

26. O/N 16/P21/Q1/c

(a) *two from*
organise microtubules ;
(to), form spindle / assemble spindle fibres (in prophase) ; AW
ref. to centriole pair / centrioles, at (both) poles ; **R** if description is linked to incorrect mitotic stage
ref. to role in contraction of spindle fibres, at anaphase / to separate sister chromatids ;
AVP ; e.g. make microtubules (as part of the centrosome) [2]

27. M/J 16/P22/Q5

(a) (i) coiling / supercoiling / condenses / condensation ;
A become shorter and thicker **R** contracts

(ii) *accept from labelled diagram*
two chromatids ;
identical / sister, chromatids ;
joined by a centromere ; **A** kinetochore
one from
(reach chromatid) DNA complexed with protein
histone proteins / histones
telomeres at end of chromatids ;

(b) *metaphase versus anaphase*
idea of single chromosome of two chromatids versus two separated chromatids / daughter chromosomes

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e.g. two chromatids versus, one chromatid / one daughter chromosome ;
sister chromatids joined at centromere versus chromatids separated
distance between sister chromatids zero versus increasing distance between chromatids
share a centromere versus do not share a centromere / centromere divides
two DNA molecules versus one DNA molecule ;
at, equator / metaphase plate versus towards / at, poles ; **R** centre **R** ends
linear / straight versus V shape / AW ;

(c) acts at <u>target</u> cell ;
binds to receptor ; **R** receptor cells *allow ecf for other mps*
R trapped / caught
ref. specificity ; **A** receptor complementary (shape) for cytokinin
A cytokinin fits into receptor *this is also mp2*
A recognition of cytokinin by receptor
receptor (located) in, cell surface / plasma, membrane ;
A cell membrane **A** phospholipid bilayer **A** transmembrane receptor
sets off / AW, response in the cell / described response(s) ; e.g.
triggers secondary messenger
activates enzyme(s)
I signals / causes / stimulates, cell to divide / cytokinesis
(acts) <u>extracellularly</u> / <u>extracellular signal</u> **or** (acts) <u>intracellularly</u> / <u>intracellular signal</u> ; *must be in context of candidate's answer* [9]

28. M/J 16/P21/Q5/a

(a) (i) *if draw other stages mark first one only – either left to right or top to bottom*



four chromatids / daughter chromosomes, drawn as single structures between equator and poles ;
V shaped, chromatids / daughter chromosomes, in correct orientation ;
spindle (fibres) attached to all four, centromeres / kinetochores / apex, and centrioles ; **R** if these extend between chromatids

(ii) **1** attach to the, centromeres (at prophase) ; **A** kinetochores
I *if attach at metaphase*
2 attach to, centrioles ; **A** centrosome / MTOC
3 arrange the chromosomes on the, equator / metaphase plate ;
4 pull / move, (daughter) chromosomes, apart / to the <u>poles</u> ;
A separates *for moves apart* **A** (sister / identical) chromatids
I ends **R** homologous chromosomes [5]

29. O/N 15/P22/Q3

(a) **A** = interphase **I** *ref. to early / late*
C = metaphase ;
both needed for one mark

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(b) (C) **L**, **N**, **M**, **K** ;

(c) **1** *idea that* centromere, has divided / divides (separating, sister / identical, chromatids) ;
2 centromere attached to spindle fibre; **A** spindle
3 shortening / contraction, of spindle fibres (pulling centromeres) ; **A** spindle, contracts / shortens
4 (so) sister / identical, chromatids, move to opposite poles ; *need idea of separated, so* **A** ends / sides / halves
A sister / identical, chromatids, will end up, at separate poles / in separate cells [5]

30. O/N 15/P21/Q3

(a) (late) anaphase / (early) telophase ; **R** early anaphase

(b) produce more genetically identical cells / AW ;
for growth (of the root) ;
asexual reproduction ;
replace (old / worn out) cells ;
repair (damaged tissue) ; **A** *ref. to* wounds **R** repair cells

(c) **(i)** 8 ;
(ii) for sexual reproduction ;
to form gametes ; **A** pollen and, egg / ovum **R** sperm
ref. to diploid number must be restored (in zygote) **or**
fusion / fertilisation, of two haploid cells results in, diploid cell / zygote ;
prevents chromosome number doubling each generation ;

(d) **1** DNA double helix unwinds ; **I** unzips **R** DNA strand unwinds
2 hydrogen bonds break between, base pairs / bases / strands ;
3 both strands used as templates ;
4 catalysed by / AW, DNA polymerase ;
5 *ref. to* (free) activated nucleotides / AW ;
6 complementary DNA nucleotides added ; **A** described in terms of complementary base pairing
7 step-by-step / sequentially / AW ;
8 *idea that* process, occurs / continues, along whole DNA molecule ;
9 replication bubbles / described **or** *ref. to* Okazaki fragments ;
10 replication is semi-conservative / each newly formed molecule contains one original and one newly synthesised strand
11 AVP ; e.g. *ref. to* repair / proofreading *ref. to*, helicase / ligase *in correct context* [12]

31. M/J 15/P21/Q1

(a) *one mark for the stages of the cell cycle in the correct sequence*
one mark for correct matching of each stage with a cell

stage of mitosis	label from Fig. 1.1
prophase	**A / H** ;
metaphase	**G** ;
anaphase	**C / E / F** ;
telophase ;	**B** ;

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(b) microtubules / spindle (fibres), attach to centromere / kinetochore (of chromosome during prophase) ; **I** metaphase
arranging / aligning / orienting / AW, chromosomes at the equator / metaphase plate ; **R** centre
fibres, shorten / contract / retract ; **A** microtubules disassemble / AW
move / pull, (sister) chromatids / (daughter) chromosomes, to opposite poles / centrioles ;
idea that equal number of chromosomes in each daughter, nucleus / cell ;

(c) maintaining number of chromosomes ;
ensuring genetic stability / maintaining genetically identical cells / AW ;
asexual reproduction ; **A** vegetative reproduction / cloning
cloning / clonal expansion, of (named) lymphocytes ; **A** B / T cells
replacement of (worn out / dead / damaged) cells ;
regeneration, of (named) tissues / organs ;
(wound) repair (of tissues) ; **R** repair of cells
ref. to production of gametes ;
e.g. mitosis in gametogenesis / gamete production in plants
R 'copying of cells'

(d) (i) *accept biological N fixation or Haber-Bosch process for mp1*

1 *either*
converts, (inorganic) nitrogen / dinitrogen / N_2, into organic nitrogen / ammonia / NH_3 / ammonium / NH_4^+ ; **R** if nitrate given
or
lightning converts, nitrogen / ammonia / NH_3 / ammonium / NH_4^+, into, nitrite / nitrate (ions) ;

2 reduces nitrogen / breaks triple bond ;

3 makes (fixed) nitrogen available to, legumes / other organisms / community / AW ; **A** ref. to amino acids / proteins
not to be awarded if it follows nitrification

4 increase soil fertility ;

5 balances the loss of fixed nitrogen in, denitrification / ocean deposits ;

(ii) 1 *idea of* decay / decomposition ;
e.g. breakdown by, (saprophytic) bacteria / fungi

2 legumes eaten by, detritivores ; **A** named detritivores

3 decomposers produce proteases ;

4 to, hydrolyse / convert / change / AW, protein to amino acids ;

5 amino acids are deaminated ;

6 (amino acids) to, ammonia / NH_3 / ammonium (ions) / NH_4^+ ;

7 nitrifying bacteria / *Nitrosomonas*, convert ammonia to nitrite (ions) ;

8 nitrifying bacteria / *Nitrobacter*, convert nitrite to nitrate (ions) ;
if mp7 or mp8 not awarded allow one mark for the following as mp9

9 (named) nitrifying bacteria convert, ammonia / ammonium, to nitrate (ions) ;
mp10 only to be awarded following nitrification

10 nitrate (ions) used for making, amino acids / proteins (hence increase in growth of cereals) ; [14]

32. O/N 14/P22/Q6

(a) 1 proteins produced (for growth) ;

2 DNA replication ;

3 organelles / named organelles synthesised ; **A** more organelles

4 uncontrolled mitosis / **AW**

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or continuous cell cycle
or cell cycle checkpoints not controlled ;

5 (new cells) do not differentiate ; **A** do not become specialised

6 loss of function (of tissue) ; **A** changed function / new cells do not function as tissue of origin

7 (abnormal) mass of cells formed ;

8 **AVP** ; e.g. no programmed cell death / apoptosis / cells immortal / cells grow independently of normal programming / no contact inhibition

(b) travels in phloem / phloem sap / translocation ; **R** in xylem
from cell to cell via plasmodesmata ;
in symplast pathway ;
in apoplast pathway ; **R** in xylem
ref. to bacterial motility, e.g. flagella ;

(c) 1.1–1.13 (µm) ;; **OR** 1.2–1.22 (µm) ;;

$\left[\frac{13\text{ mm}/13000\ \mu\text{m}}{11500}\right]$ $\left[\frac{14\text{ mm}/14000\ \mu\text{m}}{11500}\right]$

one mark only for
correct formula and measurement (13 / 14 mm) but incorrect conversion
or for correct formula used with a measurement of 12 or 15 mm [7]

33. O/N 14/P21/Q4

(a) one mark for correct cells in column 2 ;

name of stage	cell in Fig. 4.1	behaviour of chromosomes	nuclear envelope
interphase ;	**B**	chromosomes uncoiled, may be replicating	intact
prophase	**D**	chromosomes, coiling/condensing/seen as two sister chromatids/AW ;	intact, but then breaks down
metaphase	**A**	chromosomes on equator/AW ;	not present
anaphase	**C**	chromosomes/chromatids, moving to opposite poles	not present ;
telophase	**E**	chromosomes uncoiling	reforming/present/intact ;

(b) *mitosis*
needs number of chromosomes to remain constant/diploid ;
needs all daughter cells to be genetically identical/have no genetic variation ; **A** clones
needs genetic stability ;
meiosis
halves the number of chromosomes/diploid → haploid ; **A** undergoes a reduction division
daughter cells are all genetically different ; *accept once only*
produces genetic variation ; *accept once only*
involved in sexual reproduction (in flowering plants) not growth ; **A** production of gametes
idea that cells that are genetically different will not function together in tissues ; ora

(c) asexual reproduction/vegetative propagation ;
(tissue) repair ; **R** cell repair

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(cell/tissue) replacement ;
AVP ; e.g. clonal expansion/part of gametogenesis/spores in fungi [10]

34. O/N 14/P23/Q1

(a) cell wall(s) ;
vacuoles ;
regular shape of cells / fixed shape / description of shape / AW ;
I 'no centrioles', 'thicker' as in 'thicker cell walls'

(b) (i) B;
(ii) C ;

(c) chromosomes / chromatin / chromatids, condense / coil up / thicken / AW ;
A chromosomes / chromatids, become visible / shorten
spindle formation / spindle fibres made / assembly of microtubles / AW ;
nucleolus disappears ;
nuclear envelope, breaks down / disintegrates / disassembles / AW ;
A nuclear membrane
I *ref. to* centrioles and centromeres

(d) (i) producing (more) cells ;
genetically identical / no genetic variation ;
same, number / type, of chromosomes ; **A** 'remain diploid'
I 'set of chromosomes'
repair / replacement (of root tip / tissue) ; **R** 'repair of cells'
idea that mitosis makes cells for, different tissues / for differentiation ;
e.g. use of examples, xylem / phloem / root hair / epidermis
I *ref. to* elongation

(ii) change in DNA, nucleotide / base, sequence ;
substitution, deletion, insertion, inversion, frameshift
change in, DNA / (m)RNA, codons / triplets
change in, amino acid sequence / primary structure, protein / polypeptide ;

(e) *acceptable range for measuring line 14 mm to 16 mm*
if the answer is between 700 and 800 allow 2 marks
if measurement of 14–16 mm is incorrectly converted allow one mark for correct measurement and correct formula – scale length divided by 20
15 000 / 20
750 ;; [11]

35. O/N 13/P22/Q1/d

(a) (i) *(produce genetically identical daughter epithelial cells for)*
1 (for tissue) repair ;
R cell repair
2 *idea of* replacing, dead / destroyed / damaged / worn-out / AW, cells ;
A replacement of cells, unqualified *if mp 1 gained*
3 ref. protection of, underlying tissue / muscle and elastic layer / tunica media / AW ;
4 meiosis produces, haploid cells / cells with n chromosomes / cells with one set of chromosomes ;
A cells with half the number of chromosomes
5 meiosis for gamete formation ;
A sex cells
R meiosis in gametes

(ii) *ignore ref. to 23/46 chromosomes*
(mitosis to), maintain genetic stability / produce genetically identical cells / produce clones ora ***or***
meiosis produces genetically different cells ;

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(mitosis), ensures cells retain function / cells function as tissue / AW ;
(mitosis) maintains chromosome number ;
A maintains, diploid number / 2n
meiosis produces, haploid cells / cells with n chromosomes / cells with one
A cells with half the number of chromosomes
meiosis for gamete formation ;
A sex cells
R meiosis in gametes [4]

36. O/N 13/P21/Q1

(a) (i) prophase ;
R prophase I

(ii) two homologous chromosomes shaded ;

(iii) centriole ; **A** centrosome / microtubule organising centre / MTOC
one from
produces spindle / produces spindle fibres ;
produce / organises, microtubules ;
disassembles / AW, spindle / spindle fibres / microtubules ;
A one e.g. of role of, spindle fibres / microtubules *if a link to centriole has been made*
allow if centriole incorrectly named or if not given

(b) *max 2 if no attempt made at both **X** and **Y***
***X** / cell surface membrane*
1 forms a (cleavage) furrow ; **A** 'pinches in' / constricts / AW
2 ref. fusion ;
3 to divide cell into two ; **A** *idea of* formation of two (separate) cells linked to behaviour of (cell surface) membrane;
4 ref. to cytokinesis / contractile ring ;
Y / *nuclear envelope*
5 disassembles / breaks down / AW ;
6 during prophase / by end of prophase / before metaphase ;
A by the end of prometaphase
7 re-forms / AW, during telophase (from ER) ; [7]

37. O/N 13/P23/Q3

(a) (i) **R** *if more than one stage given*
A = prophase ; **I** early / late
B = interphase ;

(ii) *no ecf from* **(a)(i)**
***I** information about other phases*
1 chromatin / chromosomes / chromatids, condense / become visible ;
A described e.g. coiling, supercoiling, shorten, thicken
2 each chromosome is two (sister) chromatids joined together (at a centromere) ;
R 'two chromatids, join together / pair up'
3 nucleolus disappears ;
4 nuclear envelope, disassembles / breaks down / AW ;
5 centrioles / centrosomes, move to poles ;
A MTOC / microtubule organising centre
R 'ends' / 'sides'
6 ref to spindle ; e.g. spindle (fibres) start to form
centrioles organise microtubules (to form spindle fibres)
microtubules assemble

(b) 6 ;;

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if answer not given or incorrect allow one mark for correct measurement and correct use of formula

distance between **P** and **Q** is 30 mm, conversion to micrometres = 30 × 1000

either (magnification) $= \frac{30000}{5000}$

or $5000 = \frac{30 \times 100}{\text{actualsize}}$

look carefully for correct use of standard form

allow a tolerance of ± 2 mm (28–32 mm, i.e. 28 000–32 000 in formula)

(c) **I** *general references to LM v EM*

A ora *for electron microscope*

1 living cells can be viewed (with light microscope) ;
2 can watch the cell cycle happen (in real time / time lapse) / AW ;
3 all chromosomes can be seen (at once) ;
4 can see, whole chromosomes / all the stages of mitosis or cell cycle ;
5 do not need take sections to see mitosis ;
6 dyes / stains, can be used ; **I** ref. to natural colours of specimens
A ref. to fluorescence microscopy [11]

38. M/J 13/P22/Q1

(a) (i) *if one box of a pair left blank, no mark for that row*
mark first on row unless one row left completely blank

	mitosis	*meiosis*
1	diploid / two chromosome sets / 2n	haploid / one chromosome set /n ;
2	same number of chromosomes as parent / AW	half the number of chromosomes as parent / AW ;
3	two, copies / alleles / forms, of each	one, copy / allele / form, of each ;
4	(cells) genetically identical (to, each **A** (cells have) same / AW, DNA / **A** no genetic variation	(cells) genetically different **A** (cells have) different / AW, DNA / genetic material **A** genetic variation ;

(ii) **1** for sexual reproduction ; **A** for, gamete / sperm and egg / pollen and ovum, formation *or* **A** gametogenesis

2 to produce, haploid cells / cells with one set of chromosomes, for, fertilisation / fusion ; **A** to form zygote
A cells with half the number of chromosomes for, fertilisation / fusion

3 restores / AW, diploid / original, number when, fertilisation / fusion (of gametes) occurs ; *only need ref. to fertilisation / zygote once*

4 *idea of* ploidy consequences at fertilisation if not ;
e.g. ref. to doubling of chromosome number of original

5 ref. genetic variation, linked to evolution / natural selection;

(b) (i) 13 μm ; ; *two marks for correct calculation*
(39 000 / 3000)
allow one mark
if calculation of 12.6 μm or 13.3 μm (i.e. measured as 38 mm or 40 mm and not rounded to nearest micrometre)

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measurement of, 39 mm / 3.9 cm, incorrectly converted to μm but correct formula used (i.e. divided by 3000)

(ii) *assume cancer cell unless stated otherwise*
(undergoing) uncontrolled, mitosis / division ; **A** fast / rapid / abnormally
mitochondria, provide / produce, ATP ; **R** ATP energy
A provide energy **R** produce energy
RER, produce / synthesise / make / AW, (more), proteins / enzymes, for (cell) growth / mitosis / division ; *if mp 1 gained, no need ref. to mitosis* [8]

39. M/J 13/P21/Q6

(a) ref. to mutation(s) ;
in context of initiating uncontrolled mitosis OR as a consequence of uncontrolled mitosis
proto-oncogenes convert to oncogenes / oncogenes switched on / tumour suppressor genes switched off ;
(cell division is by) mitosis ;
formation of, tumour / mass of (unspecialised) cells ;
no response to (extracellular / intracellular) signals to control mitosis / AW ;
no contact inhibition / AW ;
no cell death / no apoptosis ;
immune system does not recognise the cells as foreign and destroys them ;
A reference to, not non-self / self
metastasis / described ;

(b) **R** way in which cancer develops / epidemiological evidence
A beagles for dogs
1 tar painted on skin of, mice / rabbits / rats / (small) mammal, led to development of (cancerous / malignant) tumour ;
2 dogs that smoked (plain) cigarettes developed, cancer / tumour ;
3 dogs that smoked filter-tipped cigarettes did not develop cancer / tumour ;
A developed precancerous changes
4 control group / dogs, which did not smoke and did not develop, cancer / tumour ;
5 AVP ; e.g. evidence from any other named mammal
e.g. inhaling substances from, tar / tobacco

(c) *similarities*
1 all (named) countries, increase and decrease / reach a peak and decrease ;
differences
2 peaks / AW, have occurred at different years in at least two countries ;
3 all maximum mortality rates are different ;
4 any comparative, data quote / calculation, with units given at least once ;
e.g. dates and mortality rates for at least two countries
e.g. mortality rates for one country at two different dates

accept a range or a single figure within the ranges given

countries	peak mortality rate	year
USA	53–57	1984–1990
Spain	45-48	1993–1997
Finland	69–71	1970–1973
UK	72–75	1970–1975
Hungary	83–87	1996–2000

[9]

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40. M/J 13/P23/Q5

(a) growth (by increase in cell number) ;
production of genetically identical cells ;
replacing (damaged) cells ;
repair (of tissue) ; *allow 'regeneration' if mp3 and mp4 not awarded*
R repair cells
asexual reproduction ;
A cloning **A** vegetative propagation

(b) one tick in each box ;

(c) appearance of chromosomes / condensation of chromatin / AW ;
chromosomes visible as two, sister chromatids / chromatids joined by a centromere ;
spindle formation / spindle fibres form / microtubules assemble / AW ;
centrioles, move to / reach, opposite poles ;
R sides / ends
disappearance of nucleolus ;
disassembly / breakdown of, nuclear envelope ;
A nuclear membrane

(d) mitosis / prophase, will begin again, too soon / immediately ;
uncontrolled / repeated, cell division / mitosis ;
ignore (risk of), tumour formation / cancerous growth
ref. to consequences on the timing of the cell cycle ; [11]

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Unit 6
NUCLEIC ACIDS AND PROTEIN SYNTHESIS

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

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Syllabus

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Unit 6: Nucleic Acids and Protein Synthesis

1. **M/J 22/P22/Q4**
The enzyme carbonic anhydrase has been found in a wide range of organisms and acts as a catalyst in many tissues.
Studies have shown that there are differences in the protein structure of the enzyme and differences in the number and organisation of introns and exons of the gene coding for the enzyme.
All carbonic anhydrase enzymes catalyse the same reversible reaction, shown in Fig. 4.1.

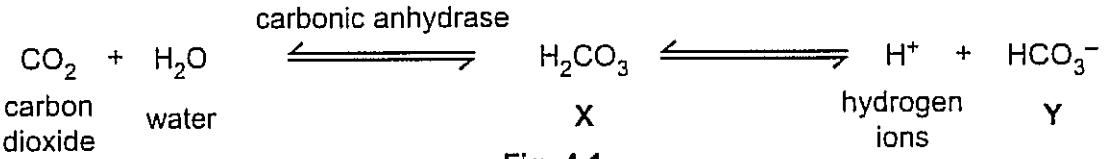


Fig. 4.1

(a) With reference to Fig. 4.1, name **X** and **Y**.

X .....

Y .....[2]

(b) Carbonic anhydrase enzymes can have different primary structures.
Suggest how all carbonic anhydrase enzymes can catalyse the same reaction, even though they have different primary structures.

..... [1]

(c) Genes coding for proteins in eukaryotes consist of introns and exons.
Outline the similarities and differences between the introns and the exons of genes coding for proteins such as carbonic anhydrase.

.....

.....

..... [3]

All mammals have the same type of carbonic anhydrase, known as α-carbonic anhydrase. Many different forms, or isoforms, of α-carbonic anhydrase have been identified in mammals.

There are 15 isoforms of α-carbonic anhydrase (CA) in humans. Cells of different tissues have one or more isoforms. Within cells the isoforms may be in different locations.

(d) Red blood cells contain two isoforms, CA1 and CA2.
Suggest the location of CA1 and CA2 in red blood cells **and** give a reason for your answer.

.....

..... [2]

(e) Isoform CA6 forms part of human breast milk. Mammary gland cells package CA6 in Golgi vesicles for release from the cells.
Name the transport mechanism associated with CA6 secretion.

..... [1]

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(f) Human CA isoforms in some epithelial cells in the eye have a role in the formation of the clear fluid of the eye known as aqueous humour. Overactivity of the enzyme may lead to a harmful increase of pressure within the eye and cause a condition known as glaucoma.

Acetazolamide is a therapeutic drug that can be used in the treatment of glaucoma. It acts as a reversible non-competitive inhibitor.

Describe the mechanism of action of acetazolamide as a reversible non-competitive inhibitor of carbonic anhydrase.

.....

.....

..... [3]

2. M/J 22/P21/Q6

Cotransporter proteins are membrane proteins found in companion cells of phloem tissue.

Messenger RNA (mRNA) is the molecule in cells that carries genetic information in the DNA that codes for cotransporter proteins to the sites of protein synthesis in the cytoplasm.

(a) Complete Table 6.1 to compare the structure of a molecule of mRNA with the structure of a molecule of DNA.

Table 6.1

feature	mRNA	DNA
names of four bases		
name of pentose sugar present		
number of strands		

[3]

(b) Fig. 6.1 shows the events that occur in the nucleus of a companion cell in phloem tissue to synthesise molecules of mRNA.

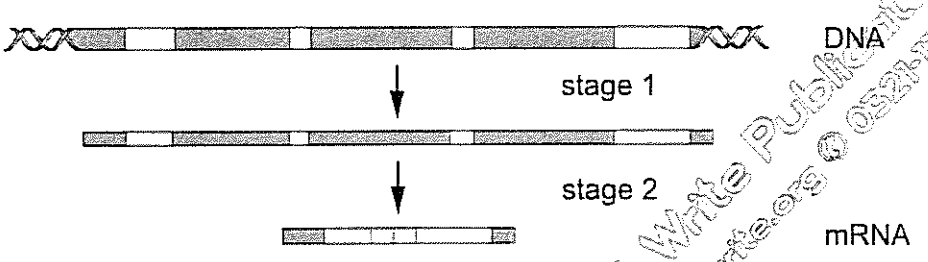


Fig. 6.1

(i) Name stage 1 shown in Fig. 6.1.

..... [1]

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(ii) Describe what happens at stage 2, shown in Fig. 6.1, to shorten the length of the RNA molecule.

.....

..... [2]

(c) Cotransporter molecules are proteins produced in companion cells.
Fig. 6.2 shows what happens in the cytoplasm of a companion cell to a transfer RNA molecule before the cotransporter proteins can be produced.

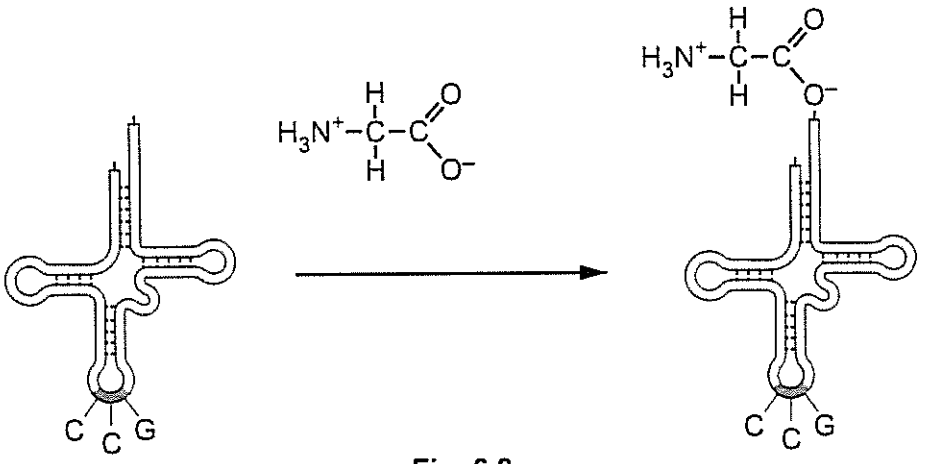


Fig. 6.2

(i) Describe the role of the transfer RNA shown in Fig. 6.2 in the synthesis of a cotransporter protein.

.....

.....

.....

..... [4]

(ii) Outline the role of cotransporter proteins in companion cells.

.....

.....

..... [3]

3. O/N 21/P22/Q3/c,d

(a) A polyhedrin molecule is composed of three identical polypeptides. Each polypeptide is 245 amino acids long. The first 10 amino acids of the polypeptide are shown in Fig. 3.1.

1	2	3	4	5	6	7	8	9	10
met —	pro —	asp —	tyr —	ser —	tyr —	arg —	pro —	thr —	ile —

Fig. 3.1

Fig. 3.2 **A** is a ribbon diagram of a single polypeptide. Fig. 3.2 **B** shows a polyhedrin molecule composed of 3 polypeptides.

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The two diagrams are not to the same scale.

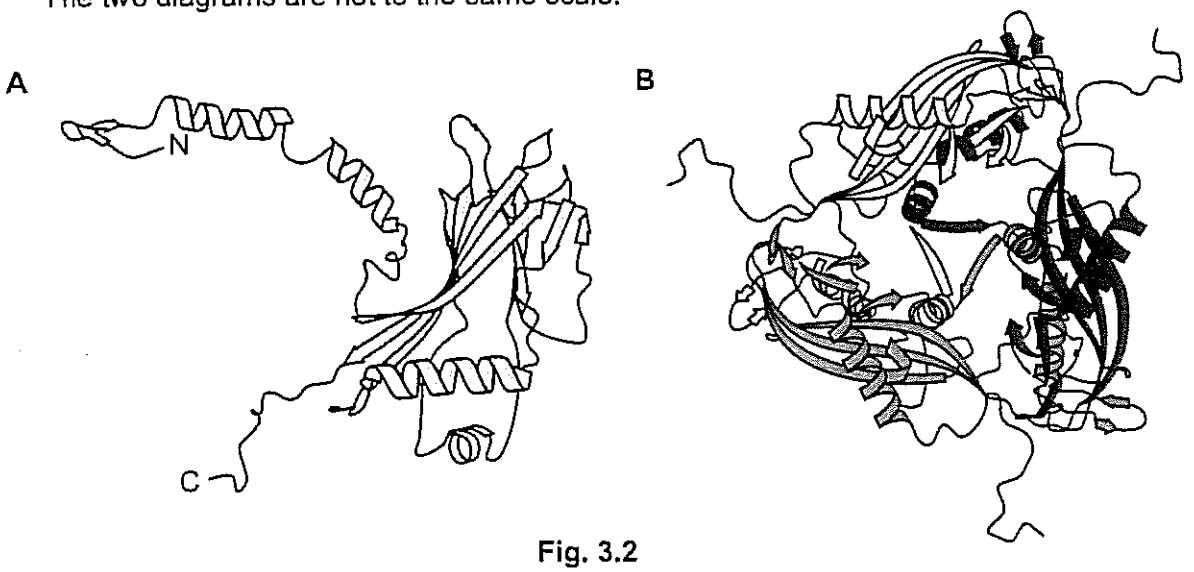


Fig. 3.2

With reference to Fig. 3.1 and Fig. 3.2, describe the structure of a polyhedrin molecule.

.....

.....

.....

..... [4]

(b) The sequence of DNA nucleotides for the gene in baculovirus that codes for the polyhedrin polypeptide has been determined.
Explain why the amino acid sequence of the polypeptide **cannot** be used to deduce this sequence of nucleotides in the gene that codes for the polyhedrin polypeptide.

.....

.....

..... [3]

4. O/N 21/P22/Q5/a
The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(a) The genetic material of *Morbillivirus* is a strand of RNA.
Statements **A**, **B** and **C** relate to the structure of RNA.
State the correct term or terms to match each of statements **A** to **C**.
A The names of the two purines and two pyrimidines in RNA.

purines .....

.....

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pyrimidines .....

.....

B The type of covalent bond between RNA nucleotides.

.....

C The pentose sugar of the RNA nucleotide.

..... [4]

5. O/N 21/P23/Q1

Fig. 1.1 is a diagram showing a stage in protein synthesis.

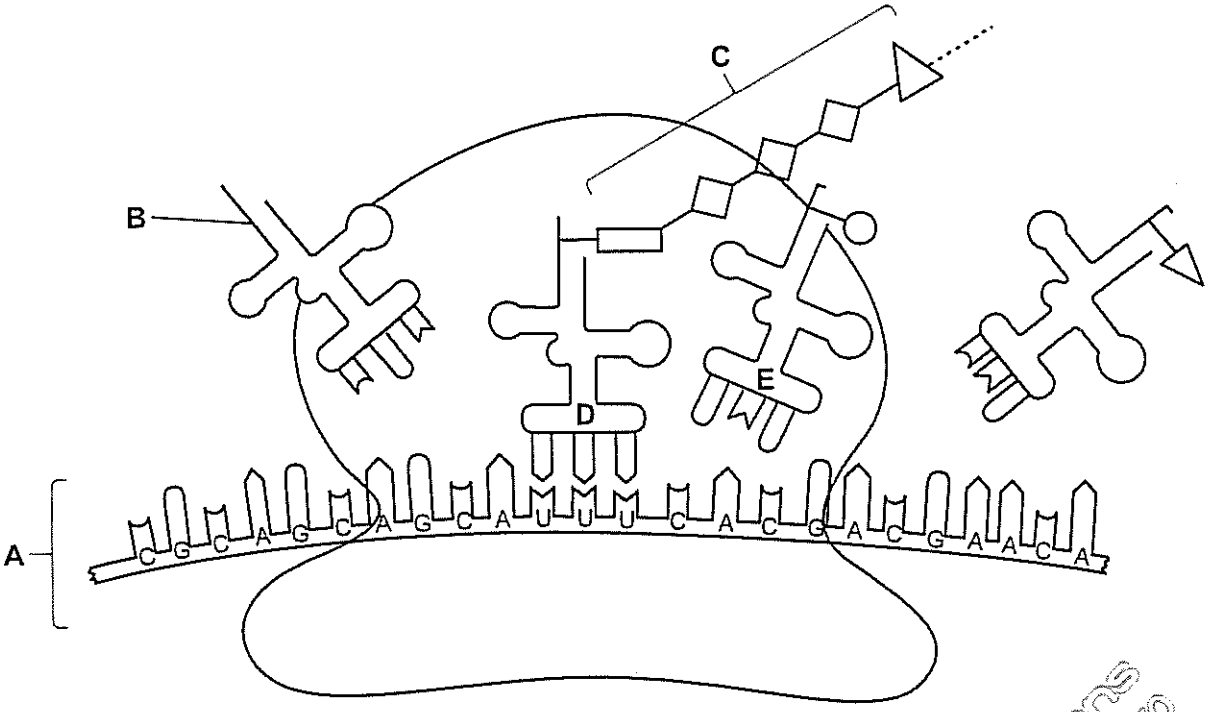


Fig. 1.1 **Not to scale**

(a) (i) Name the stage of protein synthesis that is shown in Fig. 1.1.

..... [1]

(ii) Identify **A**, **B** and **C** in Fig. 1.1.

A .....

B .....

C ..... [3]

(iii) State the base sequences at **D** and **E**.

D .....

E ..... [1]

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(b) Mutagenesis is a process that leads to a change in the amino acid sequences of proteins. Scientists carry out mutagenesis to investigate the importance of particular amino acids in protein structure and function.
Outline how changing one amino acid in the β-globin polypeptide of haemoglobin may change the structure and function of a molecule of haemoglobin.

.....

.....

.....

..... [4]

6. M/J 21/P23/Q3
HIV protease is an enzyme composed of two identical polypeptide chains. Each polypeptide chain is 99 amino acids long. During translation, the amino acids are joined by peptide bonds to form the polypeptide chain.

(a) Describe how a polypeptide of HIV protease is produced by the process of translation.

.....

.....

.....

..... [4]

(b) The synthesised polypeptide has a primary protein structure and can form a tertiary protein structure after translation. There are more bond types in the tertiary structure.
Compare the peptide bond formed during translation with the types of bond made during tertiary structure formation.

.....

.....

..... [3]

(c) Some polypeptides are translated as part of one long polyprotein chain. After translation, enzymes cut the polyprotein into separate functioning proteins.

HIV protease cuts a polyprotein that has been produced within the host cells of actively replicating HIV. The separate proteins are required in the replication of the virus.

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Fig. 3.1 shows how the two polypeptide chains of HIV protease form an enzyme with an active site enclosed by flaps, forming the flap region.

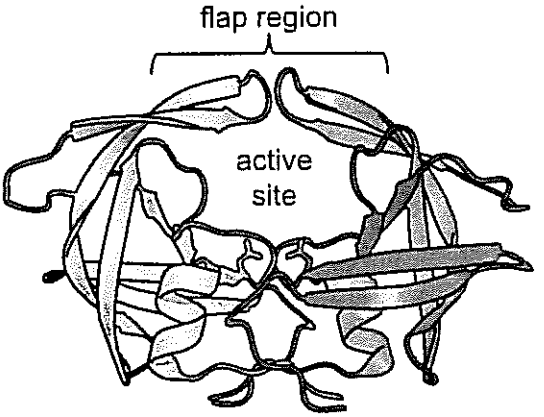


Fig. 3.1

(i) The flap region of HIV protease is flexible.
With reference to Fig. 3.1, suggest **and** explain how the mechanism of action of HIV protease can be described as an induced fit.

.....

.....

..... [3]

(ii) Indinavir is one of the therapeutic drugs used in HIV anti-retroviral therapy (ART). It is similar to the polyprotein substrate of HIV protease.
Suggest **and** explain how indinavir acts as a therapeutic drug.

.....

..... [2]

7. O/N 20/P22/Q2/b,c

Rifampicin binds tightly to an RNA polymerase molecule close to its active site. This affects the activity of the enzyme.

(a) (i) RNA polymerase catalyses the formation of messenger RNA (mRNA) from DNA.
State the term for this process.

..... [1]

(ii) During the formation of RNA, a number of events occur that involve the action of RNA polymerase.
Suggest ways in which rifampicin can affect the activity of RNA polymerase.

.....

.....

..... [3]

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(b) RNA polymerase is composed of five different polypeptides. Gene *rpoB* codes for one of these polypeptides known as the β-subunit.

One or more mutations in a specific region of *rpoB* result in strains of *M. tuberculosis* that are resistant to rifampicin. In these strains, mutations often occur in two DNA triplets in this region, in positions 526 and 531.

Table 2.2 summarises the results of an investigation into seven rifampicin-resistant strains, **A** to **G**, that have amino acid changes for positions 526 and 531.

Table 2.2 includes:

- the change in the **mRNA codon** for position 526 or position 531
- the amino acid change that has occurred as a result of the mutation
- the minimum concentration of rifampicin required to inhibit growth of the bacterial strain (MIC)
- the number of **other** mutations occurring within the specific region of *rpoB*.

Table 2.2

Key
≈ approximately ⩾ greater than or equal to ⩽ less than or equal to

strain	codon involved	mRNA codon change	amino acid change	MIC / $\mu g\,cm^{-3}$	number of other mutations in the specific region
A	526	CAC ⟶ UAC	His ⟶ Tyr	⩽50	0
B	526	CAC ⟶ AAC	His ⟶ Asn	⩾100	1
C	526	CAC ⟶ CGC	His ⟶ Arg	≈50–75	2
D	526	CAC ⟶ CGC	His ⟶ Arg	⩾100	3
E	526	CAC ⟶ CGC	His ⟶ Arg	≈50	3
F	526	CAC ⟶ UUC	His ⟶	⩾100	3
	531	UCG ⟶ UUG	Ser ⟶ Leu		
G	526	CAC ⟶ UAC	His ⟶	⩾100	3
	531	UCG ⟶ UUC	Ser ⟶ Phe		

(i) Complete Table 2.2 to show the amino acid changes that have occurred in strains **F** and **G**.

[1]

(ii) With reference to Table 2.2, list the strains of *M. tuberculosis* that show the greatest resistance to rifampicin.

..... [1]

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(iii) Suggest reasons to explain why strains **C**, **D** and **E** show:

- resistance to rifampicin
- different levels of resistances to rifampicin.

.....

.....

..... [3]

8. O/N 20/P21/Q6/a

(a) Mutations in body cells can sometimes result in a tumour. Some tumours are cancerous.

(i) Outline how mutations can result in the development of a tumour.

.....

..... [2]

(ii) Tumour cells have antigens on their cell surface that are not present on non-tumour cells.

These antigens are the result of gene mutations and are known as tumour specific antigens (TSA).

One type of TSA differs in structure from the protein found on the cell surface of non-tumour cells by a single amino acid.

Explain how a gene mutation could result in the production of this TSA.

.....

..... [2]

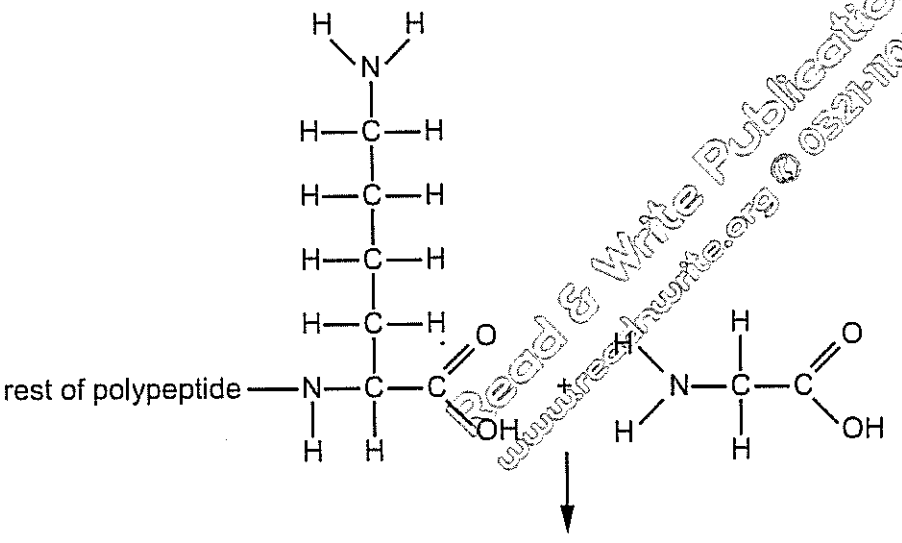
9. O/N 20/P23/Q5/a,b

A molecule of collagen consists of three identical polypeptides that form a triple helix.

The amino acid glycine forms one third of the amino acids in a collagen molecule.

Fig. 5.1**A** shows a polypeptide molecule during protein synthesis. A molecule of glycine is shown just before it is added to the polypeptide.

A



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B

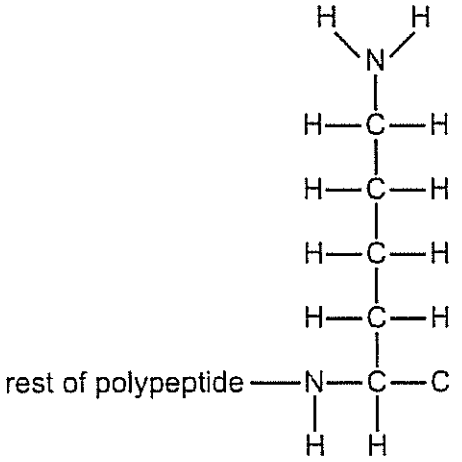


Fig. 5.1

(a) (i) Complete Fig. 5.1**B** to show the molecule of glycine added to the end of the polypeptide. [2]

(ii) State the type of reaction that occurs when glycine is added to the end of the polypeptide.

..... [1]

(iii) Explain the importance of glycine in a collagen molecule.

.....

..... [2]

(b) Collagen is a fibrous protein.
Explain how the structure of collagen is related to its functions within the mammalian body.

.....

.....

.....

..... [4]

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10. M/J 20/P21/Q6

Fig. 6.1 shows the formation of a polypeptide during translation in a eukaryotic cell.

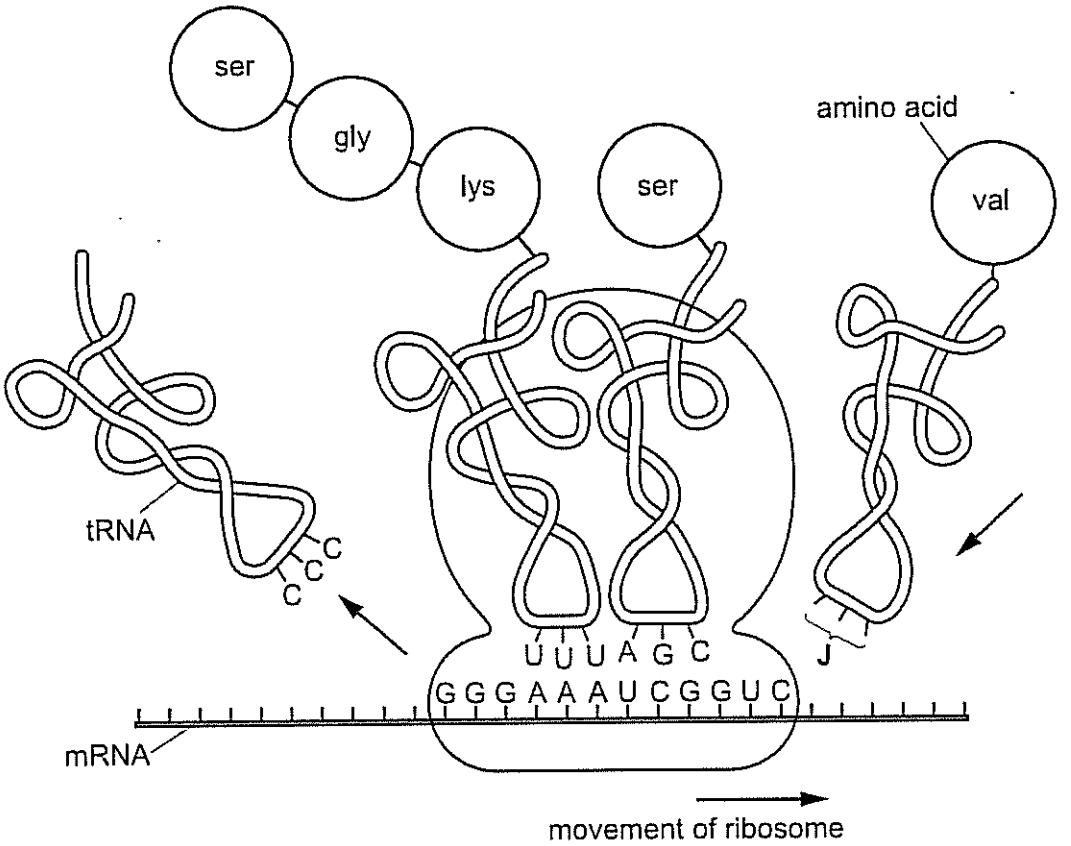


Fig. 6.1

(a) Name the purine bases shown in Fig. 6.1.

..... [1]

(b) State the name given to the group of three bases found at **J** on the tRNA molecule.

..... [1]

(c) Identify the three bases at **J**.

..... [1]

(d) State how the three bases at **J** on tRNA interact with the bases on mRNA.

..... [1]

11. O/N 19/P22/Q3/c,d,e

(a) 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.

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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.

(b) 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.

.....

..... [2]

(c) 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.

.....

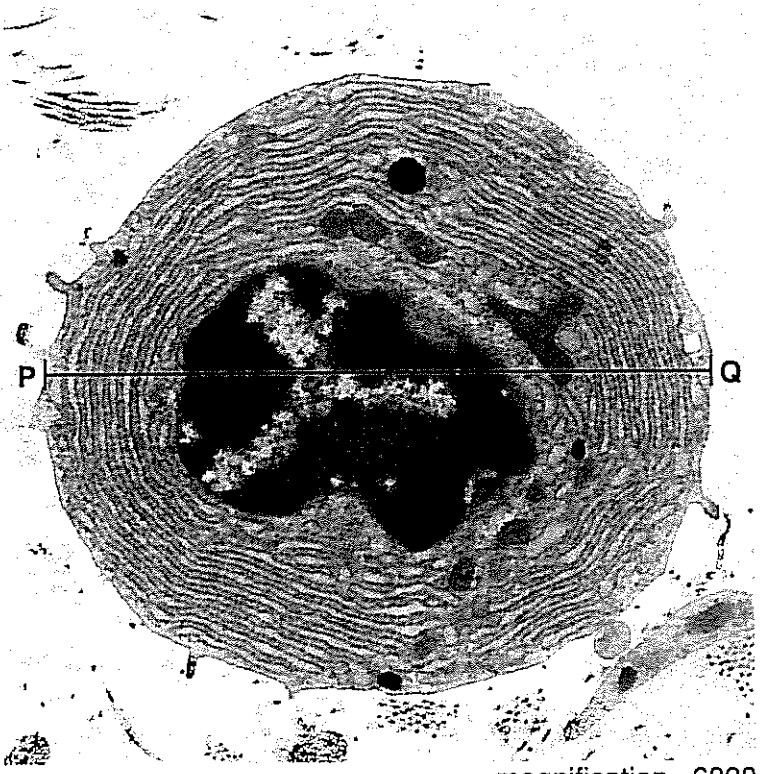
.....

..... [3]

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12. O/N 19/P21/Q1/b,c

(a) 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.

..... [1]

(b) 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.

.....

..... [2]

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13. O/N 19/P23/Q3/b

(a) 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*.

.....

.....

..... [3]

14. M/J 19/P21/Q6

(a) The DNA in the nucleus is known as nuclear DNA.

(i) In the cells of the grasshopper, *Chorthippus brunneus*, 20% of the nucleotides in nuclear DNA contain thymine.

Calculate the percentage of nucleotides in the nuclear DNA of *C. brunneus* that contain guanine **and** explain your answer in terms of the structure of DNA.

percentage .....

explanation .....

..... [3]

(ii) State another location, **other than** the nucleus, where DNA occurs in cells of *C. brunneus*.

..... [1]

(b) Fig. 6.1 is a diagram of a molecule of tRNA.
The region labelled **R** shows detail of part of the tRNA molecule.

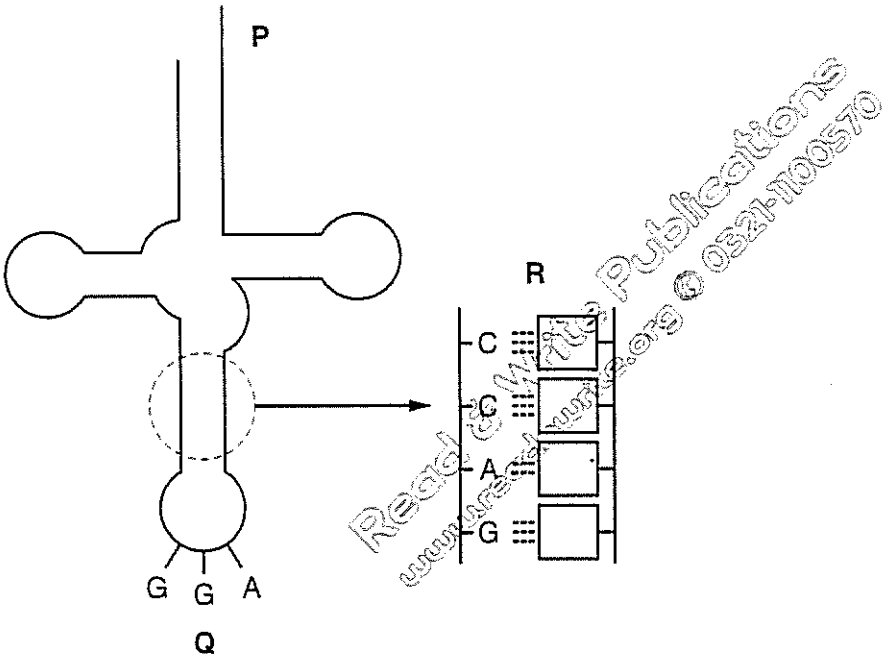


Fig. 6.1

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(i) Complete Fig. 6.1 by writing the sequence of bases in the region labelled **R**. [1]

(ii) State the name of region **Q and** explain the role of region **Q** in translation.

name .....

explanation .....

..... [3]

(iii) State the function of region **P**.

..... [1]

15. M/J 19/P23/Q1

Fig. 1.1 is a diagram showing the structure of a section of a DNA molecule.

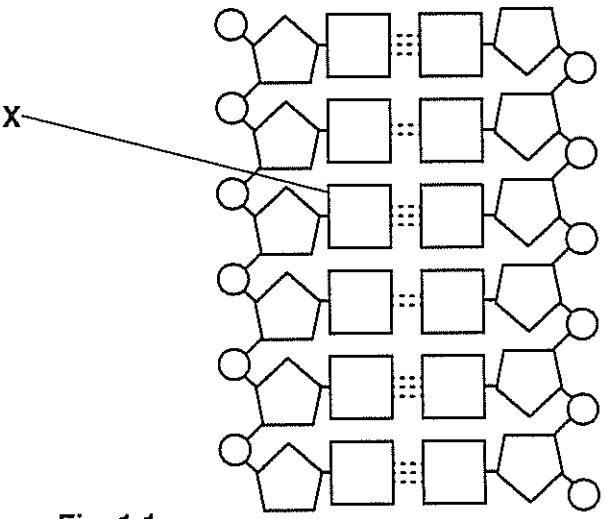


Fig. 1.1

(a) Draw a circle around **one** monomer of DNA in Fig. 1.1. [1]

(b) Name the two bases forming the base pair at **X** in Fig. 1.1 **and** give a reason for your answer.

bases .....

reason ..... [2]

(c) The statements 1–5 describe events that occur during DNA replication.

1 DNA polymerase forms a phosphodiester bond
2 DNA double helix forms
3 hydrogen bonds break
4 hydrogen bonds form
5 two strands of the double helix separate

Write the numbers 1 to 5 in the spaces below to show the order in which these events occur. The first one has been done for you.

3 .... [1]

(d) The telomere is a region found at the end of a chromosome.
Outline the function of telomeres.

.....

..... [2]

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16. O/N 18/P22/Q5

DNA and RNA are nucleic acids.

(a) Explain why RNA can be described as a polymer **and** as a macromolecule.

.....

.....[2]

(b) The sugar component of DNA is a reducing sugar.
Outline the test for reducing sugars **and** describe the observations for a positive result.

.....

.....[2]

(c) Nucleotides are structural components of nucleic acids. Each nucleotide consists of a pentose sugar, a phosphate group and a nitrogenous organic base.
Complete Table 5.1 to compare DNA nucleotides with RNA nucleotides as structural components of nucleic acids.

Table 5.1

feature	DNA nucleotides	RNA nucleotides
pentose sugar component		
purine bases		
pyrimidine bases		

[3]

17. O/N 18/P22/Q6/b

(a) State the most appropriate term to match each of the descriptions **A** to **C**.

A The part of the haem group that binds oxygen in each haemoglobin polypeptide.

.....

B The compound formed when carbon dioxide binds to haemoglobin.

.....

C The compound formed when hydrogen ions (H^+) bind to haemoglobin.

..... [3]

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18. O/N 18/P21/Q5/c

(a) DNA and RNA both contain nucleotides with adenine.
Complete Table 5.1 to compare:

- a DNA nucleotide with adenine
- an RNA nucleotide with adenine
- ATP.

Table 5.1

feature	DNA nucleotide with adenine	RNA nucleotide with adenine	ATP
contains nitrogen (yes or no)			
contains a pyrimidine base (yes or no)			
number of phosphate groups			
name of the sugar component			

[5]

19. O/N 18/P23/Q3

(a) Fig. 3.1 is a diagram of a monomer of the nucleic acid, messenger RNA.

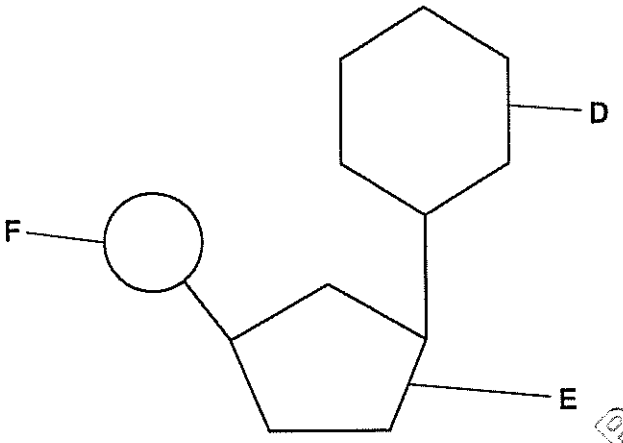


Fig. 3.1

(i) Name **D**, **E** and **F** in Fig. 3.1.

D .....

E .....

F ..... [3]

(ii) State **one** way in which the **structure** of DNA differs from the structure of messenger RNA.

.....[1]

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(b) Telomeres are repeating sequences of bases located at the ends of DNA molecules. These repeating sequences do not code for proteins.

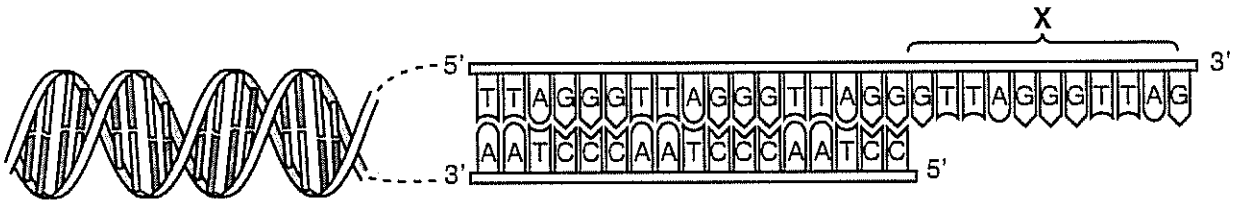
The enzyme telomerase ensures that telomeres do not shorten each time DNA is replicated.

Fig. 3.2**A** shows the end of a DNA molecule during replication. DNA polymerase cannot attach to the region labelled **X**, so it cannot complete the synthesis of the new strand without the action of telomerase.

Telomerase synthesises additional lengths of DNA that are added to the telomere. These additional lengths are used by DNA polymerase to complete the process of replication.

Fig. 3.2**B** is an enlarged view of region **X** to show the action of the enzyme telomerase.

A



B

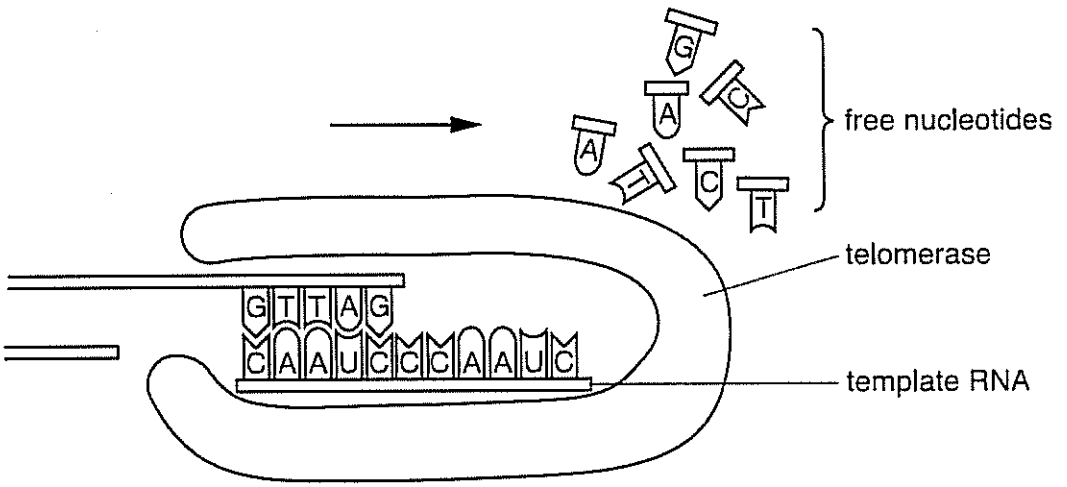


Fig. 3.2

Telomerase contains a short length of RNA that acts as a template for the synthesis of DNA as shown in Fig. 3.2**B**.

Explain how a molecule of telomerase synthesises additional lengths of DNA.

.....

.....

.....

.....[4]

(c) Telomerase is not present in prokaryotic cells.

Suggest why prokaryotes do not have telomerase.

.....[1]

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(d) One of the ways to diagnose lung cancer is to determine the concentration of telomerase in cells from the lining of the bronchus.

Explain why determining the activity of telomerase may be useful in the diagnosis of lung cancer.

.....

.....[2]

20. M/J 18/P22/Q2

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.

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

A .....

T .....

G .....

C ..... [2]

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

.....

.....

.....[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.

.....

..... [2]

21. M/J 18/P23/Q3/d,e,f

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.

(a) (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.

.....[1]

(b) 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.

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

.....

.....

.....

.....[4]

(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]

(c) 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.

.....

..... [2]

22. M/J 18/P23/Q4/c,d

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.

(a) Define the term *disease*.

.....

..... [2]

(b) 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.

.....

.....

.....

.....

..... [5]

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23. O/N 17/P22/Q3/e

Hydrolytic enzymes can function within the cell or can be secreted by the cell, where they are able to catalyse reactions.

(a) Glucocerebrosidase is an enzyme synthesised by macrophages to hydrolyse glucocerebroside, a glycolipid found in cell membranes.

The *GBA* gene codes for glucocerebrosidase. There are a number of different mutations of the *GBA* gene. Some mutations result in a single amino acid change in the enzyme molecule produced, and this causes a disorder known as Gaucher's disease. Two of these mutations, at different positions in the *GBA* gene, are shown in Table 3.1.

Table 3.1

	amino acid change caused by mutation		severity of Gaucher's disease
	from	**to**	
mutation 1	asparagine (Asn)	serine (Ser)	mild
mutation 2	leucine (Leu)	proline (Pro)	severe

With reference to Table 3.1,

- outline how a mutation leads to a single amino acid change in the enzyme glucocerebrosidase **and**
- suggest why the two different amino acid changes, Asn to Ser and Leu to Pro, will result in differences in the tertiary structure of the enzyme.

.....

.....

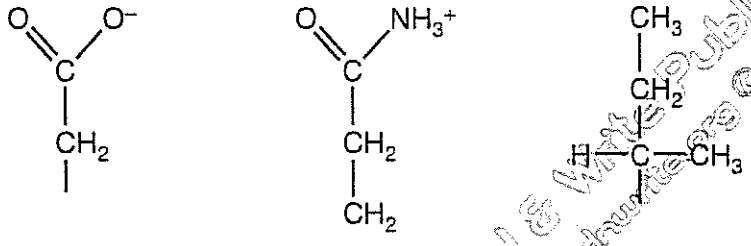
.....

.....

.....[5]

24. O/N 17/P21/Q4/a

Fig. 4.1 shows the structure of the R groups of three amino acids, aspartate (Asp), glutamine (Gln) and isoleucine (Ile).



Asp R group **Gln R group** **Ile R group**

Fig. 4.1

(a) One of the mRNA codons for the amino acid Gln is CAA.
A mutation could change this codon from CAA to UAA.
UAA is a STOP codon.

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State what is meant by a STOP codon.

.....[1]

25. M/J 17/P22/Q6

As a result of transcription and translation, a polypeptide chain is produced. Proteins with quaternary structure contain two or more polypeptide chains.

An antibody molecule and a haemoglobin molecule both show quaternary structure.

(a) Table 6.1 shows some features of an antibody molecule and a haemoglobin molecule. Complete Table 6.1 to produce a summary of the features of the two molecules.

Table 6.1

feature	antibody	haemoglobin
fibrous or globular		
number and names of polypeptide chains	two heavy and two light chains	
type of bond holding polypeptide chains together		ionic

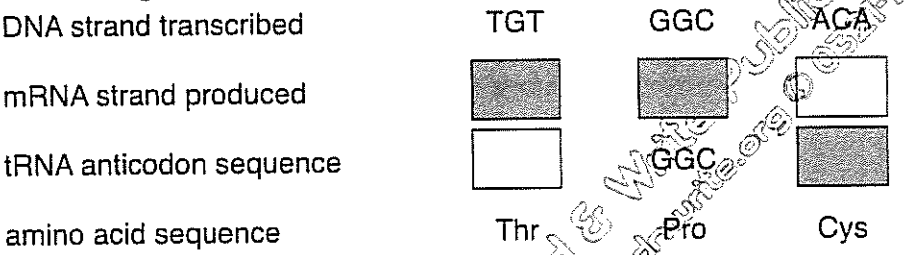
[3]

(b) The base sequence shown in Fig. 6.1 is a short section of a longer length of DNA that is transcribed to produce mRNA. When translated, this short section produces the amino acid sequence threonine (Thr), proline (Pro), cysteine (Cys).

Fill in the two **unshaded** boxes in Fig. 6.1 to show:

- the mRNA codon for Cys
- the tRNA anticodon for Thr.

You do **not** need to give the codon and anticodon sequences in the shaded boxes.



[2]

Fig. 6.1

26. M/J 17/P21/Q4

(a) Fig. 4.1 shows part of a DNA molecule.

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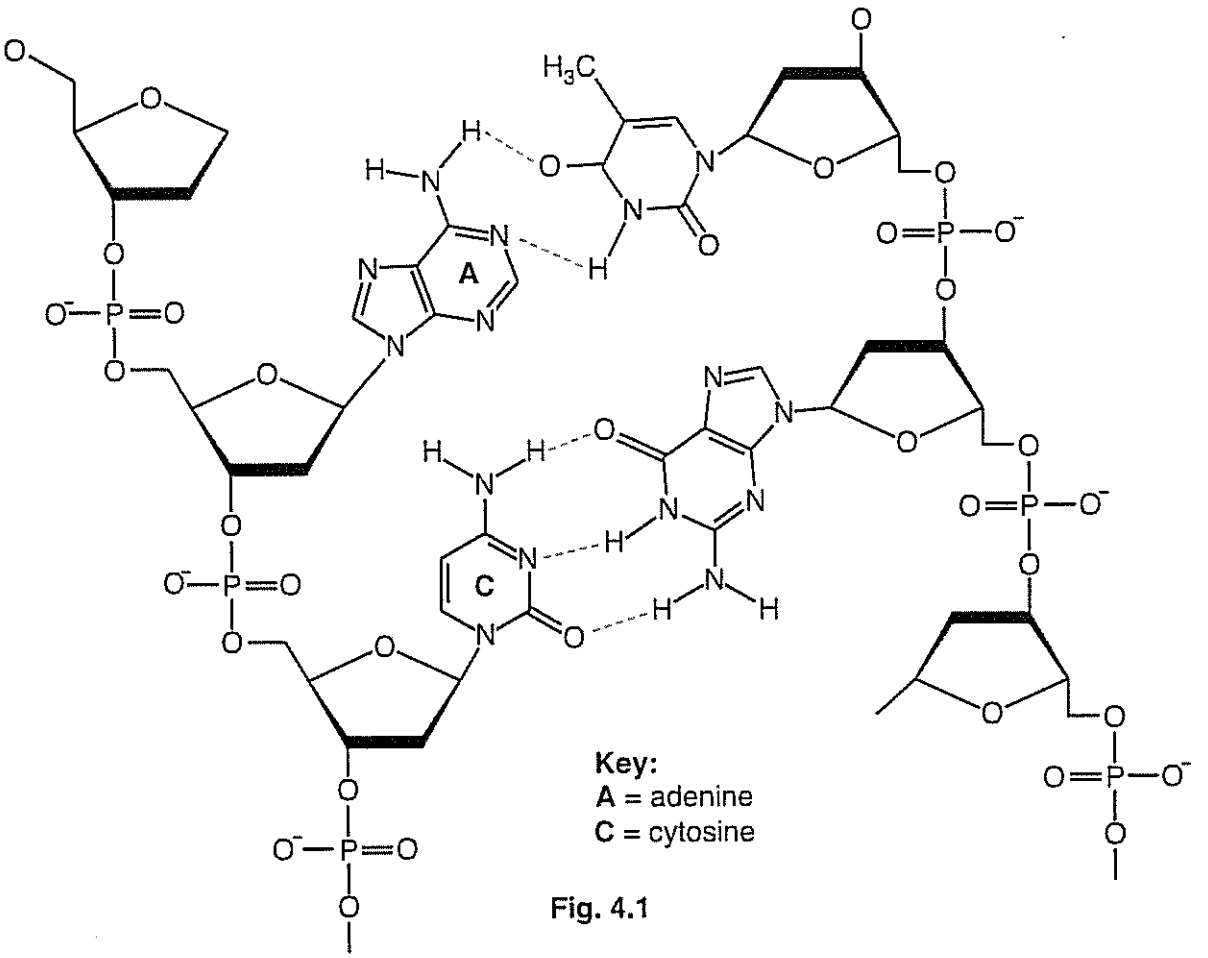


Fig. 4.1

Use Fig. 4.1 to explain how the structure of mRNA differs from the structure of DNA.

.....

.....

.....

.....[4]

(b) Fig. 4.2 shows:

- the first seven amino acids of the β chain of haemoglobin
- the first amino acid in the sequence is valine (Val)
- the 21 base pairs in the sequence of DNA that code for these seven amino acids.

amino acid sequence	Val	His	Leu	Thr	Pro	Glu	Glu
base sequence in DNA	CAC	GTG	GAC	TGA	GGA	CTC	CTC
	GTG	CAC	CTG	ACT	CCT	GAG	GAG

Fig. 4.2

Table 4.1 shows the triplets of bases that code for seven amino acids.
Using Fig. 4.2 and Table 4.1, state what will happen to the sequence of amino acids in the first part of the β chain of haemoglobin:

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(i) if the base pair at position 6 is deleted

.....[1]

(ii) if the three base pairs at positions 7, 8 and 9 are deleted.

.....[1]

Table 4.1

amino acid		DNA triplets
cysteine	(Cys)	TGT TGC
glutamic acid	(Glu)	GAA GAG
histidine	(His)	CAT CAC
leucine	(Leu)	CTT CTC CTA CTG
proline	(Pro)	CCT CCC CCA CCG
threonine	(Thr)	ACT ACC ACA ACG
valine	(Val)	GTT GTC GTA GTG
no amino acid	STOP	TAA TAG TGA

(c) DNA is involved in the processes of replication and transcription.
Complete Table 4.2 by using a tick (✓) to indicate which features apply to each of the processes. Use a cross (✗) for features that do **not** apply.
The first row has been completed for you.

Table 4.2

feature	replication	transcription
a single-stranded molecule is produced	✗	✓
hydrogen bonds are broken		
both strands of DNA act as templates		
phosphodiester bonds are formed		
DNA polymerase is used		

[4]

(d) Telomeres are parts of chromosomes. Describe the function of telomeres.

.....

.....[2]

(e) Describe the function of ribosomes in protein synthesis.

.....

.....

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.....[4]

27. M/J 17/P23/Q2/e

(a) Some plant cells produce a polypeptide called systemin.

(i) Describe the role of DNA in the production of systemin.

.....

.....[2]

(ii) Systemin stimulates plant cells to produce enzyme inhibitors known as serpins.

One of these serpins is a competitive inhibitor of some protease enzymes. It inhibits the protease enzymes found in herbivores, but does **not** inhibit the proteases in plants.

Suggest how this serpin inhibits **only** the protease enzymes in herbivores but **not** those in plants.

.....

.....

.....[3]

(iii) The presence of competitive inhibitors, such as serpins, increases the Michaelis-Menten constant (K_m) for the enzymes they inhibit.

Explain why the K_m value increases.

..... [1]

28. O/N 16/P22/Q3/d

(a) The amino acid sequence of the enzyme glucose isomerase has been determined. The first five amino acids of this sequence are shown in Table 3.1.

Table 3.2 (on page 11) shows the genetic code (mRNA codons).

A student was asked to use Table 3.2 to work out an mRNA nucleotide sequence that would correspond to the first five amino acids of glucose isomerase. The student's sequence is shown in Table 3.1.

Table 3.1

amino acid sequence	met	tyr	glu	pro	lys
student's nucleotide sequence	AUG	UAU	GAC	CCU	UGU
correct = ✓ incorrect = ✗					

(i) Complete Table 3.1 using a ✓ or a ✗ to indicate whether the student has used Table 3.2 correctly to identify the codons for each amino acid in the nucleotide sequence. [1]

(ii) Discuss, with reasons, how an mRNA nucleotide sequence worked out to correspond to the first five amino acids using Table 3.2 may not be the same as the mRNA nucleotide sequence for those amino acids present in the bacterial cell.

.....

.....

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..... [3]

Table 3.2

first position	second position U	second position C	second position A	second position G	third position
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

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29. O/N 16/P21/Q4/b

(a) The bacteria that cause cholera can become resistant to antibiotics by a substitution mutation. A substitution mutation occurs when one nucleotide in the DNA sequence is replaced by a different nucleotide.

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(i) Explain how a substitution mutation could result in a change in the amino acid sequence of a polypeptide.

.....

..... [2]

(ii) The antibiotic nalidixic acid acts as an inhibitor of an enzyme involved in DNA replication in the bacteria that cause cholera.
The gene *gyrA* codes for this enzyme. A substitution mutation in this gene results in resistance to the antibiotic nalidixic acid.
Suggest how a change in the amino acid sequence of the enzyme results in antibiotic resistance.

.....

.....[2]

30. O/N 16/P23/Q4

Protein synthesis requires ribosomes, mRNA, tRNA, amino acids and enzymes.
Fig. 4.1 is a diagram of a molecule of tRNA.

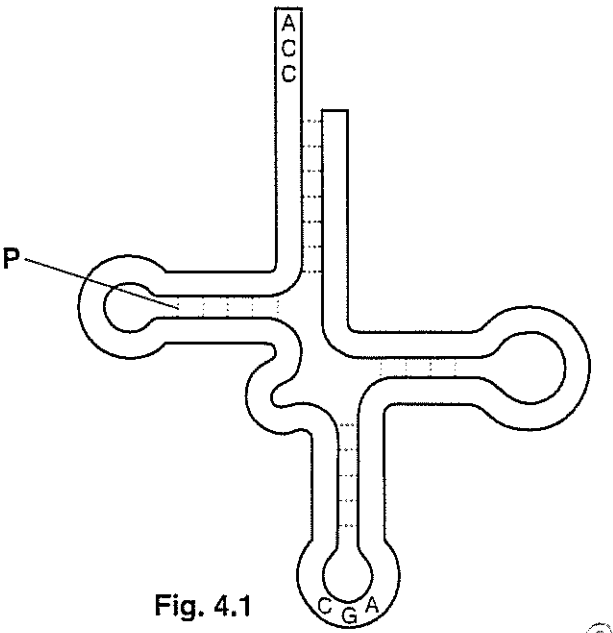


Fig. 4.1

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(a) Name the bond labelled **P**.

.....[1]

(b) Use Fig. 4.1 to describe the role of tRNA in protein synthesis.
You may annotate Fig. 4.1 to help your answer.

.....

.....

.....[3]

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(c) tRNA molecules are synthesised inside the nucleus of eukaryotic cells.
Outline the process by which tRNA molecules are synthesised in the nucleus.

.....

.....

.....[3]

31. M/J 16/P22/Q6/b,c

(a) The gene coding for glycogen synthase in muscle cells is known as *GYS1*.

(i) Explain what is meant by a *gene*.

.....

.....[2]

(ii) There are a number of known mutations for *GYS1*.
Outline how a mutation in *GYS1* can lead to the formation of an altered polypeptide where one amino acid is replaced by a different amino acid.

.....

.....

.....[3]

(c) Table 6.1 shows three functions of cell structures that are involved in the synthesis of glycogen synthase.
Complete Table 6.1 by naming the cell structure that carries out the function listed.

Table 6.1

function	name of cell structure
assembles ribosomes for polypeptide synthesis	
synthesises ATP to provide a supply of energy for transcription of *GYS1*	
folds and modifies synthesised polypeptide to produce functioning glycogen synthase	

[3]

32. M/J 16/P21/Q2/a

Macrophages synthesise intracellular enzymes.
Fig. 2.1 is a summary diagram of events that occur in a macrophage.

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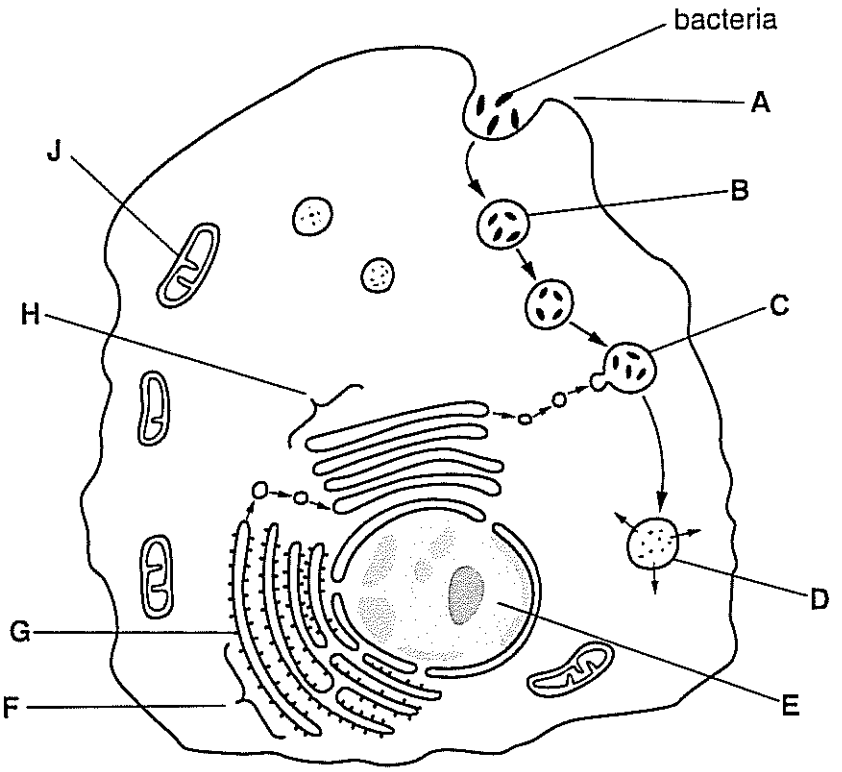


Fig. 2.1

(a) (i) Name the process at **A**.

.....[1]

(ii) Name the stages of protein synthesis that occur at **E** and at **F**.

E .....

F .....[2]

(iii) Name organelles **B**, **G**, **H** and **J**.

B .....

G .....

H .....

J .....[4]

33. M/J 16/P23/Q5/c

(a) The antibiotic rifampicin was introduced as an alternative to streptomycin.
Rifampicin acts by inhibiting the enzyme RNA polymerase.
RNA polymerase is the enzyme used in transcription.

(i) Explain what is meant by transcription.

.....

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.....[2]

(ii) *M. tuberculosis* and humans both use RNA polymerase for transcription.
Suggest why rifampicin does **not** affect transcription in human cells.

.....[1]

34. O/N 15/P23/Q1/a

Antibodies are secreted by activated B-lymphocytes known as plasma cells.
Fig. 1.1 is a diagram showing the cellular processes involved in the production of a polypeptide of an antibody molecule (not drawn to scale).

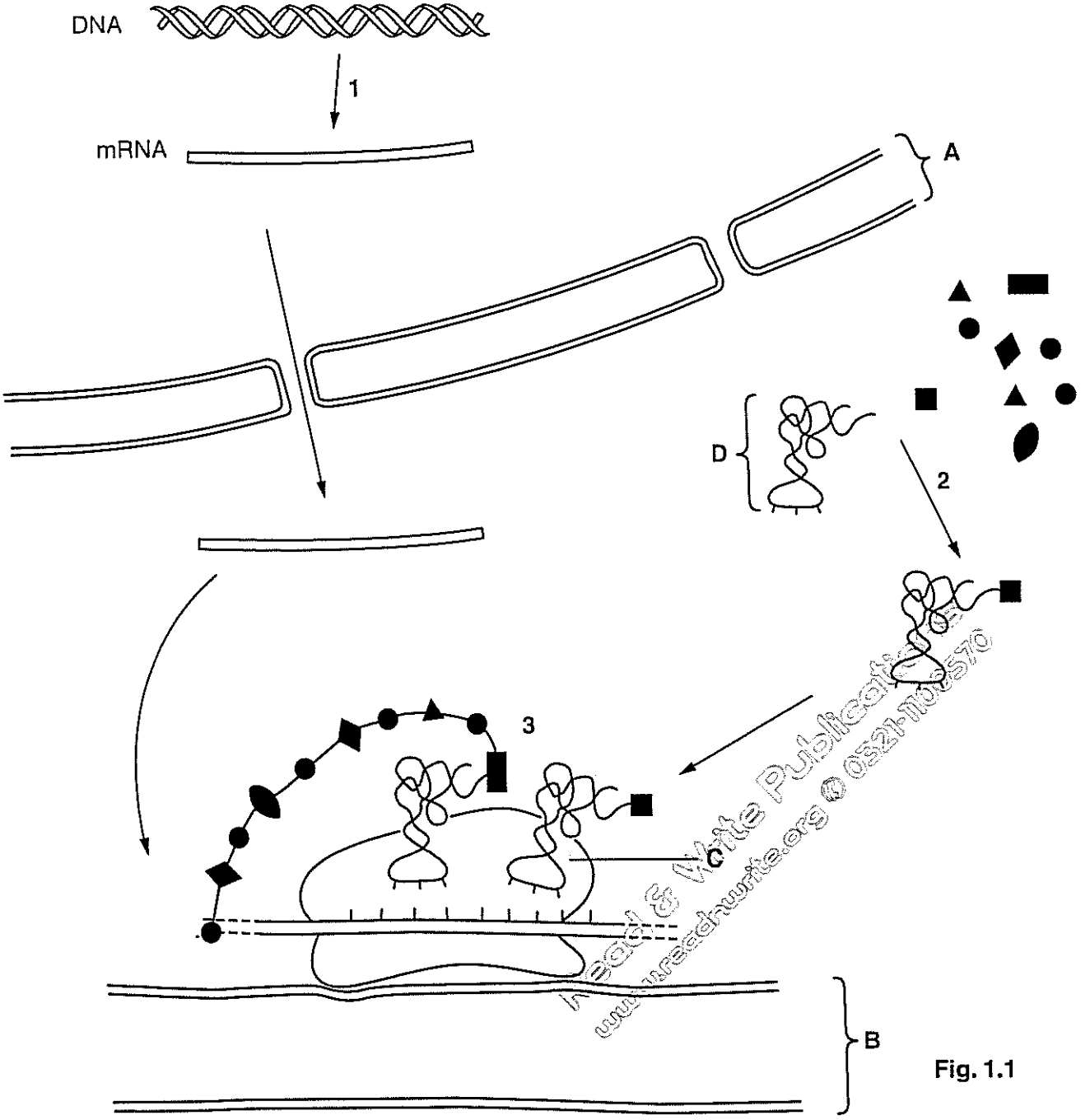


Fig. 1.1

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(a) (i) Name structures **A**, **B** and **C**.

A .....

B .....

C ..... [3]

(ii) Name molecule **D**.

D ..... [1]

(iii) State what is occurring at **1**, **2** and **3**.

at 1 .....

at 2 .....

at 3 ..... [3]

35. O/N 15/P23/Q3/b

The enzyme catalase is found in many plant and animal tissues.
The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism. The reaction is:

$$2H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2H_2O$$

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *Anopheles gambiae*, an important vector of malaria. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.
The results are shown in Fig. 3.1.

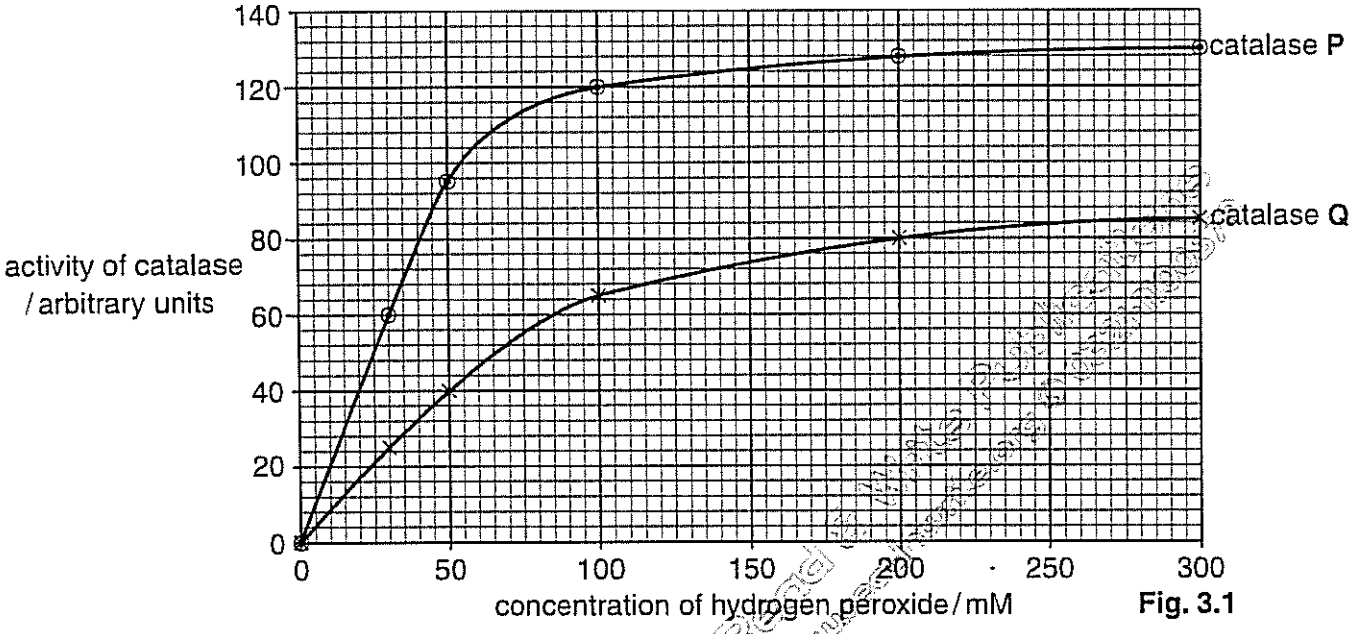


Fig. 3.1

(a) Each molecule of catalase consists of four identical polypeptides. The two forms of catalase in *A. gambiae* differ by only one amino acid at position 2 in the amino acid sequence. Catalase **P** has serine and catalase **Q** has tryptophan.
Suggest how the difference in one amino acid is responsible for the lower activity of catalase **Q** compared with catalase **P**.

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.....

..... [2]

36. M/J 15/P21/Q6

Red blood cells are formed from cells called reticulocytes. Stem cells in the bone marrow produce reticulocytes which differentiate into red blood cells. During differentiation haemoglobin is produced.

Fig. 6.1 shows the structure of small sections of DNA and messenger RNA (mRNA) in the nucleus of a reticulocyte during transcription.

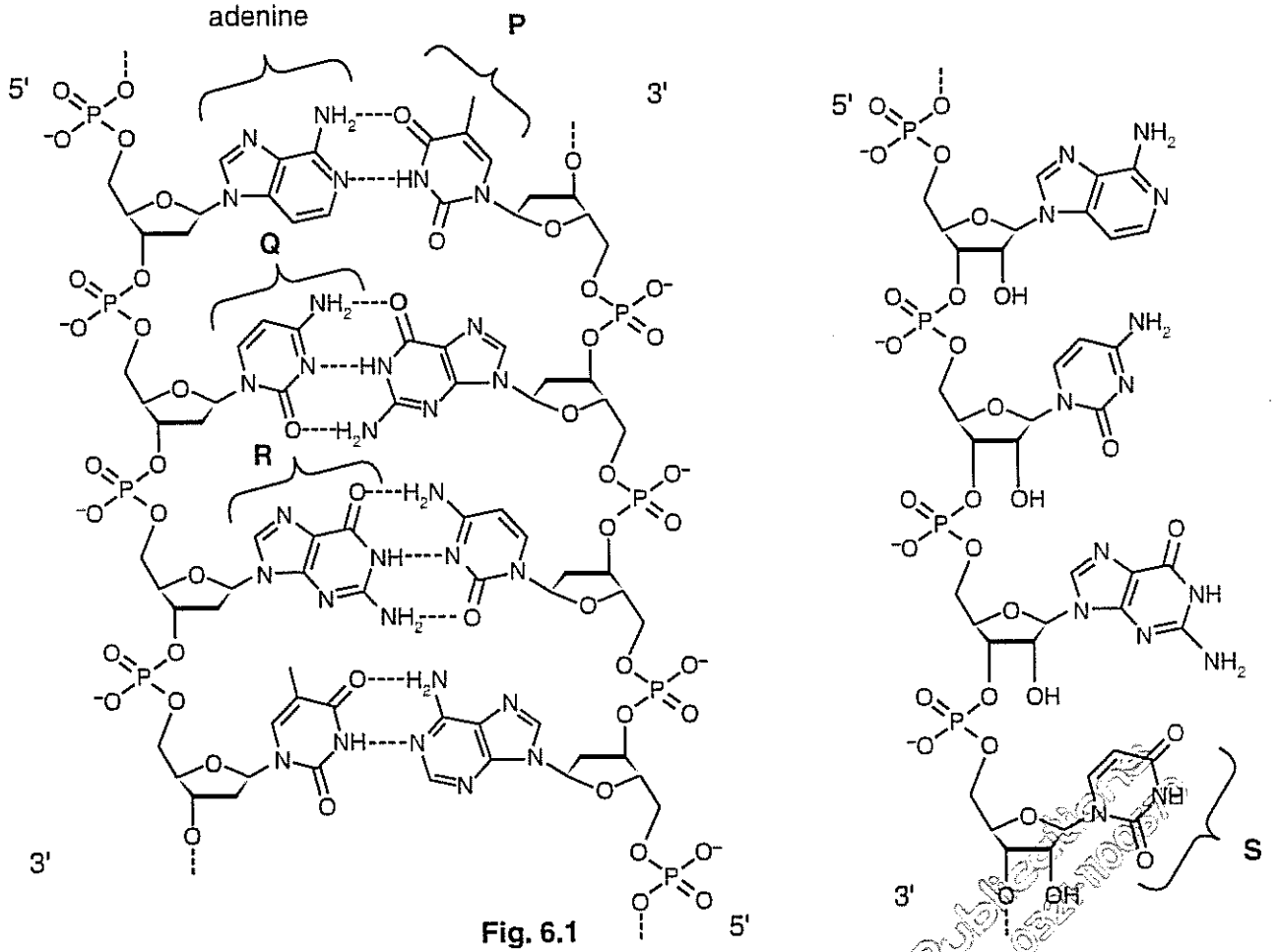


Fig. 6.1

(a) Name the bases **P** to **S**.

P .....

Q .....

R .....

S .....[4]

(b) Describe the role of the mRNA molecule shown in Fig. 6.1.

.....

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.....

.....[3]

37. M/J 15/P23/Q2

DNA replication is an important event in the cell cycle.

(a) State when, during the cell cycle, DNA replication occurs.

.....[1]

(b) Fig. 2.1 shows pairing between two bases, **X** and **Y**, in a DNA molecule.

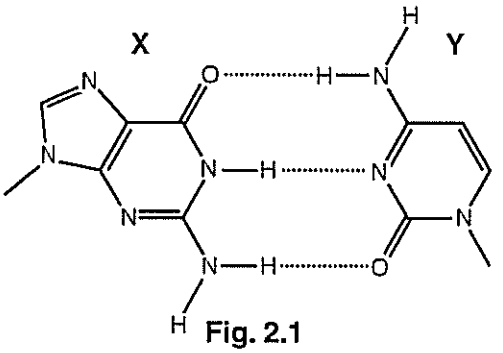


Fig. 2.1

(i) Name the type of bond shown by the dotted lines between the bases.

.....[1]

(ii) State which base, **X** or **Y**, is a pyrimidine **and** explain your answer.

.....[1]

(c) The compound benzopyrene, found in tar from tobacco smoke, can become chemically changed in cells and interferes with DNA replication, causing gene mutations.

(i) State what is meant by the term *gene mutation*.

.....

.....[2]

(ii) Mutations that occur in dividing cells of the gas exchange system may result in lung cancer.

Suggest the differences in the cell cycle of a cancer cell compared with that of a normal cell of the same type.

.....

.....[2]

38. O/N 14/P21/Q3/c,d

(a) Angiotensinogen is an inactive protein molecule. When blood pressure decreases, part of angiotensinogen is removed to form a short polypeptide, angiotensin that stimulates an increase in blood pressure.

Fig. 3.2 shows the base sequence within the gene for angiotensinogen that codes for this short polypeptide, the RNA codons and the primary structure of angiotensin.

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DNA base sequence	CTA	GCA	CAA	ATG	TAG	GTG	GGG	.....
RNA codons	.....	CGU	.....	UAC	AUC	CAC	CCC	UUC
polypeptide primary structure	Asp	Arg	Val	Tyr	Ile	His	Pro	Phe

Fig. 3.2

(i) Complete Fig. 3.2 to show the missing DNA triplet and the RNA codons. [1]

(ii) State the full name of the type of RNA shown in Fig. 3.2.

.....[1]

Table 3.1 shows the blood pressure in the right ventricle and in the pulmonary artery of a person who is in good health.

Table 3.1

phase of cardiac cycle	blood pressure / kPa	
	right ventricle	pulmonary artery
Ventricular systole	3.33	3.33
Ventricular diastole	0.67	1.33

(b) Use the information in Table 3.1 to explain why the blood pressure in the pulmonary artery is the same as the pressure in the right ventricle during systole, but higher during diastole.

.....

.....[3]

39. O/N 13/P21/Q5

Table 5.1 shows the triplets of bases on the template polynucleotide of DNA for some amino acids.

Table 5.1

amino acid		DNA triplets
glutamic acid	(glu)	CTT CTC
histidine	(his)	GTA GTG
leucine	(leu)	GAA GAG GAT GAC
proline	(pro)	GGA GGG GGT GGC
threonine	(thr)	TGA TGG TGT TGC
valine	(val)	CAA CAG CAT CAC

Fig. 5.1 shows the base sequences in DNA and mRNA for the first seven amino acids of the β chain of haemoglobin.

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DNA	CAC	.....	GAC	TGA	GGA	CTC	CTC
mRNA	GUG	CAC	CUG	.....	CCU	GAG	GAG
β chain	val	his	.....	thr	pro	glu	glu

Fig. 5.1

(a) **(i)** Use Table 5.1 to complete Fig. 5.1. [3]

(ii) State the term used to describe the sequence of amino acids in a polypeptide.

..... [1]

(b) In sickle cell anaemia, the amino acid at position 6 in the β chain is valine and not glutamic acid.
Explain how a single change in the DNA triplet for the sixth amino acid of the gene coding for the β chain leads to the production of a different amino acid sequence.

.....

.....

.....

.....

..... [5]

40. O/N 13/P23/Q2/b,c

(a) Fig. 2.1 shows the base sequence of a DNA triplet code used to produce mRNA. Fill in the corresponding tRNA anticodon in the space provided.

DNA triplet	T A C
tRNA anticodon	

Fig. 2.1

[1]

(b) More mRNA molecules than tRNA molecules are synthesised in cells.
Suggest a reason for this.

..... [1]

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Answers Section

1. M/J 22/P22/Q4

(a) **R** if choice given and one is incorrect
carbonic acid ;
hydrogencarbonate (ions) ; **A** bicarbonate (ions)

(b) *any **one** from:*
similar / same, active site ;
have the same catalytic amino acids ;
similar / same, tertiary structure ; **A** same quaternary structure

(c) *allow pre-RNA for primary transcript*
*either exon **or** intron statement required for mp2 to 7, one mark each row*
*any **three** from:*

exons	introns
1 both, are (nucleotide sequences that are) transcribed / form part of the primary transcript ;	
2 (DNA/RNA) coding (sequences) **R** coding genes **I** exons have the genetic code	(DNA/RNA) non-coding (sequences) **R** non-coding genes
3 (RNA exons) needed / involved / AW, in translation **or** for formation of, polypeptides / proteins / carbonic anhydrase	not involved in translation / AW
if mps 2 and 3 not gained 'exons code for proteins' or ora 1 mark	
4 not removed, from primary transcript / from RNA / during gene splicing / during RNA splicing	removed, from primary transcript / from RNA /during gene splicing / during RNA splicing
5 (join to) form mRNA / contain mRNA codons **A** remain in mRNA	not part of mRNA / in primary transcript only
6 not involved in regulating activity of genes / AW	may have regulatory roles **A** other suggestions for role
7 AVP e.g. (as part of mRNA) leave the nucleus / go to cytoplasm / go to ribosomes	AVP e.g. remain in nucleus

if all are differences and all statements are reversed (i.e. introns for exons and vice versa) max 2 marks

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(d) *allow Hb or hb or Hgb for haemoglobin*
two marks for points in left column ***or*** *two marks for points in right column*

cytoplasm / cytosol ;	(bound to) cell surface membrane ;
close to haemoglobin (for H^+ uptake) **R** in / on / with, hb **or** *idea of* being dispersed within cell because haemoglobin is distributed throughout ;	close to, anion exchanger / transport protein, for (easy) exit of hydrogen carbonate (ions) ;
quick for hydrogen carbonate (ions) to be transported out of cell / AW **or** H^+ (from dissociation) binds rapidly to haemoglobin **or** cytoplasm provides water for reaction to form carbonic acid ;	able to, hydrate / react with, carbon dioxide as it enters cell ;

if stated cytoplasm and cell surface membrane, one mark
reason can be taken from either column if correctly linked, one mark

(e) exocytosis ;

(f) *any* ***three*** *from:*
1 acetazolamide / inhibitor, binds / attaches / AW, to, allosteric site / site other than active site ; **R** alternative active site
2 (which) changes, shape / tertiary structure / 3-D structure, of active site ;
A active site distorted **I** protein structure
allow ecf for mp3 and 4 if competitive described (to max 2)
3 substrate(s) / CO_2 / HCO_3^-, cannot, enter / bind to / fit in / AW, active site ;
A active site no longer complementary to, substrate / AW
A enzyme substrate / ES, complexes cannot form
A ESCs cannot form
I 'substrate / CO_2 / HCO_3^- / 'cannot bind to enzyme' *without a link to active site*
4 product, not formed / released ; **A** named product
5 *ref. to* acetazolamide / inhibitor, leaves, allosteric site / enzyme ;
I reversibly binds [12]

2. M/J 22/P21/Q6
(a) ***one*** *mark each correct row*

feature	**mRNA**	**DNA**
names of four bases	adenine, cytosine, guanine, uracil	adenine, cytosine, guanine, thymine
name of pentose sugar present	ribose	deoxyribose ;
number of strands	1 ; **I** single	2 ; **I** double

(b) (i) transcription ;
(ii) *can award either mp1 with mp2 ,* ***or*** *mp3 with mp4*
1 removal of introns (from primary transcript / RNA) ;
2 exons joined together ;
or
3 splicing ;
4 of, primary transcript / RNA ;

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(c) (i) *any **four** from:*
1 *ref. to* amino acid activation / charging amino acids before attachment to tRNA / AW ;
A aminoacylation
2 tRNA attached to, specific amino acid / glycine ; **R** 'picks up'
3 *idea that* anticodon / CCG, identifies specific amino acid ;
4 tRNA transports / AW, amino acid to ribosome ;
5 *ref. to* (tRNA) entering the A (aminoacyl) site in ribosome ;
6 tRNA, anticodon / CCG, binds to mRNA, codon / GGC ;
A correct ref. to, complementary pairing / base pairing / H bond formation *as AW for binding*
7 (specific) amino acid / glycine, in correct position in the polypeptide chain / AW ;
A helps to form / AW, primary structure of cotransporter protein
8 AVP ;
e.g. tRNA, recycled / reused
forms aminoacyl tRNA / amino acid-tRNA complex
tRNA-ligase / aminoacyl-tRNA synthetase

(ii) *any **three** from:*
1 movement of sucrose with, protons / H^+ ions, into companion cells ; **A** correct *ref. to* (other named) assimilates
2 (sucrose moved) from, apoplast / cell wall / mesophyll cell ;
3 sucrose moves against its concentration gradient (into companion cell) ;
4 (needs cotransporter protein because) sucrose is polar so cannot pass through membrane ;
5 maintain concentration gradient for sucrose between companion cell and sieve tube (element) ; [13]

3. O/N 21/P22/Q3/c,d

(a) if detail is linked to incorrect level of structure or levels of structure not named, **max 3**
1 primary structure detail ;
e.g. sequence of amino acids / ref. to sequence in Fig 3.1
(many) amino acids joined by peptide bonds
2 secondary structure detail ;
e.g. has, α / alpha, helices
has β / beta, pleated sheets **A** β / beta, pleats
has areas of random coils / AW
3 tertiary structure detail ;
e.g. interactions between, side chains / R groups
(R group interactions are) H bonds, ionic bonds, hydrophobic interactions, disulfide bridges any two folding and coiling *in context of polypeptide chain*
4 quaternary structure detail;
e.g. <u>three</u> (identical) polypeptide chains
ref. to interaction of polypeptide chains
A polypeptides *for polypeptide chains*

(b) *any **three** from:*
ref. to <u>genetic code</u> ; *in correct context*
amino acids coded for by more than one codon / two or more codons for (most) amino acids ;
A triplet (of, bases / nucleotides)
64 codons and 20 amino acids ;
third base in codon can be different / only first two bases in codon are same ;

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AVP ; *idea that* amino acid sequence is only the result of exons / gives information only about introns only sure of sequence for, two amino acids / met and trp
degenerate code / degeneracy of code **R** degenerative
ref. to control sequences
STOP codons (also) have more than one triplet (of bases)
STOP codons do not specify amino acids [7]

4. O/N 21/P22/Q5/a

(a) *ignore single letters for the bases*
A *purines* = adenine and guanine ; *in either order*
pyrimidines = cytosine and uracil ; *in either order*
B phosphodiester (bond) ;
C ribose ; [4]

5. O/N 21/P23/Q1

(a) (i) translation ;

(ii) **A** – messenger RNA / mRNA ;
B – transfer RNA / tRNA ;
C – (poly)peptide (chain) ;
I PPC / (primary structure of) protein / amino acid chain

(iii) *accept names of bases*
D – AAA
E – GUG ;

(b) *any **four** from:*
structure to max three
ignore all refs to DNA and red blood cells

1 different amino acid will have different, R group / side chain ;
A glutamic acid / glu, to, valine / val
2 may prevent formation of bond(s) between R groups ;
3 may form, new / different, bond(s) between R groups ;
4 change in, secondary / 2° / tertiary / 3° / quaternary / 4°, structure ;
A change in, globular shape / 3D shape
A different folding of, β-globin / polypeptide / haemoglobin
R quaternary if referring to, a single polypeptide / β-globin
5 any further detail on, 2° / 3° / 4°, structure ;
e.g. interactions between α-globin and β-globin may change / AW
6 AVP ;
e.g. change from, polar / charged / hydrophilic, to, non-polar / non-charged / hydrophobic (R group / amino acid)

function

7 change in ability, to bind / AW, to oxygen / carbon dioxide ;
A lower / higher for change
A change in percentage saturation of haemoglobin with oxygen
A change in affinity for, oxygen / carbon dioxide
A changes the volume of, oxygen / carbon dioxide, carried
A carry, more / less, oxygen / carbon dioxide
R if haemoglobin is said to have an active site [9]

6. M/J 21/P23/Q3

(a) *any four from*

1 mRNA, attaches to / associates with / AW, ribosome ;
A ribosome reads mRNA

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2 two codons, exposed / AW ;
A A and P sites / first and second binding sites, (on ribosome)

3 tRNA, qualified carries an amino acid to ribosomes / each type carries a specific amino acid / first amino acid is met / tRNA with met / $tRNA^{met}$;
ref. to ribosomes can be implied in mp 3 if mp1 gained

4 anticodon (on tRNA) binds to codon (on mRNA) ; **I** matches
A complementary / base, pairing between codon and anticodon
A H-bonds form between bases on codon and anticodon
R if anticodon on mRNA

5 START (mRNA) codon / (mRNA) AUG first codon ;

6 second tRNA with its amino acid binds next to first tRNA / (two) amino acids are held in place close to each other by tRNA binding / AW ;
A *ref. to* two tRNAs next to each other

7 (after peptide bond formation) first tRNA detaches / ribosome moves along one codon
or
process repeats / elongation occurs, until, STOP codon /
polypeptide chain synthesised (and released from ribosome);

8 tRNA molecules, reused / leave ribosome to attach to another amino acid ;
must be in context of leaving after peptide bond formation

9 AVP ; e.g. peptidyl transferase for peptide bond formation
ref. to, 99 / 100 / 101, codons, qualified
A number of bases in length of mRNA

(b) *any three from*
similarity
peptide bond and disulfide bond are covalent bonds ;
differences
tertiary structure bonds are between, R groups / side chains, (of different amino acids ;
H bond / ionic bond / hydrophobic interaction, versus covalent peptide bond ;
A tertiary structure bonds apart from disulfide are not covalent
peptide bond, stronger / more thermostable, than, tertiary structure bonds / two named bonds ; peptide bond is between, carboxylic acid / COOH, and, amino / NH_2, group (of the adjacent amino acid) ;

AVP; detail of a tertiary structure bond e.g.
hydrophobic between non-polar R groups
disulfide between sulfur-containing R groups
ionic between carboxyl and amino groups of R groups
H bond between oxygen on —CO groups and H on either the —OH or —NH groups of R groups

(c) (i) *any three from:*
suggestion that

1 flap region, opens / moves, to let, substrate / polyprotein, enter
or
flap region, closes round / AW, substrate / polyprotein **I** flap region is closed

2 induced fit / HIV protease action, involves, change in shape of active site / active site moulding around substrate / AW; **I** *ref. to* enzyme or substrate changing shape

if mp1 and mp2 not gained allow one mark if stated that activity of flap region changes shape of active site or that flap region changes shape because it is the active site

3 *ref. to* better fit / fully complementary / AW;

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4 *ref. to* formation of, enzyme-substrate complex ; **A** ESC
5 AVP ; e.g. (induced fit) substrate / polyprotein, not (fully) complementary to (shape of) active site **A** does not (fully) fit active site / enzyme, returns to original shape on release of product change of shape (to give complementary fit), lowers activation energy / puts strain on bonds / AW

(ii) *any two from*
acts as competitive inhibitor ;
binds to active site, qualified ;
e.g. instead of, substrate / polyprotein
to prevent, entry / binding, of, substrate / polyprotein
so competes with substrate
to prevent ESC formation
I *ref. to* flap region as active site
any one from
will be permanent / non-reversible ;
causes / induces, flap region to open to bind to active site ;
no (**A** few / fewer) polyprotein products / polyprotein not cut, so viral replication prevented / AW ; **R** polyprotein not broken down [12]

7. **O/N 20/P22/Q2/b,c**
(a) (i) transcription ;
(ii) *any **three** from:*
I stops transcription
1 alters shape of / blocks, active site ;
R enters / fits into, active site *as it is not competitive*
R *ref. to* choice of competitive or non-competitive
A alters shape of enzyme *only if mp2 gained*
2 substrate / nucleotides, cannot, bind to / enter, active site ;
A fewer / no, enzyme-substrate complexes / ESCs, form
allow ecf from mp1 if rifampicin described as, competitive / enters active site
3 complementary (base) pairs / (complementary) base pairs, cannot form / form less easily (between DNA and RNA nucleotides) ;
4, 5, 6 *(in context of rifampicin binding to RNA polymerase)*
prevents / AW, unwinding of DNA (double helix) ;
A uncoiling
I unzipping prevents / AW, attachment to DNA (strand)
A prevents / AW, attachment to promoter
prevents / AW, movement along DNA (strand) ;
prevents / AW, elongation (of polynucleotide) / formation of polynucleotide /nucleotides being joined ;
prevents / AW, phosphodiester bond formation ;
prevents / AW, proof reading ;
7 AVP ; e.g. prevents / AW, tRNA / rRNA, formation

(b) (i) Phe
Tyr ; *one mark for both correct*
(ii) **B D F G** ; *in any order*
(iii) *resistance*
1 shape / tertiary structure, of, β-subunit / enzyme, altered / AW ;
I active site changes shape
A quaternary structure of enzyme altered
2 rifampicin / antibiotic, cannot / does not, bind (as well) ; AW
R *if context is binding to active site*
different levels of resistances

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*any **two** from:*

3 (because) other mutations are involved ; AW
A described from Table 2.1
e.g. **C** has 2 (other) mutations and **D** and **E** have 3

4 mutations may result in different changes to, structure / shape of, β-subunit / enzyme, and result in different, effects / levels of resistance ;

5 data from Table 2.2 to support mp 4 ; *must be linked to concept of mp4*

6 AVP ; e.g. *ref. to* different binding abilities (of rifampicin to enzyme)
some (of the other) mutations may cause more of a change to binding site for rifampicin
mutation(s) may make it harder to bind
lower resistance = binds, more strongly / for longer time
lower resistance = higher proportion of transcription events hindered
e.g. idea that mutations still, produce functioning enzyme / allow catalysis to occur [9]

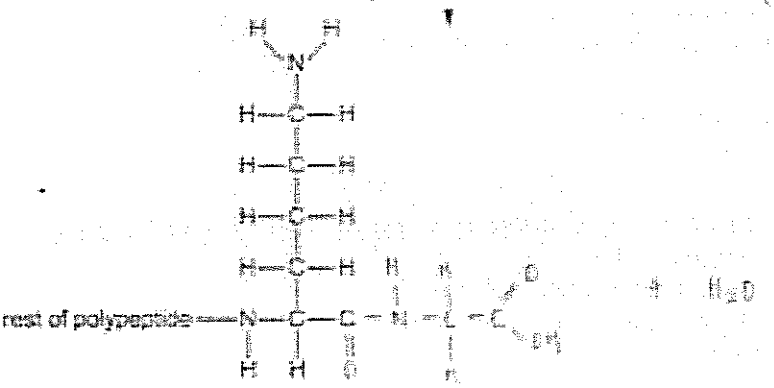
8. O/N 20/P21/Q6/a

(a) (i) *in context of mutations in genes*
*any **two** from:*
uncontrolled, (cell) division / mitosis ;
cell cycle not regulated ;
programmed cell death does not occur / cell becomes immortal ;
uncontrolled growth not suppressed ;
ref. to mass of abnormal cells ;
AVP ; e.g. cell cycle checkpoints impaired
proto-oncogenes become oncogenes
tumour supperssor grnes switched off

(ii) *any **two** from:*
ref. to change of a single, nucleotide / base (in sequence of DNA)
or
one base substitution (mutation) ;
change in one, DNA triplet / mRNA codon ;
ref. to tRNA with a different anticodon / tRNA brings a different amino acid ;
idea that different primary structure leads to different tertiary structure ; [4]

9. O/N 20/P23/Q5/a,b

(a) (i) **I** *presence or absence of water*
diagram shows bond between C (of lysine) and N (of glycine) **and** double bond to O shown correctly ;
glycine drawn correctly ;
R if R is used instead of H on glycine



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(ii) condensation ; **A** dehydration (reaction)
(iii) **I** high tensile strength
*any **two** from:*
allows close packing of, triple helix / three polypeptides ; **A** chains
I tight coiling **A** 'binds more tightly'
glycine, has smallest R group / R group of glycine is H / is smallest amino acid ; **A** glycine is small glycine, is every third amino acid in the, polypeptide / chain ;

(b) **I** collagen is insoluble / collagen is strong
*any **four** from:*
1 collagen, has high tensile strength / does not stretch / AW ;
A withstands large pulling forces
2 *any ref. to* use of collagen in the body ;
e.g. (walls of) arteries or veins / tendons / cartilage / skin / basement membranes / around alveoli / bones / teeth **I** hair / **R** if any *ref. to* elastic(icity)
three from
3 triple helix has many hydrogen bonds between, polypeptides / chains ;
mp4, 5, 6 and 7 – must be clear that answers are about molecules, but accept triple helix for molecule
4 collagen molecules form, fibrils / fibres ;
5 strong / covalent, (cross) links between molecules ;
6 (ends of) molecules (in fibril / fibre) are staggered ;
7 AVP ; e.g. (many) collagen molecules lie parallel [9]

10. M/J 20/P21/Q6
(a) adenine and guanine ;
(b) anticodon ;
(c) CAG / cytosine, adenine, guanine ; A GAC
(d) hydrogen bonds form (between complementary bases) ; [4]

11. O/N 19/P22/Q3/c,d,e
(a) (i) *3 structures correct and involvement, incorrect / not stated, allow 1 mark*
three correct rows
I *extra rows added with additional structures*

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nucleus / chromosome	(has) gene / DNA, coding for protein **or** (for) transcription / mRNA synthesis ; **A** produces ribosomes *if stated as made in nucleolus*
nucleolus	produces, rRNA / ribosomes / ribosomal subunits ;
ribosome **A** ribosomal subunit	(site of) polypeptide / protein, synthesis **A** described **I** makes amino acids **A** to synthesise enzymes **or** (for) translation **or** binding of, mRNA / tRNA ;
<u>rough</u> endoplasmic reticulum **A** rough ER / RER **R** wrong word for 'rough' if RER also stated	site of, polypeptide / protein, synthesis **A** described **A** to synthesise enzymes **or** (for) translation **or** (for) attachment of ribosomes **or** protein / post-translational, modification **A** examples **or** protein transport ; **I** packaging proteins
transport vesicle	to move protein from RER to Golgi (body / apparatus / complex) ;
Golgi (body / apparatus / complex)	for, protein / post-translational, modification / AW ; **A** examples **I** packaging proteins
mitochondrion	provides / produces, ATP for, tRNA aminoacylation / charging amino acids before attachment to tRNA ;

(ii) carbonic anhydr<u>ase</u> ;
R carbon anhydrase / anhydrase

(b) *assume spherocytosis type 2 unless stated otherwise*
any two from:
spherical means reduced surface area (to volume ratio) (so less oxygen diffuses in) ;
A SA *for surface area*
idea of further distance for oxygen to reach, (some) haemoglobin molecules / centre of red blood cell ;
not enough time to reach, same level of / 98%, saturation of haemoglobin ;
idea of blood flowing through

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ref. to spherical shape / larger / less flexible, so less able to pass through, (pulmonary capillary) network / AW ;

(c) *any three from:*
(water potential gradient created / loss of equal water potentials, so)
similarities
1 water enters cells, by osmosis / down the water potential gradient / from high to low water potential ;
A Ψ for water potential
2 both type of cell, swell / increase in size ;
differences
3 spherocytosis cells, burst / lyse, more easily / before red blood cells ;
A spherocytosis cells burst more quickly
A spherocytosis cells burst and red blood cells do not burst
4 AVP ;
e.g. spherocytosis cells already more swollen spherocytosis cells have more pressure exerted (on their cell surface membrane) than normal red blood cells AW
idea of spherocytosis cells unable to take in as much water and stay intact
ref. to less stable / less support for membrane, so weaker membrane (for spherocytosis cells)
I less flexible [9]

12. O/N 19/P21/Q1/b,c

(a) (i) label line to any area of the nucleus ;
(ii) correct formula ; e.g. actual diameter = image length / magnification
15 (∝m) ;
(iii) *any one valid suggestion* ;
e.g. *idea of* only very thin section of cell
mitochondria found in other sections

(b) *two from*
idea that reduces resistance to flow through sieve tube ;
idea that less space taken up so increased volume of sap / AW, can pass through (per unit time) ; pressure flow / mass flow, does not need energy from the cell / AW;
AVP ; (organelles not needed as) metabolic reactions / AW, carried out by the companion cell [6]

13. O/N 19/P23/Q3/b

(a) **I** *any ref. to mutation / inhibition of (RNA) polymerase*
1 microRNA binds to mRNA ;
A forms hydrogen bonds with (bases on) mRNA
2 bases in microRNA are <u>complementary</u> to bases on mRNA ;
3 microRNA makes mRNA too large to leave nuclear pore / mRNA cannot reach ribosomes ;
***mp4 and mp5** accept alternatives to bind*
4 mRNA cannot, bind / AW, to (small sub-unit of) ribosome ;
A prevents ribosome moving along mRNA
5 anticodons of tRNA cannot, bind / AW, to (some) codons on mRNA ;
6 no / not all, amino acids are brought to ribosome / AW ;
7 AVP ;
e.g. complex of microRNA and mRNA recognised for degrading [3]

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14. M/J 19/P21/Q6

(a) (i) 30% ; **A** anywhere in the answer
bases, are paired / are complementary ; **A** with *ref. to* binding
A hydrogen bonds between, A and T / C and G
A thymine *or* T pairs with adenine *or* A / cytosine or C pairs with guanine or G
calculation / explanation for 30% ; e.g. A+T = 40%, C+G = 60%, half of 60% = 30%

(ii) mitochondria / mitochondrion (in cytoplasm) ;
R whole answer if anything else is first or second in answer
R 'mitochondria and / or cytoplasm'

(b) (i) G
G
U
C ;

(ii) anticodon ;
any two from:
Q / anticodon, binds / AW, to, codon on mRNA ;
I *ref. to* complementary bases alone
idea that
specificity ensures correct primary structure (of polypeptide / protein) ;
A correct amino acid sequence (of polypeptide / protein)

(iii) site of attachment of (specific) amino acid (to tRNA) / amino acid binding site ; [9]

15. M/J 19/P23/Q1

(a) one nucleotide circled ;

(b) cytosine and guanine ;
three hydrogen bonds between the base pairs ;

(c) (3) 5,4,1,2 ;

(d) **I** maintains length of chromosomes / prevents chromosome shortening
any two from:
permit continued replication ;
prevent loss of genes ; **I** prevents gene damage
A genetic / coded, information
A protein coding regions of DNA
protect ends of chromosomes from being, degraded / AW ;
AVP ; e.g. prevents ends of chromosomes from being attached to each other
not mistaken for a break in DNA that needs repairing [6]

16. O/N 18/P22/Q5

(a) *polymer – context of a chain / strand*
(similar) repeating, smaller molecules / subunits
or
repeating / many, monomers / (RNA) nucleotides ; **R** branching
A *idea of* nucleotides joined together to form a chain
A made of nucleotides to form polynucleotide
'made of nucleotides' 'made of monomers' not enough
macromolecule (in context of RNA)
large (biological) molecules / 1000 or more atoms / high molecular mass ;
A giant / huge, structure **I** long

(b) add Benedict's (solution / reagent) and, boil / heat to 95 °C ;
A temperature 80 °C and above
precipitate / (change from clear blue to) green / yellow / orange / red / brown ;
R if a wrong colour included e.g. black / purple

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(c)

feature	DNA nucleotide	RNA nucleotide
sugar component	deoxyribose	ribose ;
purine bases	adenine / A guanine / G	adenine / A guanine / G } ;
pyrimidine bases	cytosine / C thymine / T	cytosine / C uracil / U } ;

[7]

17. O/N 18/P22/Q6/b

(a) **A** iron / Fe ;
I oxidation status of Fe
A iron atom / iron ion
R iron molecule
B carbaminohaemoglobin ;
C haemoglobinic acid ;

[3]

18. O/N 18/P21/Q5/c

(a)

feature	DNA nucleotide with adenine	RNA nucleotide with adenine	ATP
contains nitrogen (yes or no)	yes	yes	yes ;
contains a pyrimidine base (yes or no)	no	no	no ;
number of phosphate groups	1	1	3 ;
name of the sugar component	deoxyribose ;	ribose	ribose ;

[5]

19. O/N 18/P23/Q3

(a) (i) **D** (nitrogenous organic / nucleotide) base ;
A pyrimidine / uracil / cytosine **R** purine
E ribose ;
I pentose
F phosphate (group) ;

(ii) *any one from*
two, strands / polynucleotides (not one) ;
A two chains
R polypeptides
deoxyribose (not ribose) ;
A correct ref. to –OH (on C2) instead of –H group on the pentose / sugar
thymine (not uracil) ;
R thiamine
have base pairs ;
(double) helix / helical (not straight chain) ;
longer ;

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(b) *any four from*
1 template RNA binds to (part of) region **X** ;
2 in <u>active site</u> of, telomerase / enzyme ;
3 DNA / free, nucleotides, pair with / bind to / align with, RNA ;
4 ref. to complementary, bases / base pairs ;
5 A–T and C–G and U–A ;
6 phosphodiester bonds form, between (DNA) nucleotides / AW ;
treat as neutral any *refs.* to likely enzymes, e.g. ligase, etc.
7 telomerase moves, in the direction of the arrow / to the right ;
8 AVP ; e.g. hydrogen bonds between bases
telomerase acts as a reverse transcriptase

(c) *prokaryotes*
have, circular DNA ;
A 'loop of DNA'
I plasmid(s)
do not have telomeres ;
do not have chromosomes ;
AVP ;
e.g. 'DNA has no ends'

(d) *any two from*
cancer cells divide, uncontrollable / continuously ; **ORA**
A cancer cells divide but do not undergo cell death
telomerase is required to ensure, <u>chromosomes</u>, do not shorten ;
telomerase is, synthesised / produced / found, in cancer cells ; **ORA**
high levels of telomerase indicate cells that are cancerous / AW ;
AVP ;
idea that gene for telomerase switched on [11]

20. M/J 18/P22/Q2

(a) (i) A = adenine
T = thymine **R** thiamine / thyamine
G = guanine
C = cytosine
all correct = 2 marks
one, two or three correct = 1 mark

(ii) *three from:*
1 complementary base pairing / complementary bases / base pairing / base pairs / complementary pairing ;
2 A with T <u>and</u> G with C ;
3 hydrogen bonding / hydrogen bonds ;
in context of between base pairs / holding strands together
4 ref. to purines with pyrimidines ;
5 double ring (bases) with single ring (bases) ;
A *idea of* longer base with shorter base
6 two (DNA), strands / polynucleotides ;
A two chains
A double helix (as double implies two strands)
7 strands (anti)parallel / distance between strands always the same ;

(b) deoxyribose ; **A** 2-deoxyribose / 2-deoxy-D-ribose

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(c) *two from:*
(information could be) sequence of <u>amino acids</u> ;
A idea that a polypeptide/protein has amino acids arranged in an order / AW
I primary structure / chains of amino acids
(different) proteins have, different / specific, sequences (of amino acids) ;
(up to) 20 different amino acids in proteins ; **A** approximately 20
idea that there is a great variety in protein structure ;
I have many functions [8]

21. M/J 18/P23/Q3/d,e,f

(a) (i) change in the, sequence / AW, of, bases / nucleotides (in, the DNA / the gene / *cyFBP*) ;

(ii) *one valid suggestion that prevents polypeptide synthesis or prevents synthesis of functional enzyme:*
e.g.
no mRNA produced ;
A transcription, does not / cannot, occur
mRNA produced unable to attach to ribosome ;
A translation, does not / cannot, occur
no start codon on mRNA ;
shortened polypeptide chain produced ;
A ref. to STOP codon
premature chain termination mutation / nonsense mutation ;
polypeptide produced cannot fold to form, tertiary structure / active site ;
R changes shape of active site preventing function
polypeptide produced cannot form quaternary structure of protein ;

(b) (i) *accept cell for lymphocyte throughout*
four from:
1 (primary) immune response ;
2 cyFBPase / enzyme, is antigen ;
3 formation of, APC / antigen-presenting cell ;
A antigens presented on surface of macrophages
4 antigen, recognition / binding (in context of B-, or T-lymphocytes) ;
5 detail ;
e.g. clonal selection
have receptors, complementary / specific, to, antigen / cyFBPase
A immunoglobulin / antibody, as receptors for B-lymphocytes
A surface molecules as receptors for T-lymphocytes
6 divide by mitosis / clonal expansion ;
7 (specific) B-lymphocytes form plasma cells ;
8 plasma cells, synthesise / secrete, specific antibody / antibody to cyFBPase ;
9 T-helper / Th, lymphocyte, secretes, cytokine / interleukin ;
10 stimulates, humoral / B-lymphocyte, response ;

(ii) no binding of (monoclonal) antibody to, antigen / cyFBPase / enzyme / AW ;

(c) *two from:*
(less cyFBPase / enzyme, so) less sucrose synthesised ;
A no enzyme to synthesise sucrose
less sucrose transported (source to sink) ;
A less sucrose unloaded at sink ;
ref. to less glucose for synthesis of starch / AW (on context of sucrose hydrolysis) ; [9]

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22. M/J 18/P23/Q4/c,d

(a) *idea of* abnormal, change in the body / condition, which produces, poor / ill-, health
or
absence of, good health / well-being ;
A disorder / illness
further detail ; e.g. having an adverse effect
reduces the effectiveness of functions
produces, (specific) signs / symptoms
lack of social, physical and mental, well-being
can be infectious or non-infectious AW

(b) *five from:*
1 base substitution (in gene coding for, β-globin / polypeptide) ;
2 different / altered, mRNA codon ;
3 different tRNA brings a different amino acid (to ribosome) / leads to a change in one amino acid (in the polypeptide chain) ;
4 altered, primary structure / sequence of amino acids (in β-globin) ;
5 changed, tertiary / quaternary, structure ;
6 haemoglobin / molecule, less soluble ;
7 (haemoglobin) molecules, stick together / form fibres ;
8 (haemoglobin) less able to bind oxygen / AW ;

points above may be qualified
9 details ; ;
\+ e.g. thymine / T, replaces, adenine / A
10 in sixth, codon / triplet **or** sixth amino acid in sequence is changed
(non-template strand) GTG instead of GAG / GTA instead of GAA
or
(template strand) CAC instead of CTC / CAT instead of CTT
mRNA codon is, GUG instead of GAG / GUA instead of GAA
11 (amino acid change is) valine instead of glutamic acid ;
12 amino acid with non-polar side chain instead of polar side chain ;
13 position of amino acid, is to the exterior / faces cytosol ; [7]

23. O/N 17/P22/Q3/e

(a) *five from*
1 change in nucleotide / base, sequence (of, DNA / gene / *GBA*) ; *must be in context of DNA, ignore if in context of RNA*
2 (because of) base substitution ; **A** substitution of a base
3 altered / AW, mRNA codon ; **A** mRNA triplet **R** genetic code **I** triplet code
4 *idea that* a, codon / triplet, specifies a particular amino acid ; *in context of DNA or RNA*
5 (different) tRNA with different amino acid (brought to ribosome) / tRNA brings Ser instead of Asn / tRNA brings Pro instead of Leu ; **R** tRNA makes a different amino acid
6 altered, primary structure **or** altered, sequence / order / arrangement, of amino acids ; **R** if describing result of
frameshift, deletions or insertions e.g. all amino acids changed from mutation
on / missing amino acid / added amino acids
7 affects (folding into) / different, secondary structure ;
different tertiary structure
8 *ref. to* different interactions between, R groups / side chains
(because of changed primary structure) ; **A** *idea of*
different bonds forming (*if R-groups not stated*) **I** peptide bonds change
9 *idea that* differences give different shapes of active site *if shape not stated, allow point if linked to idea of 'tertiary structure changes shape'* **or** *idea of* change to complementarity to substrate

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10 mutation 1 / asparagine (Asn) to serine (Ser), change less effect on, active site shape / catalysis **or** mutation 2 / leucine (Leu) to proline (Pro), change greater effect on, active site shape / catalysis ; [5]

24. O/N 17/P21/Q4/a

(a) *codon that*
terminates / AW, translation / polypeptide synthesis **R** stops production of amino acids
or
does not specify any amino acid
or
has no complementary, tRNA / anticodon
or
causes the release of the (completed) polypeptide chain ; [1]

25. M/J 17/P22/Q6

(a) *row 1* globular + globular ;
row 2 2, alpha / α, globin, and 2, beta / β, globin (chains) ;
A 2 alpha and 2 beta chains
row 3 disulfide (bridges / bonds) ; covalent is neutral

(b) *mRNA strand produced* UGU ;
tRNA anticodon sequence UGU ; [5]

26. M/J 17/P21/Q4

(a) *mRNA*
1 single-stranded ;
2 no hydrogen bonding / only DNA has hydrogen bonding ;
3 no base pairs / only DNA has base pairs ;
4 uracil and not thymine / DNA has thymine instead of uracil ;
treat as neutral T and U, look for complete term
5 ribose not deoxyribose ;
6 detail, e.g. –H and not –OH on C2 ;
7 short(er) / DNA is longer ; **A** smaller / bigger
8 not a helix ;

(b) (i) *third triplet is a stop codon so*
only two amino acids are joined by peptide bonds / chain only 2 amino acids long ;
A will still have Val-His as the first two amino acids
very short molecule is produced / chain stops after His(tidine) ;
R frameshift / description of frameshift

(ii) *a triplet is deleted so*
(polypeptide / sequence / β chain) has one less amino acid ;
polypeptide does not have Leu (as the third amino acid) ;
I Leu is not, produced / made / synthesised

(c)

feature	DNA replication	transcription
a single-stranded molecule is produced	✗	✓
hydrogen bonds are broken	✓	✓ ;
both strands of DNA act as templates	✓	✗ ;
phosphodiester bonds are formed	✓	✓ ;

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DNA polymerase is used	✓	× ;

(d) **I** *functions of telomerase*
permits continued replication (in stem cells / meristematic cells) ; **A** ora
prevents loss of, genes / genetic material / DNA ; **A** ora
A prevents shortening of, chromosomes / DNA
length of telomere determines lifespan of, cells / cell lineage ;
AVP ; e.g. prevents ends of chromosomes attaching to each other prevents apoptosis / cell death / cell destruction

(e) 1 translation / construction of polypeptide(s) ;
2 provide binding site for mRNA / mRNA attaches to ribosome / AW ;
A entering ribosome
3 provides binding sites for (two) tRNA molecules ;
A entering ribosome
4 two amino acids are held close together ;
5 formation of peptide bond(s) ; **R** dipeptide / polypeptide, bond
6 (allows) assembly of amino acids into, sequence / primary structure ;
7 AVP ; e.g.
P and A site (and E site)
bond between amino acids catalysed by peptidyl transferase [16]

27. M/J 17/P23/Q2/e

(a) (i) gene coding for systemin is (a length of) DNA ;
A *idea that* a length of DNA codes for systemin
transcription / production of mRNA ;

(ii) herbivore proteases and plant proteases have different (shaped) active sites ;
serpin / competitive inhibitor, only complementary to (shape of) active site of herbivore proteases ; **ora** **A** can only fit
serpin is specific to (active sites of) herbivore proteases ; AW
proteases act on different, substrates / (parts of) proteins ;
A similar shape only to herbivore substrates
AVP ; e.g herbivore proteases cut at different amino acid sequences
allow other acceptable suggestions e.g.
suggestion that serpin physically separated from plant proteases ;
detail, e.g. in vesicle / plant proteases in vacuole ;
cannot bind to active site of plant proteases ;
serpin released when plant parts ingested by herbivores ;

(iii) affinity for substrate has decreased ;
needs a higher concentration of substrate to saturate active sites / AW ;
A needs a higher concentration to reach, ½ Vmax / Vmax
idea that inhibitor prevents substrate from binding (to active site)
so more substrate required (to compete) ; [6]

28. O/N 16/P22/ Q3/d

(a) (i)

amino acid sequence	met	tyr	glu	pro	lys
student's nucleotide sequence	AUG	UAU	GAC	CCU	UGU
correct = ✓ incorrect = ×	✓	✓	×	✓	×

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one mark if bottom row correct ;

(ii) *three from*

1 genetic code is, degenerate ; **A** redundant

2 64 codons and 20 amino acids ;
A 61 codons for 20 amino acids *(3 STOP codons)*

3 *idea that* more than one, codon / triplet, specifies an amino acid ;
specific to the first five amino acids of glucose isomerase

4 example of choice of codons to specify the same amino acid ;
(must use Table 3.2 to find codons for the amino acids from Table 3.1)
tyr UAU UAC
glu GAA GAG
pro CCU CCC CCA CCG
lys AAA AAG
use of another example from Table 3.2 may be used to support mp3

5 AVP ; e.g.
start codon always AUG / met has only one codon, so only sequence for amino acids 2-5 may be different
start codon, may be different / may not always be AUG ^{met} [4]

29. O/N 16/P21/Q4/b

(a) (i) *two from*
different mRNA codon (formed during transcription) ;
A triplet / triplet of bases / triplet code / 3-base code
R codons
idea that, each codon specifies a particular amino acid / a different codon specifies a different amino acid ; **A**
(different) tRNA with different amino acid binds to, ribosome / mRNA ;

(ii) *two from*
change in, tertiary / quaternary, structure (of enzyme) ;
A change in polypeptide, folding / coiling ;
(enzyme) binding site for antibiotic, lost / changes shape ;
R active site *unless clear that substrate binding and catalytic site remains unchanged*
antibiotic / nalidixic acid, cannot bind (so enzyme remains active) ;
allow ecf for active site [4]

30. O/N 16/P23/Q4

(a) hydrogen (bond) ;

(b) *three from*

1 tRNA carries an amino acid to ribosomes ;

2 (each type of) tRNA carries a specific amino acid ;

3 anticodon (on tRNA) binds to codon on mRNA ; *anticodon may be labelled on Fig. 4.1*

4 tRNA molecules hold amino acids, in place / in P and A sites (of ribosome), for peptide bond formation ;

5 tRNA molecules, reused / described ; **I** tRNA leaves ribosome unqualified

6 AVP ; e.g. amino acid is attached to ACC region / examples of complementary base pairing between codon and anticodon

(c) *max 2 if in context of making mRNA*

1 gene for each tRNA (molecule) is transcribed ;

2 hydrogen bonds in DNA are broken ;
I unwinding / unzipping

3 one strand of DNA is the template ;

4 RNA polymerase ;

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5 (free RNA) nucleotides joined together / formation of phosphodiester bonds ;
I complementary base pairing
6 AVP ; e.g. correct ref. to helicase in breaking hydrogen bonds [7]

31. M/J 16/P22/Q6/b,c

(a) (i) *treat as neutral unit of inheritance*
sequence of, nucleotides / bases ;
section / length / part, of DNA (molecule) ;
codes for a polypeptide ; **A** protein *for polypeptide* **A** enzyme
A information to produce a polypeptide
A codes / information, for sequence of amino acids / primary structure (of a, polypeptide / protein)
R genetic code for a polypeptide

(ii) 1 (in DNA / gene) altered, sequence / AW, of, nucleotides / bases ;
I DNA sequence
2 base substitution
or base / nucleotide, replaces another, base / nucleotide;
A example *must be in context of, DNA / gene*
3 (mRNA synthesised) during transcription ;
4 (mutation leads to) altered / AW, mRNA / messenger RNA ;
5 (only) one (mRNA) codon changed / a different codon ;
A one DNA, triplet / codon, changed **I** *ref. to* codons changed
6 tRNA, with / has, a different anticodon ;
7 (tRNA) brings, a different / a changed / the incorrect, amino acid, during translation / to the ribosome ;
8 codon-anticodon, binding / complementary / AW ; **A** matches
R amino acid with anticodon

(b) nucleolus ; **R** if other cell structures given
mitochondrion ; **R** if other cell structures given
rough endoplasmic reticulum **or** Golgi (body / apparatus / complex) ; [8]

32. M/J 16/P21/Q2/a

(a) (i) phagocytosis / endocytosis ; **R** pinocytosis **I** engulfing
(ii) **E** transcription ;
F translation ; **A** post translation(al) modification
(iii) **B** (phagocytic / endocytic) vacuole / phagosome ; **A** vesicle
R incorrectly qualified vacuole or vesicle (e.g. permanent / large / secretory / Golgi / excretory)
I food / pathogenic
G (80S) ribosome ; **A** rough endoplasmic reticulum **R** RER / rough ER
I 70S or any other type of incorrect S as a qualification
H Golgi (body / apparatus / complex) ;
J mitochondrion; **A** mitochondria [7]

33. M/J 16/P23/Q5/c

(a) (i) making / synthesis of, (m)RNA ;
from a DNA, template / sequence of bases / sequence of nucleotides ;
A from a gene

(ii) *idea that* pathogen and human RNA polymerase are (slightly) different ; e.g. (slightly) different shaped active sites
A rifampicin unable to, cross cell surface membrane / enter nucleus / cross nuclear envelope [3]

34. O/N 15/P23/Q1/a

(a) (i) **A** – nuclear envelope ;

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B – rough endoplasmic reticulum ; **R** RER / ER / smooth ER
C – (large sub-unit of) ribosome ; **A** ribosomal RNA, **R** rRNA

(ii) **D** – transfer / t, RNA ;

(iii) *at* **1** – transcription ;
A post-transcription modification / removal of introns
A DNA / gene, copied (to synthesise mRNA)
A genetic information copied
R DNA copied onto mRNA
R DNA code copied onto mRNA
at **2** – amino acid activation ;
A attachment / AW, of (specific) amino acid (to specific tRNA)
at **3** – translation / condensation of amino acids / formation of peptide bond(s) (between amino acids) ;
A codon-anticodon binding
I (poly)peptide synthesis [7]

35. O/N 15/P23/Q3/b

(a) amino acid at position 2, is part of active site / helps to give shape to active site / helps form the structure of the active site ;
plus one from:
idea of different, R group / side chain, gives different properties ;
A tryptophan has a, hydrophobic / larger, R group / serine has a polar R group, different properties ;
(slightly) different, folding of polypeptide / secondary structure / tertiary structure / active site / catalytic site / binding site ;
suggested reasons e.g. electrons less easily transferred
ref. to induced fit , more efficient with **P** ; ora
different interactions between polypeptides (in catalase) ; [2]

36. M/J 15/P21/Q6

(a) **P** – thymine ; **R** thiamine / thiamin / thyamine
Q – cytosine ;
R – guanine ;
S – uracil ;

(b) **1** copy of the, DNA / gene, (coding) for a, polypeptide / globin ; **A** protein
2 travels from, DNA / nucleus / chromosome, to ribosome ;
A mRNA made in nucleus, attached to ribosome *so movement is implied*
3 for translation / for (haemo)globin production ;
4 mRNA codes for, sequence / order, of amino acids ; **A** for primary structure
5 *idea that* (nucleotide / base) sequence is a series of codons ;
6 base pairing / AW, between codon on mRNA and anticodon on tRNA ;
e.g. of AW
hydrogen bonds between bases
examples of base pairing: A–U / C–G
R binding between bases [7]

37. M/J 15/P23/Q2

(a) (late) interphase / phase / after G1 phase / before G2 phase ;
A after first growth phase / before prophase / before mitosis / after cytokinesis

(b) **(i)** hydrogen / H, (bonds) ;
(ii) Y, single ring structure ; **A** smaller molecule compared to **X**

(c) **(i)** change in, nucleotide / base, sequence of DNA ;
any one from

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new allele fomed ;
deletion / substitution / addition / frame shift , (mutation) ;
change to / altered, mRNA ; **A** altered codon(s)
(causing) change in, primary structure / amino acid sequence, of, polypeptide / protein ;
A different protein / altered function of protein / non-functional protein

(ii) cell cycle shorter / interphase shorter / division more frequent ;
(cell cycle) checkpoints not controlled ;
uncontrolled (growth / division) / AW ;
AVP ; e.g. no differentiation (into epithelial cell)
A no cell death / apoptosis [7]

38. O/N 14/P21/Q3/c,d

(a) (i) GAU GUU } AAG ;

(ii) messenger ;

(b) during systole semi-lunar valve is open ;
during diastole semi-lunar valve is closed ;
proximity/AW pulmonary artery to (right) ventricle (so no pressure lost) ;
elastic recoil of pulmonary artery maintains blood pressure/AW ;
no/little blood in (right) ventricle, after contraction/during diastole ;
fills with blood at low pressure ; [5]

39. O/N 13/P21/Q5

(a) (i) GTG ;
ACU ;
leu ;

(ii) primary structure ;

(b) 1 mutation ;
2 base substitution / T→ A in template strand of DNA / AW ;
transcription
3 DNA has CAC as 6th triplet ;
4 (so) mRNA has GUG as (6th) codon ;
allow one mark for altered mRNA codon *if no marks gained for mps 3 and 4*
translation
5 different tRNA involved / tRNA specific to val and not glu ;
6 anticodon on tRNA has CAC (with valine) ;
7 tRNA brings, incorrect amino acid / val, to ribosome ;
8 further detail ; e.g. incorrect amino acid incorporated into growing polypeptide chain [9]

40. O/N 13/P23/Q2/b,c

(a) UAC ;

(b) mRNA, less stable / broken down sooner / used only for a short time / does not last long / is temporary / has short (half-) life ; **I** 'used up'
tRNA is re-used (for a longer time); no ora
unless correct ref. to mRNA 'shelf life' [2]

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Unit 7
TRANSPORT IN PLANTS

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

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Syllabus

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Unit 7: Transport in Plants

1. M/J 22/P22/Q6

The transport tissues of plants are phloem and xylem.

The role of xylem is the transport of water and mineral ions from the soil solution to the different parts of the plant body.

The role of phloem is the translocation of assimilates and other substances from sources to sinks.

(a) The source of mineral ions for the plant is the soil solution. These mineral ions are transported from the roots in the xylem. Mineral ions are also found in the phloem sap within phloem sieve tubes.

Suggest why mineral ions are found within phloem sieve tubes **and** state how they are transported within phloem sieve tubes.

.....

.....

..... [3]

(b) Phloem tissue consists of different cell types.

Complete the passage using the most appropriate terms to summarise some of the features of phloem tissue.

The end walls of sieve tube elements are modified to allow efficient flow of phloem sap by the formation of ..... . These structures also prevent the cells from bursting under pressure. The cytoplasm of sieve tube elements is very much reduced and is found at the ..... of the cells. Most of the organelles in the cell are absent. Adjacent to sieve tube elements are ..... cells that carry out the metabolic processes of the missing organelles, allowing the sieve tube elements to function. [3]

2. O/N 21/P22/Q1/c

There are two types of cell, prokaryotic and eukaryotic. Bacterial cells are prokaryotic and plant cells are eukaryotic.

(a) Fig. 1.1 is a photomicrograph showing chloroplasts in plant leaf cells.

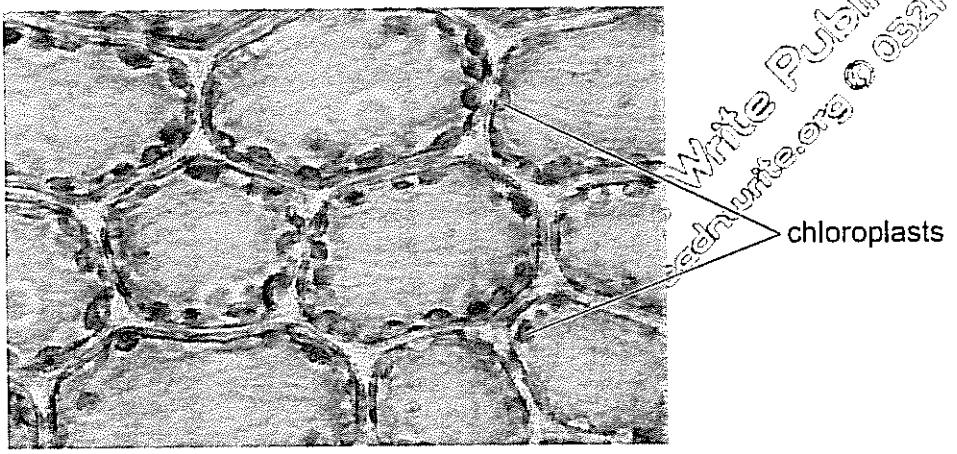


Fig. 1.1

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Explain why the chloroplasts are seen only around the periphery (edge) of each plant cell.

..... [1]

3. O/N 21/P22/Q4

Barlinka is a variety of the common grapevine, *Vitis vinifera*. Barlinka grapes are used for making wine and are sold as fruit. There are economic and ecological benefits from using less water to irrigate grapevine plants, while still producing a high crop yield.

The rate of flow of sap within xylem vessels from roots to leaves can be used as an estimate of the rate of transpiration. This also indicates water uptake.

(a) The hydrogen bonding of water molecules is important in the transport of sap within xylem vessels.

State the terms used to describe:

- water molecules sticking together within the xylem vessel

.....

- water molecules sticking to the cellulose molecules in the lining of the xylem vessel

..... [2]

(b) An experiment was carried out to investigate the effect of leaf area on the rate of flow of the xylem sap during fruit development.

The flow rate was measured over a three-day period in three Barlinka grapevine plants with different total leaf area. The plants were growing in the same conditions.

The results are shown in Fig. 4.1.

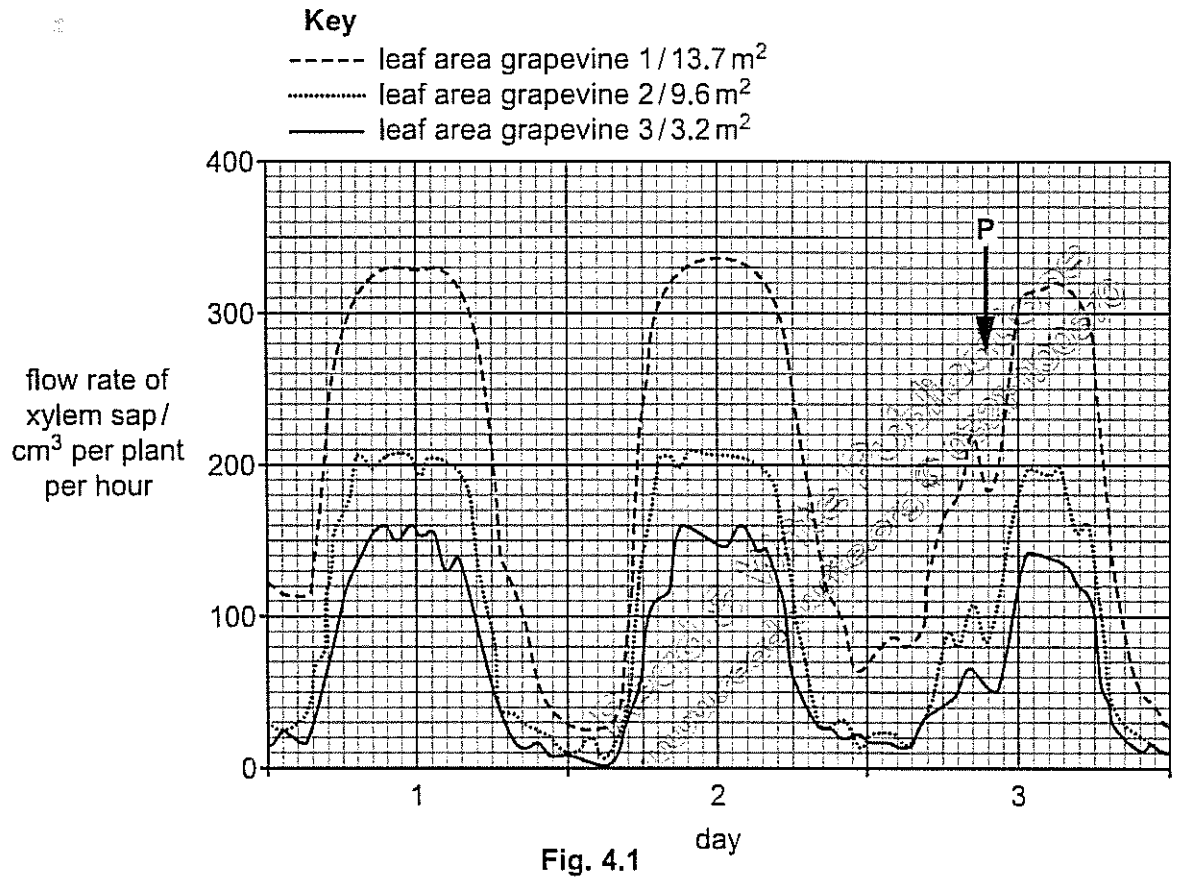


Fig. 4.1

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(i) The general pattern of results in Fig. 4.1 is the same for the three Barlinka grapevines. Explain why the general pattern of results is the same.

.....

..... [2]

(ii) With reference to Fig. 4.1, explain the differences in the results between the three grapevines, **1**, **2** and **3**.

.....

..... [2]

(iii) Suggest an explanation for the decrease in flow rate of xylem sap shown at time **P** in Fig. 4.1.

..... [1]

(iv) Outline how you would determine the surface area of one side of a leaf.

.....

..... [2]

4. O/N 21/P21/Q5

A student investigated the effects of air movement on the rate of transpiration by using a potometer.

(a) Define the term transpiration.

.....

..... [2]

The potometer used by the student is shown in Fig. 5.1.

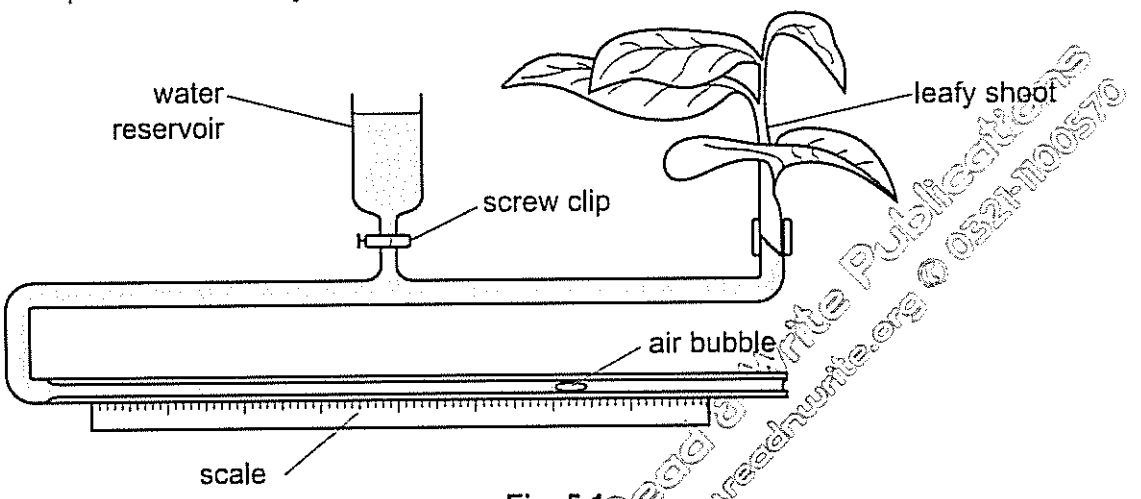


Fig. 5.1

The student recorded the distance the air bubble in the apparatus had moved after ten minutes with no air movement.

The rate of water uptake was used as a measure of the rate of transpiration.

The apparatus was then reset using the reservoir, and the experiment was repeated a further

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two times. All other variables were standardised during the three experiments.
Table 5.1 shows the results recorded by the student.

Table 5.1

experiment	distance moved by the bubble in 10 minutes / mm
1	12.5
2	12.0
3	11.5

(b) Use Table 5.1 to calculate the mean rate of movement of the bubble.

..... mm min^{-1} [1]

(c) The student carried out another experiment using the same plant. In this experiment a fan was used to blow air across the leaves of the plant. All other variables were standardised.
The results showed that the bubble moved further in 10 minutes.
The student concluded that air movement increases the rate of transpiration.
Explain why air movement increases the rate of transpiration.

.....

..... [2]

(d) Explain how water moves up through a xylem vessel in the stem of the plant in the potometer, shown in Fig. 5.1.

.....

.....

.....

..... [4]

5. M/J 21/P22/Q2
Sugars are transported within phloem sieve tubes from a source, such as a mature leaf, to a young leaf, which acts as a sink. The young leaf also needs water and dissolved mineral ions, which arrive at the leaf within xylem vessels.

(a) As the young leaf matures, the quantity of sugar taken up by the leaf decreases to zero, but the need for water increases.
Suggest **and** explain why the quantity of sugar taken up by the developing leaf decreases to zero over time, but the need for water increases.

.....

.....

..... [3]

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(b) The features listed in Table 2.1 are present in one or more of the three cell types:

- companion cell
- phloem sieve tube element
- xylem vessel element.

Complete Table 2.1 using a tick (✓) if the feature is present and a cross (✗) if the feature is absent.

Table 2.1

feature	companion cell	phloem sieve tube element	xylem vessel element
cytoplasm			
cell surface membrane			
lignified cell wall			
nucleus			

[4]

6. M/J 21/P23/Q4

Phloem sap is transported within phloem sieve tubes.

(a) Monosaccharides and disaccharides are transported as part of phloem sap, but polysaccharides are not components of phloem sap.

Define the terms disaccharide **and** polysaccharide.

.....

..... [2]

(b) Sieve tubes are composed of phloem sieve tube elements.

Fig. 4.1 is a diagram of one sieve tube element and its companion cell.

Some of the structural features of the sieve tube element have not been included in the diagram.

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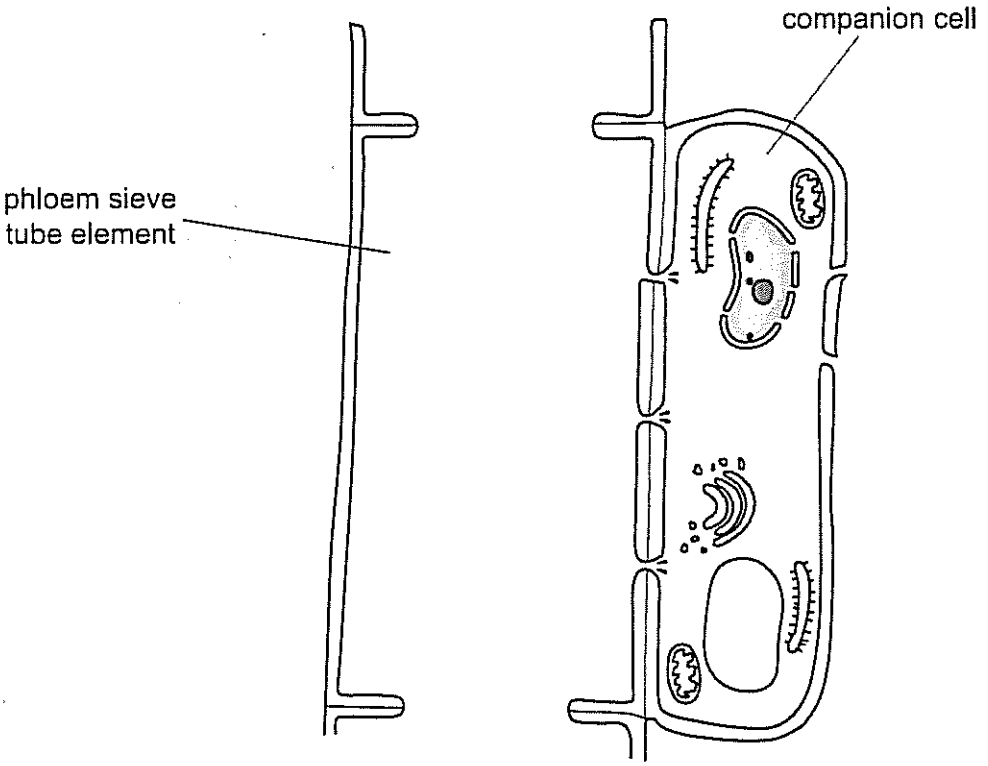


Fig. 4.1

(i) Complete Fig. 4.1 by drawing **and** labelling the structural features of the sieve tube element that have not been included in the diagram. [3]

(ii) A pressure gradient in a sieve tube causes the mass flow of phloem sap from the source to the sink.
At the source, a decrease in water potential in the phloem sap and an increase in the hydrostatic pressure of the phloem sap can be measured.
Describe the events that cause each of these changes in the phloem sap.

decrease in water potential .....

increase in hydrostatic pressure ..... [2]

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7. O/N 20/P22/Q1

Fig. 1.1 is a diagram drawn from a photomicrograph of a transverse section through part of a leaf.

The arrows in Fig. 1.1 show the movement of water through the cells of the leaf after it has left the xylem.

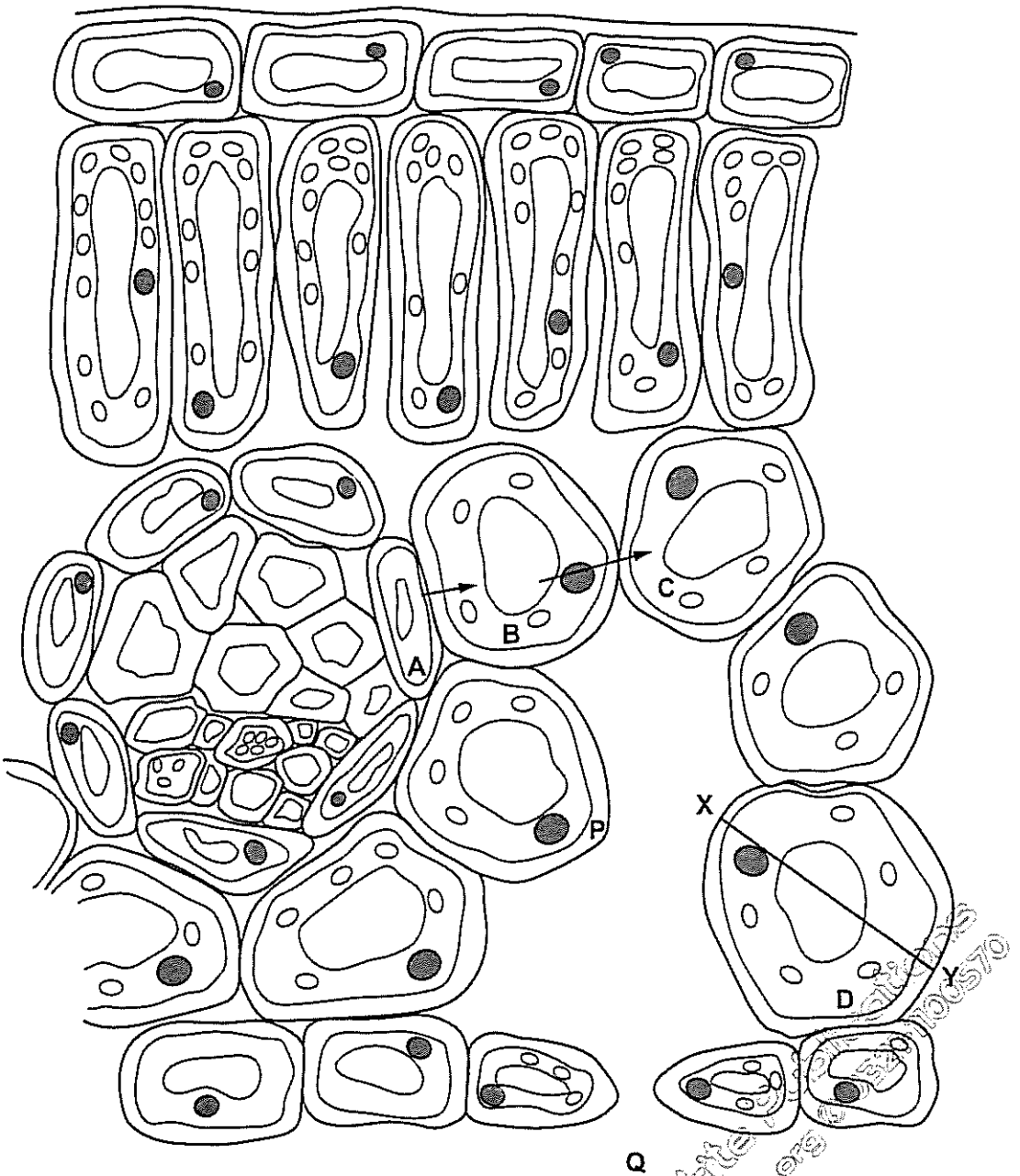


Fig. 1.1

(a) Water from the xylem can enter cell **A** and then moves to cells **B** and **C** without crossing their cell walls.

The cell structures through which water passes from cell **A** to cell **B** are **not** visible in Fig. 1.1.

(i) Name the cell structures through which water passes from cell **A** to cell **B** without crossing their cell walls.

..... [1]

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(ii) Explain what causes water to move from cell **B** to cell **C**.

..... [1]

(iii) Name the pathway taken by water between cell **A** and cell **C**.

..... [1]

(b) Most of the water that arrives at the leaf passes to the external atmosphere.

With reference to Fig. 1.1, describe **and** explain the sequence of events occurring between point **P** and point **Q**.

.....

.....

.....

..... [4]

(c) The actual diameter of cell **D** in Fig. 1.1 along the length **X–Y** is 25 μm.

Calculate the magnification of the image.

Write down the formula used to make your calculation. Show your working.

formula

answer = × ..... [3]

8. O/N 20/P21/Q4/b(ii)

(a) Viruses can infect plant cells.

(i) Many plant viruses can travel through the plant to enter companion cells in the phloem tissue. The viruses then travel with assimilates in the phloem sap to other areas of the plant.

Explain the mechanism that allows assimilates and viruses to travel through phloem sieve tubes to other areas of the plant.

.....

.....

.....

.....

..... [5]

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9. O/N 20/P23/Q2

The veins of a leaf contain transport tissues. Fig. 2.1 is a drawing made from an electron micrograph showing a cross-section of the transport tissue in a leaf vein.

The cells labelled **A** are modified companion cells, known as phloem transfer cells. Transfer cells move sucrose and other assimilates from mesophyll cells, **B**, into the phloem sieve tube element, **C**.

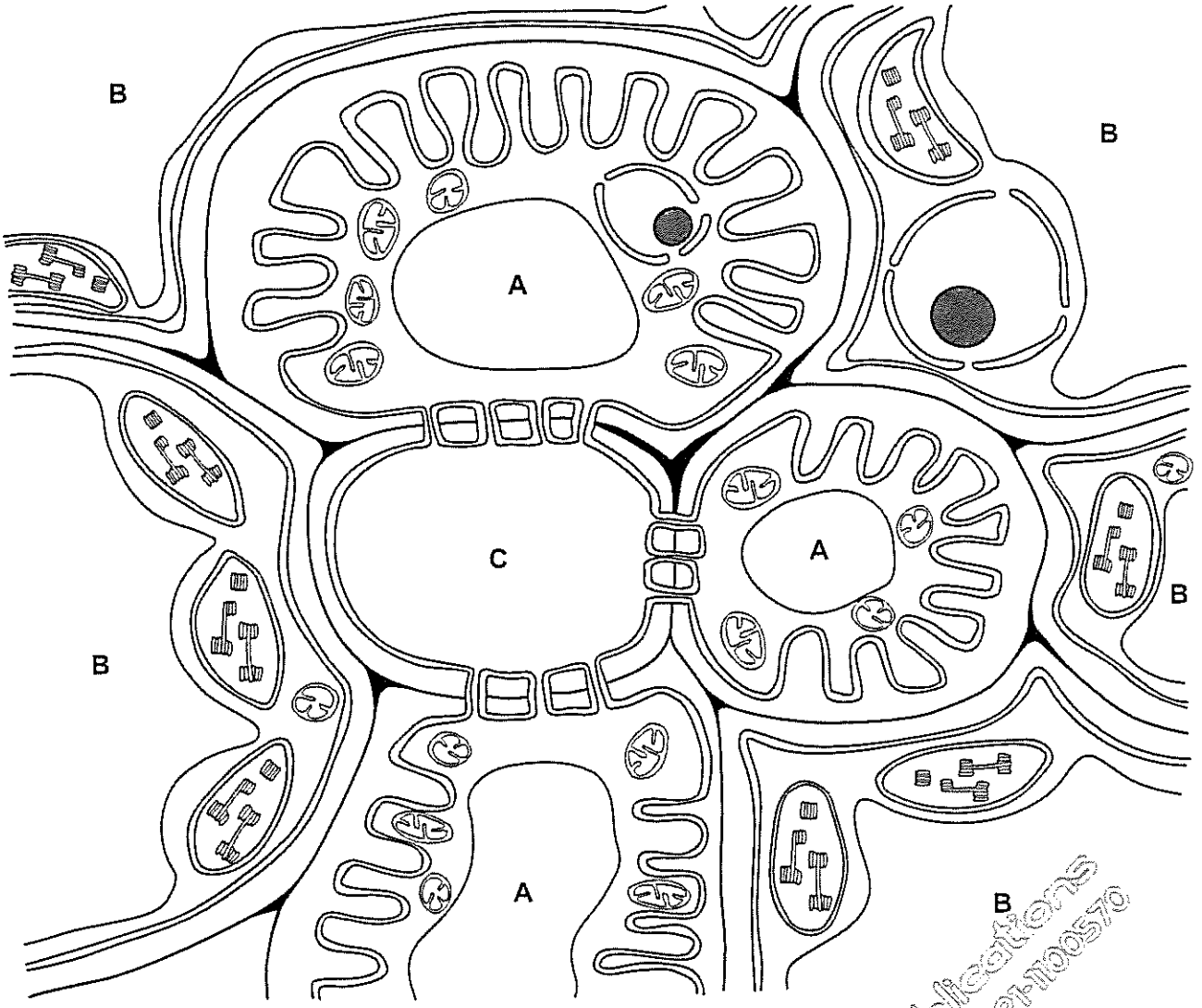


Fig. 2.1

(a) State the functions of the mesophyll cells, **B**, and sieve tube element, **C**, **and** explain how their structure is adapted for their function.

cell **B** – function .....

adaptation .....

cell **C** – function .....

adaptation ..... [5]

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(b) The cell walls of the transfer cells, **A**, shown in Fig. 2.1, have infoldings.
Explain the advantages of these cell wall infoldings for the movement of sucrose from mesophyll cells to phloem sieve tubes.

.....

.....

..... [3]

10. M/J 20/P22/Q5/a,b(i,ii)
In most plants, sucrose is the main sugar that is transported from sources to sinks.

(a) In the source, sucrose is transferred from a mesophyll cell to a phloem sieve tube through a companion cell.
Describe **and** explain how the transfer of sucrose into a phloem sieve tube from a companion cell can lead to the transport of the sugar to a sink.

.....

.....

.....

..... [4]

(b) Fig. 5.1 shows part of one pathway that is used in plant cells to synthesise sucrose. The enzyme sucrose synthase catalyses the transfer of glucose from UDPG (uridine diphosphate glucose) to fructose.

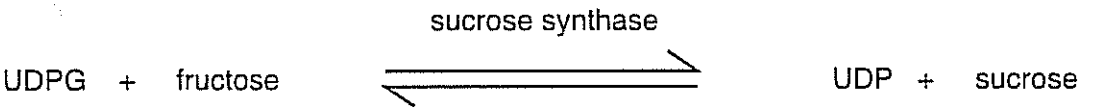


Fig. 5.1

The structure of UDPG is shown in Fig. 5.2.

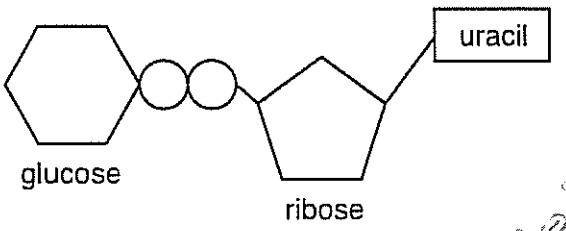


Fig. 5.2

(i) Name the type of bond formed when sucrose is synthesised.

..... [1]

(ii) Explain why UDP can be described as a phosphorylated nucleotide.

.....

..... [2]

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11. M/J 20/P23/Q1

Water and mineral ions are transported up the stem of a plant to the leaves within xylem vessels.

Some water and mineral ions can pass out of xylem vessel elements to supply parenchyma tissue in the stem.

(a) Fig. 1.1 is a plan diagram of a section through a stem.

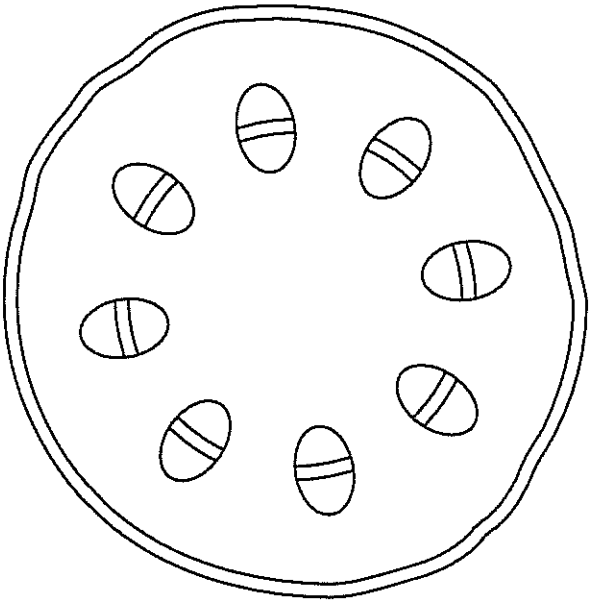


Fig. 1.1

Identify **one** location where xylem tissue occurs in the stem by drawing a label line and the letter **X** on Fig. 1.1. [1]

(b) Explain how hydrogen bonding between water molecules contributes to the movement of water within xylem vessels up the stem to the leaves.

.....

.....

..... [3]

(c) Fig. 1.2 is a diagram of a photomicrograph showing three adjacent parenchyma cells in the stem. These parenchyma cells can be described as typical plant cells.

The arrows show the direction of movement of water between the cells.

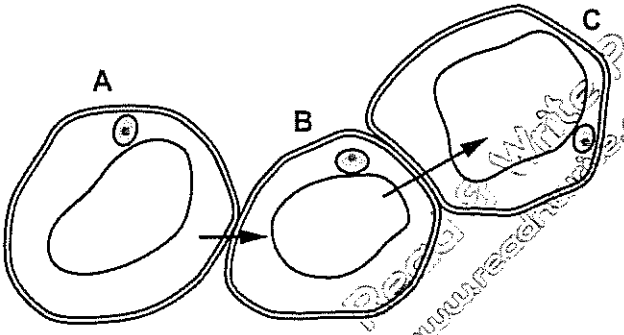


Fig. 1.2

(i) Describe **and** explain the movement of water shown in Fig. 1.2.

.....

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.....

..... [3]

(ii) Only some of the structures visible using the light microscope have been included in Fig. 1.2.

List the features that can be seen using the high power of a light microscope that help identify a parenchyma cell as a plant cell and **not** as an animal cell.

.....

.....

..... [3]

12. O/N 19/P22/Q1

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

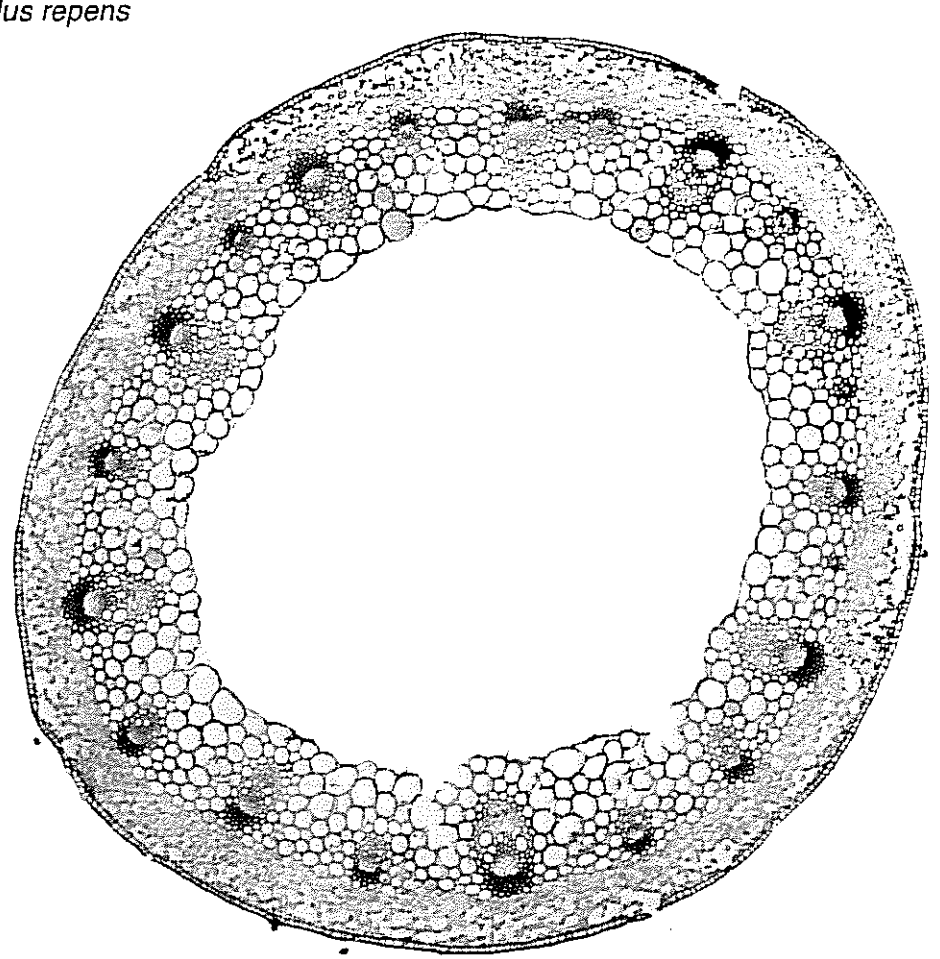


Fig. 1.1

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

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(b) State the role of phloem sieve tubes.

.....

..... [2]

(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]

13. O/N 19/P23/Q3/a

(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.

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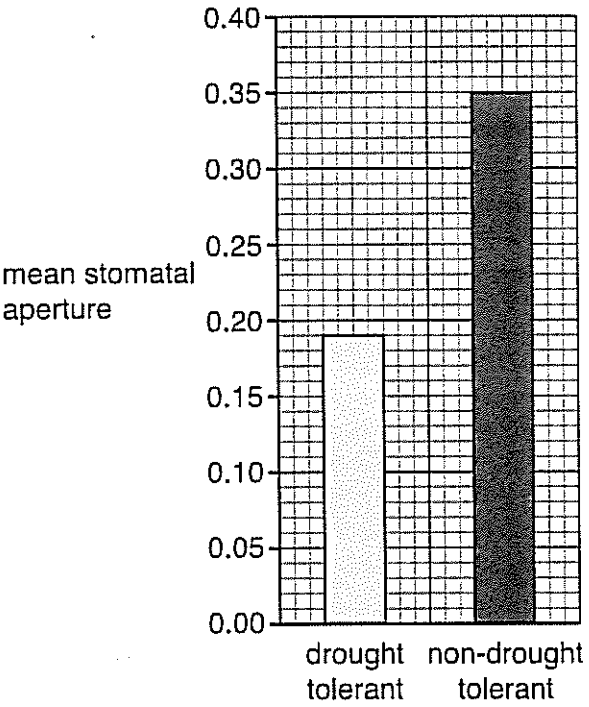


Fig. 3.2

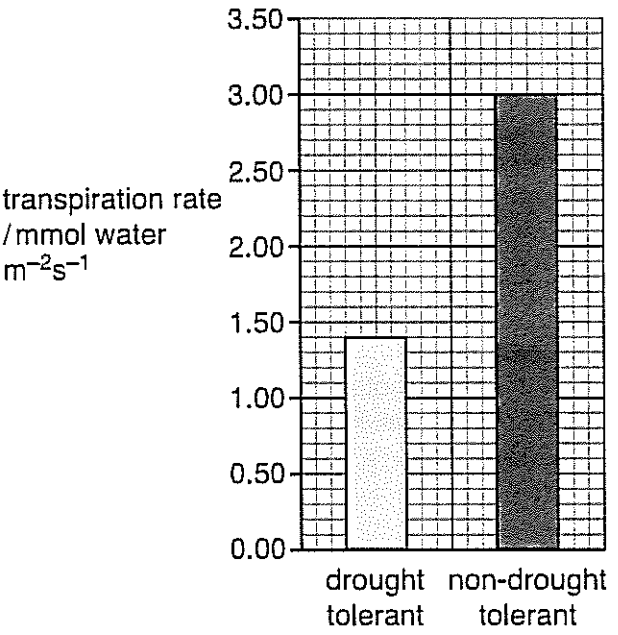


Fig. 3.3

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.

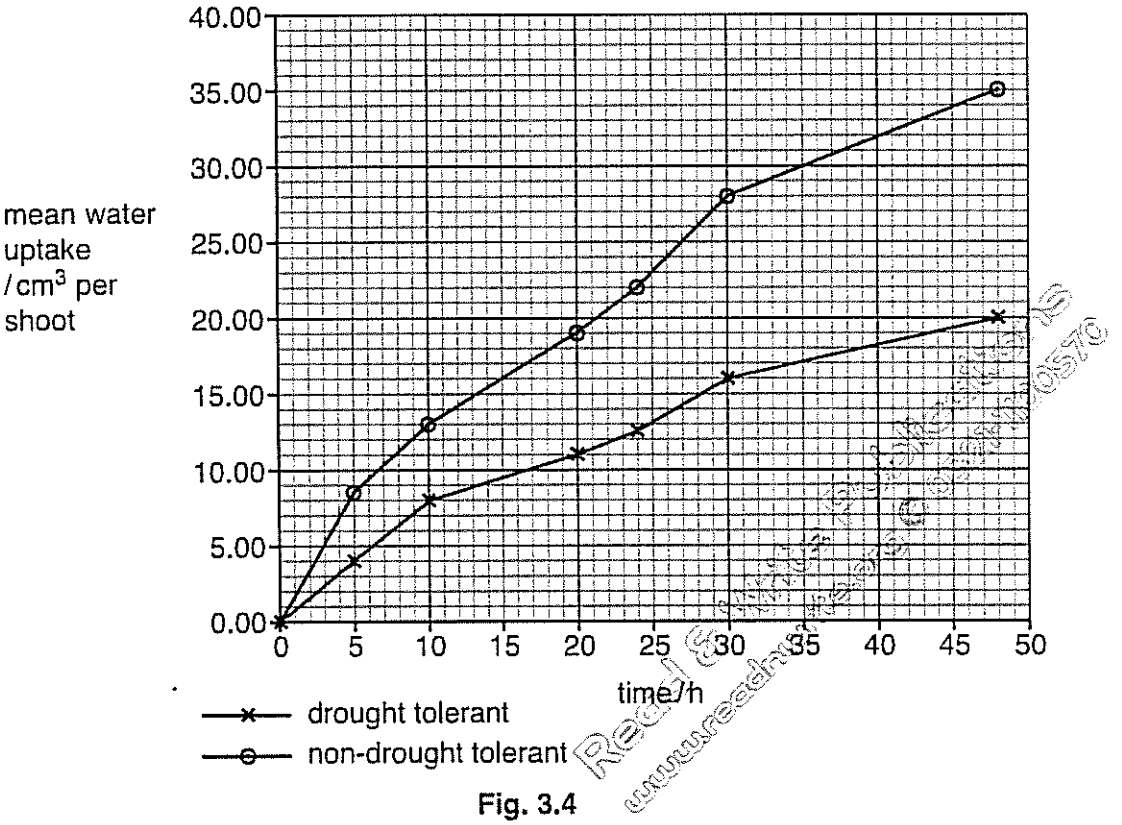


Fig. 3.4

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]

14. M/J 19/P22/Q1

Fig. 1.1 is a photomicrograph of a low power image of part of the common sunflower, *Helianthus annuus*. Fig. 1.1 is a transverse section.

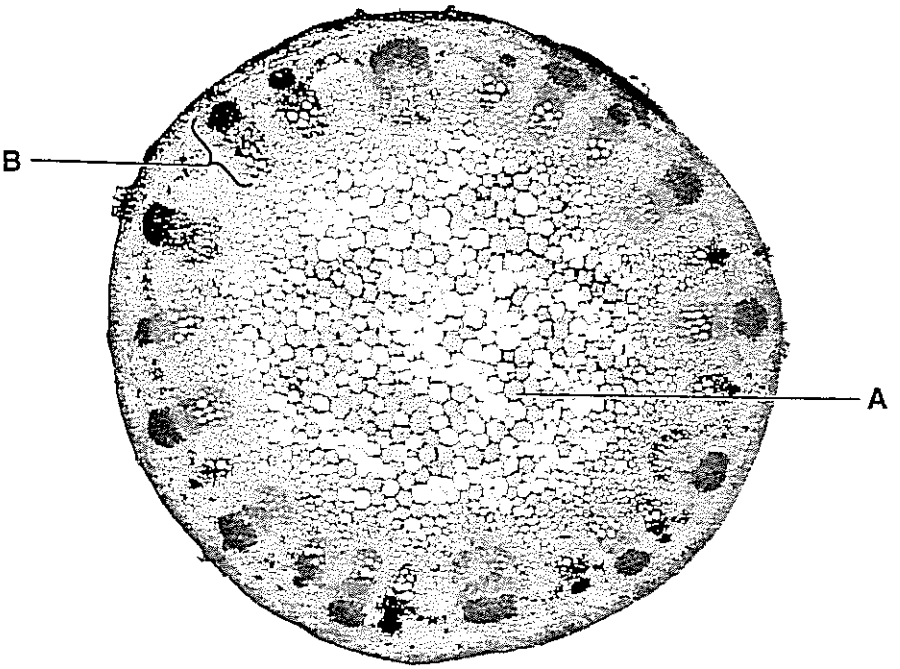


Fig. 1.1

(a) State, **with a reason**, whether Fig. 1.1 shows a section through the root or the stem of *H. annuus*.

..... [1]

(b) Cell type **A** in Fig. 1.1 has a large central vacuole.
Suggest, with reasons, the role of the tissue formed by this type of cell.

.....

..... [2]

(c) Structure **B** in Fig. 1.1 contains phloem tissue and xylem tissue and other tissues that provide support.

(i) Name structure **B**.

..... [1]

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(ii) The actual length of structure **B** is 650 μm.
State the actual length of structure **B** in mm.

..... [1]

(d) When structure **B** is observed at a higher magnification, more detail of xylem vessel elements and phloem sieve tube elements can be seen.
Outline the differences in the structure of a xylem vessel element and a phloem sieve tube element.

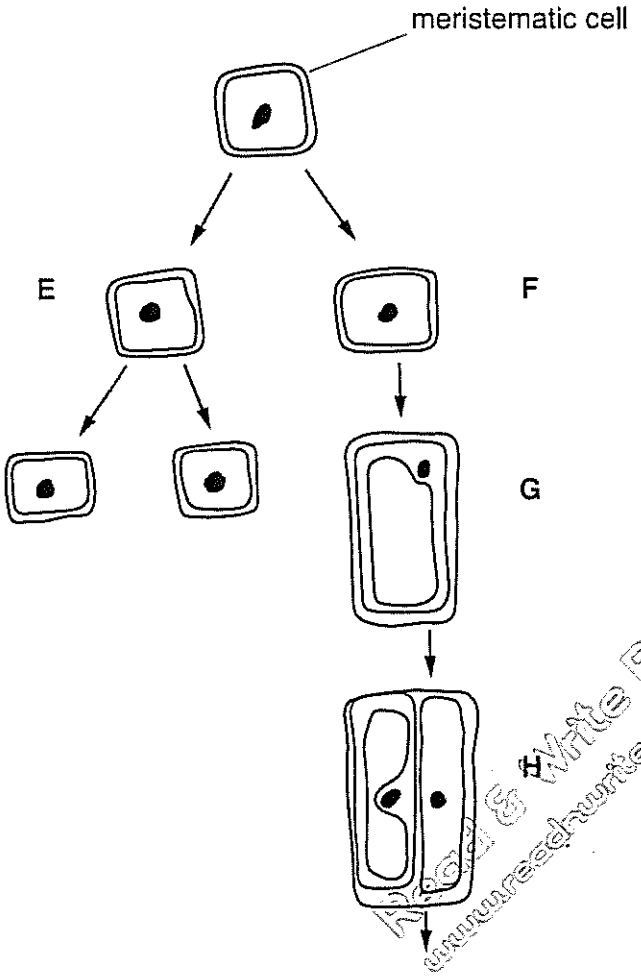
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..... [3]

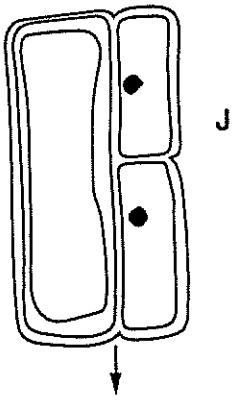
15. M/J 19/P21/Q4/c,d

Meristematic tissue is found in the growing regions of plants, such as shoot tips. Meristematic cells have a similar role to stem cells in animals.
Fig. 4.1 shows some of the stages in the formation of a mature phloem sieve tube element and companion cells from a meristematic cell.



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mature sieve tube element and companion cells

Fig. 4.1

(a) Explain how the structure of a mature sieve tube element is related to its function.

.....

.....

.....

..... [4]

(b) Describe the functions of companion cells in transport in the phloem.

.....

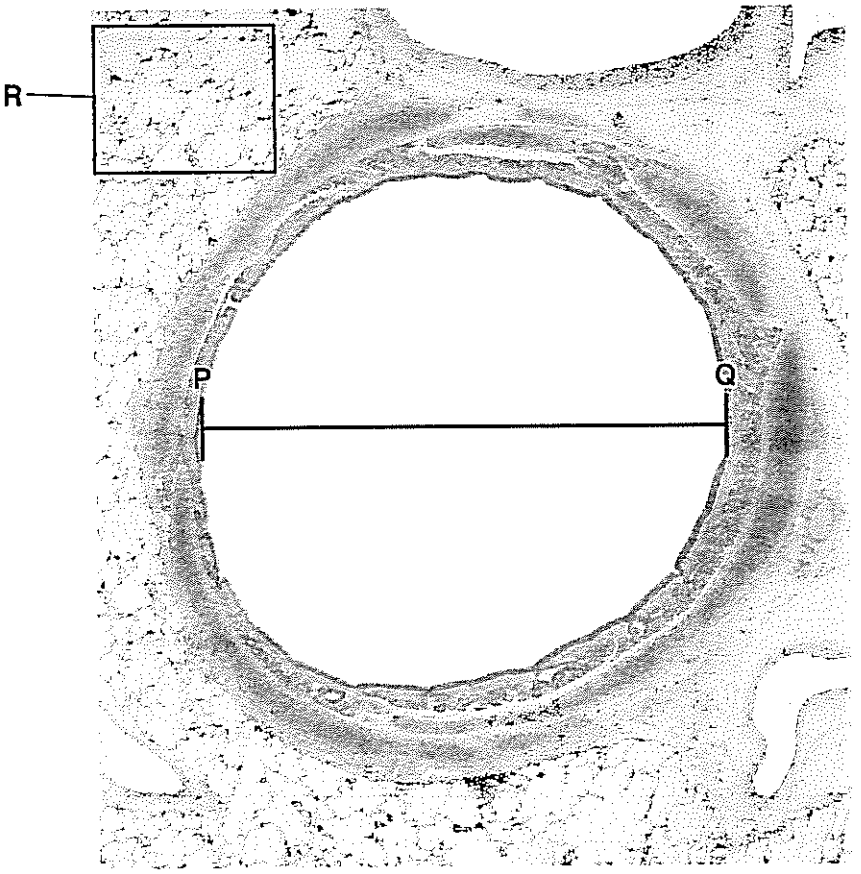
..... [2]

16. M/J 19/P23/Q2/c,d

Fig. 2.1 is a photomicrograph showing a transverse section through a bronchus and the surrounding lung tissue.

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magnification x40

Fig. 2.1

(a) In the leaves of plants, both gas exchange and transpiration occur through open stomata. Suggest how the arrangement of cells in the leaf of a dicotyledonous plant contributes to the loss of water by transpiration.

.....

.....

..... [3]

(b) Fig. 2.2 shows the mean transpiration rate of a xerophyte between 08:00 and 19:00.

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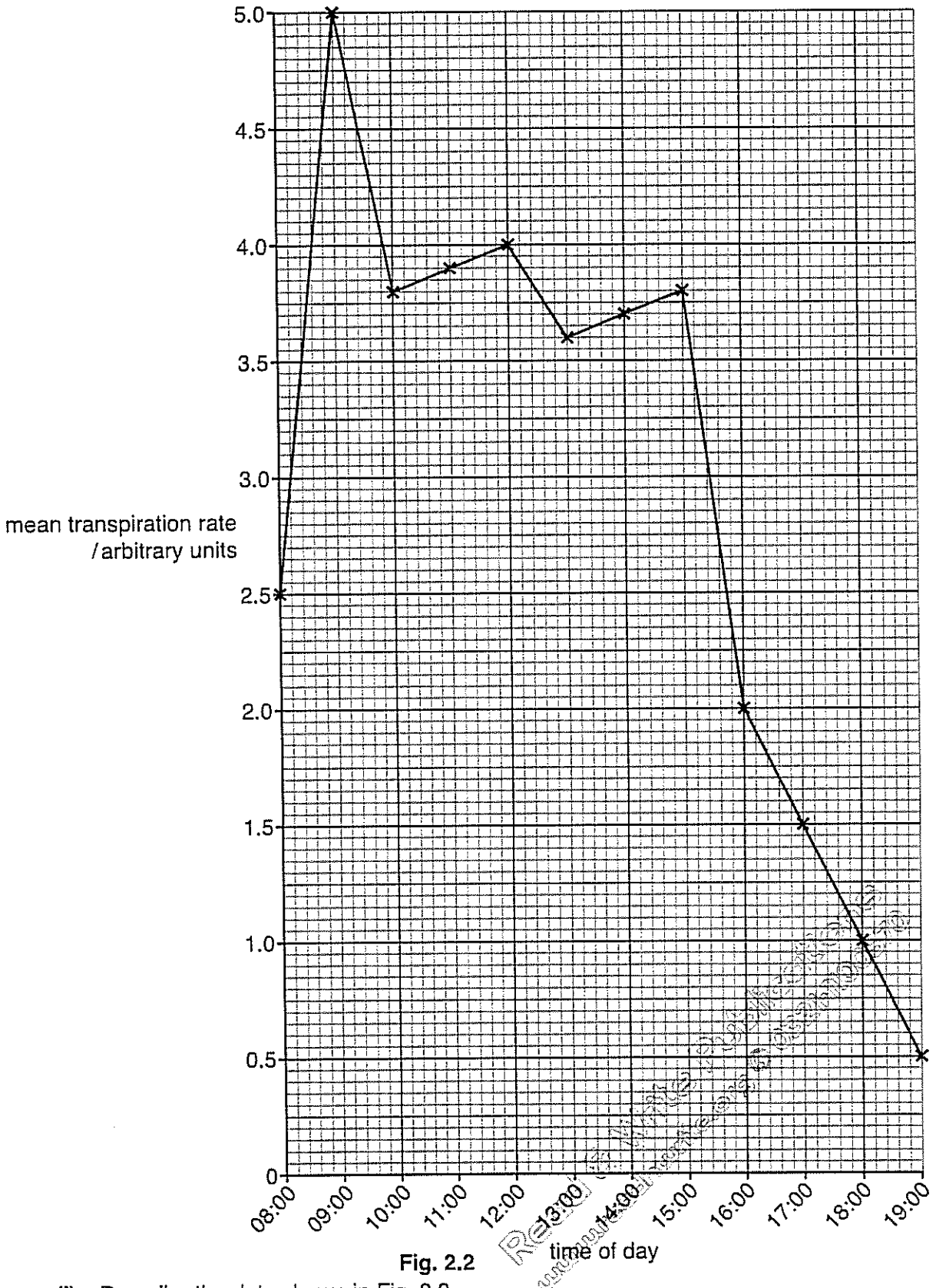


Fig. 2.2

(i) Describe the data shown in Fig. 2.2.

.....

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.....

..... [3]

(ii) Suggest why the transpiration rate changed between 09:00 and 10:00.

..... [2]

17. M/J 19/P23/Q4

Phloem sieve tube elements and xylem vessel elements are cells that are involved with the transport of substances in plants.

(a) Describe **two** differences between the structure of a phloem sieve tube element and a xylem vessel element.

.....

..... [2]

(b) Sucrose is transported in phloem sieve tubes.
A student carried out a test to identify the presence of sucrose in a sample of sap taken from inside a phloem sieve tube. One of the steps in the procedure instructed the student to heat the phloem sap with hydrochloric acid.
Explain why it is necessary to carry out this step in the procedure.

.....

..... [2]

(c) The process of loading sucrose into a phloem sieve tube element involves a companion cell.

(i) Fig. 4.1 shows a stage in the process of loading sucrose into the phloem.

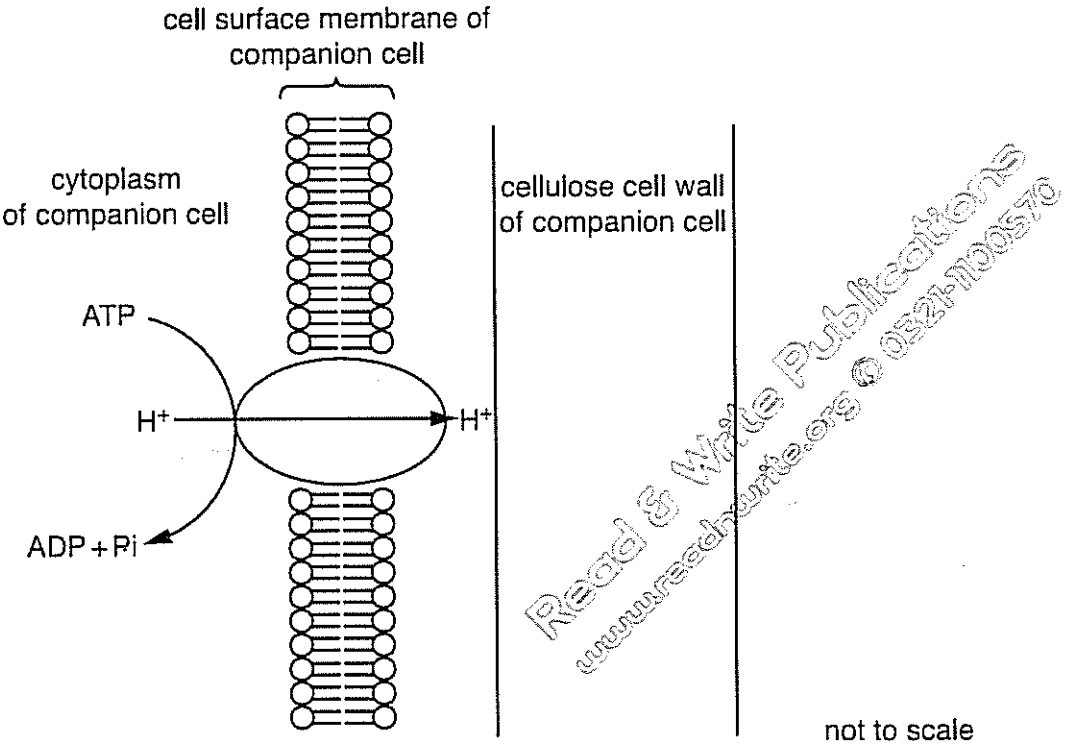


Fig. 4.1

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Companion cells contain large numbers of mitochondria and ribosomes.
Explain the roles of mitochondria and ribosomes for the stage shown in Fig. 4.1.

.....

..... [2]

(ii) Describe **and** explain how sucrose is transported from the cell wall of the companion cell into the cytoplasm.

.....

.....

..... [3]

18. O/N 18/P22/Q2/a,b

Woolly foxglove, *Digitalis lanata*, shown in Fig. 2.1**A**, and common oleander, *Nerium oleander*, shown in Fig. 2.1**B**, are plants grown for the attractive flowers that they produce.

Both plants are poisonous, as their leaves produce toxic organic compounds known as cardiac glycosides. Cardiac glycosides have a powerful effect on the action of cardiac muscle.



A **B**

Fig. 2.1

(a) *N. oleander* is able to grow in very dry conditions. The leaves have adaptations to reduce water loss by transpiration.

State the term used to describe a plant, such as *N. oleander*, that has adaptations to allow it to grow in conditions where water is in short supply.

..... [1]

(b) Aphids are small insects that feed on plant fluids using piercing and sucking mouthparts. When aphids feed on the sap present in vascular tissue of leaves and stems, a sugary liquid called honeydew is passed out of the gut. The honeydew can be analysed to find out what is present in the sap.

(i) State the name of the vascular tissue from which the aphids feed.

..... [1]

(ii) An investigation found that aphids feeding on *D. lanata* produced honeydew containing cardiac glycosides.

Suggest why cardiac glycosides were present in the sap from the vascular tissue.

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.....

..... [2]

19. O/N 18/P21/Q5/b

(a) Some prokaryotes are plant pathogens.

Liberibacter is a group of prokaryotic plant pathogens that causes severe damage to a variety of plant crops across the world.

Scientists made observations about plants infected with these pathogens compared to uninfected plants:

- starch accumulates in the leaves
- starch does not accumulate in roots and other storage organs
- fruits are smaller
- the pathogen is widely distributed throughout the plant and is found in a number of different organs including the root and leaf.

The scientists deduced that the pathogen infected the phloem tissue.

Suggest why the scientists were able to deduce that the pathogen infected the phloem tissue.

.....

..... [2]

20. M/J 18/P22/Q1/d

(a) 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*.

.....

..... [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.

.....

.....

.....

..... [4]

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

.....

..... [2]

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21. M/J 18/P21/Q2/c

(a) 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.

.....

.....

.....

..... [4]

22. M/J 18/P21/Q6/a,b,c

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*.

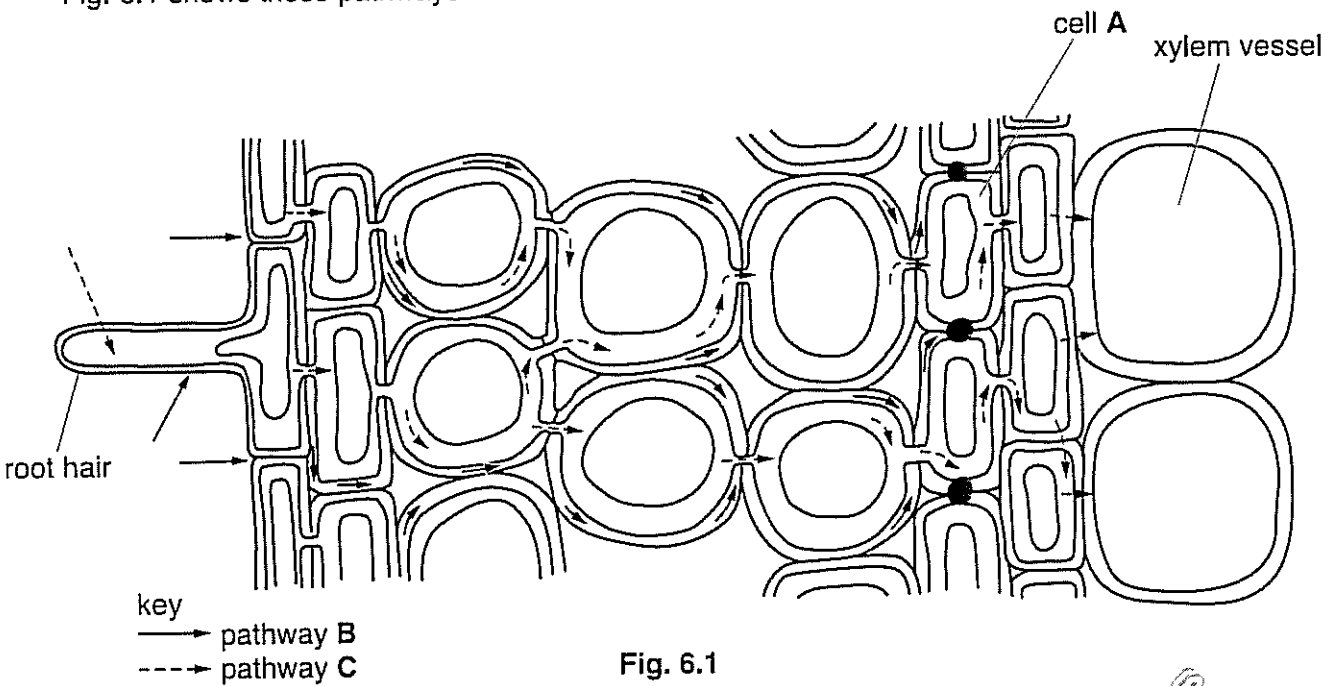


Fig. 6.1

(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.

.....

.....

.....

.....

..... [5]

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

.....

..... [2]

23. M/J 18/P23/Q3/a,b,c

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

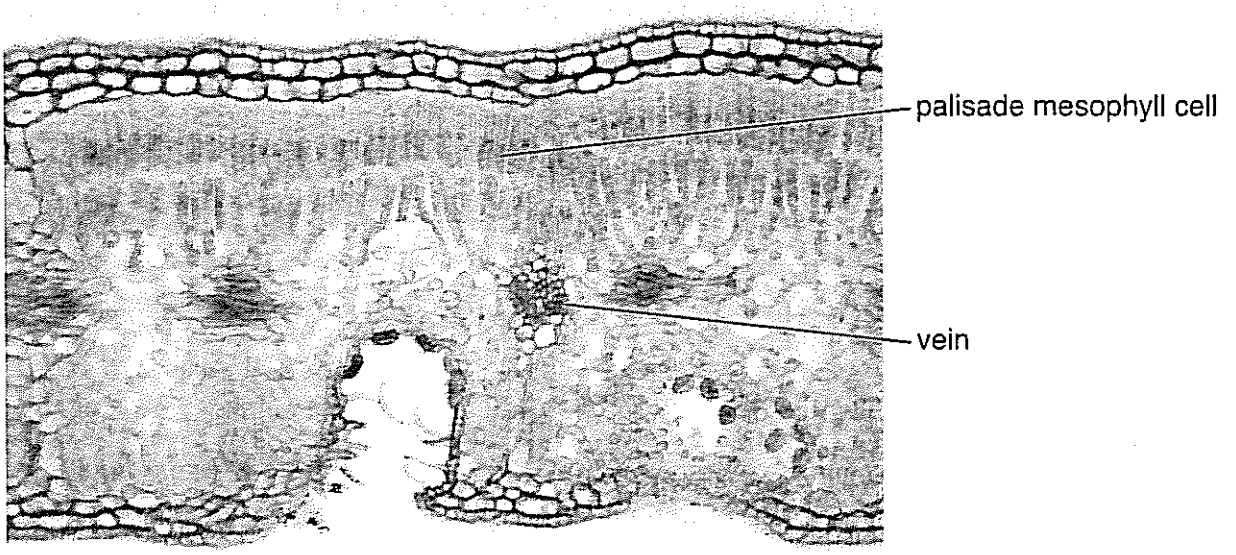


Fig. 3.1

(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.

.....

..... [2]

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24. O/N 17/P22/Q5

(a) Descriptions **A**, **B** and **C** relate to the movement of water from the soil to the xylem in roots. State the correct term to match each of the descriptions **A**, **B** and **C**.

A The specialised root epidermal cell that provides a large surface area for the uptake of water from the soil.

.....

B The band of suberin in the cell walls of the endodermis that prevents the movement of water by the apoplastic pathway.

.....

C The cell structures that allow water to pass from one cell to the next as part of the symplastic pathway.

..... [3]

(b) Explain, with reference to the structure of xylem vessel elements, why water does **not** take a symplastic pathway in the xylem to the leaves.

.....

..... [2]

(c) Explain why the rate of movement of water in the xylem may slow down at night.

.....

.....

..... [3]

25. O/N 17/P21Q6

Plants have two transport tissues, xylem and phloem.

(a) Describe **and** explain **two** ways in which the structure of xylem vessels is adapted to their function.

description 1 .....

explanation 1 .....

description 2 .....

explanation 2 ..... [2]

(b) Describe **two** differences between the vessels that transport phloem sap in flowering plants and the vessels that transport blood in mammals.

.....

..... [2]

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Fig. 6.1 shows root hair cells.

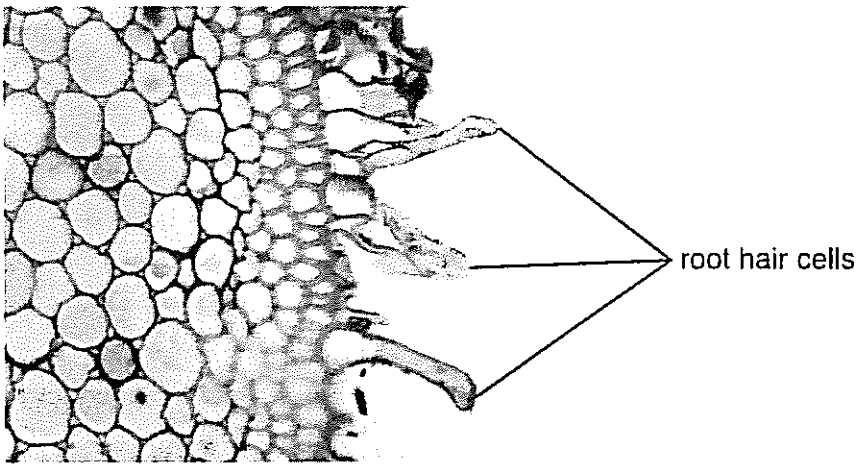


Fig. 6.1

(c) Explain why the root hair cells in Fig. 6.1 have more mitochondria than the other root cells shown.

.....

.....

.....[3]

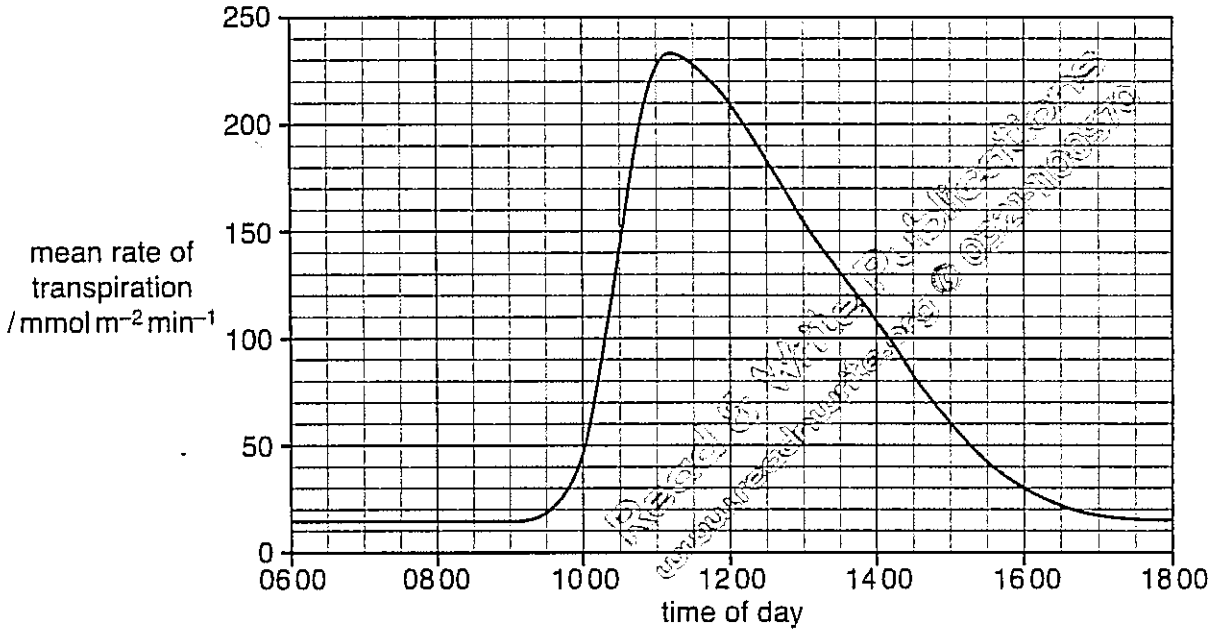
26. O/N 17/P23/Q5

The tree species *Caryocar brasiliense* grows in areas where there is very little rainfall for five months of the year. During this long dry season the trees have mechanisms to reduce the rate of transpiration.

An investigation was carried out on *C. brasiliense* to find out how the rate of transpiration and the mean water potential of leaf cells changed over 12 hours in one day during the dry season.

The results are shown in Fig. 5.1 **A** and **B**.

A



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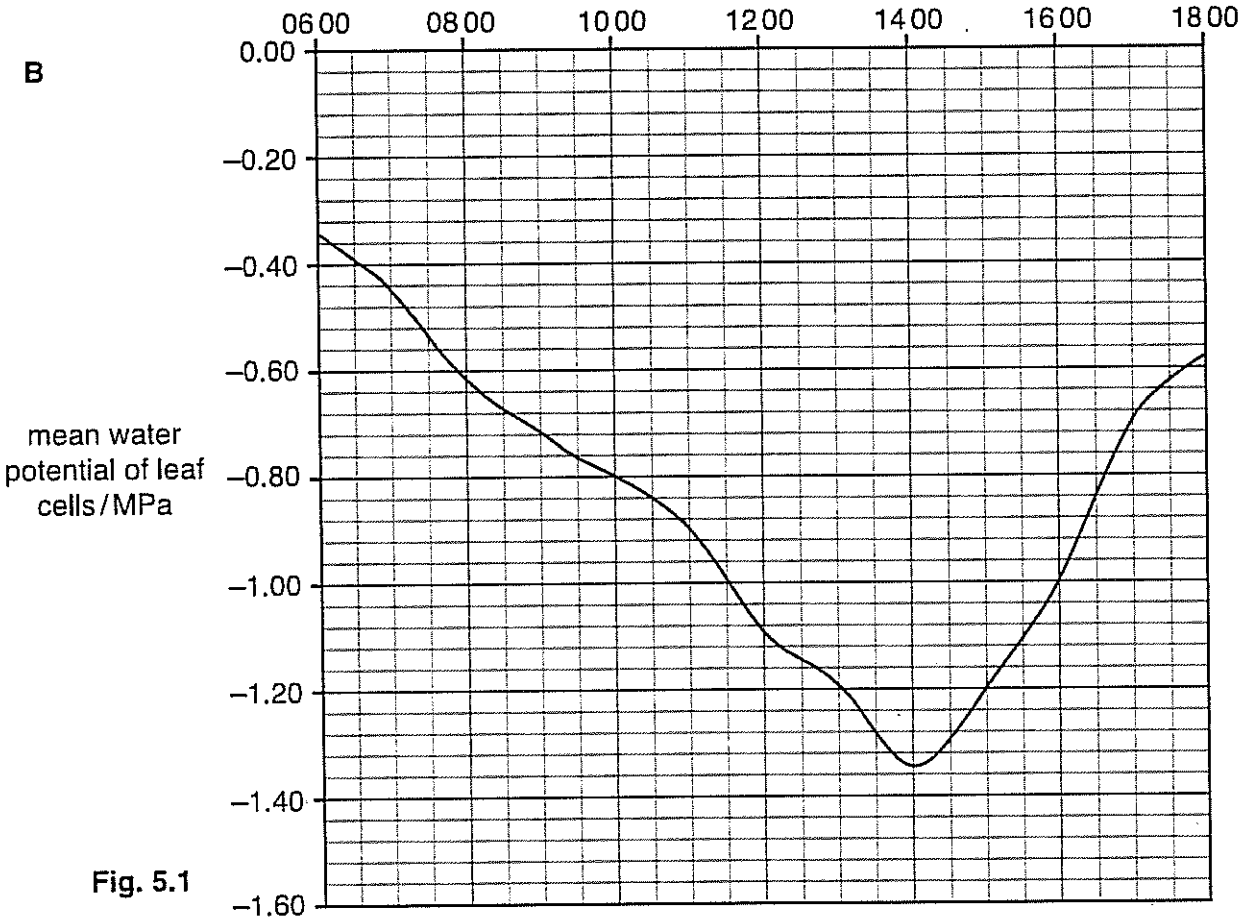


Fig. 5.1

(a) Define the term *transpiration*.

.....

.....[2]

(b) With reference to Fig. 5.1 **A** and **B**, describe the changes recorded in the mean water potential of leaf cells over the 12 hour period. Suggest explanations for these changes.

.....

.....

.....

..... [4]

(c) The tree *C. brasiliense* is able to survive through long dry periods.
Many plant species that live in areas with little rainfall have features that reduce transpiration rates. Some adaptations reduce the water potential gradient for water vapour between the air spaces inside the leaves and the surrounding air.
Outline how leaves are adapted to reduce transpiration rates in this way.

.....

.....

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..... [3]

27. M/J 17/P22/Q4/c,d

(a) Meristematic regions in the plant can sometimes be described as strong sinks.

(i) State what is meant by a *sink*.

.....[1]

(ii) Suggest what is meant by a **strong** sink.

.....[1]

(b) Describe **and** explain how sucrose is loaded into phloem sieve tubes.

.....

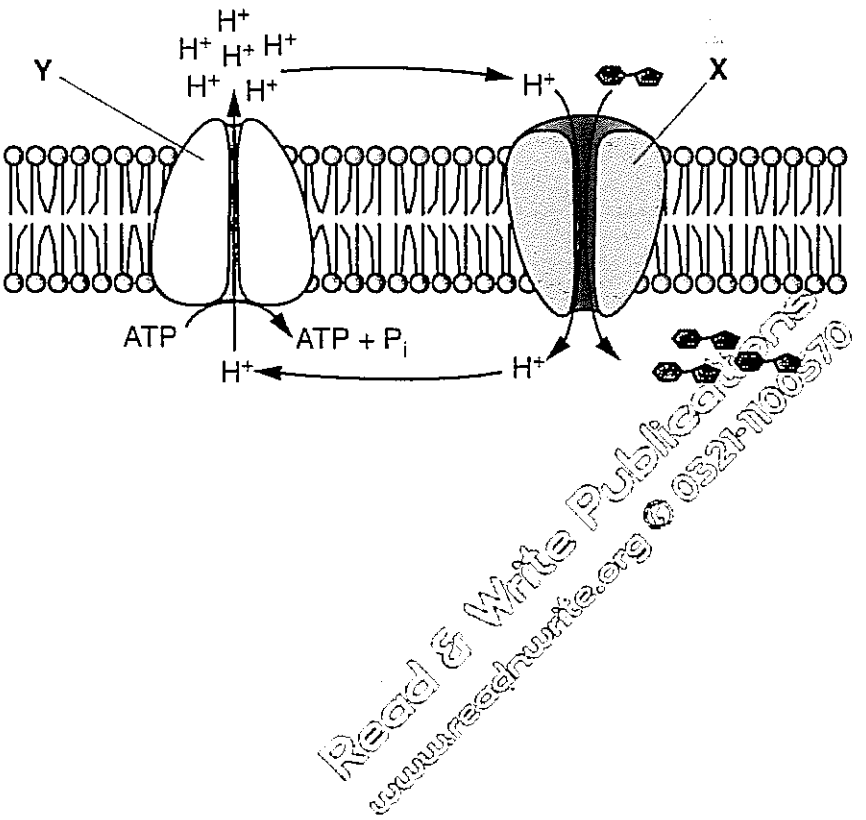
.....

.....

.....[4]

28. M/J 17/P21/Q5/b,c

Some plant cells convert fructose and glucose into sucrose for transport from sources to sinks. Sucrose is moved into phloem sieve tubes as shown in Fig. 5.1.



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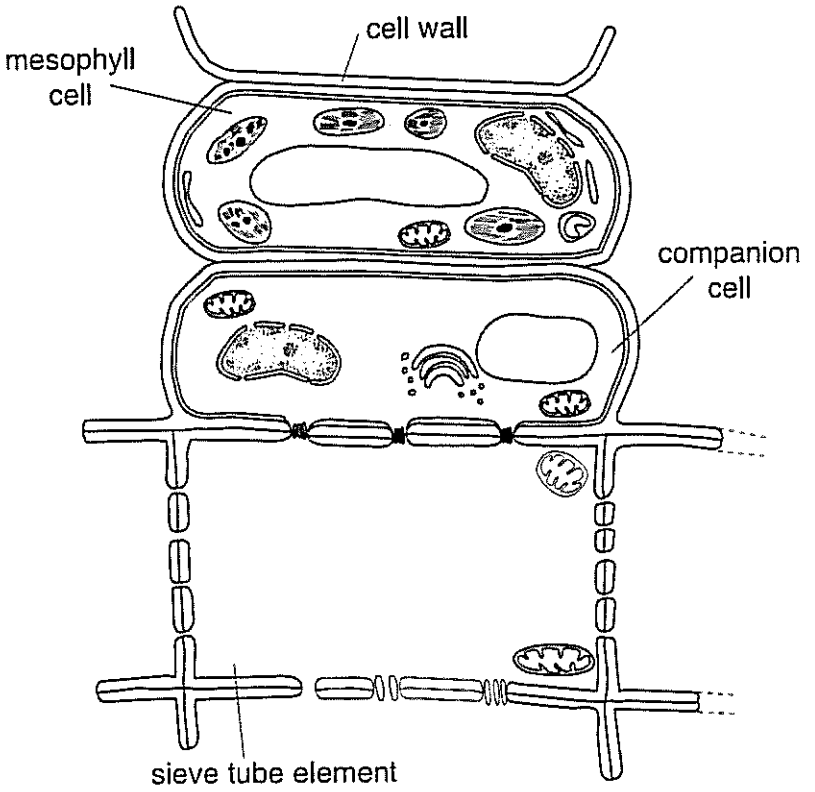


Fig. 5.1 not to scale

(a) Use the information in Fig. 5.1 to explain how sucrose:

- moves into the companion cell
- moves from the companion cell into the sieve tube element.

.....

.....

.....

.....

..... [5]

(b) Sucrose travels in phloem sieve tubes to sinks.
State two examples of sinks.

1 .....

2 .....[1]

29. M/J 17/P23/Q6

(a) In the space below, draw a diagram to show a hydrogen bond between two water molecules.

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[3]

(b) (i) Movement of water in xylem depends on the force of attraction between water molecules as a result of hydrogen bonding.
State the name given to this force of attraction.

..... [1]

(ii) State the property of water that results in a cooling effect as water evaporates from the surface of organisms.

..... [1]

30. O/N 16/P22/Q2/b

(a) Explain how osmosis is involved in the mass flow of phloem sap.

.....

.....

..... [3]

31. O/N 16/P21/Q2

(a) (i) Define *transpiration.*

..... [1]

(ii) State **two** environmental factors that affect the rate of transpiration.
Explain how each factor affects the rate of transpiration.

factor 1 .....

explanation.....

factor 2 .....

explanation..... [4]

(b) Explain how hydrogen bonding is involved in the movement of water through the xylem.

.....

.....

..... [3]

32. O/N 16/P23/Q3

Fig. 3.1 shows part of a transverse section of a root of *Ranunculus repens.*

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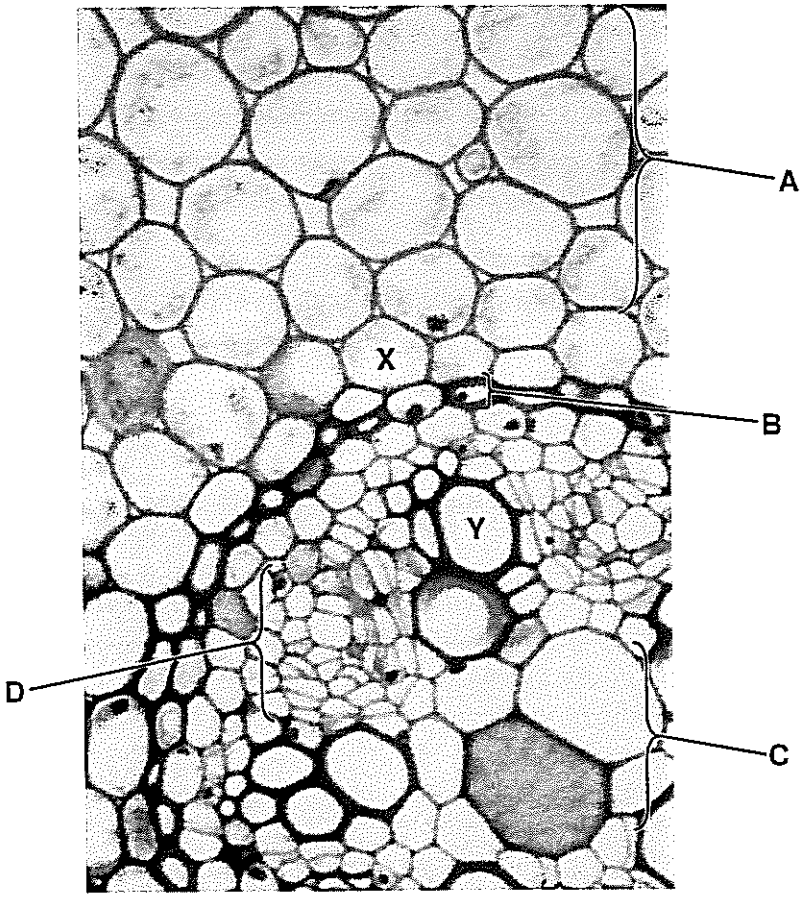


Fig. 3.1

(a) Name tissues **A** to **D**.

A .....

B .....

C .....

D .....[4]

(b) Explain how water moves from **X** to **Y**.

.....

.....

.....

.....[4]

33. M/J 16/P22/Q2

Marram grass, *Ammophila arenaria*, is an important plant of sand dunes. Leaves of marram grass are well adapted to reduce water loss by transpiration.

Fig. 2.1 is a photomicrograph of a section though the leaf of marram grass.

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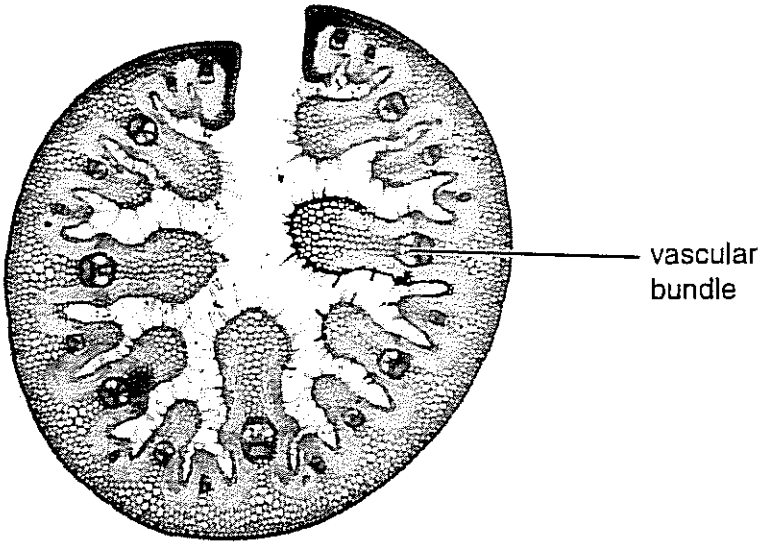


Fig. 2.1

(a) Examples of adaptations to reduce water loss by transpiration include a thick cuticle and no stomata on the outer surface, and stomata in pits on the inner surface.

(i) State **one** other adaptation, visible in Fig. 2.1, which reduces water loss by transpiration.

.....[1]

(ii) Explain how this adaptation reduces water loss.

.....

..... [2]

(b) State the term used to describe a plant type that has adaptations to reduce water loss by transpiration.

.....[1]

34. M/J 16/P21/Q4

(a) Transpiration is often described as 'an inevitable consequence of gas exchange in leaves'. Explain what is meant by this description.

.....

.....

..... [3]

(b) Explain how hydrogen bonding is involved in the movement of water in the xylem.

.....

.....

..... [3]

Southern beech trees of the genus *Nothofagus* grow in forests in the South Island of New Zealand. Fig. 4.1 shows a small part of a forest.

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Most of the trees in the forests form a thick canopy of leaves. These are known as canopy trees. The tallest trees are known as emergent trees. Some trees do not reach the canopy and are known as suppressed trees.

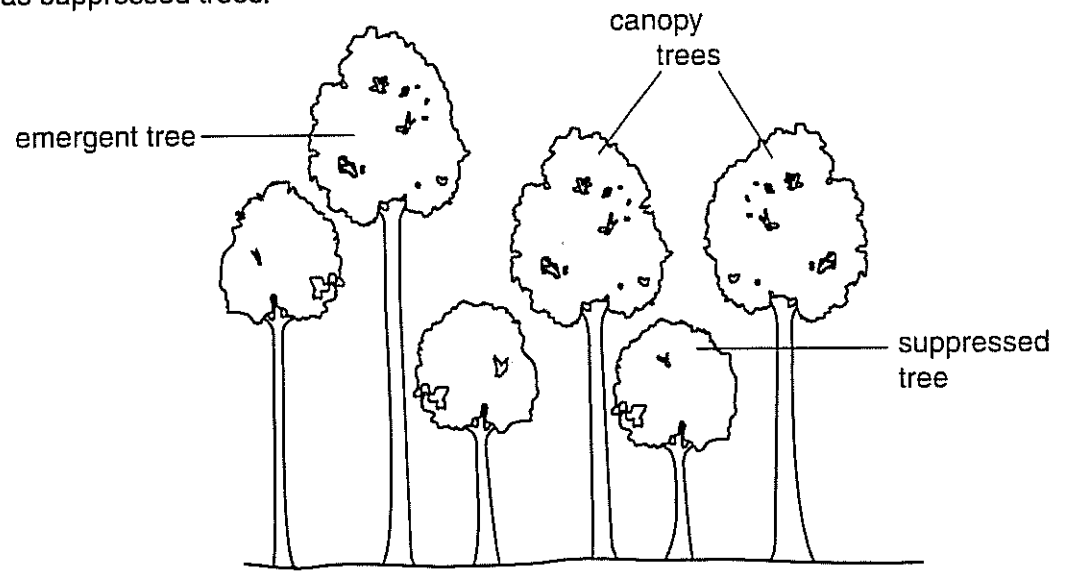
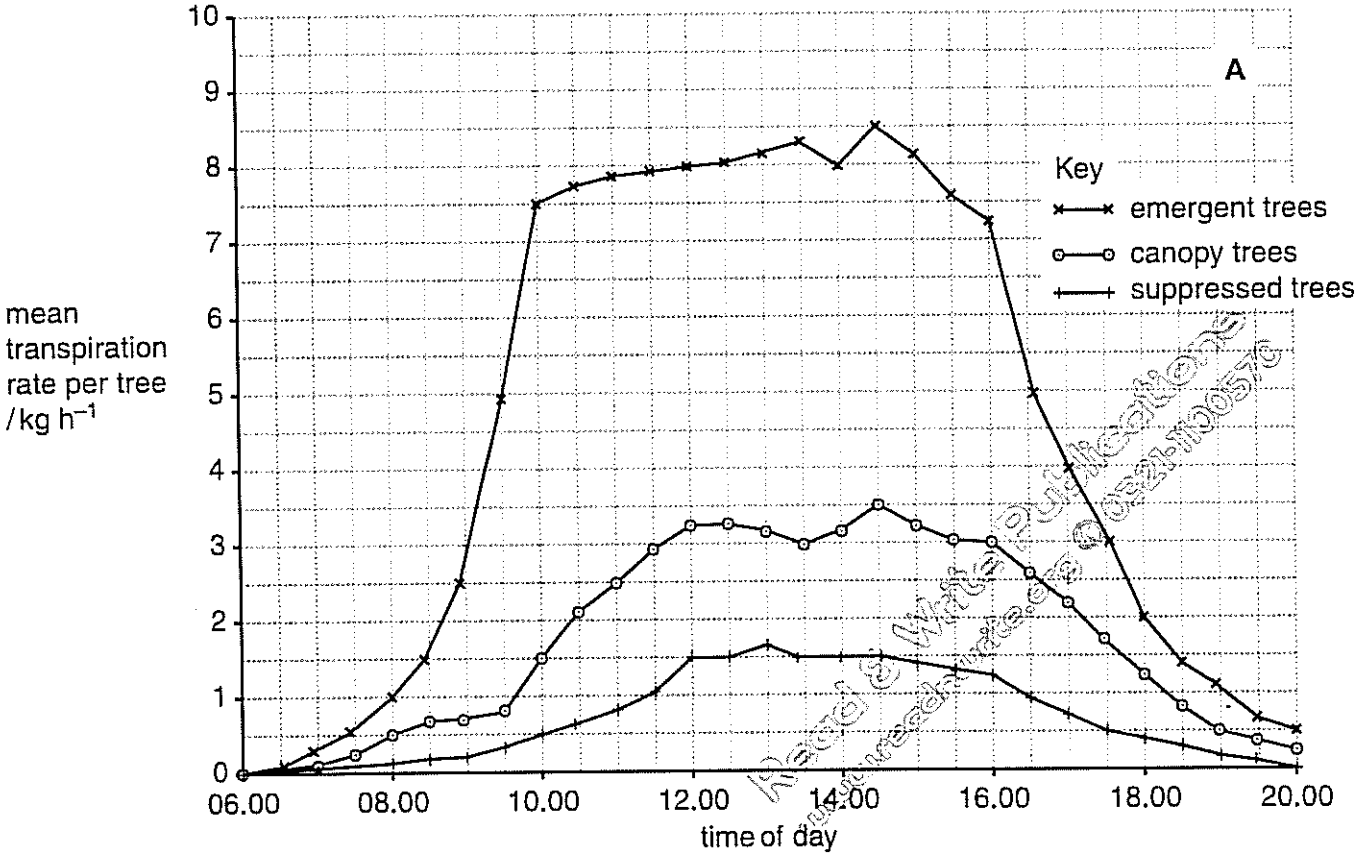


Fig. 4.1

Researchers determined the rates of transpiration of emergent, canopy and suppressed trees in a forest over a 14 hour period from 06.00 until 20.00 on one day in the summer. The results are shown in Fig. 4.2A. They also recorded changes in light intensity above the canopy over the same time period as shown in Fig. 4.2B.



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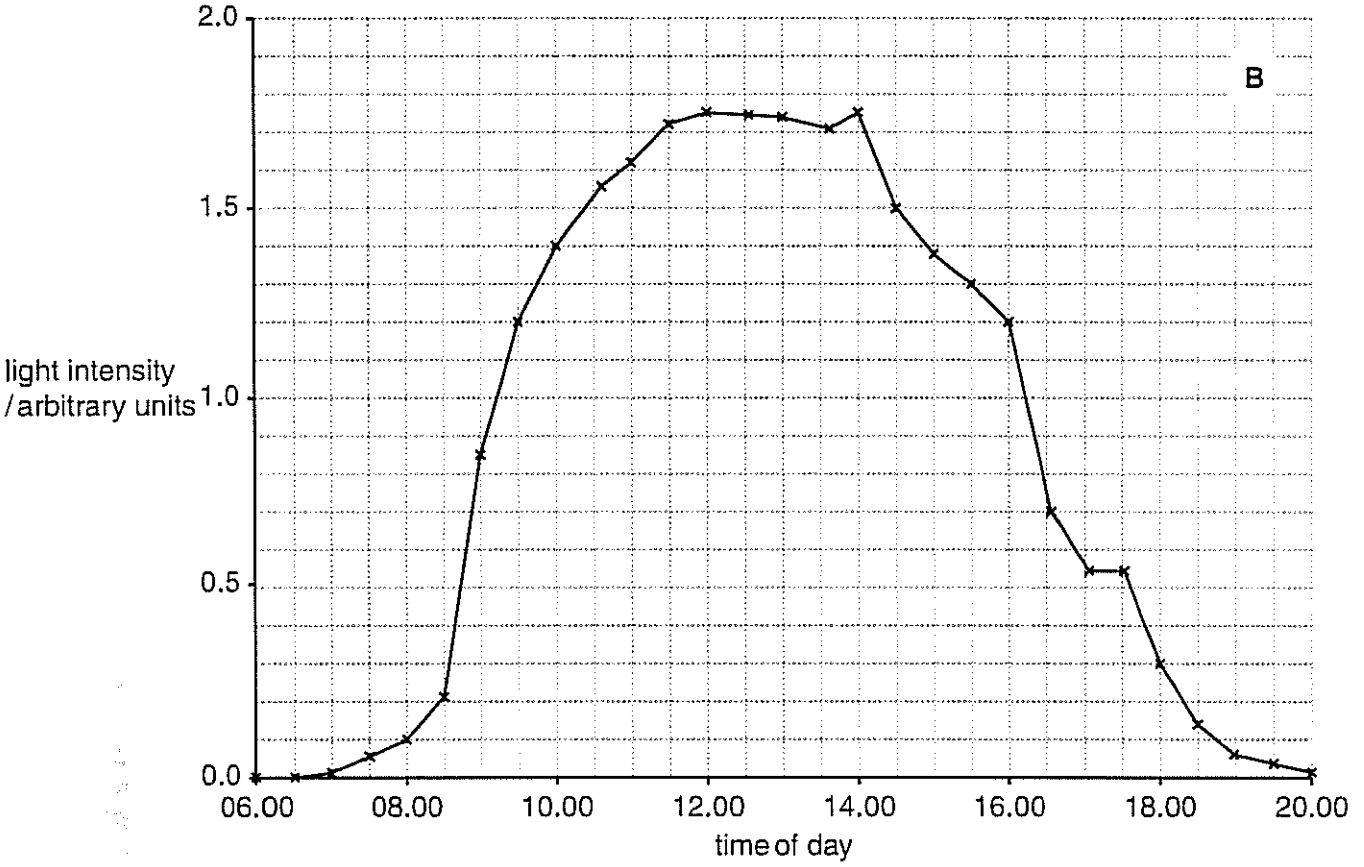


Fig. 4.2

(c) Use Fig. 4.2A to compare the transpiration rates of the emergent, canopy and suppressed trees in the forest over 14 hours.

.....

.....

.....

..... [4]

(d) The factors that affect transpiration rate vary considerably at different places inside forests. Use the information in Fig. 4.1 and Fig. 4.2 to suggest reasons for the difference in the transpiration rates of the emergent and suppressed trees.

.....

.....

.....

..... [4]

35. M/J 16/P23/Q4

Fig. 4.1 is an electron micrograph showing a section through the stem of Asian rice, *Oryza sativa*

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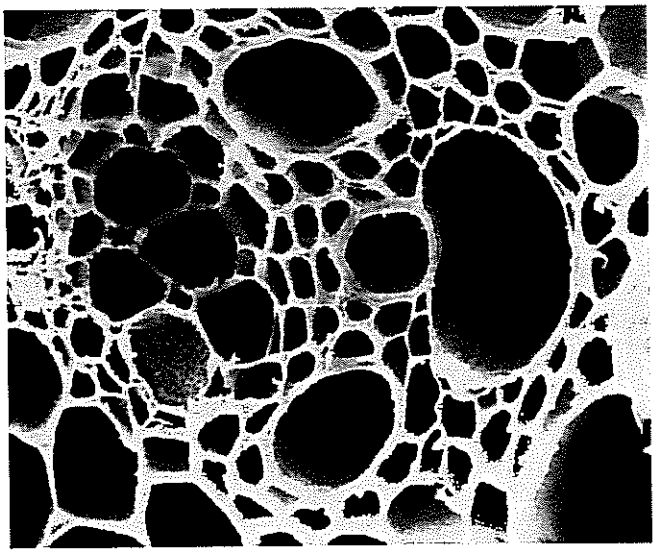


Fig. 4.1

(a) Draw a label line and label on Fig. 4.1 to show a phloem sieve tube. [1]

(b) Describe the function of phloem sieve tubes.

.....

.....[2]

(c) In the root tip, some of the cells produced by mitosis differentiate into xylem vessel elements. During this differentiation, the structure of the cell wall changes.
Explain how the structure of the walls of xylem vessel elements are adapted to their functions.

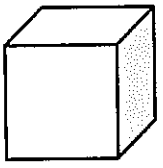
.....

.....

..... [3]

(d) Organisms can be modelled as simple shapes for the calculation of surface area to volume ratios.

(i) Calculate the surface area to volume ratio of an animal modelled as a cube of side length 0.1 m.
Show your working.



surface area ..... m^2

volume ..... m^3

surface area to volume ratio ..... [3]

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(ii) The surface area to volume ratio decreases as animals increase in size.
Use this fact to suggest why multicellular animals require transport systems.

.....

.....[2]

36. O/N 15/P22/Q6/c

(a) Transpiration and translocation are both processes occurring in plants.

(i) State **one** way in which transpiration differs from translocation.

..... [1]

(ii) State **one** way in which transpiration and translocation are similar.

..... [1]

37. O/N 15/P21/Q4

Marram grass, *Ammophila arenaria*, is a xerophyte adapted to grow in sandy soils in exposed locations.

Fig. 4.1 is a light micrograph of a section through a leaf of marram grass.

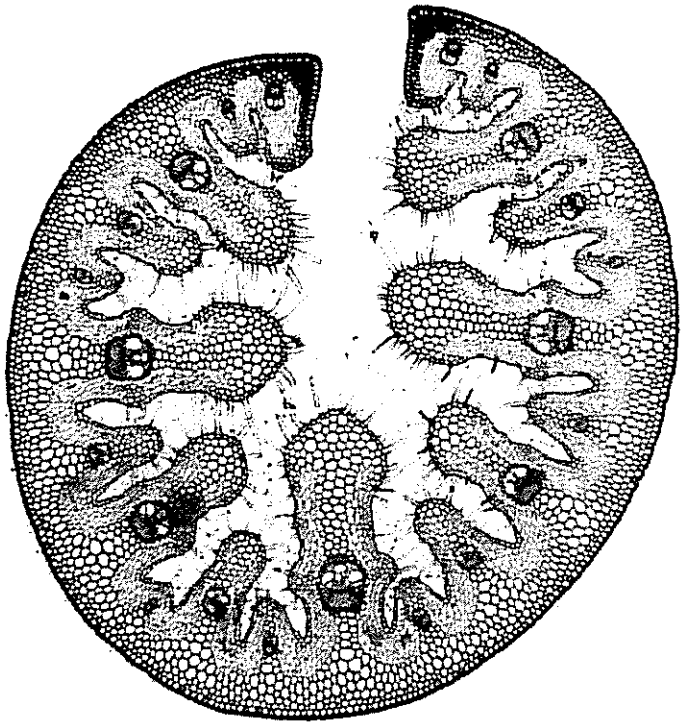


Fig. 4.1

(a) *A. arenaria* is adapted to reduce transpiration.

(i) State what is meant by the term *transpiration*.

.....

.....

..... [3]

(ii) One adaptation of *A. arenaria* is the curled leaf.

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Give **one** other adaptation, **visible in Fig. 4.1**, and explain how this reduces transpiration.
adaptation

.....

explanation

.....

..... [3]

(b) A student investigated the rates of transpiration and absorption of water by two species of plants, **P** and **Q**, over an 18 hour period between 0600 and 2400. The environmental conditions for the two species were the same.
The results are shown in Fig. 4.2.

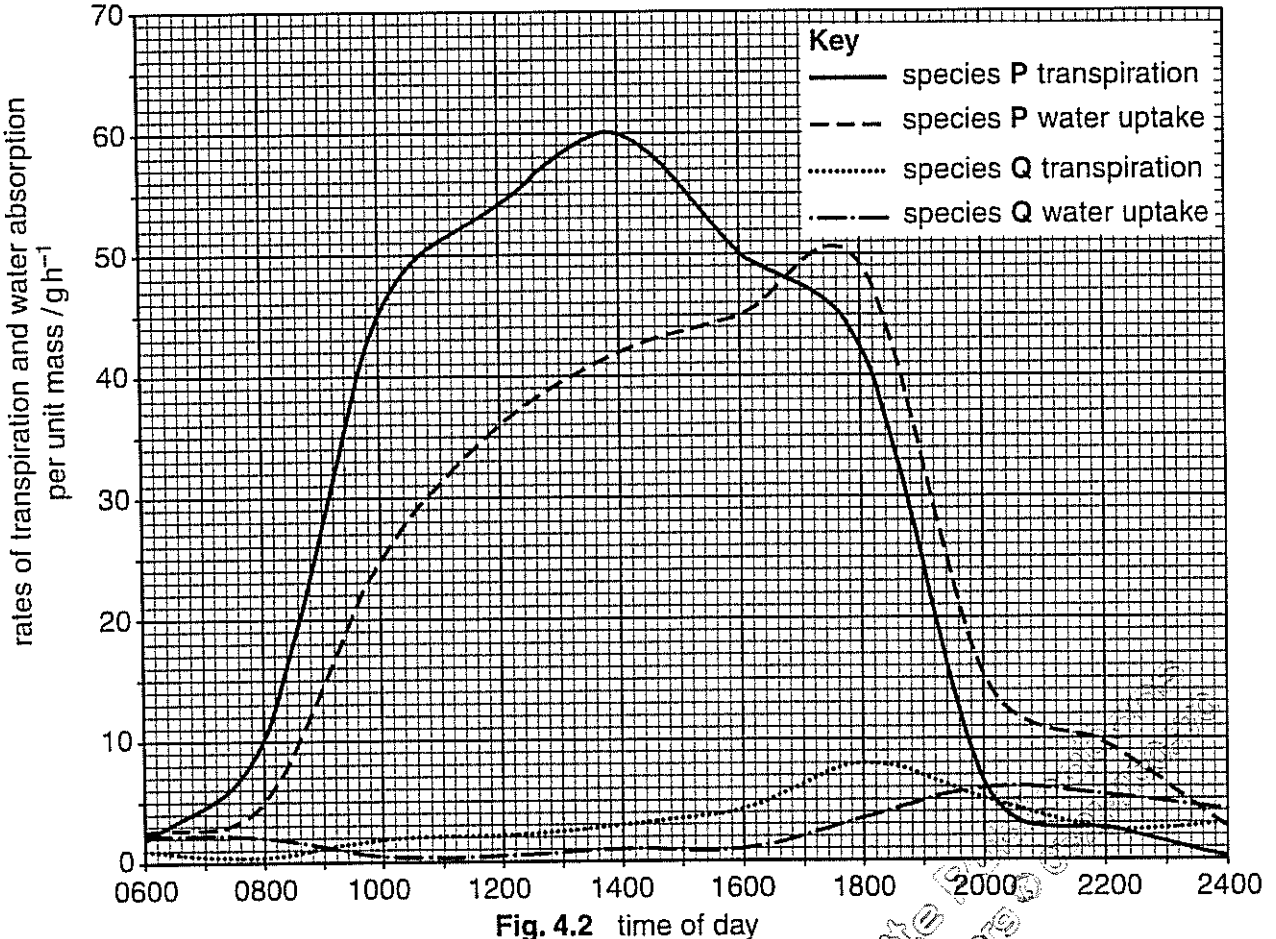


Fig. 4.2

(i) Use Fig. 4.2 to calculate the difference between the rates of transpiration and water absorption for species **P** at time 1400.

answer ..... [2]

(ii) Describe **and** explain the patterns of transpiration **and** water absorption for species **P**.

.....

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.....

.....

..... [4]

(iii) Suggest why the pattern of transpiration for species **Q** is not the same as for species **P**.

.....

..... [2]

38. O/N 15/P23/Q2

Most of the water lost from plants passes out through the stomata of leaves.
The distance between open guard cells is known as the stomatal aperture, as shown in Fig. 2.1.

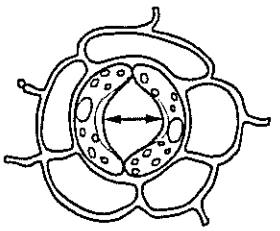


Fig. 2.1

↔ stomatal aperture

Researchers investigated the effect of stomatal aperture on rates of transpiration in leaves of *Tradescantia zebrina* under two conditions:

- air kept moving by a fan (moving air)
- non-moving air.

The results are shown in Fig. 2.2.

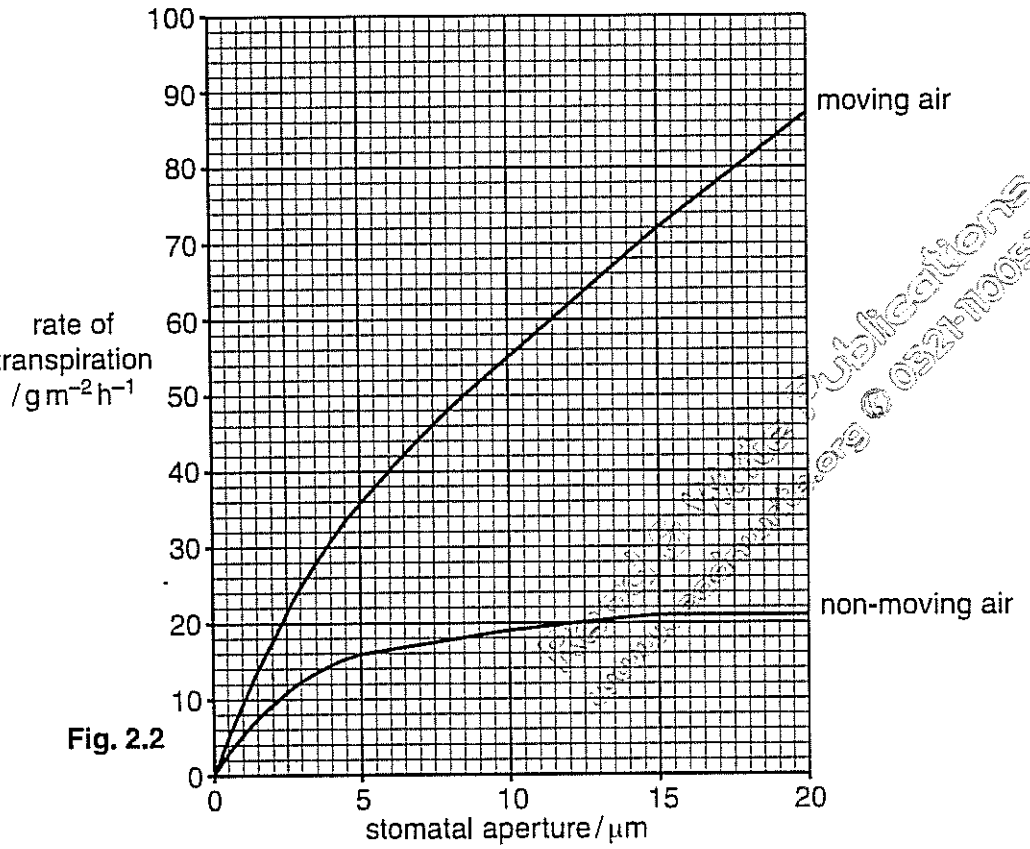


Fig. 2.2

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(a) **(i)** Compare the effect of stomatal aperture on the rate of transpiration in *T. zebrina* in the two conditions.

.....

.....

..... [3]

(ii) Explain the effect of stomatal aperture on rates of transpiration in non-moving and moving air.

.....

.....

..... [3]

(b) Spruce trees and pine trees are adapted to dry conditions where water can be in limited supply.
Fig. 2.3 shows two stomata in a spruce leaf and Fig. 2.4 shows a vertical section through a stoma from a pine leaf.

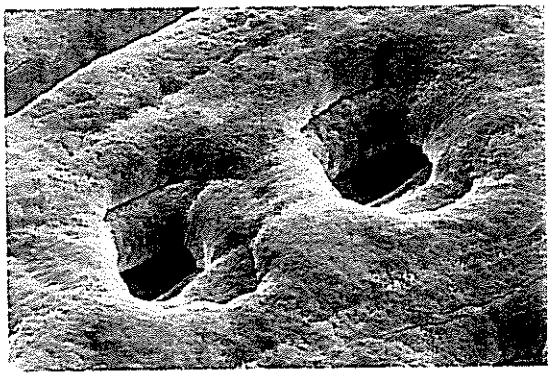


Fig. 2.3

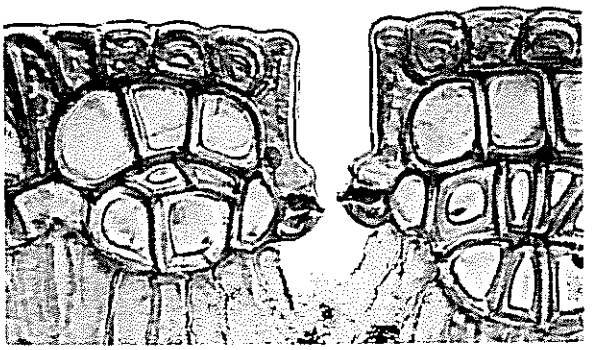


Fig. 2.4

(i) Explain how the stomatal features shown in Fig. 2.3 and Fig. 2.4 give an advantage to plants such as spruce and pine.

.....

..... [2]

(ii) Some plants that live in very dry conditions close their stomata during the day and open them at night.
State **one** disadvantage of this for these plants.

..... [1]

(iii) State **and** explain two adaptations that plant leaves have for survival in dry conditions **other** than those involving number or structure of stomata.

1. .....

2. ..... [2]

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39. M/J 15/P21/Q3

When a leaf is first formed it is described as a sink for carbohydrate. As the leaf continues to grow, it starts to photosynthesise and becomes a source of carbohydrates and other assimilates.

Fig. 3.1 shows the changes that occur to the structure of plasmodesmata in the leaf as it grows.

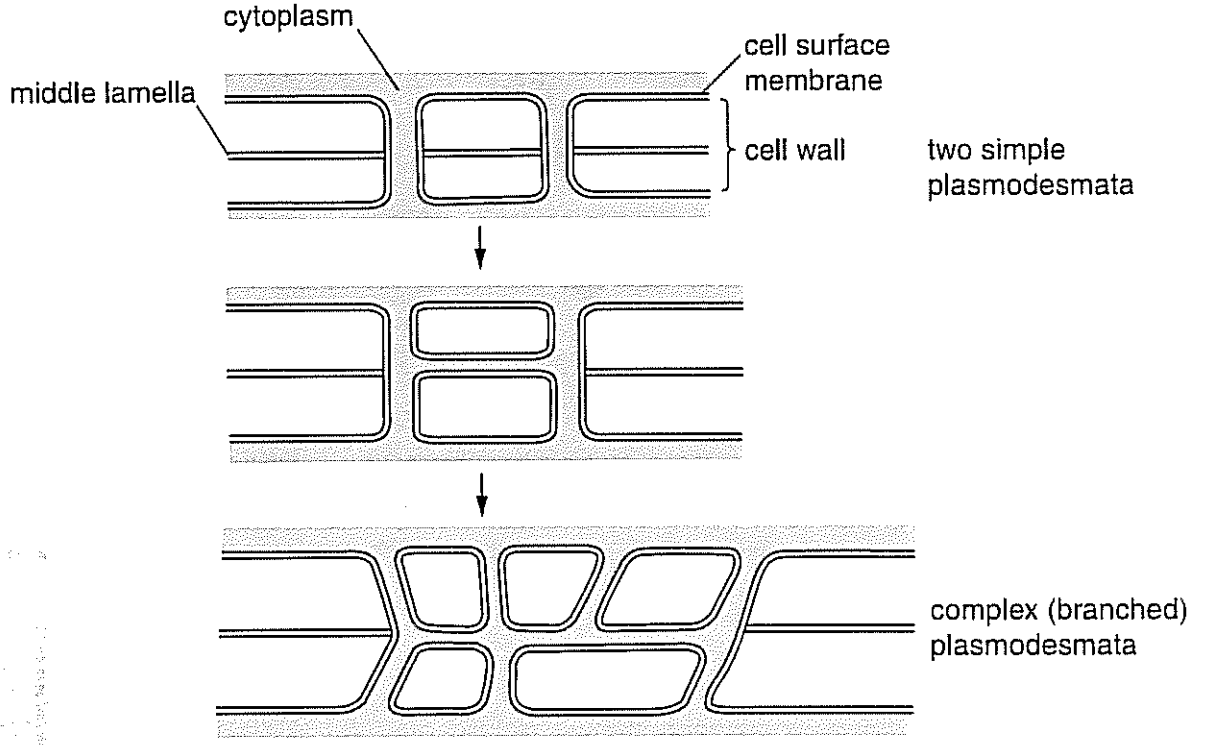


Fig. 3.1

(a) Suggest the advantage of complex plasmodesmata between cells in leaves.

.....

..... [2]

(b) Assimilates are transported into phloem sieve tubes.
Explain how assimilates in phloem sieve tubes move from the veins in a mature leaf to sinks, such as flowers and fruits, in the rest of the plant.

.....

.....

.....

..... [4]

40. M/J 15/P23/Q5

Fig. 5.1 is a light micrograph of some unicellular photosynthetic organisms called *Chlamydomonas*

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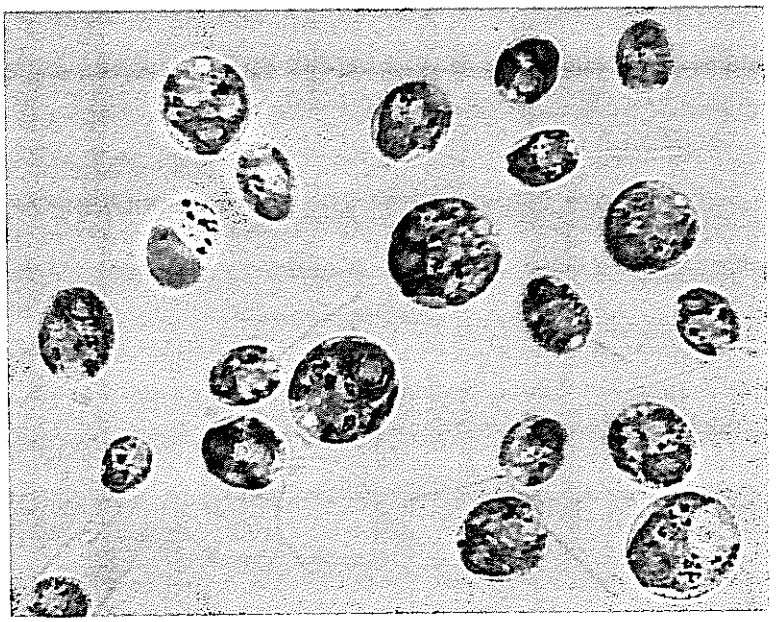


Fig. 5.1

(a) *Chlamydomonas* moves through water.
Explain why the light microscope rather than the electron microscope is used to observe the movement of *Chlamydomonas*.

.....

..... [2]

(b) *Chlamydomonas* live in water and obtain minerals, such as magnesium ions, from the water.

(i) State **one** role of magnesium ions in photosynthetic organisms.

..... [1]

(ii) State two properties of water which make it possible for organisms such as *Chlamydomonas* to live in water.

1 .....

2 ..... [2]

(c) Explain why multicellular organisms require transport systems while unicellular organisms, such as *Chlamydomonas*, do not.

.....

.....

.....

..... [4]

(d) Some plants, such as the banana plant, *Musa acuminata*, produce fruit. The banana fruit has a high content of carbohydrate.
Describe how sugars are transported in phloem sieve tubes from source to sink in plants such as *M. acuminata*.

.....

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.....

.....

.....

..... [5]

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Answers Section

1. **M/J 22/P22/Q6**
   (a) *any **three** from:*
   at (phloem) source, mineral ion entry (with water), from xylem / through plasmodesmata from companion cells ;
   dissolved in water / as solutes in water / in solution / in sap solution ;
   in context of entry from xylem or within phloem sap
   (transport) as part of mass flow ; *must be in context of phloem*
   flow down a pressure gradient / AW ;
   R differences in pressure gradient
   R from high pressure gradient to low pressure gradient
   AVP ; e.g. suggestion that mineral ions are needed for transport of some assimilates (e.g. complexed with)
   idea of reallocation of resources / arrive at (phloem) source and are moved to other parts, for use / when needed ;
   (b) sieve, plates / pores ; **A** perforated end plates / end plates with pores **I** plasmodesmata
   periphery / edge / AW ; companion ; **A** transfer [6]

2. **O/N 21/P22/Q1/c**
   (a) **I** *ref. to* light absorption
   *any **one** from:*
   chloroplasts at periphery because
   pushed by vacuole ;
   vacuole is, turgid / filled with cell sap ;
   (large permanent) vacuole is in the centre (of the cell) ; [1]

3. **O/N 21/P22/Q4**
   (a) cohesion ;
   adhesion ;
   (b) (i) *any **two** from:*
   1 higher rate of transpiration during the day / lower rate of transpiration during the night / AW ; **A** flow of xylem sap *for transpiration*
   2 stomata are open during the day ; **ora** *must be in context of transpiration*
   if mp1 and mp2 not gained, allow one mark for idea that results are related to pattern
   of, / light *daylight / day, and, dark / night (use an ordinary tick)*
   3 *idea that* all three vines were kept in the same conditions so a changed condition that affects transpiration will affect all three ;
   A all three vines have the same external factors acting that affect transpiration
   4 AVP ; e.g. (during daylight) stomata open, to obtain carbon dioxide / for *photosynthesis idea that,* increasing / decreasing, rate is related to degree of opening of stomata varying with light intensity
   (ii) *allow (xylem sap) flow rate for rate of transpiration*
   *any **two** from:*
   1 the greater the (total) area of leaf, the higher the rate of transpiration ; **ora**
   A grapevine 1 has largest leaf area and highest rate of transpiration
   accept other comparisons
   R *ref. to* SA:V but allow ecf in mp2
   2 the greater the (total) area of leaf, the more stomata are present ; AW
   A more leaves means more stomata

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3 detail of any one grapevine ;
e.g. grapevine 1 = highest transpiration rate and, highest number of / most, stomata
grapevine 3 = lowest transpiration rate and, lowest number of / least, stomata
allow use of comparative data to support mp
(if detail includes ref. to (total) leaf area then check to see if mp2 can also be awarded)

4 *ref. to* relationship between (total) internal surface area and (total) leaf area ;
e.g. larger leaf surface area means internal surface area increased

5 *ref. to* relationship between internal surface areas and rates of evaporation ;

6 AVP ; higher rate of flow of xylem sap for largest leaf area as (overall) more water used in metabolism AW **ora** (greater area so)
more leaves so more xylem vessels **ora**

(iii) overcast / cloudy / rain / shade / AW ;
A lower wind speed / temperature
A higher humidity
R if described as stomata close (transpiration is still occurring)

(iv) *valid method e.g.*
draw around / place, leaf on, squared paper / graph paper / grids ;
A square ruler
count number of (full) squares ; **R** multiply by two / do it on other side
method for part squares ; e.g. add up all part squares and divide by 2
match a larger part square with a smaller and count as one square
use graph paper with larger and smaller squares
or
photocopy leaves, cut out and weigh (cut out) ;
divide mass by mass of 1 cm^3 of same paper ;
or
ref. to using an App ;
further detail ; e.g. place leaf, flat / on white surface ;
take photo of single leaf with smart phone / AW [9]

4. O/N 21/P21/Q5

(a) *in context of from a plant*
loss of water vapour ; **I** evaporation unqualified
from, the aerial parts / leaves ;

(b) 1.2 ($mm\ min^{-1}$) ;

(c) *any **two** from:*
humid air / water vapour, moves away from the leaves ;
water potential gradient is steeper ;
higher rate of evaporation into the air spaces in the leaf ;

(d) *any **four** from:*
movement by, cohesion-tension ;
cohesion / hydrogen bonds, between water molecules ;
A cohesive force
(water moves as an) unbroken column / AW ;
transpiration pull
or
column of water, under tension / pulled up ;
ref. to adhesion of water molecules to, cellulose / lining / walls (of xylem vessels) ; **A** adhesive force
ref. to hydrophilic / polar, property of cellulose (fibres) ;
A hydrophilic / polar, parts of lignin
ref. to water potential ;
e.g. (evaporation results in) lower water potential at the top of the xylem vessel
(water moves) down a water potential gradient / from a region of high water potential to

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a region of lower water potential [9]

5. M/J 21/P22/Q2

(a) *any three from*

decrease in sugar

1 *idea that* changing / transition, from sink to source
e.g. leaf becomes the source
leaf no longer the sink
sugars are (now) being moved away from leaf
was a growing area, now translocating (sugars)

2 photosynthesis provides enough sugar / (rate of) photosynthesis increases ;
A leaf (now) makes enough sugar
I makes own food

increase in water to max 2

3 increase in size / more cells / increase in (leaf) surface area, (so proportionate increase in water) ;

4 (more cells that need) water to, maintain turgidity / prevent flaccidity / prevent wilting, (because of transpiration) ;

5 increased transpiration / greater number of stomata ;
A increased evaporation (greater internal leaf area)

6 water is, a reactant / needed, for photosynthesis ;
(in context of increased photosynthesis, more water needed)

7 AVP ; e.g. maturing leaf growth rate slows / mature leaf no growth (more cells, so more) water needed for, cellular reactions / AW
e.g. for hydrolysis of starch
(more) water needed for, cell elongation / enlarging vacuoles

(b) *one mark each correct row* ;;;
column mark can be used instead of row mark (if higher mark achieved)

feature	companion cells	phloem sieve tube element	xylem vessel element
cytoplasm	✓	✓	x
cell surface membrane	✓	✓	x
lignified cell wall	x	x	✓
nucleus	✓	x	x

[7]

6. M/J 21/P23/Q4

(a) *disaccharides* - two, monosaccharides / sugar monomers / sugar units / simple sugars ;
R sugar molecule
polysaccharides - more than two / three or more / many / large number of, monosaccharides / sugar monomers / sugar units / simple sugars ;
A sugar molecule / carbohydrate monomer
if 'monomers' is the only term given for both allow one mark (unless contradicted e.g. amino acids are monomers) correct *ref. to* glycosidic bond(s) ;

(b) (i) *max 2 if large vacuole or nucleus drawn*

1 sieve plate drawn and labelled ; **A** sieve pore label *must be to a gap doesn't need to show pores* **I** plasmodesmata

any two from

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2 cytoplasm labelled and drawn as, thin layer against wall / patches ;
if drawing not clear, allow if label indicates peripheral cytoplasm
3 mitochondrion / mitochondria, drawn within cytoplasm / at edge, and labelled ;
internal details not required
4 endoplasmic reticulum drawn within cytoplasm / at edge, and labelled ;
A ER **R** RER / SER
if no indication of peripheral cytoplasm, or structures located within peripheral cytoplasm / at edge, allow one mark for drawing and labels of <u>two</u> of mp2,3,4
5 cell surface membrane drawn in (close to cell wall) and labelled ;
A plasma membrane
6 AVP ; e.g p-proteins drawn as, strands / AW, and labelled
plasmodesmata shown as strands of cytoplasm entering sieve tube cell from companion cell and labelled

(ii) influx / entry / AW, of sucrose / organic compounds / assimilates / photosynthates / named ;
A active loading *for entry*
R active transport / cotransport / facilitated diffusion
R incorrect cell type named as donor cell e.g. xylem / mesophyll
must have idea of entry – stating that they are present in the phloem sieve tube is not enough
water enters (from xylem), by osmosis / down water potential gradient / from high(er) to low(er) water potential / from less negative to more negative water potential ;
A Ψ for water potential
A water enters, increasing volume [7]

7. O/N 20/P22/Q1

(a) (i) plasmodesmata ;
I cytoplasmic strands / cytoplasm
R if other structures also given

(ii) (existence of / down, a) water potential gradient ;
I *ref. to* solute / osmotic, potential
A lower / more negative, water potential of (cell) **C** (than cell **B**)
A higher / less negative, water potential of (cell) **B** (than cell **C**)
A Ψ for water potential

(iii) symplastic (pathway) ; **I** vacuolar / vacuole, pathway
A symplast

(b) *max 3 if no ref. to evaporation or water vapour and ref. only to water*
*any **four** from:*
1 evaporation of water / water to water vapour ; *must be in context of **P***
2 **P** described as, surface / cell wall, of (spongy) mesophyll (cell) ;
R palisade mesophyll cell
A film / layer, of moisture / water (for surface of cell)
3 water vapour enters (substomatal) <u>air space</u> ;
R <u>intra</u>cellular air space
A other correct refs. to air space in sequence of events
4 <u>diffusion</u> of water vapour (out) through stoma / <u>stomatal pore</u> (to **Q**) ;
R through guard cells **R** diffusion by osmosis
5 (towards **Q** because) down <u>water potential gradient</u> / from high to low <u>water potential</u> / to lower <u>water potential</u> ;
I potential gradient alone
A down (water) vapour pressure gradient
A Ψ *for water potential*

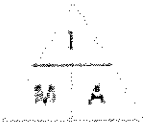
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context is movement out to atmosphere, not movement from **P** *to air space*

6 AVP ; e.g. stoma stated as open
heat energy required for evaporation / *ref. to* latent heat of vapourisation
air space described as, intercellular / saturated / substomatal

(c) 1 correct formula ;
(magnification) = image length ÷ actual length ;
A rearranged formula **A** magnification triangle



2 correct working ;
3 correct answer for magnification ; **R** if units given
(×) 1440 (36 mm) / 1460 (36.5 mm) /1480 (37 mm) / 1500 (37.5 mm)
1520 (38 mm) / 1540 (38.5 mm) / 1560 (39 mm) ;
if answer given to 2 sig. figs, look for the correct answer at the end of working
***or** allow if stated by answer that this is to 2 sig. figs.*
allow ecf for incorrect conversions used in working or incorrect measured value of X–Y [10]

8. O/N 20/P21/Q4/b(ii)

(a) (i) *allow sucrose for assimilates throughout*
*any **five** from:*
viruses / assimilates, enter via plasmodesmata ;
movement / diffusion, of assimilates into (phloem) sieve tubes, lowers water potential / AW ;
(so) water enters, by osmosis / down water potential gradient / AW ;
hydrostatic pressure increases (at source) ; **A** turgor pressure *for hydrostatic pressure*
unloading at, sink / named sink, lowers hydrostatic pressure (at sink) ;
detail ; e.g. assimilates move out and water follows osmotically
pressure gradient created / higher pressure in source (than sink) / lower pressure in sink (than source)
(so) mass flow ; *term to be used in context*
from source to sink ; *allow mp if terms source and sink used in correct context within complete response*
AVP ; (viruses and assimilates travel) through sieve pores [5]

9. O/N 20/P23/Q2

(a) *award mp1 and mp8 anywhere in each section of the answer*
*cell **B** - mesophyll cells*
mp1 photosynthesis / described ;
e.g. conversion of carbon dioxide to sugars using light energy
synthesis of complex organic compounds from inorganic compounds using light energy
adaptation – mp2 and one from mp3 to mp7

mp2 chloroplasts / chlorophyll / chloroplast pigments	to absorb light ;
any **one** from:	
mp3 large vacuole	to keep chloroplasts at the periphery ;
mp4 starch grains	as store of products of photosynthesis ;
mp5 large / moist, surface / cell wall	for evaporation of water for transpiration (stream) ; **A** provides water for photosynthesis in context of water supply transpiration

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mp6 thin cell wall	gas exchange / diffusion of gases ;
mp7 isodiametric / (roughly) spherical shape	prevents close packing / gives large air spaces ;

*cell **C** - sieve tube element*
mp8 transport / movement of, (named) sugars / (named) assimilates / photosynthates / organic substances ; **A** translocation
*adaptation – any **two** from:*

mp9 peripheral / described, cytoplasm **A** 'at the edge' / 'thin layer'	allowing maximum, volume / space, for transport of, phloem sap / assimilates ; **A** less / little, resistance to flow / AW
mp10 no nucleus / few organelles / little cytoplasm **R** 'no organelles'	allowing maximum, volume / space, for transport of, phloem sap / assimilates ; **A** less / little, resistance to flow / AW
mp11 elongate / elongated (cells, so end to end)	to make (sieve) tubes ;
mp12 plasmodesmata	(un)loading from / AW, companion cells / cell **A** ; **I** 'between cells A and C'
mp13 sieve pores	**A** flow between sieve tube elements ; AW
mp14 sieve plates	prevent, bursting / bulging ; **A** maintaining hydrostatic pressure
mp15 AVP for **C** ; e.g. phloem proteins **and** defence against pathogens / sealing wounds e.g. cell walls with cellulose microfibrils that run around the cells **and** to prevent bursting	

(b) *mp1, 2, 4 and 6 needs idea of increases / more; this is not needed for mp3 and mp5*
*any **three** from:*

1 increases surface area:volume <u>of cell</u> / increases surface area of (cell surface) <u>membrane</u> ;
2 *idea of* more space for / increased area for / more, proton pumps / carrier protein in context of moving protons
3 pumping protons, from cytoplasm / into cell wall / into apoplast / AW ; **A** create / increase, proton / electrochemical / concentration, gradient
4 *idea of* more space for / increased area for / more, <u>co</u>transporter proteins / carrier proteins in context ;
5 <u>co</u>transport of sucrose / described, into companion cell / into transfer cell / into cell **A** / from mesophyll cell / from cell **B** ; **A** secondary active transport
A *movement of sucrose <u>and</u> protons for cotransport*
6 more space for plasmodesmata (between cell **A** and cell **C**) ; [8]

10. M/J 20/P22/Q5/a,b(i,ii)

(a) presence of sucrose (in sieve tube) lowers water potential (of phloem sap) ; **A** makes water potential more negative water enters (sieve tube), by osmosis / down water

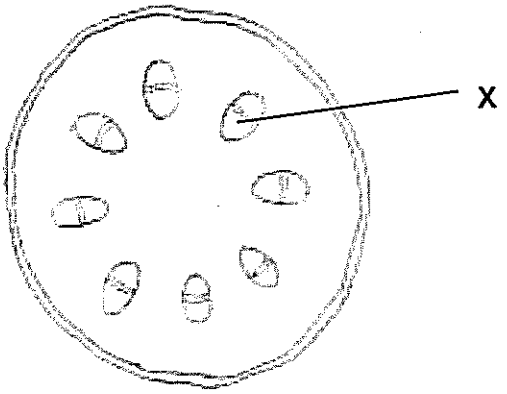
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potential gradient ; increases volume (in sieve tube) ;
increases hydrostatic pressure (in sieve tube at source) ; **A** turgor pressure
ref. to lower hydrostatic pressure (in sieve tube at sink) ;
allow ecf for no ref. to, hydrostatic / turgor
detail ; e.g. sucrose removed at sink
water follows sucrose that exits sink
movement of, (phloem) sap / sucrose, down pressure gradient / from high to low hydrostatic pressure ; mass flow ;

(b) (i) glycosidic ;
(ii) nucleotide components are base, pentose sugar, phosphate ;
UDP has, uracil and ribose and two phosphates / one extra phosphate ; [7]

11. M/J 20/P23/Q1

(a) any one correct location ;
R if more than one label line and one is to an incorrect location
allow the mark if more than one label line and all point to xylem locations



(b) **I** *ref. to* adhesion / H bonding between water molecules and cellulose lining
any three from
(hydrogen bonding causes) cohesion between water molecules ;
water molecules attracted to each other /AW ;
water leaving xylem (at top), pulls water molecules below ;
transpiration pull ;
idea that contributes to, an unbroken / a continuous, column of water (within xylem vessels) ;
AVP ; e.g. allows movement of water against (pull of) gravity

(c) (i) *any three from*
description max 2
(movement to adjacent cell) via plasmodesmata ;
(movement) through symplasm / cytoplasm / symplastic pathway / cytoplasmic pathway ;
(includes) movement through vacuole / vacuolar pathway ;
explanation
cell **B** has a lower water potential than **A** **ora**
or
cell **C** has a lower water potential than **B** ; **ora**
or
water moves down the water potential gradient / from high to low water potential / to lower water potential / from less negative to more negative water potential ;
R from high to low water potential gradient
R to lower water potential gradient
water moves, into / out of, vacuole by osmosis
or
water crosses tonoplast by osmosis ;

(ii) *any three from*
cell wall ;

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large (permanent) vacuole ;
tonoplast ;
plasmodesmata / cytoplasmic strands between adjacent cells ;
nucleus at, edge / periphery, of cell / AW ;
AVP ; many small Golgi bodies **A** dictyosomes
starch, granules / grains
I lack of centrioles
I chloroplasts [10]

12. O/N 19/P22/Q1

(a) label line to phloem in one vascular bundle ;

(b) transport / translocation, of, assimilates / photosynthates / sucrose / sugars / amino acids / other named nutrient ; **I** food
from, source / areas of synthesis, to, sink / areas of growth / areas of (high) activity / areas of storage ;
A areas where they are needed *for sink*
I 'where they used'

(c) (i) epidermis / epidermal ; **I** upper / lower
(ii) eyepiece graticule ; **I** stage micrometre

(d) *drawing max 2:*
regular shaped cell and cell wall drawn in ;
central vacuole drawn ;
labels:
max 2 if animal structures also labelled
max 1 for labels if incorrect non-cellular structure included
e.g. vascular bundle / stoma
large / permanent, vacuole ;
A central vacuole
A vacuole *if clearly drawn as large*
tonoplast ;
R *if drawn as double membrane*
(cellulose) cell wall ;
R chitin / murein
plasmodesma(ta) ;
chloroplast ;
A granum / thylakoid *i.e. chloroplast not labelled but internal structures correctly labelled*
A if drawn with a single or double membrane
starch, grain / granule ;
A amyloplast [10]

13. O/N 19/P23/Q3/a

(a) *five from*
1 drought-tolerant plants have smaller stomatal aperture **and** lower, transpiration rate / rate of water uptake ; **A ora**
2 comparative data quote for, mean stomatal aperture / transpiration rate + $\underline{\text{mmol m}^{-2}\text{ s}^{-1}}$ / mean water uptake + $\underline{\text{cm}^3}$ $\underline{\text{per shoot}}$ + time + h ;
in drought-tolerant plants
3 smaller (aperture), stomata so less water (vapour) loss ;
4 water vapour $\underline{\text{diffuses}}$ (out) through stomata ;
5 less evaporation from (cell walls of) mesophyll ;
6 so less $\underline{\text{transpiration pull}}$;
7 AVP ; suggestion of other adaptations of leaves to reduce water loss

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e.g. sunken stomata / thicker cuticle / hairs / trichomes / lower stomatal density
R closed stomata [5]

14. M/J 19/P22/Q1

(a) stem / not a root, because, transport tissue / vascular bundles / vascular tissue(s) / xylem and phloem / xylem / phloem, around the edges / not in the centre / AW ;
A stem because, pith / parenchyma tissue, is in the centre

(b) *any two from:*
(hydrostatic) support / described ;
R *if incorrect context e.g. support because of thick cell walls*
A packing tissue
(cells), turgid / store water ;
storage ;
in context of substances other than water e.g. sucrose / starch / waste

(c) (i) vascular bundle ;
(ii) 0.65 (mm) ;

(d) *mp1-3 must have statements for both xylem and phloem*
mp4-7 need statements for either xylem or phloem
three from:

	xylem		*phloem*
1	no cytoplasm / hollow / no contents		(peripheral / little / some) cytoplasm I protoplasm R full of cytoplasm / AW
2	no organelles / hollow / no contents		(a few) organelles ; A examples of organelles mitochondria or ER I has SER / RER / ribosomes R has nucleus
3	lignified R idea of lignin within element		no lignin / (only) cellulose ;
4	no end wall(s) / no sieve plate(s) A end walls have broken down	or	sieve plate(s) / perforated end wall(s) A (end walls) have sieve pores
5	(side walls) contain pits	or	no pits (in side walls) ;
6	no plasmodesmata	or	plasmodesmata (to companion cells)
7	thick(er), cell wall / walled	or	thin(ner), cell wall / walled ;

[8]

15. M/J 19/P21/Q4/c,d

(a) *any four from:*
1 elongated cells to form, long tubes / AW ;
2 little, cytoplasm / cell contents / fewer organelles, to reduce resistance to flow ;
A peripheral cytoplasm / no nucleus, to allow transport of maximum volume of, (named) assimilates / sap / nutrients
A 'more space for .....'
R no organelles R 'no cell contents'
3 sieve (plates have) pores, so little barrier to flow from cell to cell / easy (for phloem sap) to pass from cell tp cell / allows mass flow
4 sieve plates, support / stop collapse of / stop bulging of, sieve tube elements ;
A become plugged with, P-protein / callose, to prevent losses / after damage
A maintain hydrostatic pressure (in sieve tubes)
5 plasmodesmata between sieve tube and companion cell for ease of, loading / unloading / AW ;
6 AVP ; e.g. membrane around sieve tube for osmosis to occur / prevent loss of (named) assimilates

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(b) *allow assimilates / AW for sucrose*

1 movement of sucrose from, mesophyll / parenchyma / source, cells ;
A movement of sucrose to (named) sink cells

2 move sucrose, into / out of, sieve tubes (through plasmodesmata) ;

3 pump, protons / hydrogen ions / H^+, out of cell / into cell wall/into apoplast ;
A *ref. to* secondary active transport

4 provides, ATP / proteins, for sieve tubes ;
A maintain metabolism of sieve tubes [6]

16. M/J 19/P23/Q2/c,d

(a) *any three from:*

1 loosely packed spongy mesophyll cells / spongy mesophyll cells surround air spaces / air spaces between spongy mesophyll cells ;

2 large, surface / area, for evaporation (of water to air space) ;
In context of spongy mesophyll cells, surfaces / cell walls

3 (cells arranged so that), air spaces above the stomata / sub-stomatal air spaces ;

4 *ref. to* evaporation creates saturated air spaces / water vapour collects in air spaces ;

5 *idea of* creates water potential gradient between air in air spaces and air in external environment ;

6 AVP ; e.g. guard cells situated in epidermis to form stomatal pore
ref. to xylem, close proximity to spongy mesophyll cells for passage of water / passes on water to spongy mesophyll cells

(b) (i) *accept au for arbitrary units and first hour etc. for 08.00 etc.*
any three from:

1 between 08.00 and 09.00, steep increase / increase from 2.5 au to 5 au ;

2 highest rate / peak, at 09.00 ; **A** maximum rate is at 09.00

3 fluctuates / AW, between 10.00 and 15.00 ;

4 (continued) decrease between 15.00 and 19.00 ;
A steep /steepest, decrease between 15.00 and 16.00
A less steep (than 15.00 to 16.00) decrease between 16.00 and 19.00

5 comparative data quote for decrease ; e.g.
3.8 au at 15.00 to 0.5 au at 19.00
or
3.8 au at 15.00 to 2.00 au at 16.00
or
2.0 au at 16.00 to 0.5 au at 19.00

(ii) *any two from:*
change in external environmental factor
decrease in light intensity / AW ; **A** (less sunlight because it was) cloudy
decrease in temperature / AW ; *temperature decreased because it was cloudy is mp2 only*
decrease in, wind speed / air movement / AW ;
increase in humidity / raining / AW ;
stomata, decrease in (aperture) size / open less wide ;
decreased evaporation (rate) ;
water vapour diffuses out less rapidly / less steep water potential gradient ; AW
AVP ; e.g. suggestion of xerophytic feature occurring in response to increased, temperature / light intensity (to 09.00) [8]

17. M/J 19/P23/Q4

(a) *any two from:*
note that some mark points must have both xylem and phloem mentioned ('v') and some mark points only need xylem or phloem ('or' – below the line)

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xylem		*phloem*	
no cytoplasm / hollow / no contents	v	(peripheral / little / some) cytoplasm **I** protoplasm **R** full of cytoplasm / AW **or** has (a few) organelles **A** examples of organelles mitochondria or ER **I** has SER / RER / ribosomes **R** has nucleus	;
lignified **R** *idea of* lignin within element	v	no lignin / (only) cellulose	;
no end wall(s) / no sieve plate(s) **A** end walls have broken down	**or**	sieve plate(s) / perforated end wall (s) **A** (end walls) have sieve pores	
(side walls) contain pits **R** piths	**or**	no pits ;	;
no plasmodesmata	**or**	plasmodesmata (to companion cells) ;	;
thick(er), cell wall / walled	**or**	thin(ner), cell wall / walled	;

thicker lignified wall = thicker wall mark only (for lignin mark need to state what phloem has)

(b) *any two from:*
to hydrolyse / break, glycosidic bonds ;
to produce, reducing sugars / fructose and glucose ;
A to make reactive groups (to Benedicts) available
to be able to test with Benedict's solution to obtain a positive result ;
A description of positive result
sucrose, is a non-reducing sugar / has no reactive groups when tested with Benedict's solution ;

(c) (i) (large number of mitochondria) provide ATP, for active transport / for protein synthesis;
(large number of ribosomes) to synthesise the, proton pumps / carrier proteins / AW ;

(ii) *any three from:*
H^+, pumped / actively transported (out of companion cell into cell wall)
or
ref. to higher concentration of H^+ (in cell wall) / H^+ gradient builds up (between cell wall and cytoplasm of companion cell)
H^+ move back (into companion cell) by facilitated diffusion ; **I** sucrose
through, co-transporter protein / cotransporter ; **A** symporter
H^+ cotransports sucrose / sucrose moves (into cell) with H^+ ;
sucrose is transported against the concentration gradient ;
A sucrose transported by secondary active transport [9]

18. O/N 18/P22/Q2/a,b

(a) xerophyte / xerophytic ; **R** succulent / cactus / named

(b) (i) phloem ; **A** sieve tube(s) **R** phloem sieve / phloem tube
A sieve tube elements **R** phloem companion cell

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(ii) *any two from*

1 for, transport / translocation, **or** movement / AW, from source to sink ; } *accept assimilates / products of metabolism, if in context of cardiac glycosides*

I *ref. to* transport of, amino acids / sucrose

2 *ref. to* source, is place of synthesis / AW **or** sink is / movement to, area where not manufactured / storage area / area where they are required ;

3 as defence mechanism (e.g. against sap feeders) ; [4]

19. O/N 18/P21/Q5/b

(a) *any two from*

transport of sucrose / assimilates / products of photosynthesis (in phloem), is prevented / AW ;
ref. starch synthesised in root from transported assimilates / AW ;
starch not converted in leaf to sugars / sucrose, (for transport) ;
idea that pathogen and phloem present in, all organs / many organs / leaves / roots ;
AVP ;
e.g. reason(s) why it cannot be xylem [2]

20. M/J 18/P22/Q1/d

(a) (i) *two from:*

cell wall, pathway / route / AW ; **A** involves only cell walls **R** if only in roots
movement / AW, through intercellular spaces / spaces between cells ;
further detail ; e.g. water does not, enter cells / cross membranes / cross cytoplasm / move through plasmodesmata
osmosis does not occur
membranes not involved
R osmosis once only

(ii) *four from:*

hydrogen bonding (between water molecules) ;
water molecules are polar ;
movement to spongy mesophyll cells
adhesion / attraction, to, cellulose / cellulose fibres / cell walls ;
this is in context of leaf cells but also allow for xylem
R cell walls of lignin
A hydrophilic parts of lignin
cohesion between water molecules / (water molecules are) cohesive ;
idea that movement of water (molecules) towards, spongy / mesophyll, cells, pulls / AW, other water molecules ;
A transpiration pull / continuous column / unbroken column
I continuous stream
movement to intercellular air spaces
water molecules absorb heat (energy) ;
bonds break between water molecules ;
evaporation / water to water vapour ; **I** latent heat of vapourisation
from spongy cell, walls / surfaces ;

(iii) *two from:*

transpiration occurs ; *in context of via stomata or via cuticle*
diffuses / moves / AW, to, (external) environment / atmosphere / outside / out of the leaf / from leaf surface ;
R evaporation / osmosis
R from cell surface

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via (open) stomata (for, gas exchange / carbon dioxide entry / photosynthesis) ;
accept Ψ for water potential
I solute potential / ref. to concentration
(movement of water vapour) down water potential gradient ;
A down water vapour potential gradient
A high to low water potential / to lower water potential / from higher water potential
R from high to low water potential gradient [8]

21. M/J 18/P21/Q2/c

(a) *hydrostatic required once only in the answers*
four from:

1 diffusion, into phloem sieve tube (element), from companion cell (through plasmodesmata) ;
2 presence of sucrose (in phloem sieve tube element), lowers water potential / makes water potential more negative; R if in context of xylem vessels or companion cells
3 water enters (sieve tubes), by osmosis / down water potential gradient (into sieve tubes) ;
4 increase in, hydrostatic, pressure (in sieve tube elements) ;
A turgor pressure
5 low hydrostatic pressure in, storage tissues / root / sink, by removal of sucrose ;
6 movement of, (phloem) sap / sucrose (in solution), down hydrostatic pressure gradient / from high to low hydrostatic pressure ;
7 mass flow ; [4]

22. M/J 18/P21/Q6/a,b,c

(a) A – endodermal (cell) ; A endodermis / passage cell
B – apoplast(ic) ;

(b) *five from:*

1 water potential gradient, between leaves and roots ;
A water potential gradient across the root (root hair to xylem / across cortex)
2 diffusion out (via stomata) of water vapour ;
3 evaporation of water from mesophyll cell, surfaces / walls / membranes ;
4 (transpiration from leaves) creates transpiration pull ;
5 tension is, set up / present, in xylem vessels ;
6 cohesion between water molecules (*in xylem or in roots)* ;
7 hydrogen bonding between water molecules ;
8 adhesion of water molecules to cellulose (in wall of xylem vessels) ;
A to hydrophilic parts of lignin
9 movement of water from apoplast through endodermis by osmosis ;
10 AVP ; e.g. *idea that* water columns extend from centre of root to root hairs (and to soil water)

(c) *two from:*
pathway C is slower ***accept ora for pathway B is faster***
greater resistance ;
water passes across membranes ;
water flows through, cytoplasm / plasmodesmata ;
A ora ref. to intercellular spaces
A protoplast
osmosis occurs ; R through plasmodesmata
ref. to water passes through vacuoles ; [9]

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23. M/J 18/P23/Q3/a,b,c

(a) *max 2 if only one section attempted*
three from:
multilayered epidermis
reduces, cuticular transpiration / loss of water vapour through cuticle ;
increases distance for diffusion (of water vapour to cuticle) ;
ref. to protection from heat from sunlight and reduced evaporation (from spongy mesophyll cells) ;
stomatal crypts
creates area of moist air / AW ; **I** traps water
minimises effect of, external air currents / wind ;
reduces / less steep, water potential gradient (between intercellular air space and external environment) ;
A water vapour potential gradient
A diffusion gradient if referenced to water vapour
ref. to only on lower surface / shaded, and reduced evaporation (from spongy mesophyll cells) ;
A lower temperature reduces rate of diffusion of water vapour (out via stomata)

(b) phloem sieve tube element(s) ;
A phloem sieve tube (cells)
A sieve elements
I companion / transfer, cells

(c) *allow named assimilates*
source
in context of assimilates
site of synthesis ;
A described e.g. photosynthesis in leaf / storage compound breakdown in roots
sink
in context of, via phloem / from source / from leaf
I nutrients / substances, unqualifed *if assimilates / named assimilate, not stated when explaining source*
site where assimilates are stored
A described e.g. roots for storage of starch
or
area where, growth occurs / assimilates are used for growth
A described e.g. growth in developing buds / growth of immature leaf
or
area that receives, assimilates / AW ;
A area where sucrose unloaded
I place that needs assimilates
I place where assimilates are used, unless qualified [6]

24. O/N 17/P22/Q5

(a) **A** = root hair (cell) ;
B = Casparian (strip) ;
C = plasmodesmata / plasmodesma ;

(b) xylem has no cytoplasm / symplast pathway is cytoplasmic (and vacuolar) ;
A empty / hollow / no contents
A cytosol for cytoplasm
xylem (vessel elements) are dead cells / symplastic through living cells ;

(c) *three from*
stomata close ; **I** stomatal pore smaller / stomata partially open
only cuticular transpiration ;
no photosynthesis / carbon dioxide not needed ; **I** less photosynthesis

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transpiration (rate) decreases ; **A** less, transpiration / transpiration pull,. **A** described in terms of loss of water vapour from leaves
evaporation (rate) (from cell walls of spongy mesophyll cells) decreases ; **R** evaporation, from leaf surface / through stomata
water potential gradient between, soil / root, and leaf becomes less steep ; [8]

25. O/N 17/P21Q6

(a) *mark first two statements given*
cellulose, cell wall / lining, allows adhesion of water ;
thick (cellulose) cell wall prevents collapse / *idea of* providing support (under tension) ;
(cell wall impregnated with) lignin, for waterproofing / prevents water loss ;
lignin, rings / spirals / thickening / AW (of walls), prevents collapse / *idea of* providing support (under tension);
A lignified walls
no cytoplasm / lack of contents / hollow / empty (lumen), gives, less resistance to / unimpeded / uninterrupted / unhindered / ease of, flow ; **A** greater volume per unit time / faster rate
R continuous, smooth **R** dead ack of end walls / continuous tube, so, less resistance to / unimpeded / uninterrupted / unhindered / ease of, flow ; AW
R continuous, smooth
pits / pores, for lateral movement / for movement around air bubbles / supplies (water) to (surrounding), cells / tissues ;
R holes
wide / large diameter / large lumen, so large volume of water can be transported ;
if max 2 not gained, allow one mark for two correct explanations or descriptions where accompanying descriptions and explanations are in context

(b) *two from*
only sieve tubes / one type, v, arteries, veins and capillaries (any two) **A** three types;
sieve tubes are composed of cells v blood vessels composed of tissues ; **A** ref. to named tissues sieve tubes, have cytoplasm **or** blood vessels are, hollow / AW ;
sieve tubes have sieve plates ; **ora**
sieve tubes have companion cells (to fully function) ;
veins have valves ; **ora**
ref. to blood vessels and vasoconstriction ; **ora**
idea of transport open (phloem) v closed (blood vessels) ; **A** sieve tubes have plasmodesmata
ref. to unidirectional flow in blood vessels ; **ora**

(c) *three from*
mitochondria, synthesise ATP / carry out aerobic respiration ;
more ATP needs to be synthesised / increased ATP synthesis ; **A** need to produce large quantities of ATP to provide more (metabolic) energy ; **R** *in context of water uptake*
for active transport / active uptake ; *in context of mineral ions* **A** to move mineral ions against the concentration gradient [7]

26. O/N 17/P23/Q5

(a) *in context of / from a plant*
loss of water vapour ;
I evaporation unqualified
from, the aerial parts / leaves ;

(b) *description of Fig. 5.1B – accept if correct unit is used only once*
four from
1 decrease then increases ;
2 data with units and minus sign(s) in support ;

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i.e. decreases to, –1.35 ± 0.01 MPa at 1400
i.e. –0.35 ± 0.01 MPa at 0600 to –0.58 ± 0.01 MPa at 1800

explanation to max 3

overall decrease between 0600 and 1400

3 water is used *or* lost and is not being replaced ;

4 *idea of* synthesis of (named) solutes increases (so decreasing water potential) ;

0600 to 0900/0915 accept any specific time within these time frames

5 *idea that* not enough water supplied from, xylem / transpiration stream ;

6 (because) stomata are closed / only cuticular transpiration occurs ;

0900/0915 to 1400

7 *idea that there is a* high loss of water (from cell surfaces), by evaporation / because of high rate of transpiration

0900 to 1400

8 photosynthesis occurring, stomata open (for CO_2), water vapour diffuses out / rate of transpiration increases

1400 to 1800

9 less photosynthesis as, stomata closing / lower light intensity

10 (named) solutes converted to, starch / sucrose and transported away ;

11 AVP ; e.g. *0900 to 1400* water is used in photosynthesis so water potential decreases

(c) sunken stomata

or

stomata in, grooves / crypts / pits ;

trichomes / hairs ;

rolled / curled, leaves ;

A folded **R** coiled [9]

27. M/J 17/P22/Q4/c,d

(a) (i) growing / storage, area / region / correct named part of plant ;

examples of part of plant that stores / growing

root / shoot tip / bud / flower / maturing leaf / tuber / fruit / seed

I where sucrose, used / used up **I** nutrients unqualified

receives, assimilates / sucrose / AW ; **A** area where sucrose unloaded

in context of, via phloem / from source / from leaf

(ii) *strong*

high requirement for assimilates ;

fast growing / highly active ; AW e.g. requires a lot of energy

(b) *accept H^+ / protons, throughout for hydrogen ions*

1 active process / uses ATP / requires energy ;

2 hydrogen ions, pumped / active transport / move(d), out of companion cells ;

this also gets mp1 if stated as, pumped / active transport / move by proton pump

3 into cell wall / apoplast ; **A** intercellular space **R** pumped into phloem sieve tube

4 hydrogen ion gradient builds up ;

5 hydrogen ions re-enter companion cell, down gradient / AW ; **A** facilitated diffusion

6 via, cotransport protein(s) / cotransporter(s) ; **A** carrier protein(s)

'hydrogen ions diffuse back into companion cell through cotransport protein' is two marks

7 <u>cotransport</u> sucrose (molecules) ; **A** secondary active transport **A** idea of bringing sucrose into companion cell if cotransport / er stated for previous mp **R** cotransport if into phloem sieve tube from companion cell

8 transport of sucrose against gradient ;

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9 diffusion of sucrose into phloem sieve tube (element) ; **R** facilitated diffusion
A moves from high to low concentration
10 via plasmodesmata ; [6]

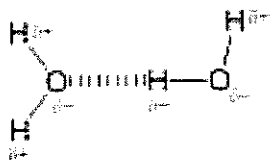
28. M/J 17/P21/Q5/b,c

(a) *accept H^+ for proton throughout*
1 (*at Y*) protons, pumped out (of companion cell) / moved out by active transport / move out through proton pump ;
A protons are moved out against concentration gradient
2 creates a, proton gradient / electrochemical gradient ;
3 protons go into the, cell wall / apoplast ; **R** mesophyll cell
4 (*at X*) protons enter cell by facilitated diffusion ;
5 (**X** is) cotransporter / cotransport protein ;
6 sucrose transported into (companion) cell together with protons ;
7 (sucrose enters) against concentration gradient ;
8 sucrose concentration, increases / maintained, in companion cell ;
9 sucrose diffuses into sieve tube (element) ;
10 through plasmodesmata ;
11 AVP ; e.g. *ref. to*, secondary / indirect, active transport

(b) *look for names of plant organs other than leaves, ignore names such as potato, iris, onions*
R leaves unqualified
any two for max 1
root / root tip
stem / stem tip / shoot / shoot tip
tubers
bulbs
corms
rhizomes
buds
flowers
fruits
seeds
young / maturing / developing / infected, leaves
AVP [6]

29. M/J 17/P23/Q6

(a) two water molecules drawn with correct bonding ;
I Fischer projections
partial charges shown as σ+ on at least one H and σ– on at least one O ;
hydrogen bond shown ; e.g. labelled or as dashed or dotted lines between H of one molecule and O of another ;



(b) (i) cohesion ;
(ii) high / large, latent heat of, vapourisation / evaporation ;
A takes a large amount of, heat / energy, to evaporate / turn liquid to water vapour [5]

30. O/N 16/P22/Q2/b

(a) *'source' and 'sink' not required but statements should be in correct context*
three from (source)

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1 *idea that* sucrose presence in, phloem / sieve tubes, causes, low(er) / more negative, water potential / Ψ ; AW
A assimilates / photosynthates / sugars / named, *for sucrose*
2 water, enters / AW (sieve tube by osmosis) ; *can be in context of direct entry or from surrounding cells* **R** from root hairs
3 presence of water increases hydrostatic pressure ; **A** turgor *(for hydrostatic)*
A *idea of: causes high(er) hydrostatic pressure because of entry of water (hence increase in volume)*
(sink)
4 *idea that* water follows sucrose (via companion cell to sink cells, hence osmosis) ;
5 lower hydrostatic pressure (at sink) ; **A** low *if in context of high at source*
hydrostatic or turgor needed only once (in mp3 or mp5)
6 movement / mass flow (of sap), down a pressure gradient / from high to low pressure ; **R** if osmosis implied for mass flow [3]

31. O/N 16/P21/Q2

(a) (i) loss of water vapour from the, leaves / aerial parts of a plant ;
R water evaporates from the surface of the leaf

(ii) *each factor 1 mark, explanation for each factor 1 mark*
look for ora for explanation
temperature ; **I** high / low or hot / cold
increased temperature, increased rate as higher rate of, evaporation (from spongy cell surfaces) / diffusion (of water vapour out via stomata)
or
at very high temperature stomata close so transpiration, stops / slows ;
humidity ; **I** high / low
one from
increased humidity, decreased rate as, less steep water potential gradient / decreased diffusion rate (of water vapour out via stomata) ;
wind (speed) / air movement ; **I** fast / slow
higher wind speed steeper, water potential gradient / higher diffusion rate (of water vapour out via stomata) / diffusion shells do not build up / wind moves moist air away / AW
or
at high wind speed the stomata close so transpiration slows ;
water availability ; **I** high / low
reduced water availability causes stomata to close (so reduced rate of diffusion)
or
more water available, steeper water potential gradient between roots and leaves ;
light intensity ; **I** high / low
higher light intensity, increased rate as stomata open more widely
A more light (as ecf from stating factor)
or
at very high light intensity the stomata close so transpiration slows ; **A** stops

(b) *three from*
cohesion and adhesion ; *in correct context*
transpiration stream / transpiration pull; **A** continuous column of water moving up (to leaves)
attraction / cohesion, between water molecules ; **A** water is cohesive
A stickiness between water molecules
adhesion / AW, of water molecules to lining of xylem (vessels) ;
only needs 'molecules' once
adhesion to / AW, cellulose molecules / hydrophilic parts of lignin ; [8]

32. O/N 16/P23/Q3

(a) **A** = cortex / parenchyma ; **A** cortical **R** cortical / parenchyma, cells

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B = endodermis ; **A** endodermal **R** endodermal cells / pericycle
C = xylem ; **I** vessels / tracheids
D = phloem ; **I** sieve tube (elements)

(b) *allow ecf from incorrect naming of **A** and **B** in (a)*
four from
*from **X** to endodermal cell (**B**) or **X** to **Y** to 3 max*
1 (movement of water) via cell membrane / via tonoplast / by osmosis ;
2 (movement of water) through plasmodesmata ; *do not award **mp1** for 'by osmosis through plasmodesmata'*
3 symplast pathway ; *in correct context only*
*from after **B** to **Y** to 3 max*
4 water moves by apoplast pathway ; *in correct context only*
5 water moves through cell walls ;
6 via pits in cell walls of, xylem (vessel) / **Y** ;
7 down a water potential gradient / described as higher water potential at **X** ; [8]

33. M/J 16/P22/Q2

(a) (i) curled / rolled, leaf ; **R** curly / curved / folded
or
trichomes / hairs ; **A** hair / hairy,-like structures **R** cilia / spines / needles

(ii) *allow explanations for stomata in pits, thick cuticle and no stomata on outer surface as ecf from (i)*
curled leaf / trichomes / stomata in pits
ref. to (creates) still / non-moving, air ;
(in enclosed area) humid / moist ; AW, e.g. traps water vapour / maintains humidity
water potential gradient less steep **or** decreased rate of diffusion of water vapour (out) ;
A (water) vapour pressure gradient for water potential gradient
I decreased concentration gradient of water vapour
assume in context of between substomatal air space and enclosed area unless stated otherwise
thick cuticle
greater layer impermeable wax / AW ; **A** thicker waterproof layer
increases distance for diffusion ;
of water vapour ;
no stomata on outer surface
most water lost via (open) stomata ;
cuticular transpiration only ;
ref. to where most exposure to, light / air currents / wind ;

(b) xerophytic / xerophyte ; [4]

34. M/J 16/P21/Q4

(a) *transpiration is an inevitable consequence because*
1 stomata open ;
2 for diffusion in of carbon dioxide / carbon dioxide required for photosynthesis ;
3 water vapour, diffuses out / moves out down the water potential gradient ;
A description of water potential gradient / high to low water potential
A vapour pressure gradient / water vapour gradient
allow water vapour if it is clear that evaporation has occurred
A water evaporates and diffuses out
R water evaporates out
I water (vapour) concentration gradient

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(b) 1 adhesion of water to, cellulose/lining/walls (of xylem vessels) ;
A adhesive force
2 ref to, hydrophilic/polar, property of cellulose (fibres) ;
A hydrophilic/polar, parts of lignin
3 cohesion between water molecules ; cohesive force
4 maintains column of water/prevents water column breaking/AW ;
5 *ref. to* transpiration pull/AW ; I transpiration *unqualified*

(c) *mp3 – units for rates of transpiration must appear once correctly in the whole answer to award this point*
1 rate (of transpiration) of all trees is 0 at, 06.00/start ; A no transpiration
2 rates (of transpiration) increase and decrease (in all three) ; A peaks
3 highest rates:
emergent trees at 14.30 at 8.5 kg h^{-1}
canopy trees at 14.30 at 3.5 kg h^{-1}
suppressed trees at 13.00 at 1.6–1.7 kg h^{-1} ;
must have units at least once
accept kg/h or kg per hour
4 emergent trees (always) have highest rate **or** suppressed trees have lowest rate ;
A emergent trees have higher rate than, canopy and suppressed, trees
5 rate of emergent trees is, much/AW, higher than rates for canopy and suppressed trees ;
6 emergent trees have, steeper/steepest, increase in (transpiration) rate ;
A emergent trees have, steeper/steepest, decrease in (transpiration) rate

(d) *following factors may be given in answers, any three of these factors = 1 mark*
light, intensity/wavelength I 'more light'
humidity
temperature
wind speed/air movement
size of tree/height/area of leaves
water availability/depth *or* length of roots
transpiration rate for emergent trees is higher because … accept **ora** *for suppressed trees*
accept vapour pressure gradient/water vapour pressure gradient/water vapour diffusion gradient for water potential gradient
1 high(er) light intensity for emergent trees increase in stomatal aperture ; ora
A more sunlight
A stomata open more
I more stomata open
2 lower humidity for emergent trees so steeper water potential gradient ; ora
A description of water potential gradient
3 higher temperature/AW, for emergent trees so higher rate of, evaporation/diffusion ; ora
4 higher wind speed for emergent trees so, steeper water potential gradient/lower humidity ; ora
A *ref. to* diffusion shells/descriptions of water potential gradient
5 emergent trees have longer roots so take up more water ;
6 emergent trees have more leaves so, greater surface area/more stomata per unit area (of leaf) ; [14]

35. M/J 16/P23/Q4

(a) label line to wall or lumen of any phloem sieve tube ;

(b) transport of assimilates ; A named assimilate e.g. sucrose/amino acids/auxins

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from source to sink ; **A** from leaves to named sink e.g. roots / fruits
translocation / mass flow ;

(c) lignin for, waterproofing ;
lignin, for support / to prevent (inward) collapse / AW (of vessel or plant) ;
R prevent bursting **I** withstand (high) pressure
cellulose for, adhesion of water / formation of hydrogen bonds with water ;
A hydrophilic parts of lignin
pits for lateral movement of water ;
AVP e.g. rings / spirals, for, extension / growth ;

(d) (i) *surface area* ($0.1 \times 0.1 \times 6 =$) 0.06 ($m^2$) ;
volume ($0.1 \times 0.1 \times 0.1 =$) 0.001 ($m^3$) ; **A** 1×10^{-3}
surface area to volume ratio
(0.06 / 0.001 =) 60 ; **A** ecf using values given for surface area or volume

(ii) *idea that*
diffusion (via, body surface / to cells), cannot satisfy needs / too slow ;
or
transport system delivers materials to cells more quickly ;
A efficient supply of, nutrients / oxygen, to all cells
long(er) distances (to reach some, cells / tissues) ;
takes, materials / AW, close to cells ; [11]

36. O/N 15/P22/Q6/c

(a) (i) **I** *ref. to* xylem / transpiration stream
transpiration
involves only water (molecules) ;
involves, evaporation / diffusion / evaporation and diffusion ;
I *ref. to* evaporating surface
movement out to (external) environment / loss from leaves ; **A** aerial parts
affected by, external factors / humidity / light / wind speed / temperature ;
occurs in one direction / from air spaces through stomata ;
ATP not required ;
translocation
involves, assimilates / photosynthates / sucrose / other named ; **A** cell sap
involves (hydrostatic) pressure gradients ; **A** mass flow
involves transport in phloem (sieve tubes) ;
flow from source to sink / AW ;
ATP used (to enable loading of sucrose into phloem sieve tube) ; **A** active

(ii) both involve, transport / movement of substances ; **R** if transport in xylem stated
both involve water ;
both require energy ; *(transpiration – evaporation requires heat energy and translocation – hydrogen ions pumping out of companion cells)* [2]

37. O/N 15/P21/Q4

(a) (i) loss from, leaves / aerial parts of plant ;
of water vapour ; *link to first point*
plus one from:
evaporation of water, from surface of spongy mesophyll cells / into air spaces ;
diffusion of water vapour, out / to atmosphere ; **R** evaporation
movement / diffusion, (out) through (open) stomata ; **R** evaporation
water vapour moves (out) down the water potential gradient ;

(ii) *adaptation for 1 mark, explanation to max 2*
thick (waxy) cuticle ;

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explanation
idea that wax is, (mainly) impermeable to water / hydrophobic / barrier to water vapour movement ;
reduces, water loss from parts with no stomata / uncontrolled water loss / cuticular transpiration ;
idea that increased distance decreases rate of diffusion of water vapour
or
reflective cuticle ;
explanation
reduces heat load ;
reduces evaporation (from spongy mesophyll cells surfaces) ;
reduces rate of diffusion of water vapour (through cuticle) ;
or
folded inner surface / AW ; **A** trichomes / hairs ;
explanation
traps water vapour / AW ;
reduces, diffusion / water potential, gradient ;
(water potential gradient) between sub-stomatal air space and outside / AW ;
or
no stomata (visible) on the, outer / exposed, surface ;
explanation
idea that stomata are main route for water loss ;
idea that reduces area where there is a high rate of water loss ;
surface directly exposed to air currents has no stomata ; ora
R curled or rolled *given as adaptation but allow explanation to max 2*
explanation
stomata on inside ;
no / away from, air currents ; **A** increases humidity within enclosed space / AW
reduces, diffusion / water potential, gradient (between sub-stomatal air space and outside);

(b) (i) 18 g h^{-1} ;;
one mark if no units given
one mark if incorrect answer but correct values extracted from Fig. 4.2 (60–42 g h^{-1})

(ii) *describe to max 3*
rate of, transpiration / water absorption, increases and decreases / reaches a peak ;
time delay between high rates of transpiration and water absorption / AW ;
lower values for water absorption until (approx.) 1645 ; **ora** **A** 1630 to 1700
data quote to support ;
explain to max 3
ref. to daylight and night and stomatal, opening / closure / AW ;
higher light intensity / greater stomatal opening, higher rate of transpiration ;
ora
idea that transpiration drives water absorption ;
further detail ; e.g. explanation in terms of water potential gradient
ref. to cohesion-tension from leaf to root

(iii) xerophyte ;
example of xeromorphic feature ; **A** *ref. to* adaptation(s) (for dry areas)
high light intensity during middle of day / AW (for species **P**) ;
idea that loss of water during the day needs to be minimised ;
suggestion that (most) stomata, closed during the day / only open at night ; [14]

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38. O/N 15/P23/Q2

(a) (i) **A** Ψ *for water potential*
I moisture
A aperture *for stomatal aperture throughout*
both units must be used at least once to award mp3 and mp7
similarities
1 when, stomatal aperture is 0 (μm) / stomata are closed, no, transpiration / water loss ;
2 as stomatal aperture increases rate of transpiration increases in both groups of plants ;
3 comparative use of figures with units in support of mp2 for either condition ;
differences
in moving air
4 stomatal aperture, influences / controls / AW, rate of transpiration at all apertures ;
in non-moving air
5 at stomatal apertures 15 μm and above rate of transpiration does not increase further / reaches a plateau / remains constant ;
6 stomatal aperture has most effect on rate of transpiration in non-moving air at low apertures ; **ora**
comparing moving and non-moving
7 comparative use of figures with units to show rates of transpiration at the same stomatal aperture ;

(ii) **A** water vapour potential *for water potential*
1 *ref. to* increasing width of stomatal aperture allows more water vapour to diffuse out; **ora**
R osmosis, **R** evaporate out
I evaporation from mesophyll
2 (intercellular) air spaces in leaf, are fully saturated / have high water potential / AW ;
3 in moving air, water vapour is blown away / does not remain around the leaf ; **A** low humidity around the leaf, **A ora** *for non-moving air*
4 in moving air, water potential gradient, is steep / maintained / increases / AW ; **ora** for non-moving air, **R** concentration gradient
5 so in moving air, high / higher, rate of diffusion of water vapour *in terms of an idea of a* gradient ; **A ora**

(b) (i) *advantage of having, stomata in pits/AW*
water vapour / moist air, builds up / trapped, in the, pit / groove / crypt ;
A sunken stoma(ta)
reduces water potential gradient, between air inside the leaf and outside / AW ;
A diffusion gradient
less transpiration / less diffusion of water vapour out (through stomata) / water is conserved ;
R prevents water (vapour) loss
less water needs to be absorbed ;

(ii) *treat 'less gas exchange' unqualified as neutral*
cannot absorb carbon dioxide (during the day when photosynthesis occurs) ;
rate of photosynthesis is reduced / no photosynthesis ;
AVP ; e.g. less water / minerals, reaches leaf cells (for other processes)
cooling effect of transpiration does not occur
slow growth

(iii) **I** moisture
1 leaves, rolled / curled, so, stomata on inside / humid layer builds up / moist

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air builds up, (in enclosed area) ;
A less steep water potential gradient
R coiled / curved

2 trichomes / hairs, create, a layer of non-moving air around the leaf / allow humid area to build up ;
A less steep water potential gradient

3 (leaves are), thick / succulent, to store water ;

4 thick(er) (waxy) cuticle reduces, transpiration / water loss ;
A makes more waterproof, **A** waxy layer for cuticle

5 reflective cuticles, reduce heat load / AW ; **A** shiny cuticles reflect heat ;

6 needle-like leaves to reduce surface area (to volume ratio so less, transpiration / water loss) ;
A small leaves
R spikes / spines, unqualified

7 layers of epidermal cells, to reduce (cuticular) transpiration / water loss ;

8 thick walled epidermal cells, to reduce (cuticular) transpiration / water loss ;

9 *ref. to* hinge cells, leaf curling / wilting / AW ;
A leaves wilt to reduce exposure to the sun ; [11]

39. M/J 15/P21/Q3

(a) increased / faster, movement / diffusion, of, assimilates / amino acids / sucrose / water / solutes / ions / molecules ;
I substances / particles / carbohydrates
I freely / easily / efficiently
I osmosis
(because) more, (symplast) pathways / passages / AW ;
accept in context of blockage of some plasmodesmata
correct ref. to symplast pathway in context of an advantage ;
e.g. of complex plasmodesmata ;
from companion cell into sieve tube (elements) / when loading sucrose into phloem
AVP ; e.g. selectivity / control / regulation, of movement

(b) 1 mass flow ; **A** pressure flow

2 sucrose / solutes / assimilates / sugars, decreases, water potential / solute potential ; **A** symbol(s) Ψ

3 water enters (sieve tubes), down water potential gradient / by osmosis ;

4 increase in / high(er), hydrostatic pressure ;

5 unloading / removal, of sucrose at the sink lowers the (hydrostatic) pressure ;

6 movement (from source to sink) is by gradient in (hydrostatic) pressure ; [6]

40. M/J 15/P23/Q5

(a) (light microscope) observe living cells / cells would be killed (with EM) ;
vacuum used in electron microscope ;
(light microscope) can have water on slide (to allow cells to move) ; ora
AVP ; e.g. more readily available for use
organisms move in response to light

(b) (i) (part of / used in synthesis, of) chlorophyll (molecule) ;
R gives chlorophyll green colour
in translation / joining of large and small subunits (of ribosomes) ;
enzyme, cofactor / activator / described ; *idea of role in enzyme catalysis*
A correctly named enzymes e.g. DNA polymerase
AVP ; e.g. stabilizing, cell wall / proteins / nucleic acids / membranes
important in energy transfers / ATP synthesis
DNA, synthesis / replication

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ref. to role in, light absorption / capture (for photosynthesis)

(ii) *any two from*
- 1 good solvent / polar (for substances needed by the organism) ; AW
- 2 transparent / allows light through, (for photosynthesis) ;
- 3 liquid over wide range of temperatures ;
- 4 high specific heat capacity ; **A** description
- 5 high latent heat of vaporisation ;
- 6 ref. to density ; e.g. ice / solid, less dense than, water / liquid
  circulation bringing nutrients to surface
- 7 ref. to low viscosity for locomotion ;

(c) *assume multicellular organisms unless stated, then accept ora*
- 1 small, surface area to volume ratio / SA:V ;
  A as organisms increase in size, SA:V decreases
- 2 ref. to (larger size means) long distances (to reach, cells / tissues) ;
- 3 diffusion, too slow / insufficient / unable to satisfy needs ;
- 4 transport system decreases time to supply cells ;
- 5 require, bulk / mass, flow ;
- 6 ref. to transport system means efficient supply (to cells) of nutrients / named / assimilates / water ; **A** brings supplies close to cells (for transfer)

(d)
- 1 mass flow ; **A** pressure flow
- 2 sucrose / solutes / assimilates / sugars, decreases, water potential / Ψ;
  A more negative / lowers, water potential
  A for water potential **A** solute potential
- 3 water enters (sieve tubes) by osmosis ;
- 4 (water enters) down water potential gradient ;
- 5 (increased volume) increase in / high(er), hydrostatic pressure ;
  ref. to hydrostatic required once only in mp 5 or mp 7or mp 8
- 6 unloading / removal, of sucrose / AW, at the sink / named sink ;
- 7 lowers hydrostatic pressure / low pressure at sink ;
- 8 movement is, down pressure gradient / from high to low (hydrostatic) pressure ;

[14]

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Unit 8
TRANSPORT IN MAMMALS

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

Editorial Board

Syllabus

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Unit 8: Transport in Mammals

1. M/J 22/P22/Q3

Hummingbirds are the smallest of birds and are found in the Americas. Some species migrate hundreds of kilometres between warmer overwintering areas and summer breeding grounds. Like mammals, birds maintain a constant body temperature.

Hummingbirds have a high requirement for sugars because they have a very high metabolic rate. Fig. 3.1 shows a hummingbird feeding on nectar, one of their main food sources.



Fig. 3.1

(a) Nectar is a sugary liquid containing mainly sucrose, fructose and glucose.
Sucrose has the molecular formula $C_{12}H_{22}O_{11}$. Fructose and glucose each have the molecular formula $C_6H_{12}O_6$.
State **two** differences between sucrose and fructose, other than the number of carbon, hydrogen and oxygen atoms present.

.....

..... [2]

(b) In preparation for migration, sugars need to be converted to triglycerides to function as energy reserves. Hummingbirds can double their body mass during this time.

(i) Fig. 3.2 shows the structural formula of one type of storage triglyceride. The triglyceride has two types of fatty acid residue, palmitate and oleate.

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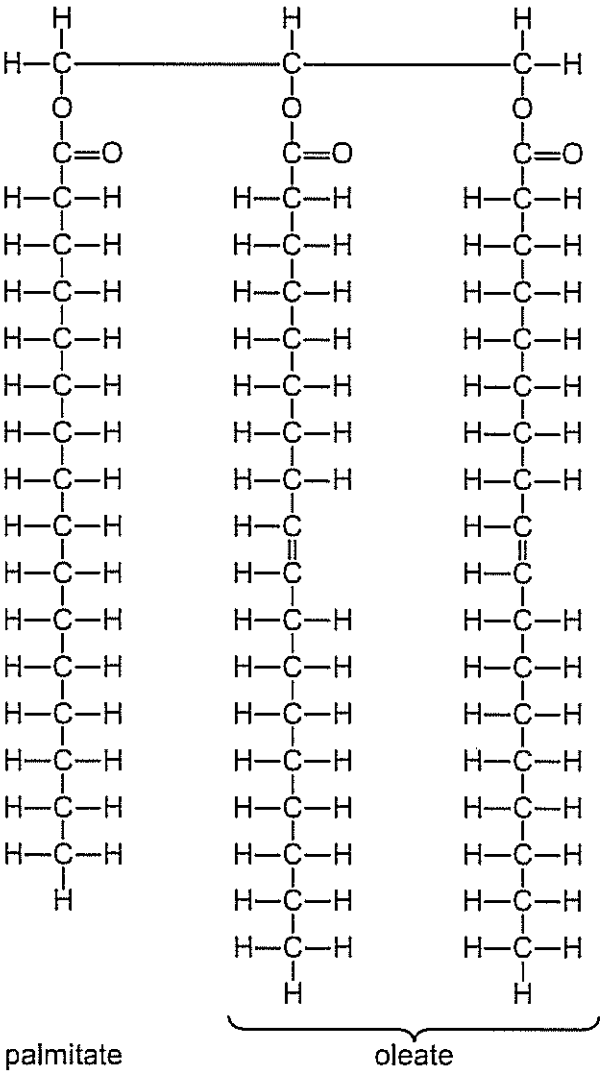


Fig. 3.2

Outline the features of the molecular structure of the triglyceride shown in Fig. 3.2.

.....

.....

..... [3]

(ii) In hummingbirds, glycogen is the long-term carbohydrate energy store.

Suggest **one** reason why hummingbirds build up a greater energy store in the form of triglyceride, rather than a greater energy store of glycogen, in preparation for migration.

..... [1]

(c) In birds such as hummingbirds:

- blood is kept within vessels
- for each complete circuit of the body, blood passes through the heart twice.

State the term used to describe this type of circulatory system.

..... [1]

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(d) The heart of birds has the same structure as the heart of mammals. Compared with the heart of mammals, the heart of birds is larger in proportion to their body size.

Suggest why the heart of birds is larger in proportion to their body size.

.....

..... [2]

(e) Complete Table 3.1 to show the names and functions of the main blood vessels associated with the heart of mammals.

Table 3.1

function of blood vessel	name of blood vessel
carries blood from the heart to the lungs	
carries blood to the heart from the lungs	
carries blood from the heart to the rest of the body	
carries blood to the heart from the rest of the body	

[3]

2. M/J 22/P23/Q6

The sinoatrial node, atrioventricular node and the Purkyne tissue have important roles in the cardiac cycle.

(a) State the precise location in the heart of the sinoatrial node.

..... [1]

(b) State the part of the cardiac cycle that is directly initiated by the wave of excitation sent out by the sinoatrial node.

..... [1]

(c) Part of the control of the cardiac cycle involves the contraction of the ventricle walls after the walls of the atria have finished contracting.

Outline how this control is achieved.

.....

..... [2]

(d) Name the valves of the heart that **open** soon after the Purkyne tissue has received an impulse from the atrioventricular node.

..... [1]

3. O/N 21/P22/Q2/a,c,d,e

The high blood pressure at the arterial end of a capillary network results in some components of blood leaving the capillaries and forming tissue fluid. At the venous end, the presence of plasma proteins allows movement of water by osmosis back into the capillaries.

Fig. 2.1 is a diagram showing a capillary network. The lymph vessels and the blood vessels at the arterial and venous ends of the network are also shown.

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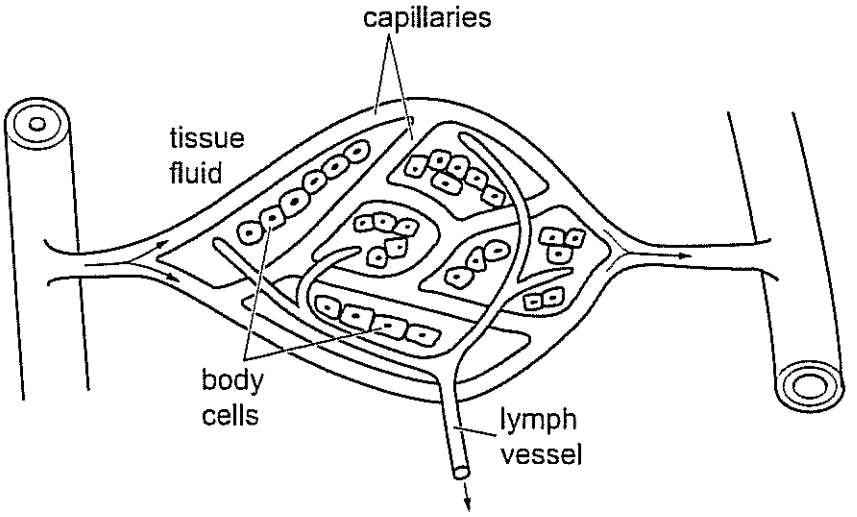


Fig. 2.1

(a) Red blood cells and plasma proteins, such as albumin, remain in the capillaries and are not found in tissue fluid.
Explain why red blood cells and albumin do not leave the capillary.

.....

..... [2]

(b) When a person moves from sea level and stays at high altitude for a few months, there is an increase in the number of red blood cells per mm^3 of blood.
Explain why this increase occurs.

.....

.....

..... [3]

(c) A low blood albumin concentration can lead to a condition known as oedema.
Oedema is a swelling of tissues caused by the accumulation of tissue fluid surrounding the body cells in the capillary network.
Suggest **and** explain how a low blood albumin concentration can lead to oedema.

.....

.....

..... [3]

(d) Albumin transports some cell signalling molecules from the cells where they are synthesised to their target cells. The cell signalling molecules bind to specific cell surface membrane proteins on the target cells.
Name the type of membrane protein to which the cell signalling molecules bind.

..... [1]

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4. O/N 21/P21/Q2/a

(a) Fig. 2.1 is a transmission electron micrograph of a transverse section through a blood capillary that is surrounded by actively respiring cells.

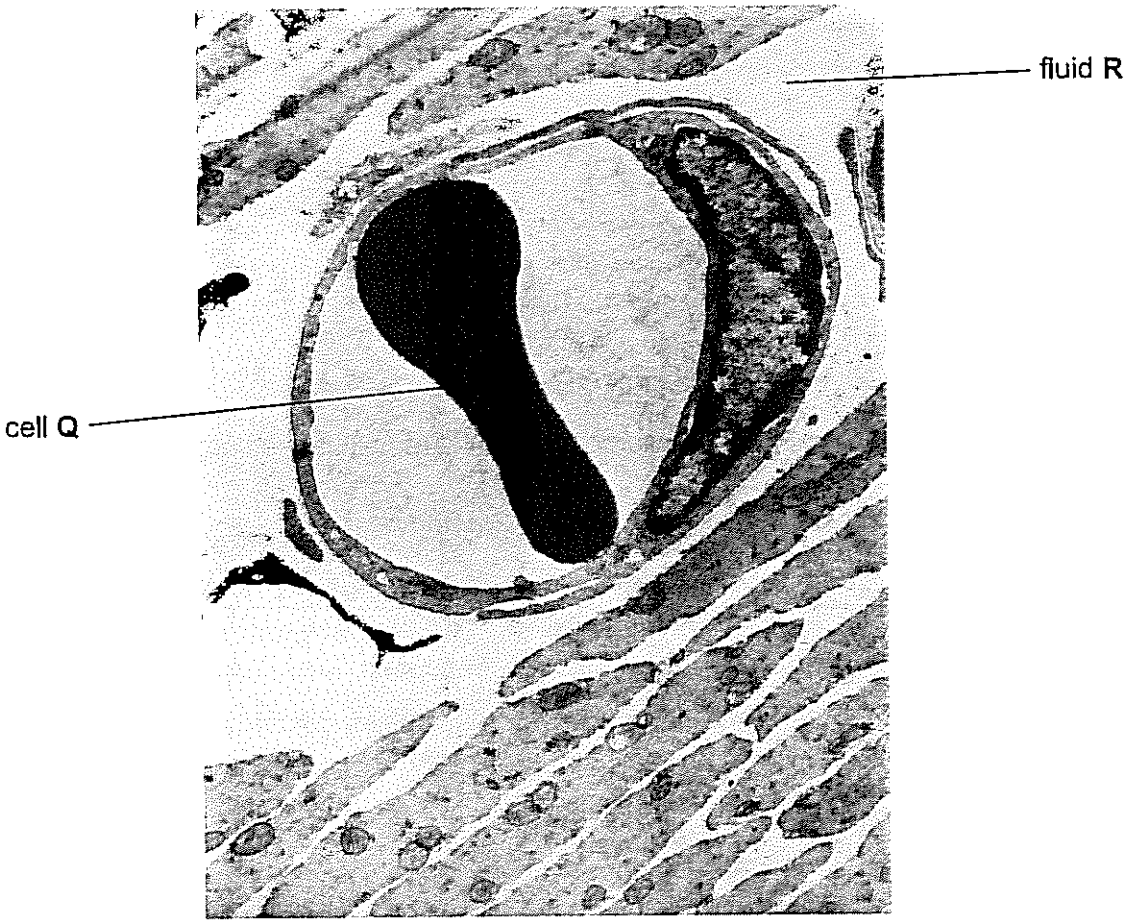


Fig. 2.1

(i) Identify cell **Q** shown in Fig. 2.1.

..... [1]

(ii) Fluid **R** is formed from blood in the blood capillary.
State **and** explain **one** difference between the composition of fluid **R** and the composition of the blood in the capillary.

difference .....

explanation .....

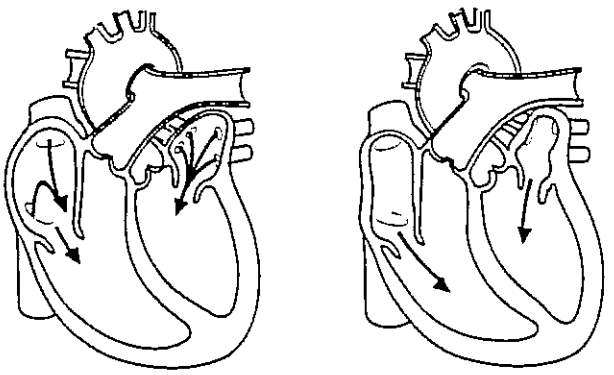
..... [3]

5. O/N 21/P21/Q6

Fig. 6.1 is a diagram of sections through the heart showing two stages of the cardiac cycle, **A** and **B**.

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Stage A Stage B

Fig. 6.1

(a) Name stage **B** in Fig. 6.1 **and** state one piece of evidence from the diagram that supports your answer.

stage **B** .....

evidence ..... [2]

(b) (i) Draw a label line on Fig. 6.1 to identify **one** semilunar valve. Label the valve **S** [1]

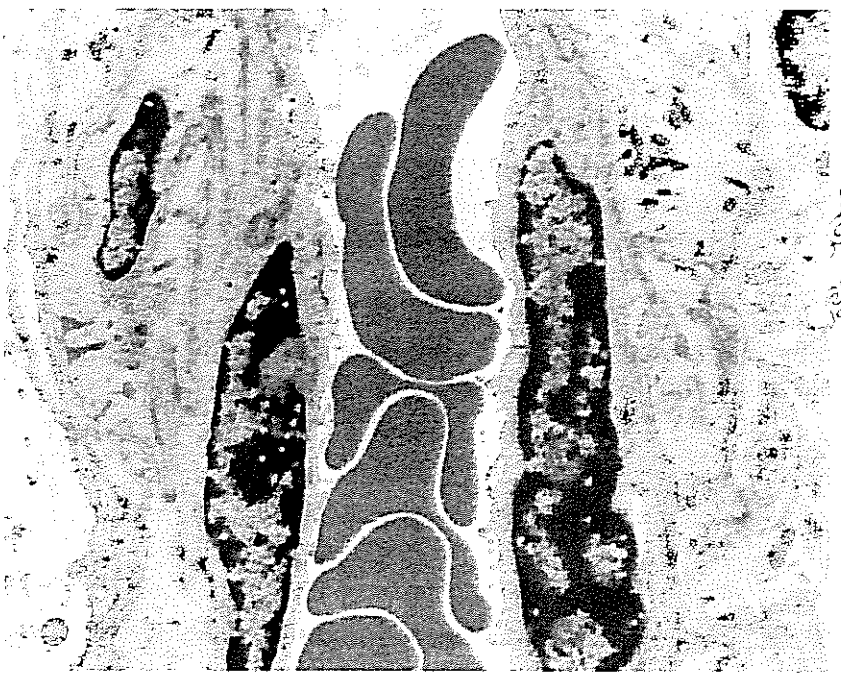
(ii) Describe the role of the semilunar valves in the cardiac cycle.

.....

..... [2]

6. O/N 21/P23/Q3

Fig. 3.1 is a transmission electron micrograph showing red blood cells in a capillary of a healthy adult.



magnification = ×4000

Fig. 3.1

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(a) (i) Explain how the cells in the capillary shown in Fig. 3.1 can be identified as red blood cells.

.....

.....

..... [3]

(ii) Capillaries are surrounded by tissue fluid.
Outline the ways in which the composition of tissue fluid differs from blood.

.....

..... [2]

(b) Scientists compared features of the physiology of three groups of people who live at different altitudes. These people were selected from populations that have lived at these altitudes for many thousands of years.
The scientists took blood samples from people in each location and measured:

- the concentration of haemoglobin in the blood
- the percentage saturation of haemoglobin with oxygen in blood leaving the lungs
- the oxygen concentration in the blood leaving the lungs.

The results are shown in Table 3.1.

Table 3.1

altitude / m	location of group of people	mean haemoglobin concentration in blood / g 100 cm^{-3}	mean percentage saturation of haemoglobin with oxygen in blood leaving the lungs	mean oxygen concentration in blood leaving the lungs / cm^3 100 cm^{-3}
100 (near sea level)	Peru	15.3	97.0	21.1
3500	East Africa mountains	15.6	95.5	21.1
3750 – 4000	Andes mountains	19.1	92.0	22.0

(i) Describe the changes in mean percentage saturation of haemoglobin with oxygen and the mean haemoglobin concentration in blood as altitude increases.

.....

.....

..... [3]

(ii) With reference to Table 3.1, suggest how the people living at high altitude can have an oxygen concentration in blood leaving the lungs similar to that of the people living at sea level.

.....

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.....

..... [3]

7. M/J 21/P22/Q3/a

In mammals, some cell signalling molecules are steroid (lipid) hormones. These hormones are transported in the bloodstream to reach capillary networks.

At a capillary network, hormones pass out of the blood into tissue fluid.

(a) Fig. 3.1 is a diagram of a capillary network.

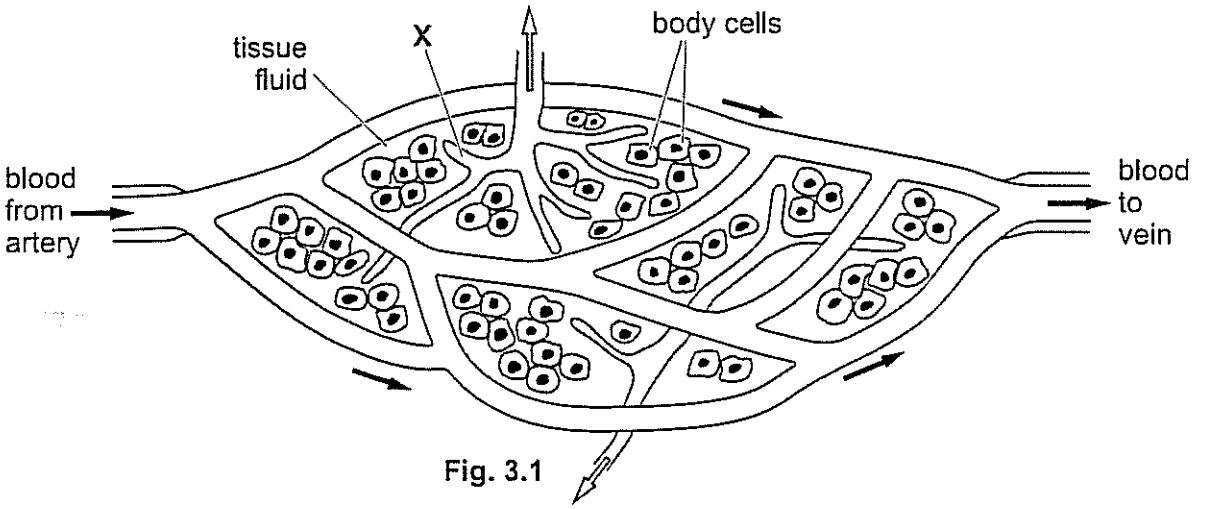


Fig. 3.1

(i) Describe the **differences** between the blood arriving at the arterial end of the capillary network and the tissue fluid surrounding the body cells.

.....

.....

..... [3]

(ii) Not all the tissue fluid passes back into the blood capillaries to enter the bloodstream. Some of the tissue fluid drains into blind-ended vessels, such as vessel **X** shown in Fig. 3.1.

Name the fluid that is formed in vessel **X**.

..... [1]

8. M/J 21/P23/Q5/a,b

(a) Fig. 5.1 shows four types of cell that can be seen in a prepared slide of blood taken from a mammal.



....

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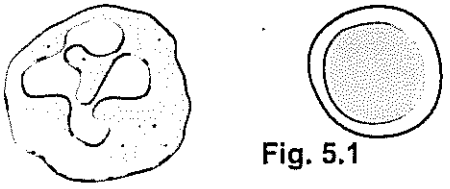


Fig. 5.1

Identify the four types of cell shown in Fig. 5.1.
Write the name of the cell type on the answer line provided by each cell in Fig. 5.1. [4]

(b) During systole and diastole of the cardiac cycle, changes in blood pressure occur in the four chambers of the heart.
Fig. 5.2 shows changes in the blood pressure in the **left** side of the heart and the aorta during one cardiac cycle.

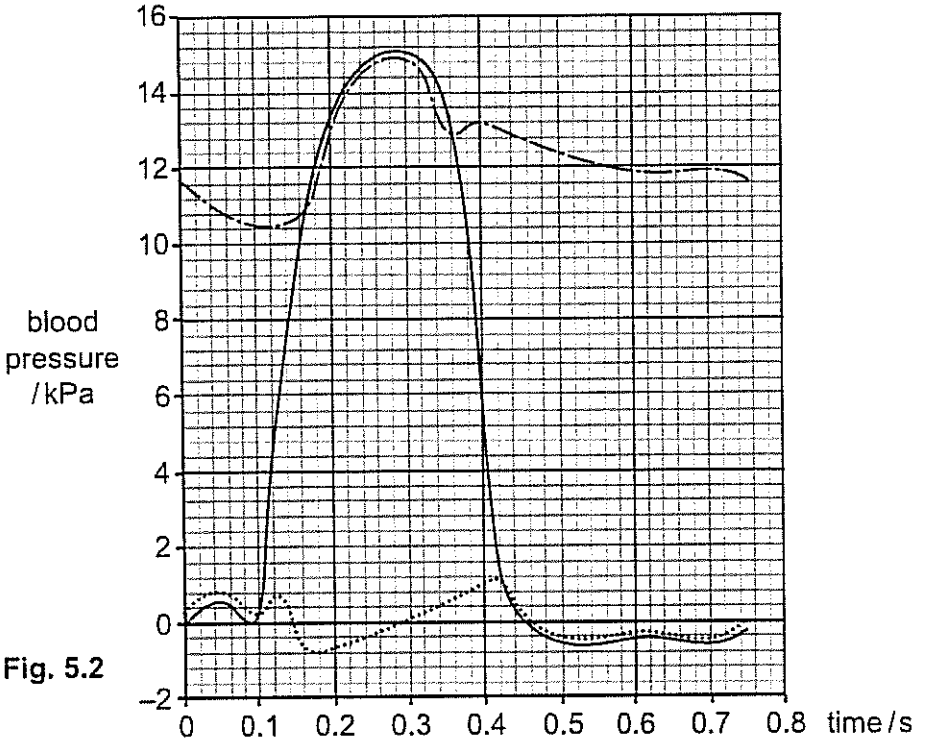


Fig. 5.2

With reference to the blood pressure changes shown in Fig. 5.2:

- state the maximum blood pressure reached in the left ventricle .....kPa
- state the time at which the bicuspid (left atrioventricular) valve closes. ..... s [2]

9. O/N 20/P22/Q6

(a) Fig. 6.1 shows an oxygen dissociation curve for adult human haemoglobin.

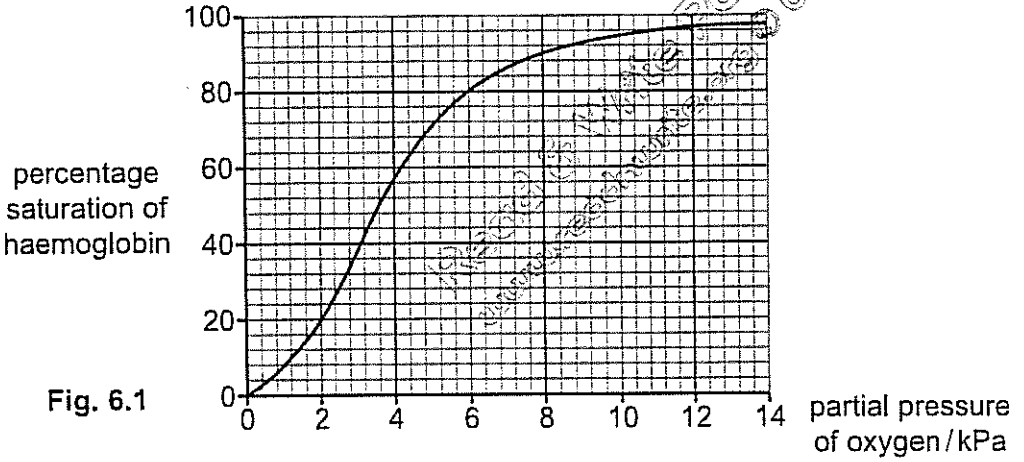


Fig. 6.1

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An increase in the partial pressure of carbon dioxide (pCO_2) in respiring tissue causes the Bohr effect.

(i) Sketch on Fig. 6.1 to show how the Bohr effect changes the oxygen dissociation curve. [1]

(ii) Explain how an increase in pCO_2 produces the Bohr effect **and** state the benefit of this effect for the tissue.

.....

.....

..... [3]

(b) Carbon dioxide (CO_2) is transported across the cell surface membrane of the red blood cell using a different mechanism to the transport of hydrogen carbonate ions (HCO_3^-).
Name the different mechanisms of transport used for CO_2 and for HCO_3^- **and** explain why they are transported across the membrane by different mechanisms.

CO_2 .....

HCO_3^- .....

explanation .....

..... [4]

10. O/N 20/P21/Q3/a

(a) The circulatory system of mammals is a double circulation.

(i) Explain what is meant by the term double circulation.

..... [1]

(ii) Fig. 3.1 is a photograph showing one valve in the mammalian heart.

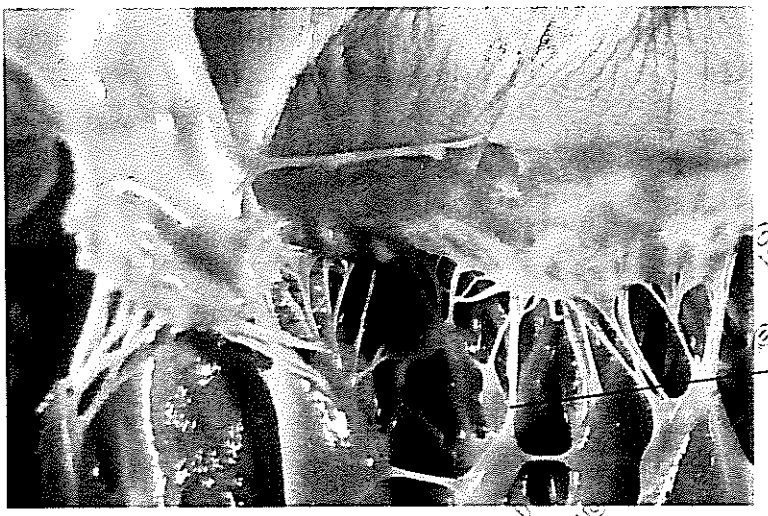


Fig. 3.1

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Identify the structures labelled **A** in Fig. 3.1 **and** describe their role during the cardiac cycle.

structure **A** .....

role of structure **A**

.....

..... [3]

11. M/J 20/P22/Q2

In a healthy mammalian heart, contraction of the four chambers is coordinated by the action of the sinoatrial node (SAN) and atrioventricular node (AVN).

(a) After the atria fill with blood, atrial systole (contraction) occurs.
State the events that occur to initiate and cause atrial systole.

.....

..... [2]

(b) State **and** explain how the structure of the heart allows the atria to contract before the ventricles.

.....

.....[2]

(c) Fig. 2.1 shows blood pressure changes that occur in the left ventricle, left atrium and aorta during one cardiac cycle.
E, **F**, **G** and **H** are the points at which a valve opens or closes as a result of blood pressure changes.

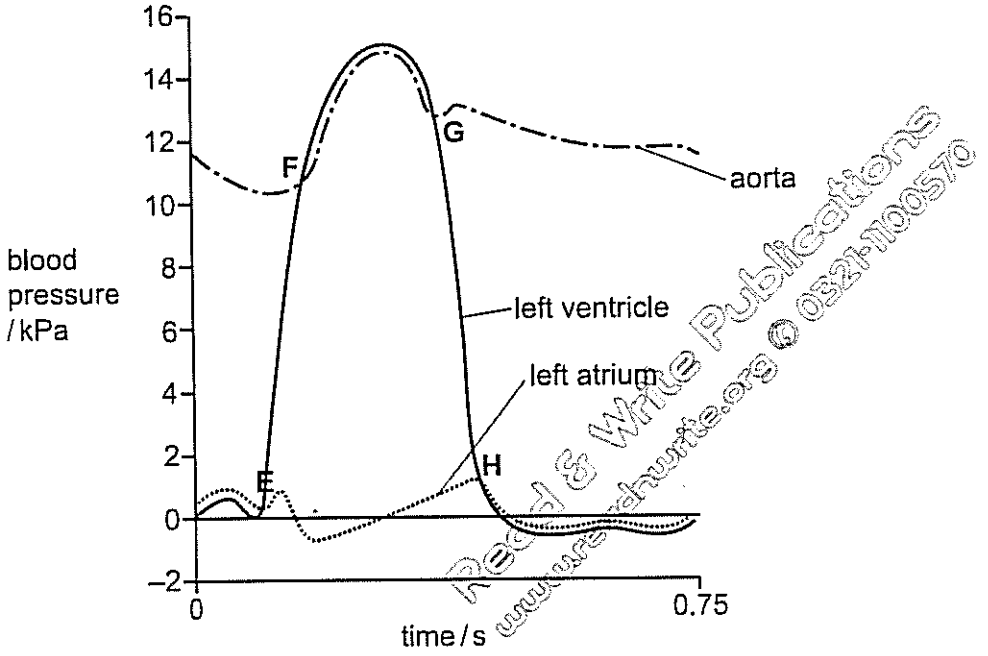


Fig. 2.1

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(i) For each of the points **E**, **F**, **G** and **H** on Fig. 2.1, name the valve concerned **and** state whether the valve opens or closes.

E .....

F .....

G .....

H ..... [3]

(ii) Explain how Fig. 2.1 provides evidence that the wall of the left atrium has a different thickness to the wall of the left ventricle.

.....

..... [2]

12. M/J 20/P21/Q4/d

(a) Scientists in Peru investigated the effect of moving from sea level to high altitude on the composition of blood. The scientists studied 10 students. Each student had lived at sea level since birth and then moved to live in the Andes at a height of 4500 metres above sea level. The scientists took samples of blood from each student before they moved to live at high altitude. The scientists took further blood samples at intervals after the students had moved to high altitude.

The relative proportions of red blood cells and plasma in each sample were determined.

The total volume of blood for each student was also determined at each sampling time. As the students were all of different body mass, the total volumes were converted to a volume per kg of body mass ($cm^3 kg^{-1}$).

Fig. 4.2 shows for each sampling time:

- the mean volume of blood per kg of body mass
- the proportions of red blood cells and plasma.

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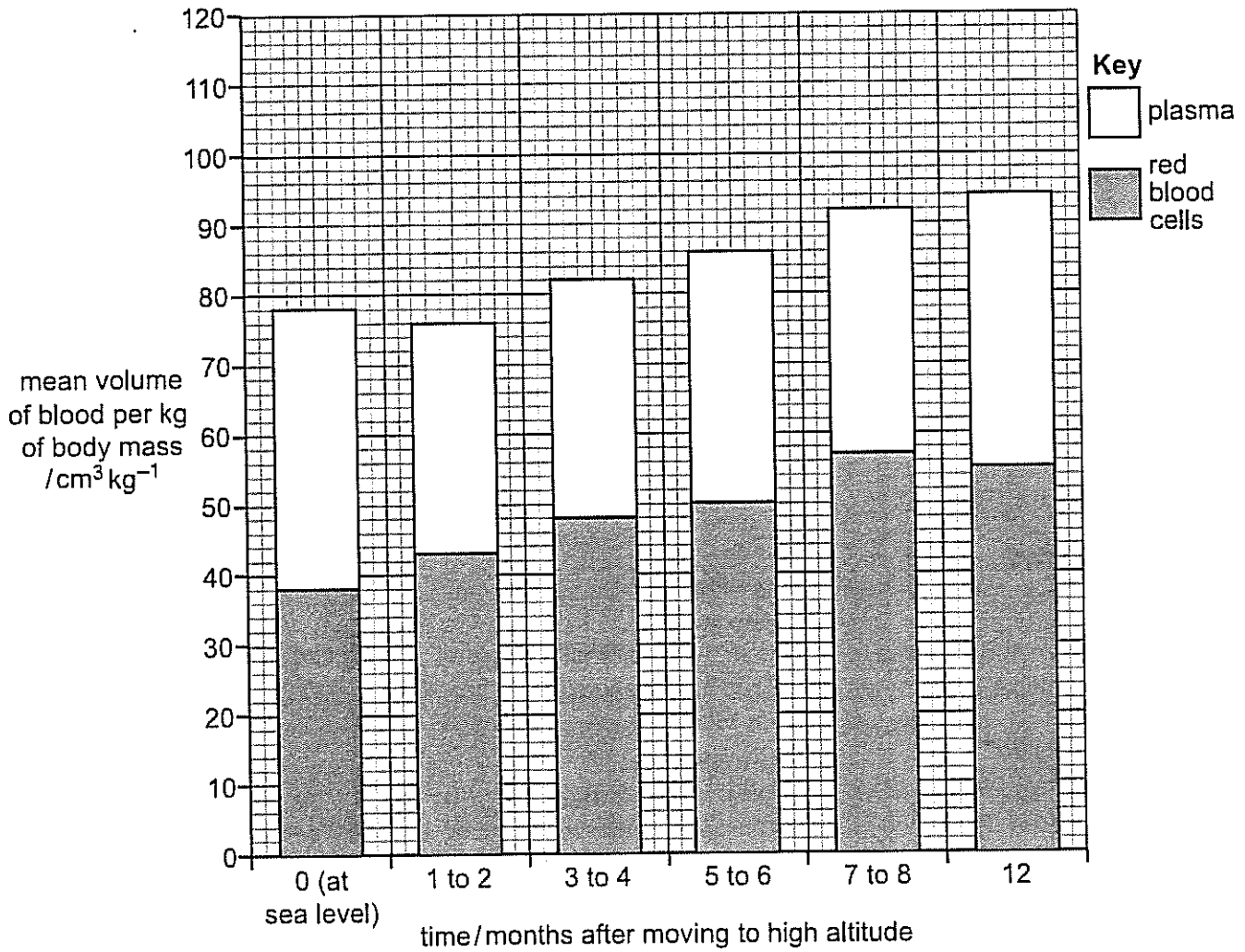


Fig. 4.2

(i) The percentage of mean blood volume that is represented by red blood cells for the samples taken at sea level is 48%.
Calculate the percentage of mean blood volume that is represented by red blood cells at 5 to 6 months after living at high altitude.
Show your working and give your answer to the nearest whole number.

answer = ...% [2]

(ii) Describe **and** explain the results in Fig. 4.2.

.....

.....

.....

..... [4]

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13. M/J 20/P23/Q3/a,b

(a) Fig. 3.1 is a photomicrograph of a section through two different types of blood vessels, **X** and **Y**.



Fig. 3.1

(i) Name the two types of blood vessel shown by **X** and **Y** in Fig. 3.1.

X .....

Y ..... [1]

(ii) State the reasons for your identification of the type of blood vessel shown by **Y** in Fig. 3.1.

.....

..... [2]

(b) Tissue fluid and lymph are formed when blood arrives in the capillary networks of body tissues.

(i) Explain why tissue fluid is more similar to blood plasma than it is to blood.

.....

..... [2]

(ii) Explain why the tissue fluid formed after blood arrives in the capillary network has a **higher** concentration of amino acids than the newly formed lymph draining away from the network.

..... [1]

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14. O/N 19/P21/Q4

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

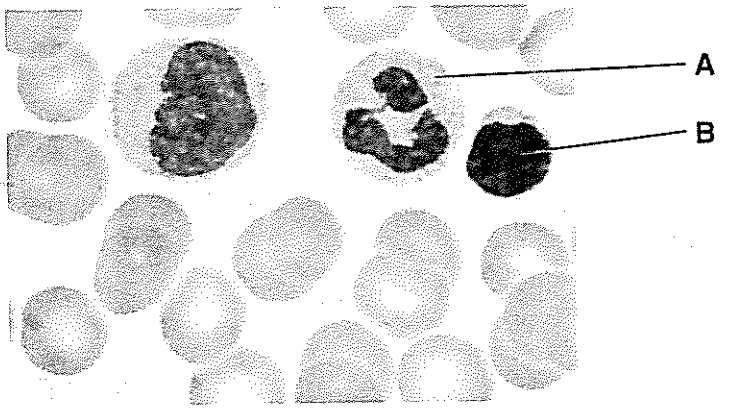


Fig. 4.1

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]

(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.

.....

..... [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.

.....

.....

..... [3]

15. O/N 19/P23/Q4
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.

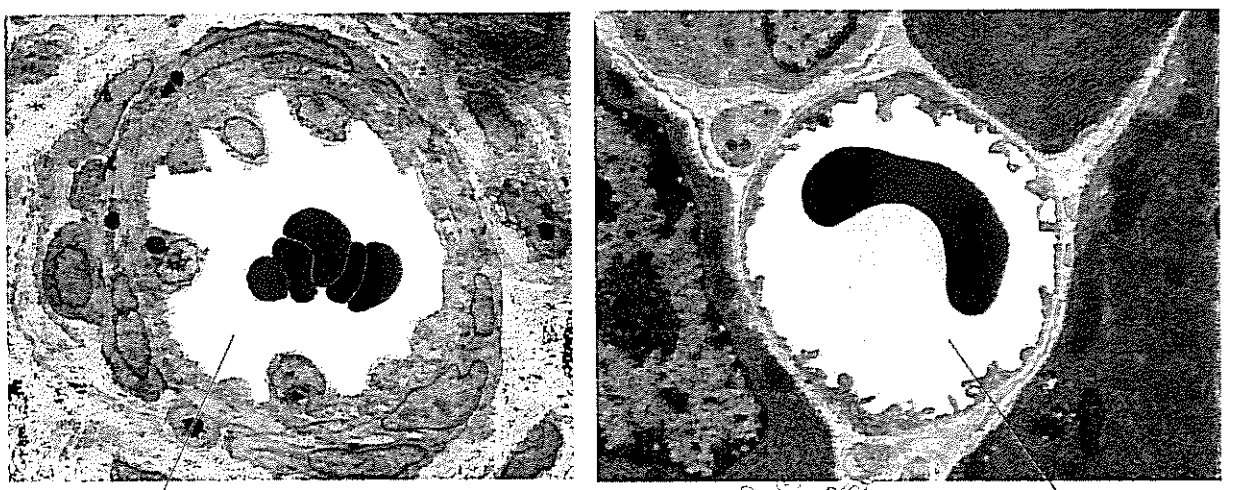
.....

.....

.....

..... [4]

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



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.

.....

.....

.....

..... [4]

Fig. 4.2 shows a capillary network in a mammalian tissue.
The arrows indicate the direction of flow of body fluids.

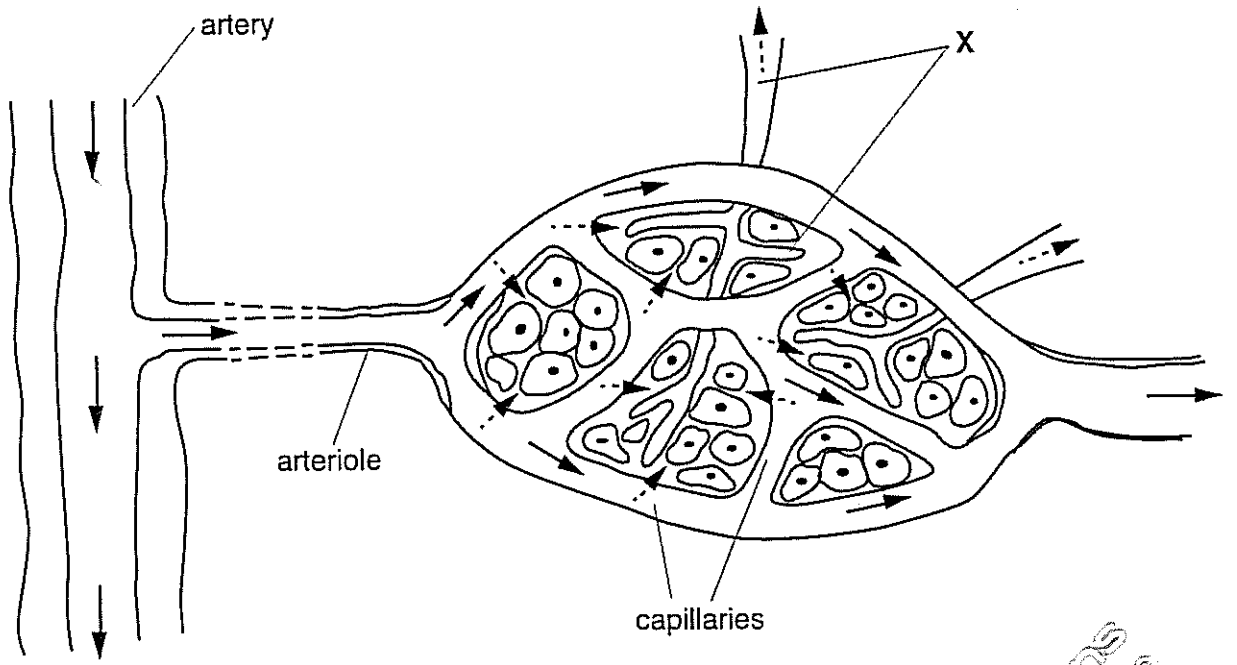


Fig. 4.2 not to scale

(c) (i) Capillaries have a role in the formation of tissue fluid.
Explain how tissue fluid is formed in the capillary network.

.....

..... [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]

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16. M/J 19/P22/Q3

Fig. 3.1 is a photomicrograph of human blood cells from a healthy individual who lives at sea level. The cells labelled **C**, **D** and **E** are white blood cells.

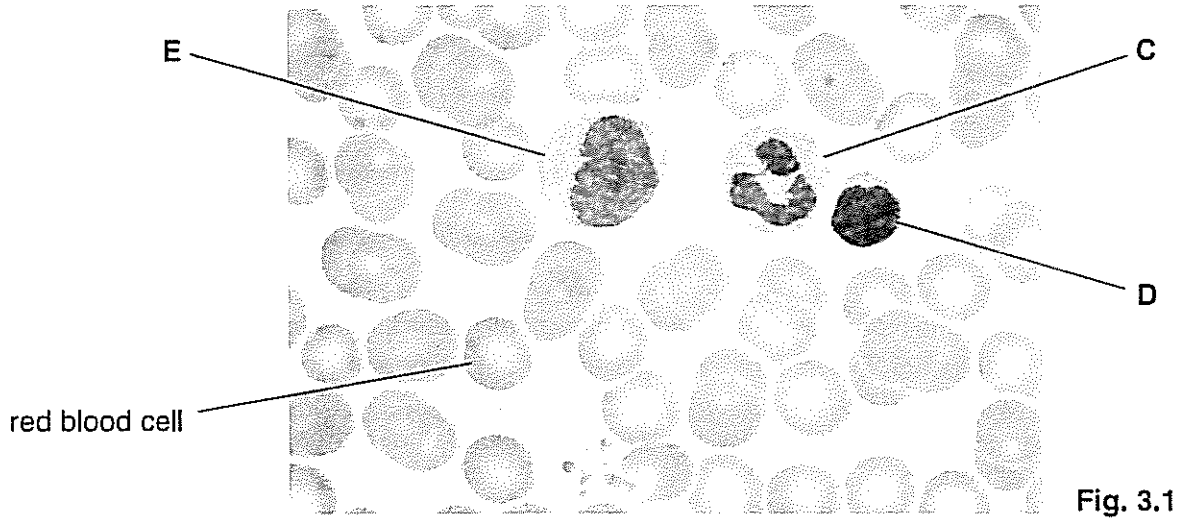


Fig. 3.1

(a) Name cells **C**, **D** and **E**.

C .....

D .....

E ..... [3]

(b) In humans, an increase in the white blood cell count can be associated with leukaemias and with infectious diseases, such as measles.
Chronic lymphocytic leukaemia (CLL) is a type of cancer that starts in the bone marrow. In the early stages, many people with CLL feel well. The disease is sometimes diagnosed by chance during a routine blood analysis, when a high white blood cell count is noticed. Many of these white blood cells are only partially mature.

(i) Suggest why CLL starts in the bone marrow and **not** in any other location in the body.

.....

..... [2]

(ii) Explain why a high white blood cell count is a feature of measles and of CLL.

measles .....

CLL .....

..... [3]

(c) Most of the oxygen that enters the mammalian circulatory system is transported by red blood cells.

(i) Describe **and** explain the passage of oxygen across the cell surface membrane of the red blood cell.

.....

..... [2]

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(ii) At a high altitude, the partial pressure of oxygen in the atmosphere is lower than at sea level. If a person travels from low altitude to high altitude and remains there for a few weeks, the red blood cell count increases.
Explain why the body needs to respond to high altitude by increasing the number of red blood cells.

.....

.....

..... [3]

(d) Polypeptide synthesis occurs before a red blood cell is released into the circulation.
The *HBB* gene codes for the β-globin polypeptide of haemoglobin.
There are two alleles of *HBB*, known as Hb^A and Hb^S.
Describe the difference between the Hb^A allele and the Hb^S allele **and** state how this difference affects:

- the β-globin polypeptide
- the haemoglobin molecule.

.....

.....

.....

..... [4]

17. M/J 19/P21/Q5

(a) The mammalian circulatory system is described as a closed double circulation.
Explain why it is called a *closed* **and** *double* circulation.

closed .....

double ..... [2]

(b) Fig. 5.1 shows a drawing of an external view of a mammalian heart.
Two cross-sections were made of the heart:

- section 1 was made across the line **A–B**.
- section 2 was made across the line **C–D**.

Drawings of the two sections were viewed from above as shown by the arrow on Fig. 5.1.
Fig. 5.2 is a drawing of section **A–B**. Fig. 5.3 is a drawing of section **C–D**.

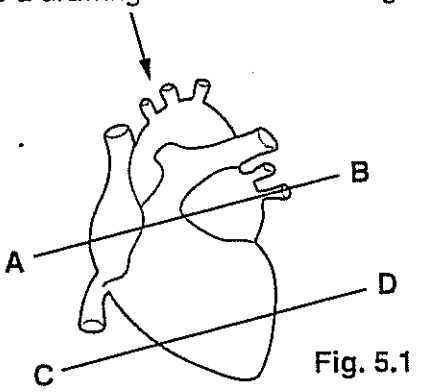


Fig. 5.1

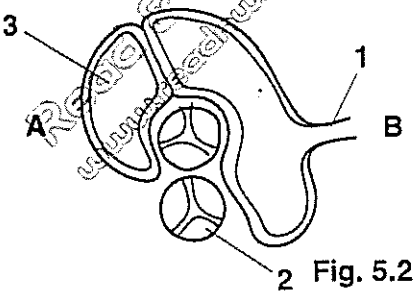


Fig. 5.2

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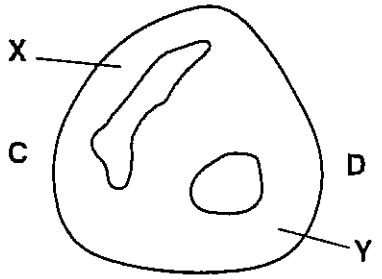


Fig. 5.3

(i) Name structures **1**, **2** and **3**, as shown in Fig. 5.2.

1 .....

2 .....

3 ..... [3]

(ii) Explain why the wall of chamber **Y** is thicker than the wall of chamber **X**, as shown in Fig. 5.3.

.....

.....

..... [3]

(c) Explain how the contractions of the chambers of the heart are coordinated during one cardiac cycle.

.....

.....

.....

..... [4]

18. M/J 19/P23/Q6

Fig. 6.1 is a diagram of a vertical section of the human heart and the associated blood vessels.

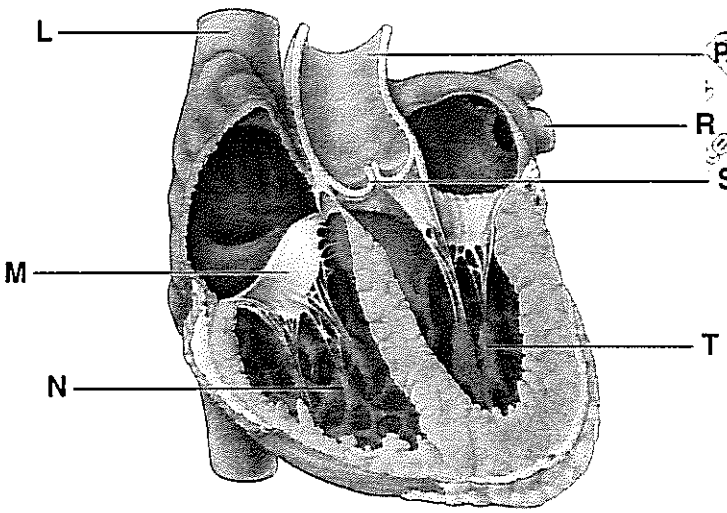


Fig. 6.1

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(a) Complete Table 6.2 by writing the letter from Fig. 6.1 that identifies each of the structures described.

Table 6.2

structure in the heart	letter
valve preventing back flow of blood into a ventricle	
blood vessel carrying blood under highest pressure	
chamber that pumps blood to the lungs	

[3]

(b) Describe the short-term effects of nicotine on the cardiovascular system.

.....

.....

..... [3]

(c) Cardiac myocytes are heart muscle cells.
Fetal cardiac myocytes are present before birth and divide rapidly during fetal development. Soon after birth the cell cycle in most of these fetal cardiac myocytes stops, forming adult cardiac myocytes. Most of the adult cells have completed the cell cycle but in some the cell cycle stops at the end of mitosis.

(i) State the difference between adult cardiac myocytes that have completed the cell cycle and those that have stopped at the end of mitosis.

..... [1]

(ii) Suggest why it could be a disadvantage that the cell cycle has stopped in most adult cardiac myocytes.

.....

..... [2]

19. O/N 18/P22/Q2/c,d

Cardiac glycosides have an effect on the movement of ions into and out of cardiac muscle cells. The outcome is an increased ability for the cells to contract.

(a) Investigations into the action of the cardiac glycoside oleandrin, extracted from *N. oleander*, have shown that it acts to prevent the correct functioning of Na/K-ATPase, a membrane transport protein.

Na/K-ATPase has a role as an enzyme **and** as a transport molecule.

- ATPase is an enzyme that catalyses the hydrolysis of ATP to ADP and inorganic phosphate.
- Energy released from this hydrolysis is used to transport sodium ions (Na^+) out of cardiac muscle cells and potassium ions (K^+) into the cells.

(i) Explain what is meant by the *hydrolysis of ATP*.

.....

..... [2]

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(ii) Name the type of transport mechanism involved in the transport of Na^+ and K^+ across the cell surface membrane of cardiac muscle cells.

..... [1]

(iii) Oleandrin is a non-competitive reversible inhibitor of ATPase.
Describe the mode of action of oleandrin **and** explain how this will affect ion movement through Na/K-ATPase transport proteins of the cell surface membranes of cardiac muscle cells.

.....

.....

.....

..... [4]

(b) Digoxin, a cardiac glycoside extracted from *D. lanata* leaves, can be purified and used as a drug to treat some heart disorders.
Examples of these heart disorders are:

- atrial fibrillation, where the normal rhythmic cardiac cycle is disrupted
- heart failure, where cardiac muscle is contracting weakly.

(i) Describe the **sequence** of events occurring in the left side of the heart during one **normal** cardiac cycle. Include reference to blood pressure changes.
The first event in the sequence is described for you.
The left atrium fills with blood during relaxation of the left atrium and left ventricle.

.....

.....

.....

..... [4]

(ii) Suggest how the health of a person with heart failure can be improved by treatment with the drug digoxin.

.....

.....

..... [3]

20. O/N 18/P21/Q6

(a) Haemoglobin is a globular protein which is able to transport oxygen and is soluble in water.

(i) Explain how the structure of a haemoglobin molecule makes it able to transport oxygen efficiently.

.....

.....

..... [3]

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(ii) Explain how the structure of a haemoglobin molecule allows it to be soluble in water.

.....

..... [2]

(b) Llamas are mammals that are adapted to live at high altitudes.
Fig. 6.1 shows oxygen dissociation curves for haemoglobin of llamas and humans.

(i) The partial pressure of oxygen in the lungs of mammals at 3500 m is 6.4 kPa.
Use Fig. 6.1 to state the percentage saturation of haemoglobin of llamas and humans at an oxygen partial pressure of 6.4 kPa.

llamas ..... %

humans ..... % [1]

(ii) With reference to Fig. 6.1, explain the advantage to llamas of having an oxygen dissociation curve positioned to the left of the curve for humans.

.....

..... [2]

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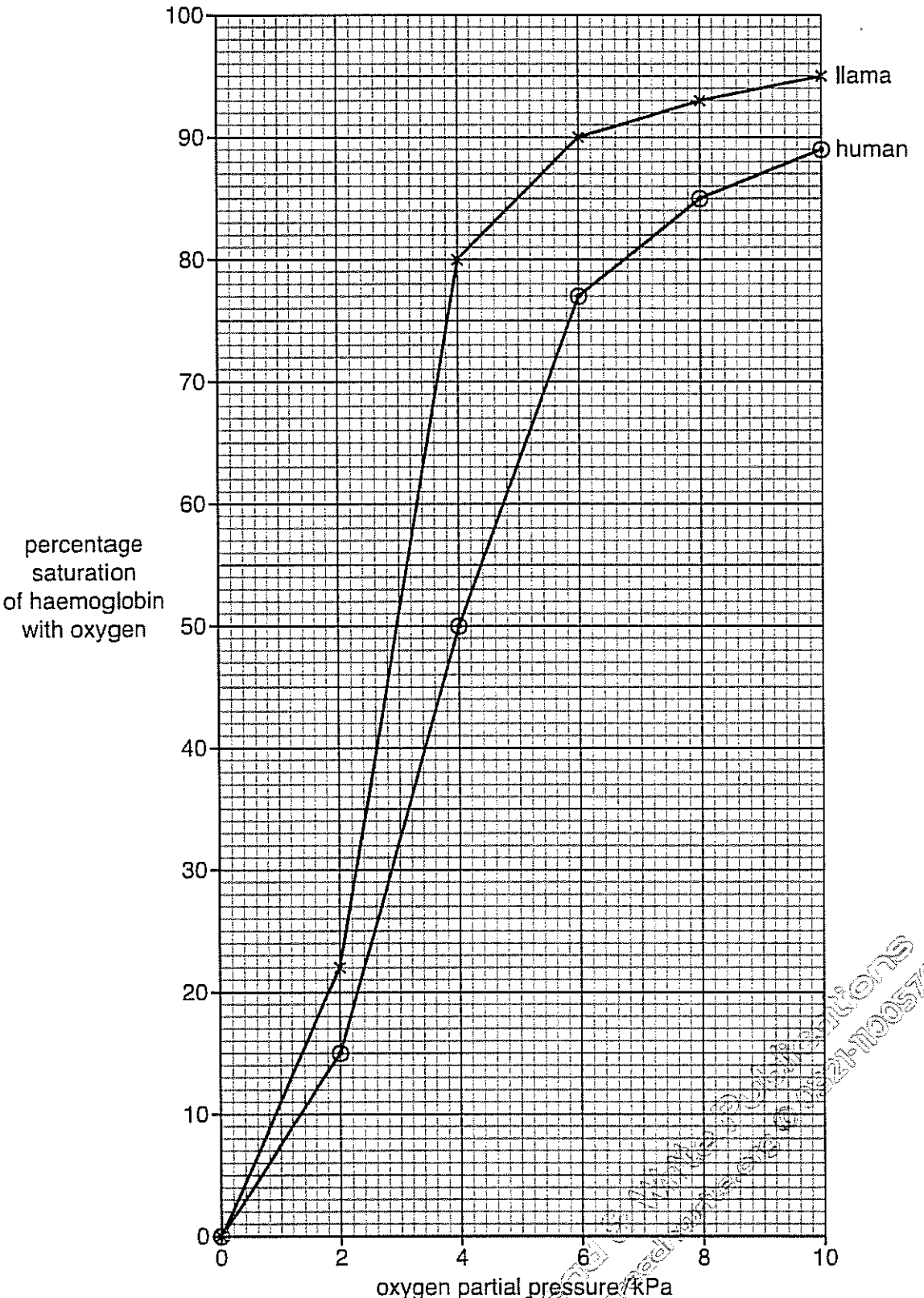


Fig. 6.1

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21. O/N 18/P23/Q4/a,b

(a) Describe the roles of the sinoatrial node (SAN) and the atrioventricular node (AVN) in the initiation and control of the cardiac cycle.

.....

.....

.....

..... [4]

(b) The Purkyne fibres pass down the septum and extend to the cardiac muscle at the base (apex) of the heart.

Explain why it is important that the Purkyne fibres extend to the base of the heart.

.....

..... [2]

22. O/N 17/P22/Q6

Fig. 6.1 is a diagram of a vertical section through the mammalian heart. The labels **Q** to **X** represent valves and blood vessels of the heart.

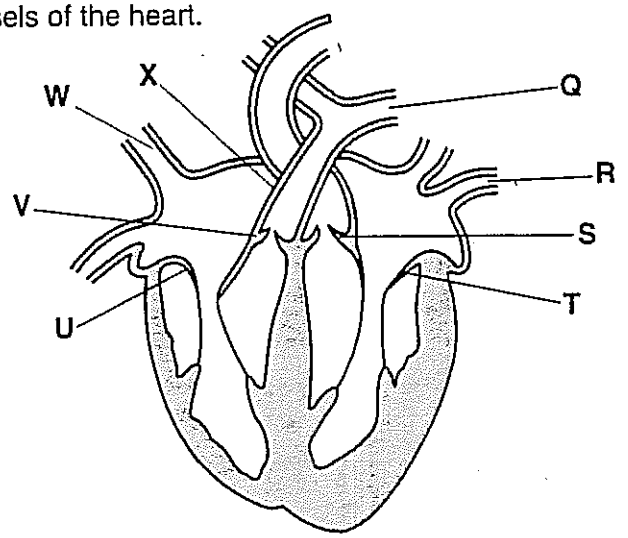


Fig. 6.1

(a) (i) State which label represents the valve that prevents the backflow of blood from the aorta into the ventricle.

..... [1]

(ii) Name the blood vessel that carries oxygenated blood from the lungs to the heart **and** state which label represents this blood vessel.

name .....

label ..... [2]

(b) State **precisely** where the sinoatrial node is located.

..... [1]

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(c) Explain the role of the atrioventricular node in the coordination of heart action.

.....

..... [2]

23. O/N 17/P21/Q2

Fig. 2.1 is a transmission electron micrograph of a section through a blood vessel.

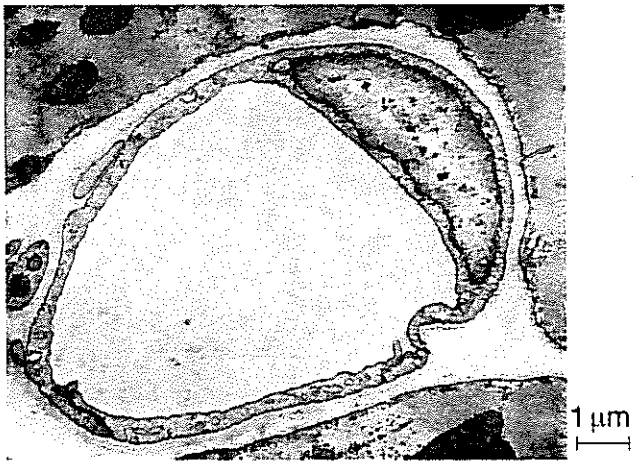


Fig. 2.1

(a) State the type of blood vessel shown in Fig. 2.1 **and** give **two** reasons for your choice.

type of blood vessel .....

reason 1 .....

reason 2 ..... [3]

Fig. 2.2 is a graph showing how the blood pressure in the pulmonary artery and in the right ventricle changes during one cardiac cycle.

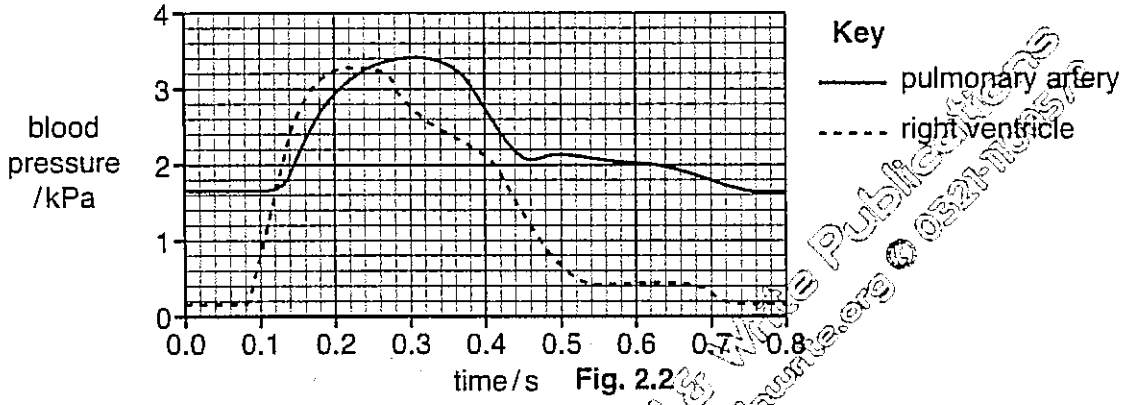


Fig. 2.2

(b) Use Fig. 2.2 to state the time at which:

(i) the valve between the right ventricle and the pulmonary artery closes

..... [1]

(ii) the ventricle begins to contract.

..... [1]

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(iii) State **and** explain the similarities and differences between Fig. 2.2 and a graph showing how the blood pressure for the **left** ventricle changes during the same cardiac cycle.

.....

.....

.....

..... [4]

24. O/N 17/P23/Q2

(a) Explain why the wall of the left ventricle in the heart is thicker than the wall of the right ventricle.

.....

..... [2]

Fig. 2.1 shows the heart and blood vessels at three stages of the cardiac cycle.

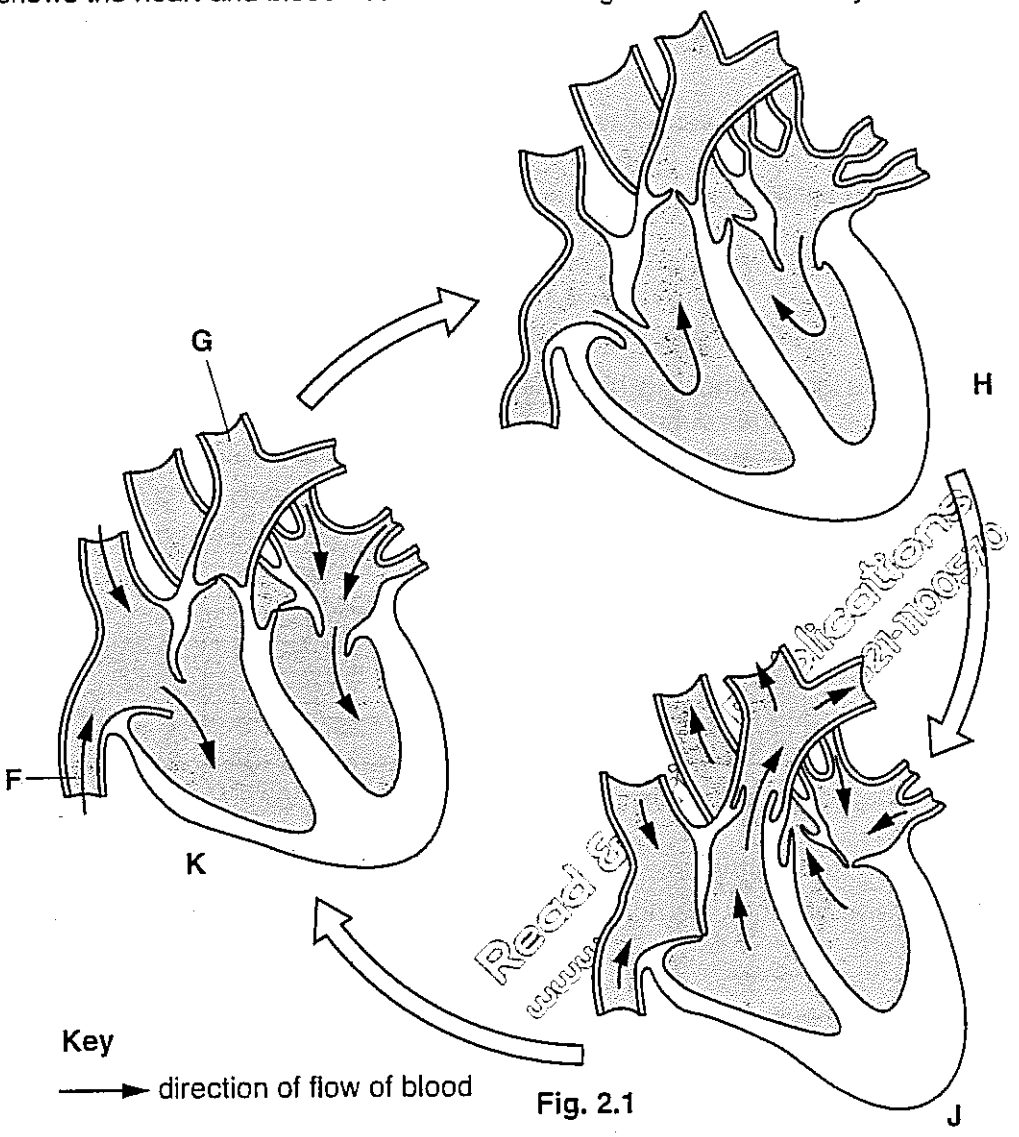


Fig. 2.1

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(b) (i) Name the blood vessels labelled **F** and **G**.

F .....

G ..... [2]

(ii) Name the stage of the cardiac cycle at **K**.

..... [1]

(c) Describe what happens in the heart between stages **H** and **J** as shown in Fig. 2.1.

.....

.....

.....

.....

..... [5]

25. M/J 17/P22/Q1/b

(a) A tissue is a collection of one or more types of cell, specialised to carry out a particular function.

An organ can be considered a structural unit within an organism that:

- consists of more than one type of tissue
- performs a particular function.

The aorta is the main artery of the body.

Explain, with reference to its structure and function, whether the aorta may be described as a tissue or an organ.

.....

.....

.....

..... [4]

26. M/J 17/P23/Q1

Mammals have a closed double circulation system.

(a) Explain what is meant by a *closed double circulation*.

.....

..... [2]

(b) Table 1.1 shows some structures in the mammalian circulatory system.

Complete Table 1.1 to show the sequence of structures through which blood flows, starting with the pulmonary vein.

Use the numbers 2 to 5 to indicate the correct sequence.

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Table 1.1

structure	sequence of blood flow
left ventricle	
vena cava	
pulmonary vein	1
aorta	
right atrium	

[2]

(c) (i) Explain why arteries have thicker walls than veins.

.....

..... [2]

(ii) Smoking causes carbon monoxide and nicotine to enter the blood.
Describe the short-term effects of each of these substances on the cardiovascular system.
carbon monoxide

.....

.....

nicotine

.....

..... [4]

27. O/N 16/P22/Q4

Fig. 4.1 is a cross-section of a human renal artery, a vessel that supplies blood to the kidney.

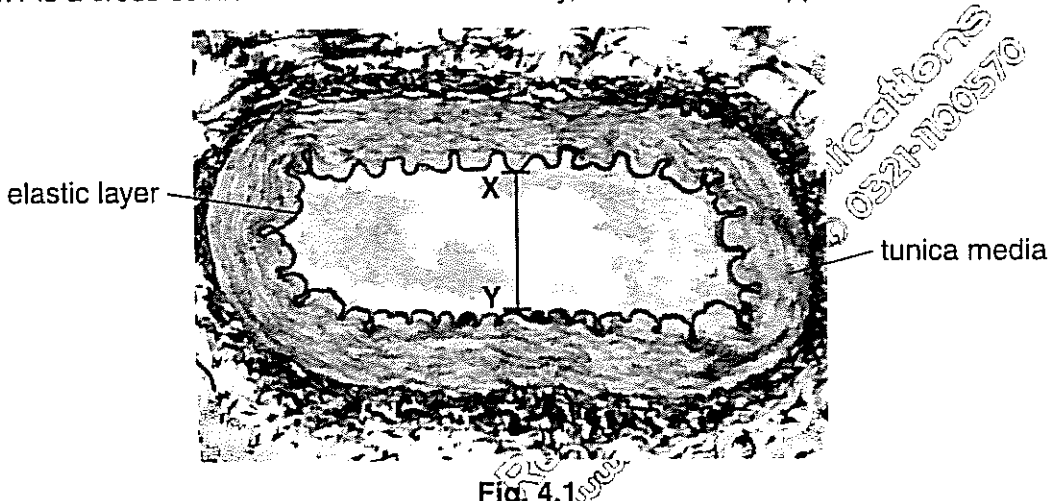


Fig. 4.1

(a) The elastic layer shown in Fig. 4.1, located between the endothelium and the tunica media, is one feature that suggests that the blood vessel is the renal artery and not the renal vein, which may be of a similar size.

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Complete the sentence to state **one** additional structural feature, **visible in Fig. 4.1**, that would identify the blood vessel as an artery.

This is an artery because it has ..... [1]

(b) Explain the relationship between the structure of the tunica media and the function of an artery, such as the renal artery.

.....

..... [2]

(c) The actual diameter of the lumen of the renal artery at the point **X–Y** in Fig. 4.1 is 5.2 mm. Calculate the magnification of the image shown in Fig. 4.1. Write down the formula you will use to make your calculation and show your working.

formula

magnification × .....[3]

(d) Blood plasma contains approximately 90% water. Many of the properties of water are due to its ability to form hydrogen bonds.
Outline how the properties of water make it ideal as the largest component of plasma.

.....

.....

..... [3]

28. O/N 16/P21/Q6/d

(a) Explain why red blood cells are in blood but not in tissue fluid.

..... [1]

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29. O/N 16/P23/Q5

In an investigation, the volume of oxygen that combined with haemoglobin at different partial pressures of oxygen was determined. The results are shown in Fig. 5.1.

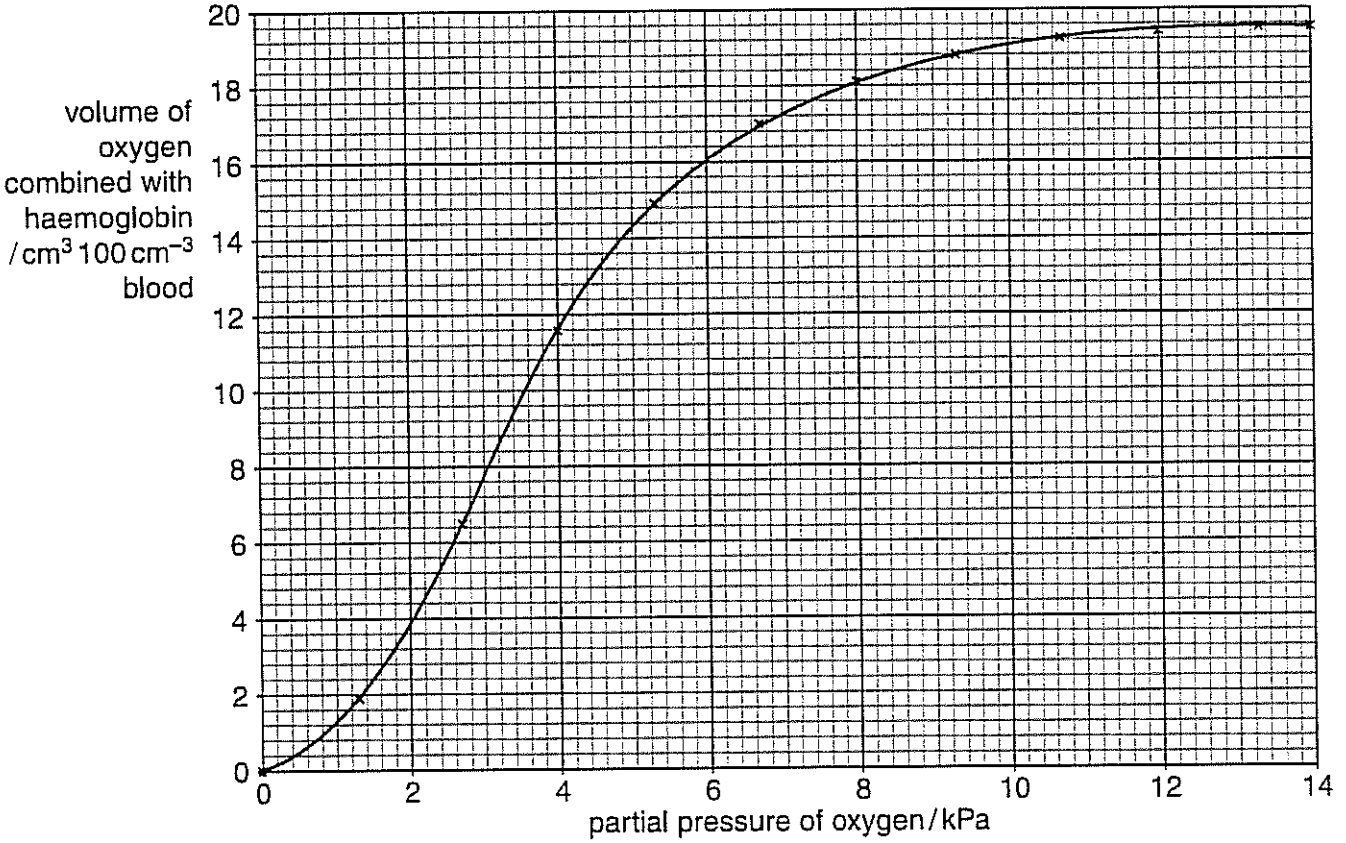


Fig. 5.1

(a) The partial pressure of oxygen in the alveoli is 13.3 kPa. At this partial pressure of oxygen the **total volume of oxygen** that is carried by 100 cm^3 blood is 19.78 cm^3 at pH 7.4 and 37 °C.

The volume of oxygen that combines with haemoglobin at 13.3 kPa is 19.48 cm^3 100 cm^{-3} blood.

(i) Calculate the percentage of oxygen that is combined with haemoglobin in 100 cm^3 blood.

answer .....% [1]

(ii) Suggest how the oxygen that is **not** combined with haemoglobin is transported in the blood.

..... [1]

(iii) Explain why a long-term smoker would have a lower volume of oxygen combined with haemoglobin in the alveoli at 13.3 kPa.

.....

..... [2]

(b) Describe the role of carbonic anhydrase in the transport of carbon dioxide.

.....

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.....

..... [3]

(c) The investigation was repeated in the presence of carbon dioxide. The volumes of oxygen combined with haemoglobin at partial pressures of oxygen below 8.0 kPa were less than shown in Fig. 5.1.

Name this effect **and** explain the advantage of this decrease at partial pressures of oxygen below 8.0 kPa.

name .....

advantage .....

..... [3]

30. M/J 16/P22/Q4

Fig. 4.1 is a simplified diagram of the circulatory system of a mammal. Some of the lymph system is also shown.

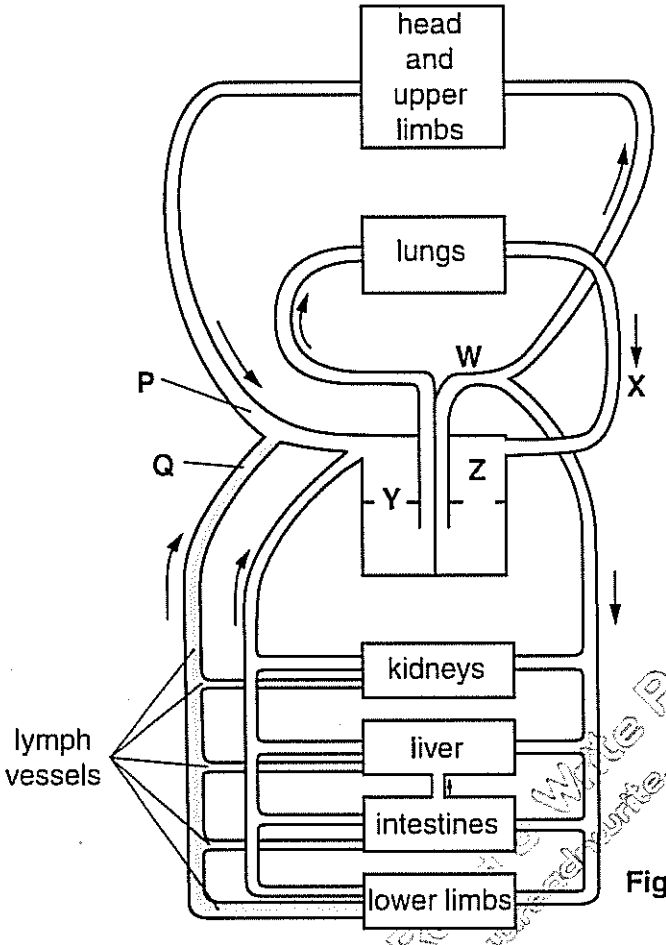


Fig. 4.1

(a) The type of circulatory system shown in Fig. 4.1 is a closed double circulation.

Explain what is meant by a *closed double circulation*.

.....

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..... [2]

(b) With reference to Fig. 4.1, name:

blood vessel **W** .....

blood vessel **X** .....

valve **Y** .....

heart chamber **Z** ..... [4]

(c) State the component present in the blood at location **P** that is **not** present in the lymph at location **Q** in Fig. 4.1.

..... [1]

(d) As blood passes through the capillary network in the lungs, gas exchange occurs. Describe the process of gas exchange between the alveolus and the blood.

.....

.....

.....

..... [4]

(e) As blood passes through the small intestine, small soluble products of digestion such as glucose are absorbed into the capillaries to be transported to the liver.
Fig. 4.2 is a transmission electron micrograph of intestinal epithelial cells.

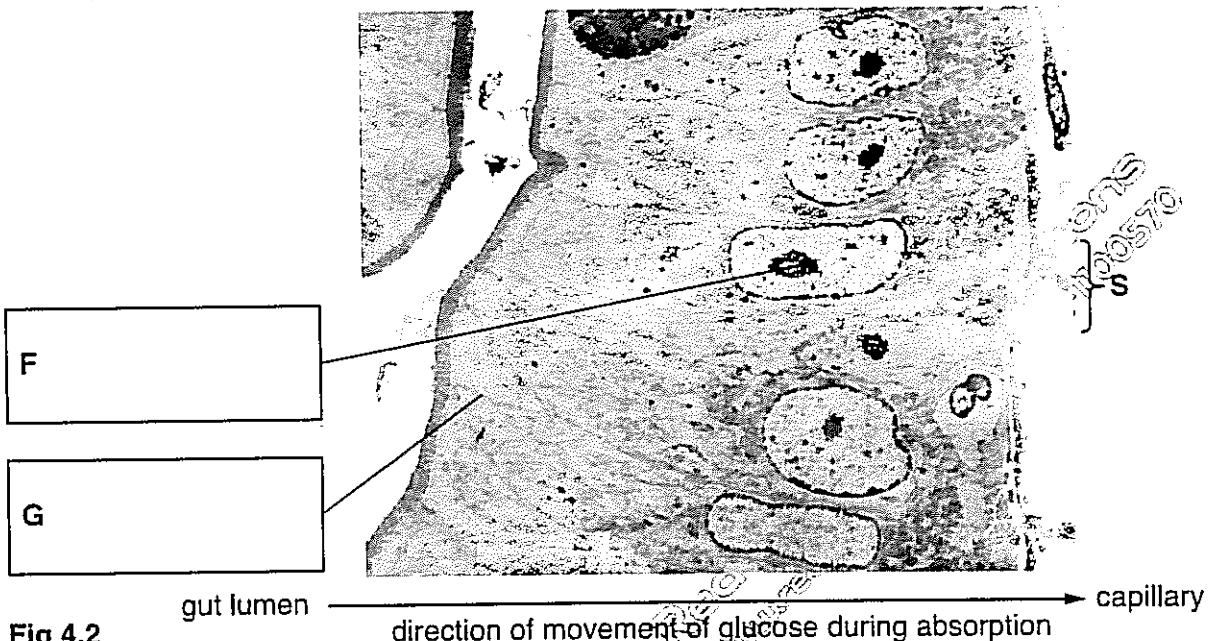


Fig 4.2

(i) Write the name of cell structures **F** and **G** in the boxes provided on Fig. 4.2. [2]

(ii) At the surface labelled **S**, movement of glucose molecules out of the intestinal epithelial cell occurs by facilitated diffusion.

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Outline the features of facilitated diffusion of glucose molecules.

.....

.....

..... [3]

31. M/J 16/P21/Q5/b,c

Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of red blood cells.

During the production of red blood cells a series of changes occur to the cell structure.

Fig. 5.2 shows the production of a red blood cell from one of these stem cells.

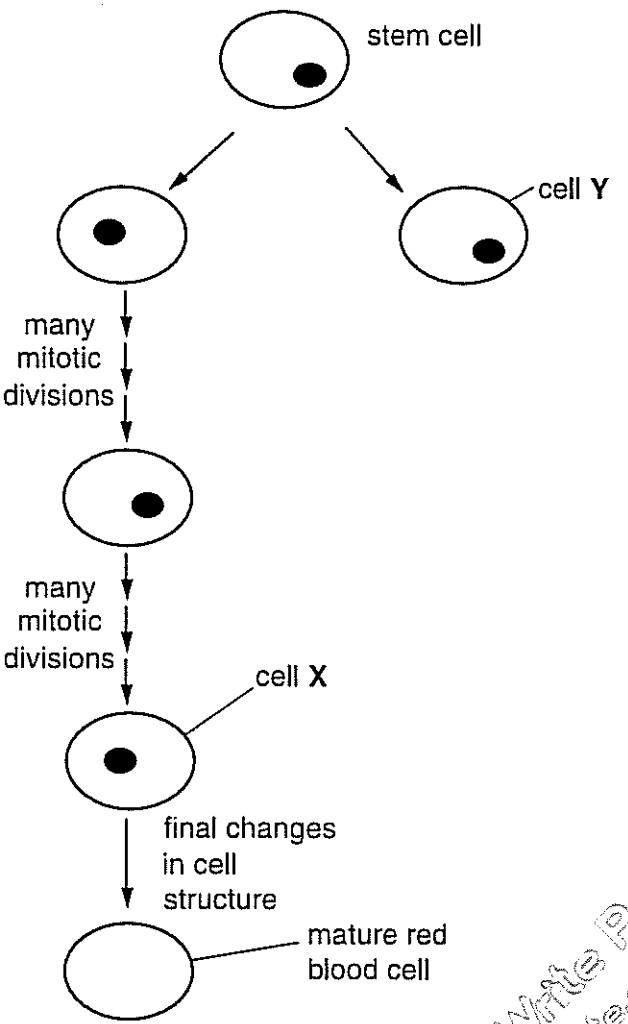


Fig. 5.2

(a) (i) Outline the changes that occur as cell **X** becomes a mature red blood cell.

.....

.....

..... [3]

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(ii) Suggest what may happen to cell **Y**.

..... [1]

(b) People who travel to high altitude become acclimatised to the conditions.
Athletes often train at high altitude before competing at sea level.
A group of male and female athletes who trained at sea level moved to high altitude for further training. Sports scientists analysed blood samples taken from the athletes to measure any changes in the concentration of haemoglobin in the blood and changes in the haematocrit.
Haematocrit is the volume of red blood cells expressed as a percentage of the total volume of a sample of blood.
The results are shown in Table 5.1. **Table 5.1**

feature of the blood	at sea level	after 19 days at high altitude	percentage increase
mean concentration of haemoglobin in the blood / g 100 cm^{-3}	13.3	15.1	.....
mean haematocrit	41.0	42.5	3.7

(i) Complete Table 5.1 by calculating the percentage increase in haemoglobin concentration. [1]

(ii) Explain why it is necessary for the athletes to increase the concentration of haemoglobin in their blood when acclimatising to high altitude.

.....

.....

.....

..... [4]

32. M/J 16/P23/Q6
Fig. 6.1 is a diagram of a section through a mammalian heart.

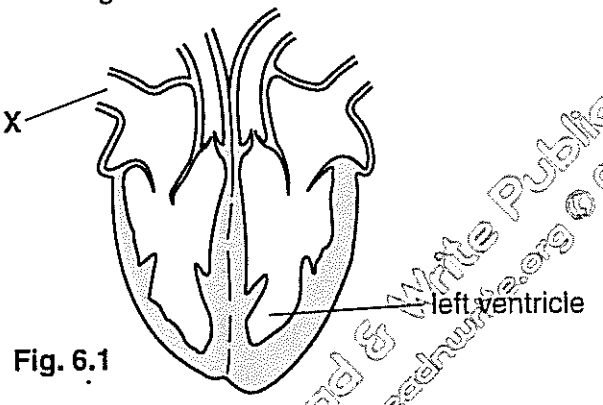


Fig. 6.1

(a) Name the blood vessel labelled **X**.

..... [1]

(b) Explain the difference in thickness between the muscle walls of the left and right ventricles.

.....

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.....

..... [3]

(c) Name the structure in the heart that acts as the pacemaker to initiate the cardiac cycle.

..... [1]

33. O/N 15/P22/Q6/a,b

(a) The thickness of the different chambers of the mammalian heart is due to the amount of cardiac muscle present. The atria have less cardiac muscle than the ventricles, and hence thinner walls.

In terms of their functions, explain why the atria have thinner walls than the ventricles.

.....

..... [2]

(b) Name the dividing wall separating the right and left sides of the mammalian heart.

..... [1]

34. O/N 15/P23/Q5/b

(a) One type of surgical treatment for coronary heart disease is to use arteries from the chest and veins from the leg to by-pass blockages as shown in Fig. 5.1.

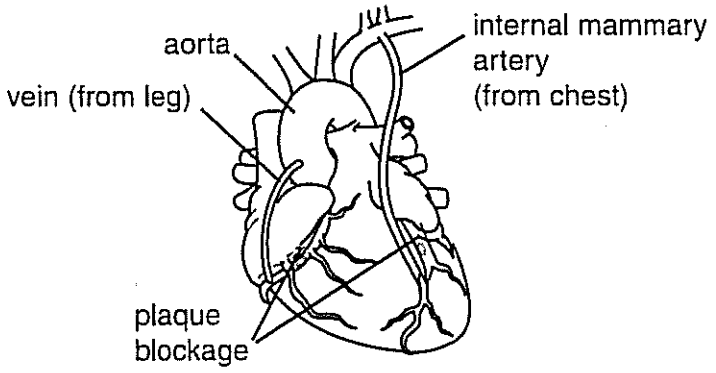


Fig. 5.1

(i) Explain how the two by-passes shown in Fig. 5.1 provide an effective treatment for coronary heart disease.

.....

.....

..... [3]

(ii) The cost of treating heart disease is very high.
Suggest the steps that governments could take to reduce heart disease in the population.

.....

.....

..... [3]

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35. M/J 15/P22/Q1

Each of statements **A to E** describe a structure associated with the mammalian heart.
For each statement, identify the structure that is being described.

A The chamber that pumps blood into the pulmonary artery.

.....

B A blood vessel that transports deoxygenated blood into the right atrium.

.....

C The specialised tissue responsible for delaying the conduction of impulses from the atria to the ventricles.

.....

D The blood vessels that supply cardiac muscle with oxygenated blood.

.....

E The valve that prevents the backflow of blood from the ventricle that contains oxygenated blood.

..... [5]

36. M/J 15/P22/Q3

Outside the body, red blood cells can be maintained in an intact state by keeping the cells in a 0.9% solution of sodium chloride. This is known as a normal saline solution.
Fig. 3.1 shows intact red blood cells.

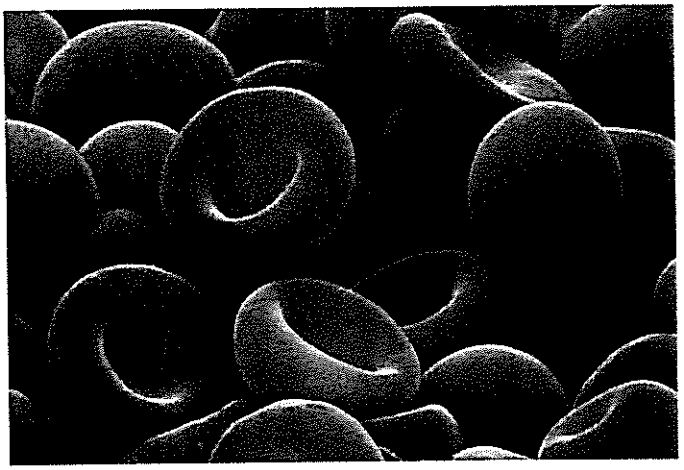


Fig. 3.1

(a) Explain why red blood cells can be maintained in an intact state by keeping them in a normal saline solution.

.....

..... [2]

(b) In the blood, red blood cells are suspended in plasma. The main component of blood plasma is water.

Suggest **one** other component of blood plasma that could enter red blood cells **and** describe how it would cross the cell surface membrane.

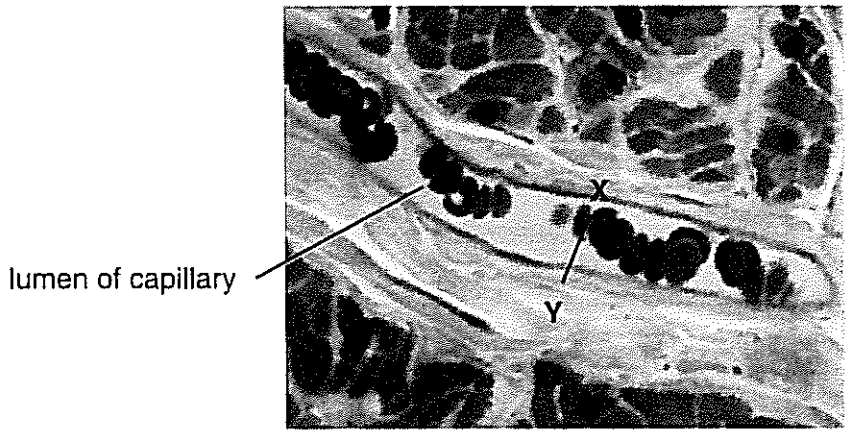
component .....

description .....

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..... [3]

Fig. 3.2 shows red blood cells within a capillary. The capillary shown in Fig. 3.2 allows the rapid exchange of substances between the blood, tissue fluid and body cells.



(c) The actual diameter of the lumen of the capillary at the point **X–Y** in Fig. 3.2 is 9.5 μm.
Calculate the magnification of the image shown in Fig. 3.2. Show your working.

magnification × ..... [2]

(d) With reference to Fig. 3.2, explain **one** feature that enables the surrounding body cells to receive an adequate supply of oxygen from the blood supplied by the capillary.

.....

..... [2]

(e) Some areas of the brain, known as blood-brain barriers, have a type of capillary that is relatively impermeable to substances.
Suggest **one** way in which the structure of a capillary in the blood-brain barrier differs from the structure of the capillary shown in Fig. 3.2.

..... [1]

37. M/J 15/P23/Q4

Fig. 4.1 shows how blood pressure changes in the human systemic circulation.

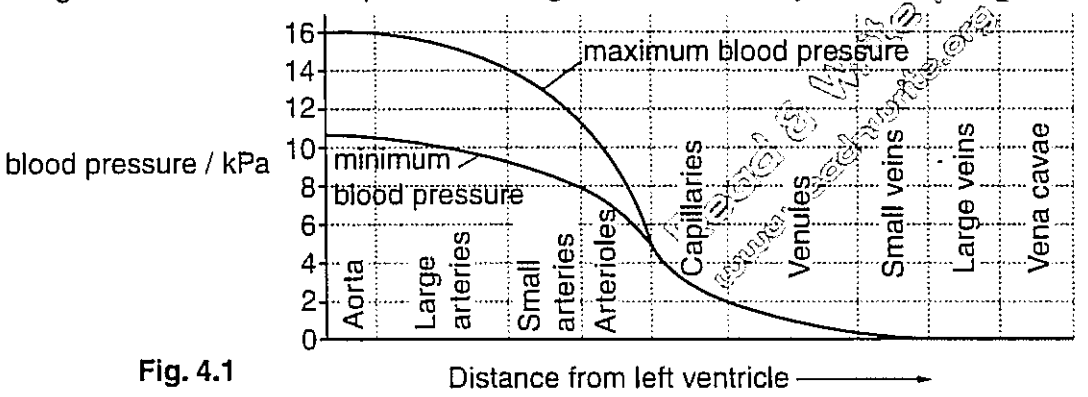


Fig. 4.1

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(a) (i) Describe the changes in blood pressure shown in Fig. 4.1.

.....

.....

..... [3]

(ii) Explain how the structure of veins is related to their function in returning blood to the heart.

.....

..... [2]

(b) Angiotensin is a polypeptide produced in the body to raise blood pressure.
Angiotensin converting enzyme (ACE) catalyses the final step in angiotensin production.
Fig. 4.2 shows this step.

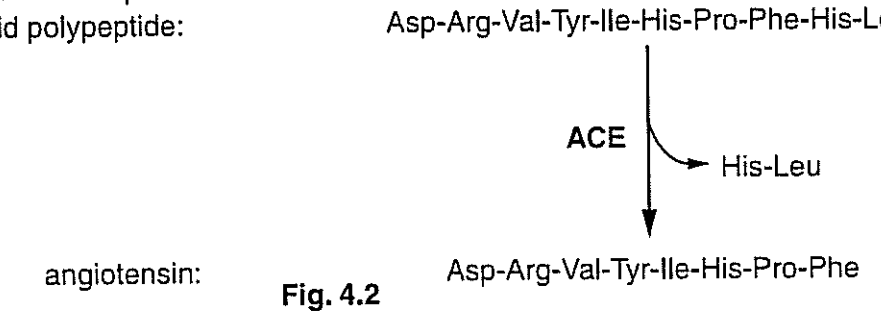


Fig. 4.2

Describe the step shown in Fig. 4.2.

.....

.....

..... [3]

(c) People with high blood pressure can be treated with a drug which lowers the concentration of angiotensin in the blood.
This drug is a competitive inhibitor of ACE.
Explain how this drug acts as a competitive inhibitor.

.....

.....

..... [3]

38. O/N 14/P22/Q3

In mammals, oxygen is transported by red blood cells in a system that is described as a closed double circulation. The majority of oxygen molecules are transported as oxyhaemoglobin. At the respiring tissues, oxygen dissociates from haemoglobin and diffuses to the surrounding cells.

(a) Explain what is meant by a *closed double circulation.*

.....

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..... [2]

(b) Fig. 3.1 is a diagram that highlights the tertiary and quaternary structure of a haemoglobin molecule.

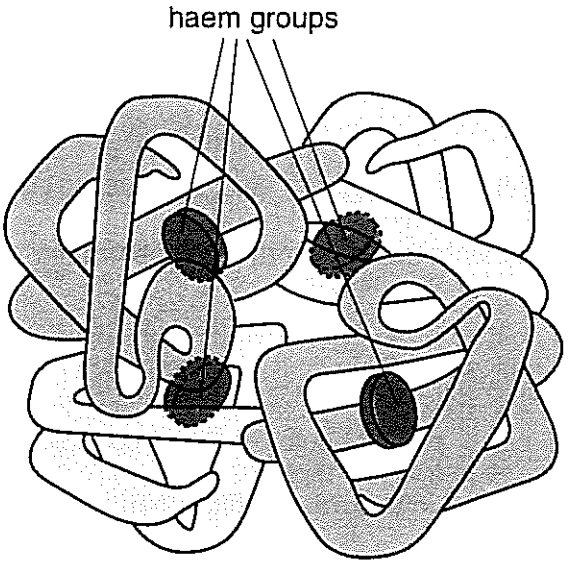


Fig. 3.1

Explain how the tertiary and quaternary levels of protein structure of the haemoglobin molecule contribute to its role in the transport of oxygen.

.....

.....

.....

..... [4]

(c) At high altitudes, the partial pressure of inspired oxygen is considerably lower than at sea level. This means that the partial pressure of oxygen in the blood is also much lower at high altitudes than at sea level.

Fig. 3.2 is an oxygen dissociation curve of adult oxyhaemoglobin.

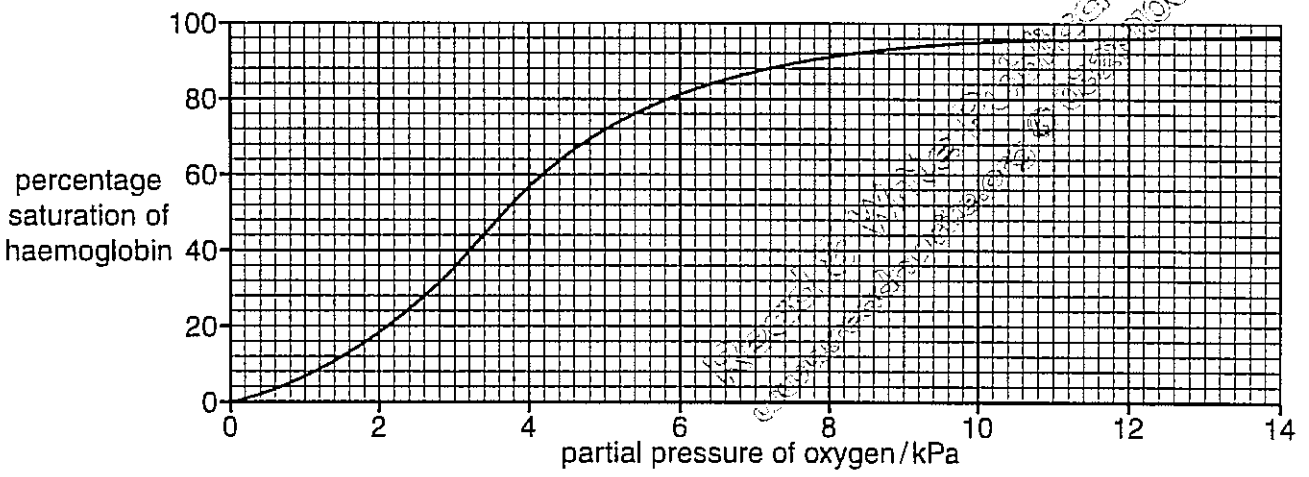


Fig. 3.2

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With reference to Fig. 3.2, calculate the difference in percentage saturation of haemoglobin at sea level, where the partial pressure of oxygen is 13.0 kPa, and at a higher altitude, where the partial pressure of oxygen is 6.2 kPa.

Show your working.

answer ..... % [2]

(d) After spending time at altitude, a person can become acclimatised. One feature of acclimatisation is an increase in the red blood cell count.
Explain the importance of the increase in the red blood cell count.

.....

..... [2]

(e) Before acclimatisation can occur, some people develop a condition known as acute mountain sickness when they travel to high altitude areas.
Acetazolamide is a non-competitive enzyme inhibitor that is used as a drug to prevent and treat acute mountain sickness.
Explain the effects of a non-competitive inhibitor on the rate of enzyme activity.

.....

.....

..... [3]

(f) Tobacco smoking can have an effect on the transport of oxygen by haemoglobin.
Fig. 3.3 shows oxygen dissociation curves with and without the presence of carbon monoxide (CO).

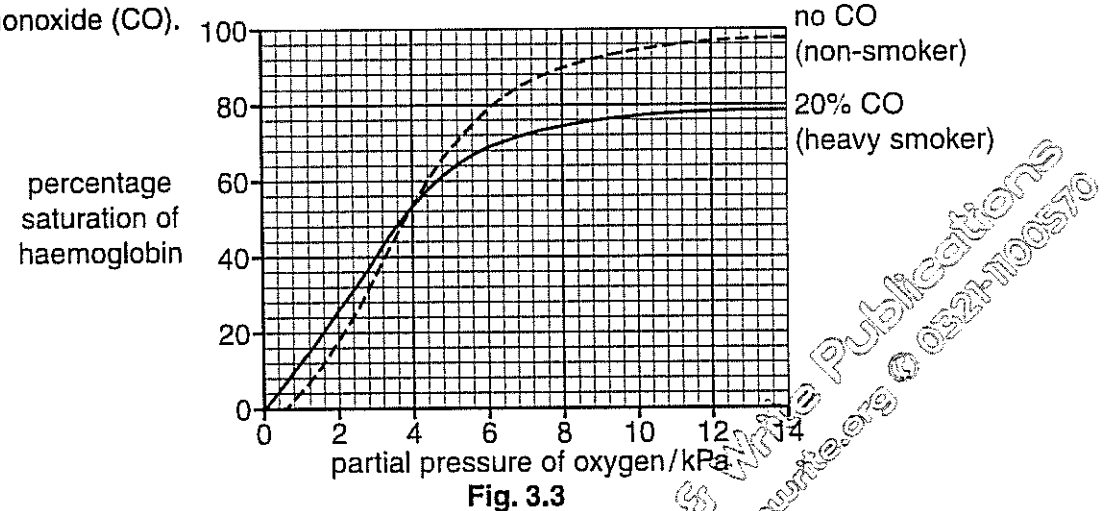


Fig. 3.3

With reference to Fig. 3.3, describe the effect of carbon monoxide on the cardiovascular system.

.....

.....

..... [3]

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39. O/N 14/P22/Q5

(a) Complete Table 5.1 by numbering each event to show the sequence occurring in the initiation and control of one heart beat.

Use **1** as the first event in the sequence.

Table 5.1

event	sequence
impulses pass down septum through conducting fibres known as the bundle of His	
atrioventricular node sends out impulses	
impulses travel across atrial walls	
impulses reach base of ventricles (apex of heart)	
impulses pass up through Purkyne fibres in ventricle walls	
sinoatrial node sends out impulses	

[3]

(b) Explain the circumstances that cause the closing of the semi-lunar valves during the cardiac cycle.

.....

..... [2]

(c) At the arterial end of a capillary bed in muscle tissue, the hydrostatic pressure is high enough to cause the formation of tissue fluid.

Explain the differences between the composition of blood and the composition of tissue fluid at the arterial end of a capillary bed.

.....

..... [2]

40. M/J 14/P22/Q3/c,d,e

(a) When a person travels from 0 m (sea level) to a high altitude, gas exchange in the lungs is affected. A condition known as hypoxia results, where the body tissues do not receive an adequate oxygen supply.

Explain how hypoxia occurs when a person ascends from sea level to a high altitude.

.....

.....

.....

..... [4]

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(b) At high altitudes, short-term responses by the body to hypoxia include:

- a decrease in the volume of plasma in the blood
- a decrease in the volume of blood pumped out of the heart per heart beat
- an increase in the heart rate
- an increase in the breathing rate.

(i) Suggest why a decrease in the volume of plasma in the blood may reduce the effects of hypoxia.

..... [1]

(ii) Explain why an increase in the heart rate occurs in response to hypoxia.

.....

..... [2]

(c) People with sickle cell anaemia have a form of haemoglobin that is unable to bind to oxygen efficiently. The cause of the condition is a mutation in the gene coding for the β-globin polypeptide of haemoglobin.
Outline how this mutation can lead to an altered amino acid sequence of the β-globin polypeptide.

.....

.....

..... [3]

41. M/J 14/P23/Q6

Fig. 6.1 shows a section of diseased artery from a smoker.



Fig. 6.1

(a) **(i)** With reference to Fig. 6.1, describe how this diseased artery differs in appearance from a healthy one.

.....

.....[2]

(ii) State one way in which nicotine in tobacco smoke affects arteries.

.....[1]

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(b) Arteries and capillaries have different structures related to their different functions.
For each type of blood vessel, give **one** structural feature and the function that it provides.

(i) artery: .....

structural feature .....

function .....
[2]

(ii) capillary: .....

structural feature .....

function .....
[2]

42. O/N 12/P22/Q6

Coronary artery bypass grafting is the most common heart operation in the world.
Fig. 6.1 is a diagram of a coronary bypass. The graft is a section of a healthy blood vessel.
The blood vessel used in Fig. 6.1 is the internal mammary artery. It is a common choice for surgeons as it is quite resistant to arteriosclerosis.

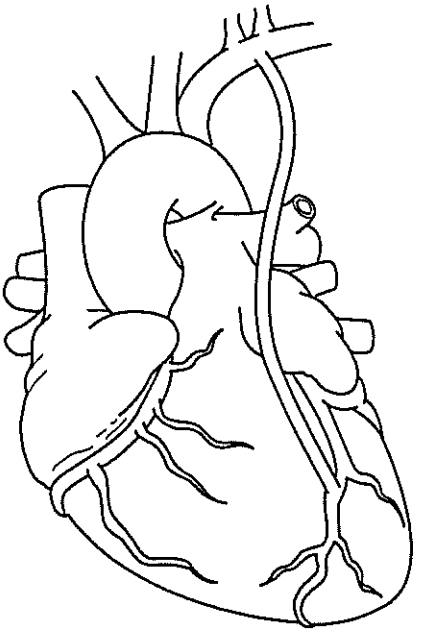


Fig. 6.1

(a) Use label lines and the following letters to label the following on Fig. 6.1:

A aorta
B coronary artery
C internal mammary artery
D pulmonary artery
E right atrium
F vena cava

[3]

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(b) On Fig. 6.1, mark with an **X**, the diseased area of the coronary artery for which the surgery has been performed. [1]

(c) With reference to coronary heart bypass surgery, discuss the difficulties in achieving a balance between prevention and cure.

.....

.....

..... [3]

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Answers Section

1. M/J 22/P22/Q3

(a) *any **two** from:*

I *ref. to* two units v one unit **or** bigger v smaller (neutral points)

sucrose		***fructose***
disaccharide **R** if incorrect monosaccharides stated	v	monosaccharide ;
non-reducing sugar ora **A** described in terms of reaction with Benedict's reagent	**or**	reducing sugar ; ora
glycosidic bond present **R** glucosidic	**or**	no glycosidic bond present ;
AVP ; e.g. always ring structure(s) hydrolysed / broken down before used as, a respiratory substrate / an energy source	v v	ring structure or straight chain form can be used immediately as, a respiratory substrate / an energy source

(b) (i) **I** three fatty acids

A fatty acid residue *for fatty acid*

*any **three** from:*

1 glycerol ;

2 ester, bond / linkage, qualified ; e.g. labelled on Fig. 3.2 / three ester bonds / ester bond between (O of) glycerol and (C of carboxyl of) fatty acid

3 palmitate is saturated **or** oleate(s) are, unsaturated / monounsaturated **or** two fatty acid(s) are, unsaturated / monounsaturated, and one is saturated ;

4 (each fatty acid has a) hydrocarbon chain ;

5 AVP ; extra detail e.g.
hydrocarbon chain palmitate 15C and oleate 17C
palmitate, $CH_3(CH_2)_{14}$ and oleate, $CH_3(CH_2)_7CH=CH(CH_2)_7$
palmitate 16C and oleate 18C
unsaturated fatty acid tail(s) / oleate
ref. to, presence of one, C=C / (carbon-carbon) double bond
not the maximum number of, hydrogen atoms / hydrogens
saturated fatty acid tail(s) / palmitate
ref. to no, C=C / (carbon-carbon) double bond
maximum number of hydrogen atoms / hydrogens

(ii) *any **one** from:*

idea that provides greater energy per unit volume ;

A higher calorific value / greater energy density

R produces more energy

less mass needed to provide same energy / low(er) mass to energy ratio ;

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ora higher energy to mass ratio
low(er) mass to volume ratio ;
AVP ; e.g. glycogen can only be stored in liver and muscles
glycogen is hydrated / uses water for storage, so mass increases
suggestion that more, areas / adipocytes / adipose tissue, in body to store triglycerides
(proportionately) more C-H bonds (to supply H for respiration)
suggestion that triglycerides provides insulation during flight (at heights)
more compact

(c) closed, double (circulation / circulatory system) ;

(d) I *ref. to* metabolism
any ***two*** *from:*
need more, / large quantities of, oxygen / glucose
or
more / large quantities, of, oxygen / glucose, delivered / reaches tissues / transported / AW
or
idea of enough, oxygen / glucose supplied to meet needs ;
idea that heart pumps blood (to tissues more) efficiently ;
e.g. forcefully / in greater volumes / more / with higher pressure / faster
more oxygenated blood is mp2 only
suggestion of reason for needing more oxygen or glucose ; I migration
e.g. more active
fly / wing muscles
search for food longer
constantly moving / move for longer time
generate heat to maintain body temperature, qualified ;
e.g. (generally) smaller size / larger SA:V
ref. to need to meet demands of carbon dioxide removal (from muscle action / respiration) ;
idea that more carbon dioxide produced (so must be removed)

(e) *note: only one mark for both pulmonary vessels*

function of blood vessel	name of blood vessel
carries blood from the heart to the lungs	pulmonary, artery / arteries ; pulmonary, vein / veins
carries blood to the heart from the lungs	
carries blood from the heart to the rest of body	aorta ; I artery
carries blood to the heart from the rest of body	I superior and inferior or anterior and posterior I vein venae cavae / vena cava ;

[12]

2. M/J 22/P23/Q6

(a) wall / muscle, of right atrium ;

(b) atrial, systole / contraction ;

(c) AVN delays impulse (from sinoatrial node / atrial muscle) ; AW
e.g. excitation wave / conduction
plus one from:
ring of non-conducting fibrous tissue prevents impulse from sinoatrial node directly passing to ventricles ;
impulse must pass through, atrioventricular node / AVN ;

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(then) passes to Purkyne tissue (to ventricles for contraction) ;

(d) semi-lunar (valves) ;
A aortic valve and pulmonary valve [5]

3. **O/N 21/P22/Q2/a,c,d,e**

(a) too large / large size ; **A** not small enough
cannot pass through endothelial, pores / gaps **I** holes
A fenestrations / AW
or
cannot, pass across / cross the membranes of, endothelial cells ;
A epithelial cells
in context of entering an endothelial cell and exiting to the tissue fluid

(b) *accept Hb / hb for haemoglobin*
*any **three** from:*
1 (at altitude) lower, partial pressure of oxygen / pO_2 (in, atmosphere / inhaled air / inspired air / alveolar air) ;
I low pO_2 in blood
R if stated as high $ppCO_2$ and low pp O_2
R low, volume / saturation, of oxygen
2 percentage saturation of haemoglobin (with oxygen), lower / decreased ;
A haemoglobin is less saturated
A fewer molecules of / less, oxygen, combine / associate, with haemoglobin **I** absorbed / taken up by
R if in context of Bohr effect but then allow ecf for overall **max 2**
3 (as) haemoglobin has lower affinity for oxygen (than at sea level) ;
4 more haemoglobin (synthesised / required / provided) ;
5 compensation / described ;
e.g. helps to transport the same quantity of oxygen as at sea level
6 AVP ; e.g.
idea of more rbc through pulmonary capillaries per unit time
ref. to EPO / erythropoietin (secreted to increase red blood cell production)

(c) *any **three** from:*
A Ψ for water potential **A** plasma for blood
mp1 and mp2 = consequence in blood of lower blood albumin than normal
1 *idea that* low blood albumin means, less / AW, solute ;
2 (so) higher water potential (in blood); *must be in context of blood context can be anywhere along the capillary*
A high water potential *if ref. to low albumin is made*
A steeper water potential gradient (than normally, at arterial end)
mp3 and mp4 = return of water to blood from tissue fluid (capillary venous end)
3 less steep water potential gradient (than normal) / little difference in water potentials ;
4 less / little, water returns to, blood / capillary (from tissue fluid) ;
A (tissue) fluid *for water*
R plasma *for water*
additional ideas
5 *idea that* more, water / plasma / fluid, enters tissue fluid (than normal)
R tissue fluid *for fluid*
A more, water / fluid, enters tissue fluid than exits (to the capillary or lymph system) ;
(compared to normal)
6 AVP ; e.g. water can enter tissue fluid for a longer time than normal
less albumin than normal to act as an osmotic force for return of water / AW

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too much excess, water / fluid / tissue fluid, to be taken up into lymph, capillaries / vessels / system

(d) (cell surface) receptor(s) ; [9]

4. **O/N 21/P21/Q2/a**

(a) (i) red blood cell ; **A** erythrocyte / red blood corpuscle

(ii) *any valid difference one mark*
*fluid **R** / tissue fluid, has,*
one from
fewer (named) proteins / no large proteins / no plasma proteins ;
A no named plasma proteins (albumen / fibrinogen)
A fewer plasma proteins only if stated, they are small / leave the blood
fewer / no, white blood cells ; **A** more macrophages
no red blood cells ;
no platelets ;
explanation to match difference 2 marks
(red blood cells, platelets, proteins, white blood cells) too large ;
(fewer white blood cells) ref to some, white blood cells / phagocytes / macrophages
monocytes, are able to move through; cannot be, filtered/ fit, through gaps / AW, between endothelial cells / in endothelial wall / in capillary wall ;
idea that not filtered out under pressure from, plasma / blood ;
or
*fluid **R** / tissue fluid, has*
one from
higher partial pressure / AW, of, carbon dioxide ;
A higher concentration / more
explanation to match difference 2 marks
produced by / waste of, (surrounding respiring) cells ;
A (waste) product of respiration
diffuses / AW, from cells to, (fluid) **R** / tissue fluid (before entering blood) ;
idea that blood has come from lungs, where carbon dioxide has been excreted ;
AVP ; e.g. diffusion through cells in capillary wall
or
*fluid **R** / tissue fluid, has*
one from
lower partial pressure / AW, of, oxygen ; **A** lower concentration / less
explanation to match difference 2 marks
carried by the blood (from the lungs) ; **A** blood is more oxygenated
diffuses / AW, from, red blood cells / **Q** / blood ;
idea that filtered out under pressure from, plasma / blood ;
AVP ; e.g. diffusion through cells in capillary wall
or
*fluid **R** / tissue fluid, has*
higher concentration of, glucose / amino acids / fatty acids ; **A** more
explanation
carried by the blood to the respiring cells ;
small ;
can be, filtered / fit, through gaps / AW, between endothelial cells / in endothelial wall / in capillary wall ;
idea that filtered out under pressure from, plasma / blood ;
AVP ; e.g. diffusion through cells in capillary wall [4]

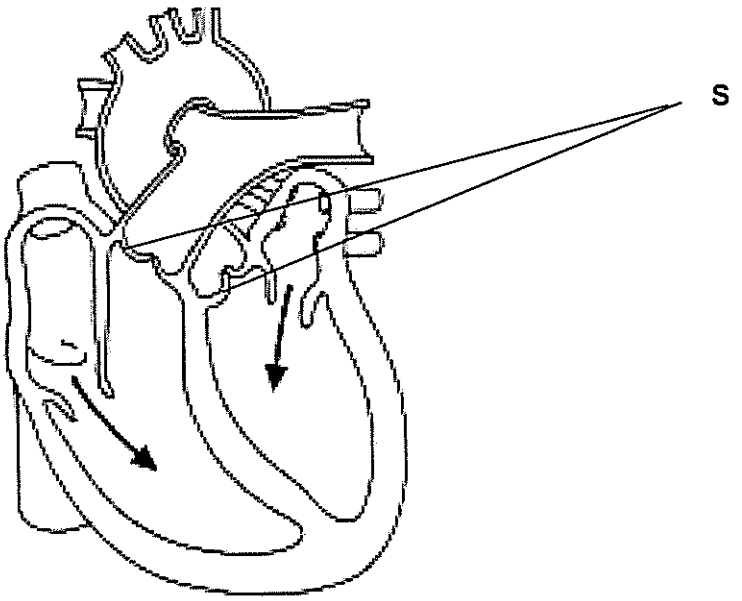
5. **O/N 21/P21/Q6**

(a) atrial systole ; **A** atrial contraction
*and **one** from:*

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volume of the atria is small(er) than in **A** ;
A atria in stage **B** are smaller than those in stage **A**
the atrioventricular / bicuspid and tricuspid, valves are open (and semilunar valves are closed) ;
the blood is flowing (from the atria) into the ventricles ;
if name of stage is incorrect accept correct description of atrial systole, no ecf for incorrectly named stage

(b) (i) label line to any part of a semilunar valve ;



(ii) prevent blood flowing backwards ;
from the (named) arteries to the (named) ventricles ;
or
ensure blood flows in one direction ;
from the (named) ventricles to the arteries ; [5]

6. O/N 21/P23/Q3

(a) (i) *any **three** from:*
1 no, nucleus / organelles ; **ora** e.g. 'if they were white blood cells …'
2 cytoplasm is, homogeneous / AW ;
3 about same, size / width / diameter, as lumen of capillary ;
4 cells about 7 µm in diameter / AW ;
5 flexible / variety of shapes / irregular shapes ;
6 AVP ; e.g. rouleau

(ii) *assume answers are about tissue fluid unless told otherwise*
*any **two** from:*
1 no red blood cells ;
2 no platelets ;
3 fewer (named) protein(s) / no large proteins / no plasma proteins ;
A no named plasma proteins (albumen / fibrinogen)
A fewer plasma proteins only if stated that they are, small / leave blood
4 less, glucose / amino acids / fatty acids ;
5 fewer, white blood cells / leucocytes / neutrophils / monocytes ;
A more macrophages
6 less / lower concentration of, oxygen
or
more / higher concentration of, carbon dioxide ;
I urea except in liver and muscle tissue
R 'waste'

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(b) (i) *ignore any explanations*
(mean) percentage saturation of haemoglobin with oxygen (in blood leaving the lungs) decreases ;
(mean) haemoglobin concentration in blood increases ;
any suitable comparative data quote with altitude in m and mean Hb concentration in g 100 cm^{-3} ***or*** percentage saturation ;

(ii) *any **three** from:*
1 more red blood cells ;
2 larger red blood cells ;
3 more haemoglobin per red blood cell ;
4 more alveoli / larger surface area for gas exchange ;
A bigger lungs / larger chest volume / broader chest / larger capacity of lungs (total or vital)
5 higher, cardiac output / stroke volume / AW ;
A higher blood pressure in pulmonary artery
6 AVP ;
7 AVP ;
e.g. higher tidal volume / deeper breaths
higher ventilation rate (minute volume) **I** faster breathing
ref. to erythropoietin / EPO, stimulating production of (more) red blood cells
more red blood cells through alveolar capillaries per unit time [11]

7. M/J 21/P22/Q3/a
(a) (i) *accept from either column for mark and assume blood if not stated*
any three from

blood	**tissue fluid**	
has red blood cells	has no red blood cells	;
more, white blood cells / leucocytes / named e.g. neutrophils, lymphocytes, monocytes **or** fewer macrophages	fewer white blood cells / leucocytes / named e.g. neutrophils, lymphocytes, monocytes **or** more macrophages	;
has platelets	has no platelets	;
has, more protein / large proteins **or** has, plasma proteins / named example e.g albumin / fibrinogen / globulin *these are large proteins*	has, fewer / no large, proteins **or** has no, plasma proteins / named example e.g. albumin / fibrinogen / globulin *only allow fewer plasma proteins if clear the proteins present are small enough to leave blood*	;
higher, concentration / AW, oxygen **A** more oxygenated	lower, concentration / AW, oxygen **A** less oxygenated	;
higher, concentration / AW, glucose / amino acids / fatty acids	lower, concentration / AW, glucose / amino acids / fatty acids	;
lower, concentration / AW, carbon dioxide **A** urea, in liver / muscles **I** waste	higher, concentration / AW, carbon dioxide **A** urea, in liver / muscles **I** waste	;
higher pressure	lower pressure	;

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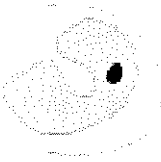
(ii) lymph ; **A** lymphatic fluid [4]

8. M/J 21/P23/Q5/a,b

(a) *allow one mark if monocyte <u>and</u> neutrophil both labelled as phagocytes and no other cell is labelled phagocyte*
allow phagocyte for either the monocyte or neutrophil if the other cell correct

red blood cell / erythrocyte ;





monocyte / macrophage;
I white blood cell
I leucocyte

neutrophil ;
A *polymorphonuclear leucocyte / basophil / eosinophil*





lymphocyte ;
I B / T
I B-cell / T-cell

(b) 15 / 15.0 / 15.1 / 15.2 (kPa) ;
0.09 / 0.10 / 0.1 (s) ; [6]

9. O/N 20/P22/Q6

(a) (i) same shape <u>and</u> shift to the right ;
must start to rise within 2 small squares of 0 and end at or near to existing curve

(ii) *max 2 if concept of more not mentioned in response*
*any **three** from:*
1 actively respiring tissue means more carbon dioxide ;
2 increase in, formation of carbonic acid / dissociation of carbonic acid / hydrogen ions, (in the red blood cell) ; **A** from equation
3 more hydrogen ions, bind to haemoglobin / form haemoglobinic acid ; **A** HHb
4 (causes) more oxygen (to be), unloaded / dissociated / AW (from haemoglobin);
I *ref. to* faster / quicker
I incorrect *ref. to* affinity causing unloading, e.g. CO_2
A lower (percentage) saturation of haemoglobin with oxygen
A oxygen released, more easily / readily from haemoglobin
5 haemoglobin <u>affinity</u> for oxygen decreases ;
6 more oxygen to meet demand for (aerobic / cellular) <u>respiration</u> ; AW
I more oxygen for respiring tissues

(b) CO_2 = (passive / simple) diffusion ;
HCO_3^- = <u>facilitated</u> diffusion ;
I *ref. to* size
CO_2 is, non-polar / not charged / not ionic <u>and</u> can cross, hydrophobic core / phospholipid bilayer ;
HCO_3^- is, charged / ionic / hydrophilic <u>and</u> (needs to) cross, via, transport / carrier, protein ; **A** channel protein
if explanation mps not gained, allow 1 mark for CO_2 is, non-polar / not charged / not ionic <u>and</u> HCO_3^- is, charged / ionic / hydrophilic [8]

10. O/N 20/P21/Q3/a

(a) (i) blood, travels through the heart twice for every one complete, circuit (of the body) / circulation

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or
blood, travels through the heart twice and through pulmonary and systemic, circulations / systems / circuits ;
A description of both circulations

(ii) chordae tendineae / tendinous cords ; **A** tendons / 'heart strings'
*any **two** from:*
idea that (atrioventricular) valve, held in position / prevented from inverting, during ventricular, systole / contraction
A AV valve *for atrioventricular valve*
connect the papillary muscle to the (atrioventricular / AV), valve ;
ref. to tension, in the chordae tendineae / AW, (during ventricular contraction) ;
(allows valve to) prevent backflow of blood into atrium / ensure one way blood flow (through the heart) ;
ecf max 2 marks for function if structure A is a correctly named valve (atrioventricular / tricuspid / bicuspid) [4]

11. M/J 20/P22/Q2

(a) sinoatrial node / SAN, sends out, wave of excitation / impulses / electrical impulses ;
R nerve impulses wave of excitation / AW, spreads across atrial wall ;

(b) *any two from*
non-conducting fibres between atrial and ventricle walls ;
impulse must pass down septum ;
AVN (in interatrial septum) delays impulse ;
(gives) time for atria to, complete contraction / empty ;

(c) (i) one mark if **F** and **G** are semilunar and **E** and **H** are bicuspid ;
one mark for **E** and **G** opens ;
one mark for **F** and **H** closes ;

E bicuspid / (left) atrioventricular, valve,	*closes*
F semilunar / aortic, valve	*opens*
G semilunar / aortic, valve	*closes*
H bicuspid / (left) atrioventricular, valve	*opens*

(ii) (during contraction) left ventricle, generates / AW, higher pressure (than left atrium) ;
A do not produce the same pressure when contracting
any one from
(because) wall of left ventricle thicker / more (cardiac) muscle, so reaches higher ;
data from Fig. 2.1 to show difference in pressure ; [9]

12. M/J 20/P21/Q4/d

(a) (i) $\frac{50}{86} \times 100$;
58(%) ;
if extracted values are different allow ecf for calculated answer
accept ± 1 mm when reading from graph (49 to 51 and 85 to 87)

(ii) *allow 'volume of blood' for 'mean volume of blood per kg body mass'*
any four from:
description to max 3
1. trend is / overall / AW, increase in volume of blood, over time / AW
or
increase in volume of blood over time except between 0 and 1–2 months ;
2. trend is / overall / AW, increase in red blood cell volume, over time / AW ;
or
increase in red cell volume over time except between 7–8 and 12 months ;
3. *ref. to* percentage of mean blood volume represented by red blood cells / haematocrit ;

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e.g. fluctuates / mainly increasing / decreases between 1–2 and 3–4months / decreases between 7–8 and 12 months ;

4. any comparative use of, figures / percentages ; *to support mp1, mp2 or mp3*

explanation to max 3

5. lower partial pressure of oxygen at high altitude / less oxygen in inhaled air ;
6. lower oxygen saturation of haemoglobin / haemoglobin has lower oxygen affinity ;
7. compensation
   or
   idea that changes occur to make up for less, oxygen taken in / transported to tissues
   R *idea of* body getting more oxygen than at sea level
8. (over time) more red blood cells produced so more haemoglobin / AW ;
9. (over time) proportion of red cells / concentration of haemoglobin, increases so, take up / AW, greater volume of oxygen ;
   A more red blood cells per unit time passes through, lungs to take up oxygen / tissues to deliver oxygen
10. AVP ; e.g. *ref. to* erythropoietin / EPO [6]

13. M/J 20/P23/Q3/a,b

(a) (i) **X** = artery **Y** = vein ;

(ii) *any two from*
cross section not regular / no defined shape / AW ; **A** not circular
tunica intima smooth; **A** inner layer *for tunica intima* **A** not, crinkly / wavy
thin / thinner (than **X**) tunica media ; **A** thin middle layer
wide lumen diameter relative to wall thickness / relatively large lumen / AW ;
tunica, externa / adventitia, as thick / thicker, than tunica media ;

(b) (i) *any two from*
tissue fluid and blood plasma do not have red blood cells ; **A** blood contains red blood cells red blood cells are too large to pass through endothelial pores ;
idea of tissue fluid and blood plasma similar viscosity / blood more viscous ;
AVP ; *ref. to* similar colour (versus blood is red)

(ii) *any one from*
taken up by / transported into / AW, (body) cells (from tissue fluid) ;
used by (body) cells to, synthesise polypeptides / proteins / enzymes ; [6]

14. O/N 19/P21/Q4

(a) **A** neutrophil ; **A** polymorphonuclear, leucocyte / granulocyte
B lymphocyte ;

(b) (i)

substance	concentration in lymph compared to the concentration in blood
oxygen	lower
carbon dioxide	higher
red blood cells	lower

three rows correct = 2 marks
one row or two rows correct = 1 mark

(ii) two from
immune response occurs (linked to antibody / cytokine production) ;
increased concentration / production of / AW, of antibodies (which are protein) ;
AVP ; e.g. cytokine production

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(c) (i) . two from
emits, impulses / waves of depolarisation / waves of excitation / AW ;
at regular intervals / AW ; e.g. acts as a pacemaker
spreads across the, atria / atrial muscles / AW
or
stimulates / AW, atrial, contraction / systole ;
A initiates, heart beat / contraction of the heart

(ii) *three from*
faster heart rate / increased rate of contraction (of ventricles) ;
no, slowing / delay of, impulse / wave of excitation / AW, by AVN ;
more impulses reaching the ventricle per unit time ;
ventricles may contract before they are full ;
irregular heart rate ;
AVP ; e.g. may have no effect if only a small proportion of impulses pass through
suggestion that ventricles may not contract from apex up [11]

15. O/N 19/P23/Q4

(a) *artery wall*
I *narrow lumen to maintain high (blood) pressure*
I *ref. to valves / ref. to inner lining being wrinkled or wavy*
1 thick, walled / tunica media, to withstand high (blood) pressure / prevent bursting ;
2 endothelium / endothelial cells / tunica intima, are smooth, little friction to blood flow / easy flow of blood / no eddies of blood flow / AW ;
3 elastic, tissue / fibres, stretches to allow surges in blood flow / recoils to maintain blood pressure or force blood forward ;
4 smooth muscle (contracts to), maintains / regulates / controls blood flow ;
A smooth muscle distributes blood
5 collagen fibres, avoid rupturing / bursting ;

(b) (i) red blood cells / erythrocytes ; **R** red and white blood cells
one from
biconcave (shape) ;
no nucleus ;
idea of uniform, cytoplasm / cell contents ;
idea of rouleau / stacked cells ; **I** 'clumped'
I size

(ii) *assuming arteriole unless told otherwise, accept alternative terminology for layers of* of wall of arteriole **I** *ref. to folding*
1 thicker wall / more than one layer of cells in wall / has tunica intima, tunica media and tunica adventitia whereas capillary has tunica intima ; **A** endothelium for tunica intima
2 more cells forming, perimeter / tunica intima ;
3 wider (vessel) / wider lumen / AW ; **A** actual width(s)
4 nucleus / nuclei, present in wall only in arteriole ;
5 cells lining lumen / endothelial cells, are thicker ;
6 lumen smaller, relative to the, thickness of the wall / overall width ;
7 more (red blood) cells (in lumen) ;
8 nuclei projecting inwards only in arteriole ;
9 AVP ; e.g. *ref. to* smooth muscle cells
capillaries are surrounded by cells
correct calculation of actual sizes using magnifications in Fig. 4.1 arteriole 20–35 μm and capillary 6–7 μm

(c) (i) 1 higher (hydrostatic) pressure of blood (at start of capillary) ;
2 (pressure / ultra) filtration of blood ;

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3 (causing) leakage / movement out / pushing out, of plasma ;
R diffusion

4 *either*
glucose / amino acids / salts, (filtered) out
or
(large) plasma proteins not (filtered) out ;

5 AVP ; e.g. *ref. to* pores / fenestrations / gaps, within / between, endothelial / lining, cells
e.g. molecules smaller than MM ~68 000 (g mol^{-1} / daltons) can pass out

(ii) lymph ; **A** lymphatic (fluid)
one from
I *any cells / waste products / toxins / antibodies / fatty acids and glycerol*
no, named / large / plasma, proteins, e.g. albumen
no / little / less, oxygen / glucose
higher concentration of / more, carbon dioxide
AVP ; e.g. higher concentration of / more, fat / lipids / lipoproteins
if fluid identified as tissue fluid give one mark as an ECF for a difference between plasma and tissue fluid e.g. no, named / large / plasma, proteins e.g. albumen [14]

16. M/J 19/P22/Q3

(a) **C** =neutrophil ; **A** polymorphonuclear leucocyte **A** basophil **A** eosinophil
D = lymphocyte ; B / T *is neutral*
E = monocyte ; **A** macrophage **I** *leucocyte / white blood cell, throughout*

(b) (i) *any two from:*
lymphocytes / blood cells, produced in / originate from, bone marrow ;
ref. to stem cell(s) ;
ref. to cell division ; e.g. bone marrow has cells that can carry out, mitosis / cell division **A**
(stem cells are) multipotent

(ii) *any three from:*
measles
immune response stimulated ;
detail ; e.g. **either** antigen recognition / presence / binding
or lymphocyte / white blood cell, stimulated / triggered } **or** clonal selection / AW
plus
clonal, expansion / proliferation / cell division / mitosis
R incorrect pathogen name **R** bacteria
CLL
result of, uncontrolled mitosis ;
A uncontrolled, division / cell cycle
I rapid mitosis
detail ; owing to, mutation / named mutation
or
cell cycle checkpoints not working
or
cells don't respond to signals to control division

(c) (i) *any two from:*
(passive / simple) diffusion (of oxygen) across the phospholipid bilayer ;
A movement from a higher to a lower concentration *for diffusion*
A between phospholipids / between fatty acid chains / across hydrophobic core / across bilayer / AW, *for phospholipid bilayer*
small size ;
non-polar / uncharged ;

(ii) *any three from:*
less oxygen in inhaled air / AW ; **A** less oxygen taken up from alveoli

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low(er) saturation of haemoglobin (with oxygen) ; **A** Hb for haemoglobin

A haemoglobin carries less oxygen *must be the context of oxygen*
R saturation, with air / carbon dioxide

haemoglobin has lower affinity for oxygen ;
(so) more haemoglobin required (so more red blood cells) / (more red blood cells) so more haemoglobin ; AW compensation / compensates ;

A so same, volume / quantity / amount, of oxygen reaches body cells (compared to lower altitude)

(d) *any four from:*

1 (alleles have) different nucleotide sequences ; **A** different base sequences

2 base substitution / substitution of a base ; **A** T replaced by A

3 (alleles have) different mRNA codons ; **A** altered mRNA codon
R altered genetic code

4 (results in) one amino acid change
or
change from, glutamic acid / glutamate / glu, to, valine / val
or
changed primary structure ; **A** changed sequence of amino acids
R *if implies whole sequence changes*

5 AVP ; e.g. Hb^A = CTC and Hb^S = CAC (on template strand)
A Hb^A = GAG and Hb^S = GTG (on non-template strand)
or
Hb^A = CTT and Hb^S = CAT (on template strand)
A Hb^A = GAA and Hb^S = GTA (on non-template strand)
*this is **not** also mp2*
ref. to amino acid substitution at position 6 (*this is **not** also mp4*)
A 6th, codon / triplet, changed

6 changed, (β-globin / Hb) tertiary structure ; **A** polypeptide / (Hb molecule) quaternary structure **R** β-globin / polypeptide

7 *ref. to* loss of globular structure / hydrophobic amino acid faces outside (instead to of towards centre) ;
A described e.g. (val) amino acid with hydrophobic R-group instead of (glu) amino acid with hydrophilic R-group
accept hydrophilic / polar, amino acid
accept hydrophobic / non polar, amino acid

8 sticky (haemoglobin) molecule formed / forms fibres with other haemoglobin molecules ;

9 oxygen taken up less easily / less oxygen carried by haemoglobin / AW ;
A β-globin takes up oxygen less easily / AW

10 AVP ; (sickle cell) haemoglobin / β-globin, less soluble / AW
I insoluble

[17]

17. M/J 19/P21/Q5

(a) *closed*
blood flows through, (blood) vessels;
A three of heart, arteries, veins, capillaries
double
blood flows through the heart twice in one complete circulation (of the body) / AW ;
A *ref. to* pulmonary and systemic circuits / to lungs and rest of body

(b) (i) pulmonary vein ;
semi-lunar / AW, valve ; **A** pulmonary valve **R** aortic valve
right, atrium / auricle ;

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(ii) *any three from:*
1 left ventricle / chamber **Y**, pumps blood into, systemic circulation / described
or
right ventricle / chamber **X** pumps blood into, pulmonary circulation / described
or
distance travelled by blood in systemic circulation is greater than distance travelled by blood in pulmonary circulation / AW;
2 to overcome great(er) resistance to flow in systemic circulation ; **ora**
3 high (blood) pressure is required for blood to travel around the systemic circulation ;
4 high pressure requires more muscular force ; **ora**
5 pulmonary capillaries, rupture easily / damaged by high pressure ;
I more cardiac muscle

(c) *any four from:*
1 impulse / wave of excitation / AW, passes from SAN to atria (muscles) ;
R nervous impulse / signal *once only*
2 atria both contract, together / at the same time ;
A atrial systole *if not contradicted by one contracting before the other*
3 atria contract before ventricles ;
4 fibrous / non-conducting, tissue prevents impulse travelling to ventricles ;
5 impulse delayed at AVN ;
6 AVN passes impulse to, bundle of His / Purkyne fibres ;
7 Purkyne fibres conduct impulses to muscle in wall of ventricles ;
8 ventricles contract together (if mp2 not awarded) ;
A ventricular systole if not contradicted as for atria
9 ventricles contract from the bottom upwards ; [12]

18. M/J 19/P23/Q6

(a)

structure in the heart	letter
valves preventing back flow of blood into the ventricle	**S** ;
blood vessel carrying blood under highest pressure	**P** ;
chamber that pumps blood to the lungs	**N** ;

(b) *treat as neutral effects of nicotine on the brain and ref. to adrenaline*
any three from:
increased heart rate ; **I** increased heart beat
increased blood pressure ;
increases risk of, blood clotting / thrombus formation ;
A increases risk of thrombosis
A increases stickiness of platelets
damages the endothelium ;
AVP ; e.g. stimulates vasoconstriction / reduces the diameter of blood vessels
A named blood vessel types

(c) (i) *any one from:*
two nuclei vs one ;
ref. to, DNA / chromosome, content ;
cytokinesis has not occurred ;
A cytoplasm has not divided (into two cells)

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(ii) *any two from:*
in context of cardiac myocyte or overall heart function
unable to replace, damaged / worn out / old, cardiac myocytes ;
R repair myocytes
unable to repair (damaged) cardiac, muscle / tissue ; **A** heart tissue
repair (to cardiac muscle may be) with, unspecialised cells / scar tissue ; [9]

19. O/N 18/P22/Q2/c,d

(a) (i) using / AW, water / H_2O ;
to break bond (between phosphate groups) ; **R** if bond incorrectly named

(ii) active transport ;

(iii) *any four from*
1 (reversibly) binds / attaches / AW, to, allosteric site / site other than active site ;
2 (which) changes, shape / tertiary structure / 3-D structure, of active site ;
A active site distorted
I protein structure
3 substrate / ATP, cannot, enter / bind / fit / AW, to active site ;
A active site no longer complementary to substrate
A enzyme substrate / ES, complexes cannot form
A ESCs cannot form
I ATP / substrate, cannot bind to enzyme *without a link to active site*
4 no / less, hydrolysis of ATP **A** breakdown
or
no / less, energy released ;
I no energy, synthesised / created / produced
5 Na^+ not moved, out and K^+ not moved in ;
I active transport, stops / decreases

(b) (i) *allow* *systole for contraction and diastole for relaxation*
bicuspid valve or mitral valve for (left) atrioventricular
aortic valve for semi-lunar valves
any four from (max 3 if whole response based on right side of heart)
before atrial contraction / during relaxation of the left atrium and left ventricle
1 atrioventricular valve, opens / is open **A** *following atrial contraction*
or
blood trickling into ventricle / some blood enters ventricle ;
2 atrial contraction, blood flow to ventricles / ventricles fill (with blood)
or
atrial contraction then ventricular contraction ;
ventricular contraction
3 biscuspid valve closes and semi-lunar valve opens ;
R *if occurs before ventricular contraction*
4 blood flows into aorta ;
R if states 'from atrium' or 'then to lungs'
R *if occurs before ventricular contraction*
5 *ref. to* atrium in relaxation during ventricular contraction ;
pressure changes
6 contraction of, atrium / ventricle, increases pressure (of that chamber)
or
ref. to (blood) pressure differences to cause opening or closing of valves ;
e.g. pressure in atrium greater than in ventricle so atrioventricular valve opens
pressure in ventricle greater than aorta so semilunar valves open
pressure in ventricle greater than atrium so bicuspid valve closes

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(ii) **I** ref. to fibrillation / cardiac cycle rhythm
any three from
1 more powerful contraction of (cardiac) muscle / increased ability for (cardiac) muscle (**A** cardiac cells) to contract;
A stronger contraction / contract strongly / increased contractility
I contracts more / increased contraction
2 blood (pumped) at higher pressure ; **I** blood at high pressure
3 more force to overcome resistance (in blood vessels) ;
4 more blood reaches lungs to obtain oxygen (per unit time) / more oxygen reaches (rest of) body / tissues (per unit time) (in blood) ;
allow idea of efficient delivery of oxygen
A more oxygenated blood can be delivered to heart, muscle / tissue AW
5 less fatigue / increased energy / increased mobility / AW ; [14]

20. O/N 18/P21/Q6

(a) (i) *any three from*
haem group containing iron (atom) ;
four haem groups (per molecule of haemoglobin) ;
each iron (atom) / haem / prosthetic group, binds one oxygen molecule ;
or
four oxygen molecule per haemoglobin molecule ;
cooperative binding / allosteric effect described ;
AVP ;

(ii) *any two from*
ref. folding of polypeptide chain(s) / globin(s) fold (to give globular structure) ;
A *ref.* to, tertiary structure / quaternary structure
(so) hydrophilic R groups (of amino acids) are on the outside of the molecule / hydrophobic R groups (of amino acids) on the inside of the molecule;
A hydrophilic and hydrophobic amino acids
hydrogen bonds form with water (molecules) ;

(b) (i) llama = 90.5% human = 78.5% ;

(ii) *any two from*
lower partial pressure of oxygen at high altitude ;
at the same partial pressure the percentage saturation is (much) higher than for humans ;
ref. to haemoglobin has a higher affinity for oxygen ;
idea that sufficient oxygen delivered to tissues to satisfy demand ; [8]

21. O/N 18/P23/Q4/a,b

(a) *any four from*
I signals
R nerve impulse first time
SAN
1 acts as a pacemaker / initiates heart beat / initiates cardiac cycle;
A regulates heartbeat
A described, e.g. as rhythm / emits impulses at regular intervals
2 releases / AW, waves of excitation / (electrical) impulses ;
A *ref.* to, action potentials / depolarisation
R nerve impulses
3 spread across / AW, atria / atrial walls **or** leads to atrial, systole / contraction(s) ;
AVN
4 allows a (short) delay / ~0.1 s ;
5 passes the impulse / wave of excitation, to the Purkyne fibres / down the septum ;

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A Bundle of His
R nerve impulse

6 detail ;
e.g. so atria contract before ventricles
allows ventricles to fill / allow atria to empty completely
so atria have, emptied / contracted, before ventricular contraction begins
so atria and ventricles don't contract at the same time

(b) *any two from*
contraction / ventricular systole, begins at the base of the ventricles ;
both ventricles contract at the same time ;
blood is forced, upwards / into arteries / through (named) semi-lunar valves ;
A pushed
idea that so ventricles, empty / pump out most of the blood ;
AVP ;
e.g. so impulses / waves of excitation, travel upwards from the base [6]

22. O/N 17/P22/Q6

(a) (i) **S** ;
(ii) pulmonary vein ;
R ;

(b) wall of right atrium ; **A** muscle of right atrium

(c) *two from*
passes the, impulse / wave of excitation, to the Purkyne fibres / down the septum ; **A** Bundle of His **R** nerve impulse allows a (short) delay ;
detail ;
e.g.
so atria contract before ventricles
allows ventricles to fill
so atria have, emptied / contracted, before ventricular contraction begins
so atria and ventricles don't contract at the same time [6]

23. O/N 17/P21/Q2

(a) capillary ;
two from
single celled wall / AW ; **A** thin wall
ref. to wall composed only of one, squamous epithelial / endothelial, cell ;
ref. to lumen diameter approx 7 μm ; **A** 5–8 μm **A** *ref. to* similarity to dimension of red blood cell in direct contact with tissue fluid ;
if vein named, allow one mark for, thin wall (relative to lumen) ***or*** *wide / AW, lumen (relative to wall thickness)*

(b) (i) 0.24 s / 0.25 s ;
(ii) 0.08 s / 0.09 s ; **A** range
(iii) *four from*
similarity
ref. to increases and decreases in pressure at same time ; **A** description for part of the graph e.g. start to rise at same point as RV, returns to minimum at same point as RV
idea that events in cardiac cycle occur are coordinated ; **A** described e.g. impulses pass up both vebtricles at the same time, ventricles both contract at same time
difference
reaches higher, blood pressure / peak, (than RV) ;

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systolic pressure higher in LV (than RV)
left ventricle pumps blood to (whole) body / RV only to lungs)
overcome greater resistance / ora for RV
walls of left ventricle, thicker / more muscular
more force exerted by LV

any two ;; [9]

24. O/N 17/P23/Q2

(a) *two from*
1 to generate a high(er) blood pressure (during systole) ; **A** force
I withstands / AW, high blood pressure
2 to overcome high(er) resistance (in systemic circuit than in pulmonary circuit) ;
3 to transport blood a greater distance / greater distance in systemic circuit ;
4 *ref. to* right ventricle generating low pressure to avoid damaging (capillaries in the) lungs / AW ;

(b) (i) **F** (inferior / posterior) vena cava ; **I** superior
G pulmonary artery ;
(ii) diastole ; **I** ventricular / atrial

(c) *five from*
1 wave of excitation / wave of depolarisation / impulses, from, atrioventricular node / AVN ;
2 pass(es) down Purkyne fibres (to ventricles) ; **A** Bundle of His
3 (both) ventricles contract / ventricular systole ;
4 from the base (upwards) / AW ;
5 blood pressure in ventricles, increases / becomes higher ;
6 blood pressure in ventricles greater than in atria ;
7 atrioventricular / AV / tricuspid and bicuspid, valves close ;
8 blood pressure in ventricles greater than in, artery / aorta / pulmonary artery ;
9 semi-lunar / pulmonary and aortic, valves open ; **A** blood flows through
10 blood flows, into arteries / to lungs and rest of the body ;
at end of description only
11 atria relaxing / atrial diastole / blood flows into atria ; [10]

25. M/J 17/P22/Q1/b

(a) **I** functions of individual tissues
if all cell types named as single cell, allow max 1 for named tissue types (organ because more than one tissue type)
three named tissue types ; ; ;

endothelium	**A** squamous epithelium **A** endothelial cells **A** epithelial cells
smooth muscle	**A** smooth muscle cells
connective tissue	
elastic tissue	**A** elastic fibres **R** elastin / elastic muscle
fibrous tissue	**A** collagen **A** collagen fibres
nervous tissue	**A** nerve cells
blood	**A** blood cells

only in context of vasa vasorum

general function
transports / carries / AW, blood ; **A** delivers **R** pumps blood **I** provides detail ; e.g. to tissues / to body cells / to body / away from heart / AW
R to lungs
(blood) is oxygenated / contains oxygen [4]

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26. M/J 17/P23/Q1

(a) blood contained in (blood) vessels AW

or

blood contained in *any three of*
heart, arteries, veins, capillaries ;
systemic and pulmonary, systems / circulation ;
A described *if circulations not named*
e.g. for each complete circuit (round the body) blood passes through heart twice
blood transported from heart to lungs and back, then to (rest of) body and back

(b)

2
4
1
3
5

1st and 5th boxes (2 and 5) correct ;
2nd and 4th boxes (4 and 3) correct ;

(c) (i) *assume answer refers to arteries unless stated otherwise*
withstand / AW, higher pressure (of blood) ;
prevent rupturing / bursting (from high blood pressure) ; **I** collapsing

one from
thicker / AW, tunica media ;
more elastic, tissue / fibres, and (smooth) muscle tissue ;
more / AW, elastic, tissue / fibres, to maintain, blood pressure / blood flow ;
more (smooth) muscle to maintain, blood pressure / blood flow ;

(ii) *carbon monoxide max 3*
forms carboxyhaemoglobin ; **A** binds to haemoglobin
less haemoglobin available to bind oxgen / haemoglobin has greater affinity for carbon monoxide / AW ;
reduces, percentage saturation of haemoglobin (with oxygen) / AW
A less oxygen binds to haemoglobin
I prevents oxygen binding
or
reduces oxygen carrying capacity of, haemoglobin / blood ;

nicotine max 3
increases heart rate ;
increases blood pressure ;
constricts, arteries / arterioles ; **A** vasoconstriction
makes platelets sticky / promotes clotting / promotes thrombosis ;

for either
damages, endothelium / tunica intima / lining of blood vessels ; [10]

27. O/N 16/P22/Q4

(a) *allow middle coat / intermediate layer / middle layer for tunica media*
allow adventitia for externa
one from
a thick tunica media ;
a thicker tunica media than tunica externa ; ora
a thick layer of, (smooth) muscle / muscle and elastic tissue ;

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A thick muscular wall
R striated / skeletal, muscle
many (layers of) smooth muscle cells ;
a, well-defined / firm / oval / regular / AW, shape (in cross section) ;
narrow / AW, lumen in relation to thickness of wall ; **A** narrow lumen
convoluted / folded / AW, endothelium / tunica intima ;

(b) *2 correct functions with no link to a structural feature – award one mark only*
R muscle / collagen, stretching and recoiling / recoiling
R elastic tissue contracting and relaxing
two from

1 (smooth) muscle / elastic tissue, maintains (blood) pressure ;
A increases blood pressure

2 thick (tunica media) / elastic tissue / (smooth) muscle / collagen (fibres), withstands high pressure / prevents rupture / AW ; **A** bursting

3 elastic tissue to smooth out (pulsatile) flow ; **R** smooths flow to give pulses

4 muscle / elastic tissue, helps to, maintain blood flow / move blood / keep blood moving forwards / AW ;
R *idea of* pumping / forcing blood forward / pushing blood

5 (smooth) muscle, contraction / relaxation, altering volume of blood delivered ;
A *idea of*, diverting blood / regulating blood flow
I muscle dilates

(c) magnification = image diameter ÷ actual diameter ; **A** M = I ÷ A
allow one mark only if correct answer but units given
if calculation is shown measurement must be correct and working must lead to correct answer
× 3.5 ;; 18 (mm) / 5.2 (mm) = 3.46
A × 4 if correct working, and / or, 3.5 shown
A × 3 if 3.46 only shown from correct working
other acceptable answers using same criteria
× 3.3 ;; 17 / 5.2 = 3.27 **A** × 3
× 3.4 ;; 17.5 / 5.2 = 3.37 **A** × 3
× 3.6 ;; 18.5 / 5.2 = 3.56 **A** × 4
× 3.7 ;; 19 / 5.2 = 3.65 **A** × 4

(d) *three from*

1 (good) solvent ; **R** organic solvent

2 statement linking solvent properties to role of plasma ; e.g.
standalone statements do not need mp1
polar molecules / ions / ionic compounds / named substance(s), dissolve in, water / plasma **R** blood cells
ions dissociate, in water / plasma
many / AW, substances dissolve in, water / plasma **R** blood cells
water is attracted to (many different) substances
water / plasma, is the transport medium for substances / transports substances
presence of solutes to maintain (constant) water potential

3 cohesion between water molecules / water is cohesive ;
A water molecules are sticky

4 so, continuous / uninterrupted / AW, blood flow ; *in context of mp3*

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5 high specific heat (capacity) ;

6 statement linking high specific heat capacity to role of plasma ;
allow ecf for high heat capacity / specific heat capacity
e.g. helps, stabilise / (body to) regulate, temperatures
helps maintain constant (blood) temperature
water resists changes to temperature

7 high (latent) heat of, vaporisation / evaporation ;

8 in body temperatures, plasma stays liquid / water does not evaporate ; AW

other acceptable points – note that mps 10, 12, 14 are linked to water property

9 low compressibility ; **A** incompressible

10 maintains efficient blood flow / helps to push blood through vessels ; AW

11 low viscosity ;

12 allows efficient circulation of blood / AW ;

13 pH 7 / neutral ;

14 *ref. to* stability proteins ; **A** prevents denaturation [9]

28. O/N 16/P21/Q6/d

(a) too large to pass through, (endothelial) pores / capillary walls ; [1]

29. O/N 16/P23/Q5

(a)(i) 98.5 / 98 / 98.48 (%) ; **R** 98.4

(ii) (in solution / dissolved) in the plasma / cytoplasm of red blood cells ;

(iii) *two from*
carbon monoxide, combines with haemoglobin / forms carboxyhaemoglobin ;
irreversible / permanent / stable compound / AW ;
reduces haemoglobin available to transport oxygen ;
alveolar walls / elastin, broken down (in emphysema/COPD) ;
less surface area for, absorption of oxygen / gas exchange ;

(b) *accept steps of reaction if in reverse – as in the lungs*

1 catalyses / AW, the reaction (in red blood cells), between carbon dioxide and water / to form carbonic acid ; **A** correct equation

2 (carbonic acid dissociates to form) hydrogencarbonate ions / bicarbonate ions / HCO_3^- ;

3 very fast reaction ;

4 maintains (steep) concentration gradient for diffusion of carbon dioxide from tissues to blood ;

5 catalyses reverse reaction in the lungs ;

6 hydrogencarbonate ions / bicarbonate ions / HCO_3^- , diffuse / AW, into the plasma ;

(c) **1** Bohr, effect / shift ;

AND

to max 2 ('more' only needs to be used once)

2 carbon dioxide decreases affinity of haemoglobin for oxygen ;

3 more oxyhaemoglobin dissociates (than at a lower concentration of carbon dioxide) ;
A oxyhaemoglobin dissociates more readily
A haemoglobin, releases / AW, more oxygen

4 more oxygen for (rapidly) respiring, tissues / cells ;

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5 to meet the demand for increase in (aerobic) respiration ;
A to provide, enough / sufficient, oxygen for respiration
ora e.g. delays onset of / prevents, anaerobic respiration [10]

30. M/J 16/P22/Q4

(a) blood contained in (blood) vessels AW
or
blood contained in *any three of*
heart, arteries, veins, capillaries ;
systemic and pulmonary, systems / circulation ; **A** 'systematic'
A described *if circulations not named*
e.g. for each complete circuit (round the body) passes through heart twice
from heart to lungs and back, then to (rest of) body and back

(b) **W** = aorta / aortic arch ;
X = pulmonary vein ;
Y = right atrioventricular / tricuspid, (valve) ;
Z = left, atrium / auricle ;

(c) red blood cells ; **A** rbc
A platelets
A plasma proteins / named

(d) **1** *idea of* carbon dioxide out (of blood to alveolus) and oxygen in (to alveolus from blood) ;
2 diffusion / diffuses
or
(movement from) high concentration to low concentration / down a concentration gradient ; **A** diffusion / pressure, gradient
3 (across) squamous epithelium / squamous cells (of alveolar wall) ;
A pavement cells
4 (and) endothelium / endothelial cells (of capillary wall) ;
A squamous cells *but must be clear that this is for capillary wall*
5 oxygen, into / AW, red blood cells ; **I** oxygen binds to Hb
6 steep gradient maintained by, ventilation / uptake by haemoglobin / blood carries oxygen away / blood arrives with carbon dioxide / deoxygenated blood arriving low in oxygen

(e) **(i)** **F** = nucleolus ; **A** nucleus
G = cell surface / plasma, membrane ;
(ii) transport / transporter / carrier, protein ; **R** pump protein
specific protein ;
glucose, binding site / AW ; **I** glucose binds **R** glucose receptor
specific binding site (in protein) = 2 marks
(glucose binding causes) conformational change ; AW, e.g. changes shape
passive / no energy required / no ATP required ;
movement is, down the concentration gradient / from high to low concentration ; *must be in context of through the membrane protein* [16]

31. M/J 16/P21/Q5/b,c

(a) **(i)** **1** produces / makes / synthesises, haemoglobin ; **I** fills up
2 produces / makes / synthesises, carbonic anhydrase ; **I** fills up
3 loss / AW, of the nucleus ;
4 loss / AW, of (named) organelles ;
e.g. ribosomes / (R)ER / mitochondria

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5 becomes biconcave / described ;
6 AVP ; e.g. cell surface / antigens / named antigens
ref. to cytoskeleton

(ii) *cell* Y
1 remains / stays as a, stem cell ;
2 divides / undergoes mitosis ;
I *ref. to* becoming a type of blood cell / platelet
R if it becomes a cell other than a blood cell / platelet

(b) (i) 13.5 ;

(ii) 1 low(er) partial pressure of oxygen (at high altitude) ;
A pO_2 / ppO_2
2 less oxygen in, inhaled air / lungs / alveoli ;
3 so haemoglobin, is not fully saturated / has lower saturation (with oxygen) (than at sea level) / lower affinity for oxygen ;
4 *idea that* more red blood cells so, higher concentration of / more haemoglobin ;
5 allows, same / similar / enough, volume of oxygen to be transported in the blood as at sea level ;
6 volume of oxygen transported in the blood is less ;
7 less oxygen for (aerobic) respiration / lack leads to anaerobic respiration ;
8 any consequence, e.g. fatigue, altitude sickness ; [9]

32. M/J 16/P23/Q6

(a) (superior / inferior) vena cava ;

(b) left (ventricle) pumps blood to the body / right ventricle pumps blood to lungs ;
A further distance
(left ventricle) requires higher pressure ; ora
ref. to overcoming greater resistance / lungs less resistance ;
pulmonary capillaries damaged by higher pressure ;
higher pressure requires more muscular force / AW ; ora

(c) sinoatrial node ; [5]

33. O/N 15/P22/Q6/a,b

(a) 1 *idea of* different distances ; *must be comparative*
e.g. atria pump blood shorter distance **ora**
atria pump blood a short distance and ventricles pump blood a long distance
atria pump blood to ventricles and ventricles pump blood to, (other parts of) body
2 (so) resistance to overcome by atria is low(er)
or
(so) ventricles need to overcome, great(er) / AW, resistance ;
3 (so) atria generates lower pressure
ventricles generate higher pressure ; AW
A force for pressure
R ventricles withstand high pressures
A low pressure / high pressure *if mp1 or mp2 gained*

(b) septum ; R atrioventricular septum [3]

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34. O/N 15/P23/Q5/b

(a) (i) (the by-pass vessels) supply (oxygenated) blood from the aorta ;
supply oxygen to, cardiac / heart / ventricle, muscle ;
supply, glucose / fat / fatty acids ;
reduce / prevent, anaerobic respiration ;
A so (muscles) can (continue to) respire aerobically
prevent death of, muscle / heart cells / heart tissue
A prevents angina

(ii) **I** lifestyles, healthy or otherwise
I 'better health care'
education
early education / educate children (about heart disease)
or
leaflets / posters / continuing education, about effects of heart disease ;
diet
encourage / educate about, healthy eating / balanced diet ;
ref. to labelling of foodstuffs ;
tax on, sugar / fats **ora** e.g. reduce cost of 'healthy' foods
or
idea of regulation against foods with, high sugar / fat ;
A junk food
smoking
educate about dangers of smoking / anti-smoking campaigns ;
provide ways to stop smoking / example ; e.g. tax on cigarettes / nicotine patches / E-cigarettes
smoking bans ;
exercise
finance use of / build more, activity centres / AW ;
encourage, greater activity / exercise ;
medical
idea of, check-ups / screening population (at risk of heart disease / high blood pressure / high cholesterol) ;
provide / subsidise, drugs to, reduce blood pressure / lower cholesterol ;
research
funding research into heart disease ; [6]

35. M/J 15/P22/Q1

(a) **A** right ventricle ; **A** r. ventricle **R** RV
B vena cava ; **A** vena cavae
I superior / upper / inferior / lower / posterior
R if other terms used
C atrioventricular node ; **A** AVN
D coronary arteries ; **A** coronary artery **A** coronary capillaries
I coronary vessels
E bicuspid / left atrioventricular / mitral (valve) ; [5]

36. M/J 15/P22/Q3

(a) same, water potential / Ψ(inside + outside) / no water potential gradient ;
A same solute potential **I** osmotic potential
(so) no, net / overall, movement of water (molecules) ;
A osmosis does not occur

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(b) *for two marks match correct plasma component and, mechanism/membrane component if no mechanism given*

plasma component ;	**mechanism ;**	**membrane component ;**
oxygen carbon dioxide steroids / steroid hormones	(passive) diffusion **A** movement from high to low concentration	(phospho)lipid bilayer / hydrophobic core (of membrane)
glucose amino acid(s) named amino acid mineral / inorganic, ions named ion e.g. sodium ions / Na^+, magnesium ions / Mg^{2+} chloride ions / Cl^-, hydrogen ions hydrogen carbonate ions / HCO_3^- phosphate ions / HPO_4^{2-} potassium ions (K^+)	facilitated diffusion ; **A** active transport **A** cotransport	transport(er) / carrier / integral / intrinsic / transmembrane, protein ; **A** channel protein for facilitated diffusion **A** pump protein for active transport

A urea, with any of the three mechanisms and relevant membrane component to match the mechanism stated

(c) (x) 1000 ;; **A** (x) 947 / 947.4 or 1053/1052.6
if units given = one mark only
if incorrect allow one mark for correct length measured 9 / 9.5 / 10 mm and knowledge of formula is correct (magnification = image length / actual length – this can also be seen by workings e.g. 9.5 mm ÷ 9.5 μm) but incorrect conversion factor used for final calculation

(d) *feature = one mark, with appropriate explanation = one mark*
F red blood cells / haemoglobin, close to body cells ;
F (capillary) endothelium / capillary wall, one cell thick / thin ; **A** epithelium
E short distance / AW (for oxygen to move to cells) ;
F ref. to, diameter / size, red blood cell and capillary (lumen) similar ;
E slows down flow (to allow sufficient oxygen to move out) / short distance (for oxygen to move to cells) ;

(e) no / fewer, gaps / fenestrations / pores, in endothelium / capillary wall ; **A** spaces
ref. tight junctions between (endothelial) cells ; **A** epithelial cells
idea that cells wrap round / fewer cells make up capillary wall, so reduces (endothelial) cell-cell contact ;
idea of layer around capillary / basement membrane, impermeable ; [10]

37. M/J 15/P23/Q4

(a) (i) ***A bp for blood pressure throughout***
1 bp decreases with distance (from, heart / LV) ; **A** named vessels to indicate distance
2 difference between minimum and maximum bp decreases (with distance) ;
3 maximum and minimum bp are the same, at the capilaries / after arterioles ;

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4 (BP) reaches zero kPa, at large veins / vena cava(e) ; **A** after small veins
A no blood pressure
5 steepest decrease in bp between aterioles and capillaries ;
6 correct data quotes ;
e.g. mp 1 from 16 kPa to 0 kPa for maximum bp
mp 1 from 10.6–10.8 kPa to 0 kPa for minimum bp
mp 2 11.6 / 11.8 kPa, in aorta / nearest to left ventricle and 0 kPa at capillaries
mp 3 (same bp of) 5 kPa

(ii) (presence of) valves ; **R** bicuspid / tricuspid, valves
to stop backflow / allows one-way flow / flow only towards heart ;

(b) hydrolysis ; **A** breaking bond using water
(of / breaking of) peptide bond ;
between Phe and His / Phe-His bond ;
removal of, two amino acids / His and Leu / dipeptide ;

(c) 1 (ACE) inhibitor / drug, has similar shape as, substrate / polypeptide ;
2 complementary (shape) to active site (shape) ;
3 binds to / fits into / enters, active site (of ACE enzyme) ;
A forms enzyme-substrate complex
4 substrate cannot, enter / bind ;
A competes with substrate for active site
A no / few / prevents formation of, ES complexes
5 reduces rate of, reaction / formation of angiotensin / product formation ; [11]

38. O/N 14/P22/Q3

(a) blood is in vessels / blood is in heart, arteries, veins, capillaries ;
any three
pulmonary and systemic circulations / described
or
blood passes through heart twice for one circuit round the body / **AW** ;

(b) 1 globular (shape) ; **A** rounded / spherical **R** circular
2 hydrophilic, amino acids / R-groups, face cytosol
or
hydrophobic, amino acids / R-groups, to the interior ; **AW**
3 (so) soluble **or** dissolved in cytoplasm / cytosol ;
4 *ref. to* haem / prosthetic (group) / porphyrin (ring) / Fe^{2+} / ferrous ion / iron (ion), binding oxygen ; **R** forms bonds with
5 four polypeptides / haems / **AW**, so 4 oxygen molecules / 8 oxygen atoms ;
A four polypeptides, each carrying an oxygen molecule / O_2
6 cooperative binding / allostery / described ;
7 **AVP** ; e.g. tertiary structure allows association of prosthetic group

(c) 13–15% ;;
one mark for correct data extraction
96 / 97% at sea level and 82 / 83% at altitude

(d) 1 more haemoglobin (molecules) / Hb ;
2 *idea of* compensation ; e.g. for decreased saturation of haemoglobin as less oxygen available so more can be taken up / transported so tissues receive same / sufficient concentration of oxygen

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(e) 1 reduces (rate of enzyme activity) ;
2 binds at a site on the enzyme other than at the active site / allosteric site ;
3 change in tertiary structure ;
4 change in shape / conformation / configuration of active site ;
5 substrate unable to bind / product unable to form / ES complexes do not form / fewer ESC ;
6 **AVP**, e.g. V_{max} not reached / increasing substrate concentration no effect

(f) *accept Hb for haemoglobin throughout*
1 carbon monoxide binds to Hb / Hb has higher affinity for CO than O_2 ;
A carboxyhaemoglobin forms (heavy smoker)
2 (with CO) Hb reaches lower % saturation / lower percentage saturation (after 3.6–, 4.0–4.2 kPa) ;
A correct figures quoted
R lower saturation at <u>all</u> partial pressures of oxygen
3 less oxygen taken up, in lungs / at higher partial pressures
or
reduces the volume of oxygen transported ; **AW**
4 below 3.6–4.2 kPa (with CO), curve shifts to left / Hb has (relatively) higher saturation ;
5 less oxygen unloaded at lower partial pressures / in tissues ;
6 heart rate increases to deliver sufficient oxygen ;
7 *ref. to* insufficient oxygen to heart muscle and effect on people with CHD ; [16]

39. O/N 14/P22/Q5

(a)

event	three marks	two marks	one mark
impulses pass down septum through conducting fibres known as the bundle of His	4	any four / five correct ;;	any two / three correct ;
atrioventricular node sends out impulses	3		
impulses travels across atrial walls	2		
impulses reach base of ventricles (apex of heart)	5		
impulses pass up through Purkyne fibres in ventricle walls	6		
sinoatrial node sends out impulses	1		

(b) following ventricular systole / contraction
or
when ventricles in diastole / relaxation ;
when pressure in arteries higher than that of ventricles
or

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when pressure in ventricles lower than in arteries ;
A aorta / pulmonary artery

(c) *in blood*
idea that red blood cells too large to leave capillaries ;
idea that (some plasma) proteins too large to leave capillaries ;
higher concentration of oxygen, qualified ;
e.g. from lungs
not yet unloaded (from haemoglobin)
not yet diffused out (from red blood cell)
not yet forced out of capillary (in plasma)
(higher concentration of) glucose / nutrients / named nutrient, qualified ;
e.g. to be delivered to cells / from absorption
tissue fluid contains
ref. to products excreted by cells (yet to enter blood) ;
e.g. waste products / (more) carbon dioxide / lactate [7]

40. M/J 14/P22/Q3/c,d,e

(a) *lower, atmospheric pressure / partial pressure of oxygen so*
lower partial pressure of / less / **AW**, oxygen in, alveolar / inspired / inhaled, air;
A breathed in *for inspired*
A less oxygen goes into lungs
decreased, diffusion / concentration / pressure, gradient ;
between, alveolus / alveoli, and capillary ;
less / **AW**, oxygen, enters / **AW** (pulmonary) capillaries / the blood ;
A less / **AW**, oxygen, transported / **AW**, by, haemoglobin / red blood cells / blood (to tissues)
(so) percentage saturation of haemoglobin is lower ;
A haemoglobin is less saturated
A fewer molecules of / less, oxygen combine with haemoglobin
(as) haemoglobin has lower affinity (for oxygen than at sea level) ; **AW**
A *ref. to* effect of 2,3 DPG
allow correct explanation in terms of oxygen dissociation curve
ref. to insufficient red blood cells to compensate ;
ora e.g. more red blood cells, need to be / will be, produced

(b) (i) greater concentration of / (proportionately) more / **AW**, red blood cells (through pulmonary capillaries per unit time) / **AW** ;
A haemoglobin for red blood cells
increases, the haematocrit / the percentage of red blood cells to the total blood volume / **AW** ;

(ii) more, blood / red blood cells, flowing to lungs (per unit time) ;
A blood flows faster to lungs
to maximise oxygen uptake (from alveoli) / takes in more oxygen / **AW** / compensates for lack of oxygen ;
more blood pumped through, systemic circulation (per unit time) / rest of body / to tissues / **AW** ; **A** blood flows faster *for more blood*
compensates for the lowered plasma volume
or
ref. need to, maintain supplies of required substances / remove waste / prevent decrease in pH ;
allow named required substances e.g. glucose / oxygen / amino acids

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allow named waste substances e.g. carbon dioxide

(c) **1** nucleotide / base, sequence of, DNA / gene, changed / **AW** ;
A new allele (formed)

2 base substitution (mutation) / (DNA) thymine replaced by adenine / (DNA is) CTC to CAC / CTT to CAT (template codon) ;
this cannot be used for mp 1 as well

3 altered / changed, mRNA codon ; *(allow codons)* **A** *idea of different mRNA*
R altered genetic code

4 (mRNA codon is) GAG to GUG / GAA to GUA ;

5 glutamic acid, substituted / replaced / AW, by valine ; **A** glutamate
A glu *and* val

6 tRNA / anticodon, with different amino acid (to ribosome) ;
A tRNA with different anticodon

7 **AVP** ;
e.g.amino acid substitution at position 6
valine, hydrophobic / **AW** (R-group)
glutamic acid, polar / **AW** (R-group) [10]

41. M/J 14/P23/Q6

(a) **(i)** deposit / build-up / presence / **AW**, of atheroma / (atheromatous) plaque ;
thicker wall ;
narrowing of the lumen ; **R** lumen, blocked / clogged
lumen no longer round ;
rougher / **AW**, lining ; **A** idea of damaged endothelium

(ii) damage / **AW**, to, endothelium / tunica intima / **AW** ;
promotes blood clotting / makes platelets sticky / increases risk of thrombosis / **AW** ;
(so) contributes to plaque / atheroma ; **A** atherosclerosis
ref. (vaso) constriction ; **A** reduces diameter
A reduces resistance to blood flow

(b) **(i)** *one correct structural feature with one relevant corresponding function e.g.*
thick / muscular, wall ; **A** thick tunica media **A** smooth muscle
withstand high blood pressure / maintains pressure / provides strength ;
elastic tissue ;
provide, stretch / recoil / **AW** ;
smooth tunica intima ;
maintain, laminar / smooth, flow ; **AW**
presence of collagen ;
prevents rupture / **AW** ;
allow the function mark for general statement
transports blood away from the heart to the (lungs and) rest of the body ;

(ii) one cell thick (wall) / endothelium only / thin wall / **AW** ;
short diffusion distance / high rate of diffusion ; **I** easy diffusion
pores / gaps / spaces, between, cells in wall / endothelium ;
to allow exchange of substances / example described / formation of tissue fluid ;
small, diameter / cross sectional area ; **A** range 7–12 μm
ref. efficient, exchange / delivery / collection, of materials ;
e.g. reaches all cells / **AW**
slows down blood flow
maximises time for red blood cells to collect / deliver, oxygen
reduces distance for diffusion to cells [7]

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42. O/N 12/P22/Q6

(a) *one mark each correct label to max 3;;;*

(b) **X** marked over coronary artery section before graft joins;

(c) cure for, coronary artery disease / atherosclerosis in artery;
A arteriosclerosis
so less risk of, myocardial infarction / heart attack / AW;
prevention of coronary artery disease to avoid bypass surgery
one example; e.g. no smoking
increase exercise
low, (saturated) fat / cholesterol, diet
reduce alcohol consumption
reduce salt intake
statins
avoid, excessive / AW, sugar
avoid obesity
ref. to difficulties in getting people to change lifestyle to prevent;
disadvantage of, surgical procedure / cure;
accept ora prevention
e.g. invasive / painful
costly medical
lost time / money, by absence from work
risk of complications / graft rejection / infection
risk / graft becoming diseased / collapsing
AVP; e.g. *idea that* as cure is available, more difficult to encourage prevention [7]

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Unit 9
GAS EXCHANGE AND SMOKING

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

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Syllabus

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Unit 9: Gas Exchange and Smoking

1. **M/J 22/P22/Q5**
Fig. 5.1 is a photomicrograph of a transverse section through part of the bronchus of the human gas exchange system. The image is of a good resolution for a light microscope.
The bronchial epithelium is a single layer of cells lining the lumen of the bronchus.

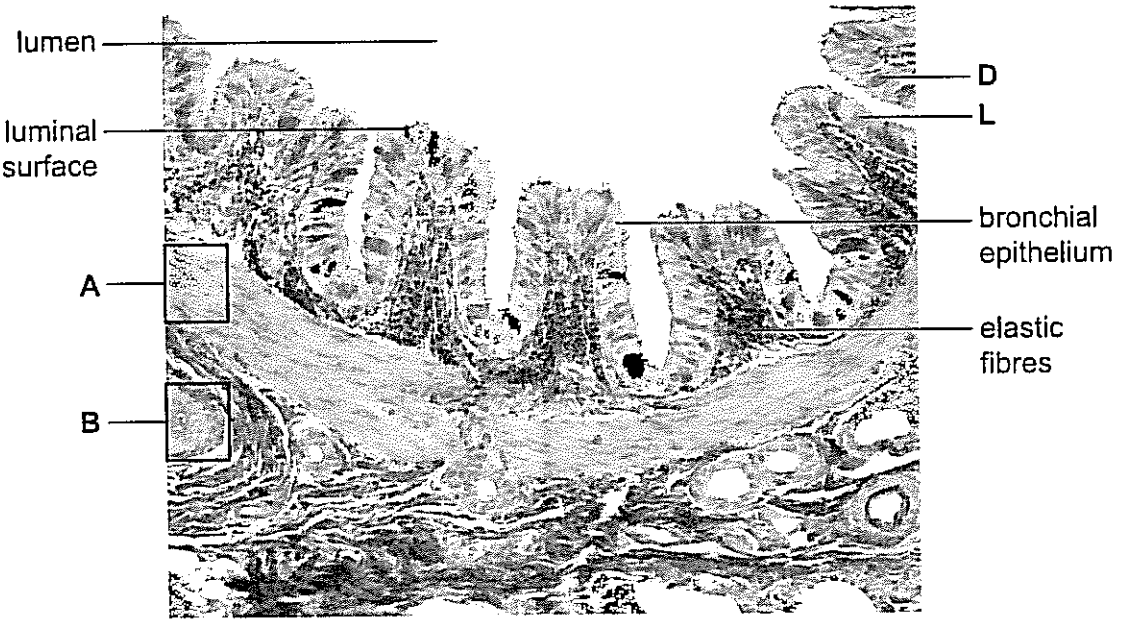


Fig. 5.1

(a) The luminal surface shown in Fig. 5.1 is not clearly defined and appears slightly blurred.
State why the luminal surface of the bronchial epithelium appears slightly blurred, even though the resolution of the image is good.

..... [1]

(b) Some cells of the bronchial epithelium shown in Fig. 5.1 appear darker than others. For example, cell **D** appears darker than cell **L**.
With reference to the bronchial epithelium shown in Fig. 5.1, explain why some cells, such as cell **D**, appear darker and other cells, such as cell **L**, appear lighter.

.....

..... [2]

(c) In Fig. 5.1 the tissue in box **B** is cartilage.
The tissue shown in box **A** is different from the tissue in box **B**.
Outline the differences in the structure **and** function of tissue **A** compared with tissue **B**.

.....

.....

..... [3]

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2. M/J 22/P21/Q1

Fig. 1.1 and Fig. 1.2 are photomicrographs showing the distribution of tissues in the lungs.
Fig. 1.1 is a photomicrograph of a section through part of the lungs.
Fig. 1.2 is a high-power view of the area indicated on Fig. 1.1.



Fig. 1.1



Fig. 1.2

(a) State the names of the tissues **A**, **B** and **D**.

A .....

B .....

D .....

[3]

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(b) Describe the role of the glands labelled **C** in Fig. 1.1 in maintaining the health of the gas exchange system.

.....

.....

..... [3]

(c) Hyperventilation occurs when a person breathes too fast or too deeply.

The effects of hyperventilation are:

- a decrease in the partial pressure of carbon dioxide in alveolar air
- an increase in the pH of the blood.

Fig. 1.3 shows the change in the oxygen dissociation curve as a result of hyperventilation.

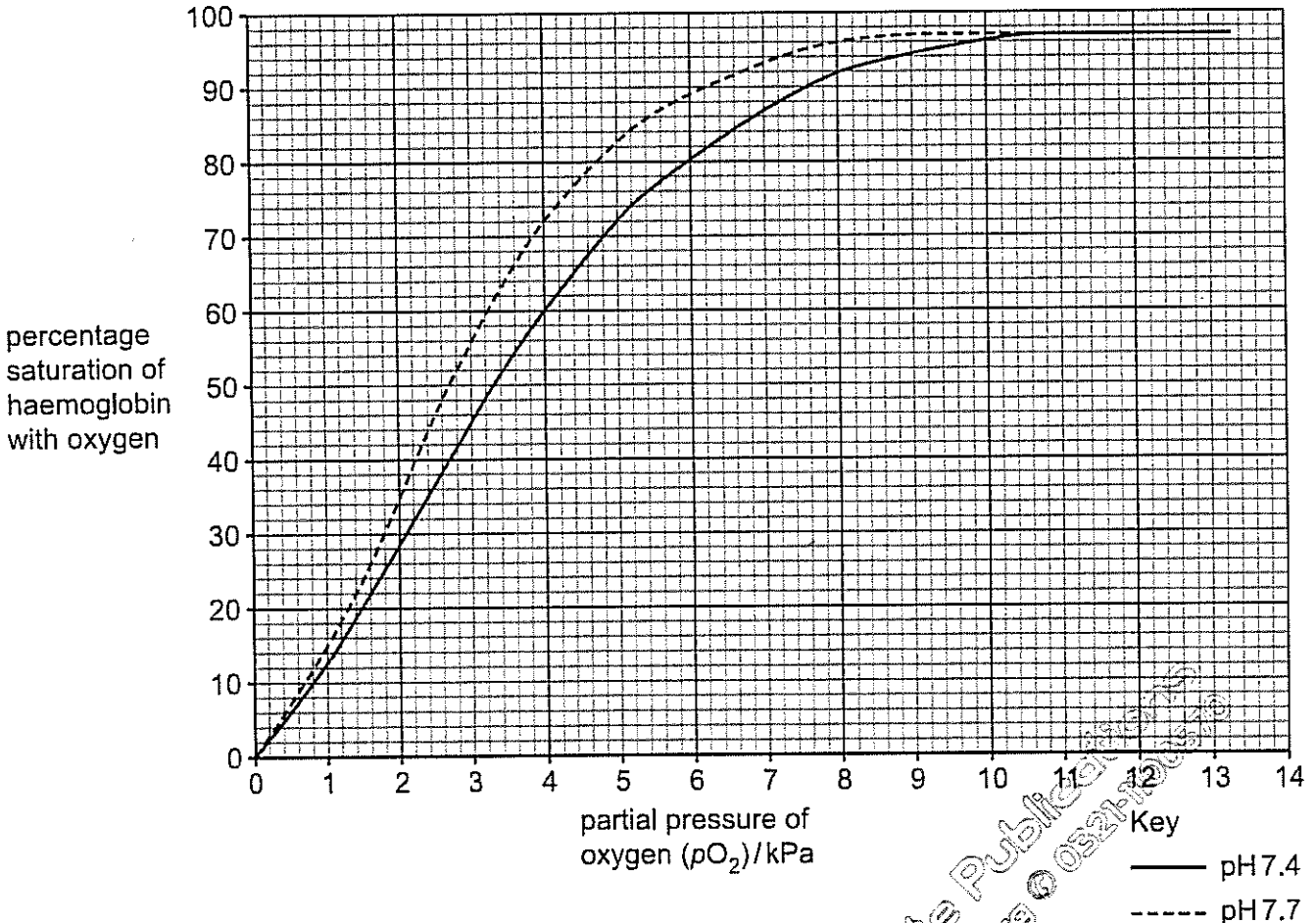


Fig. 1.3

(i) State the percentage saturation of haemoglobin at a pO_2 of 4.0 kPa.

pH = 7.7 ..... kPa

pH = 7.4 ..... kPa [1]

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(ii) Use the information in Fig. 1.3 to state **and** explain the effect of hyperventilation on the supply of oxygen to the respiring tissues.

.....

..... [2]

3. M/J 22/P23/Q1

The trachea of the gas exchange system branches into two airways, each of which enters a lung.

(a) Name the airways that branch from the trachea to enter the lungs.

..... [1]

(b) The lower part of the trachea receives blood from arteries that branch from the aorta. Different arteries carry blood from the heart to the alveoli of the lungs.

State the differences between the arteries supplying the lower part of the trachea and the arteries that supply blood to the alveoli of the lungs.

.....

..... [2]

(c) Fig. 1.1 is a photomicrograph of a section through part of the trachea.

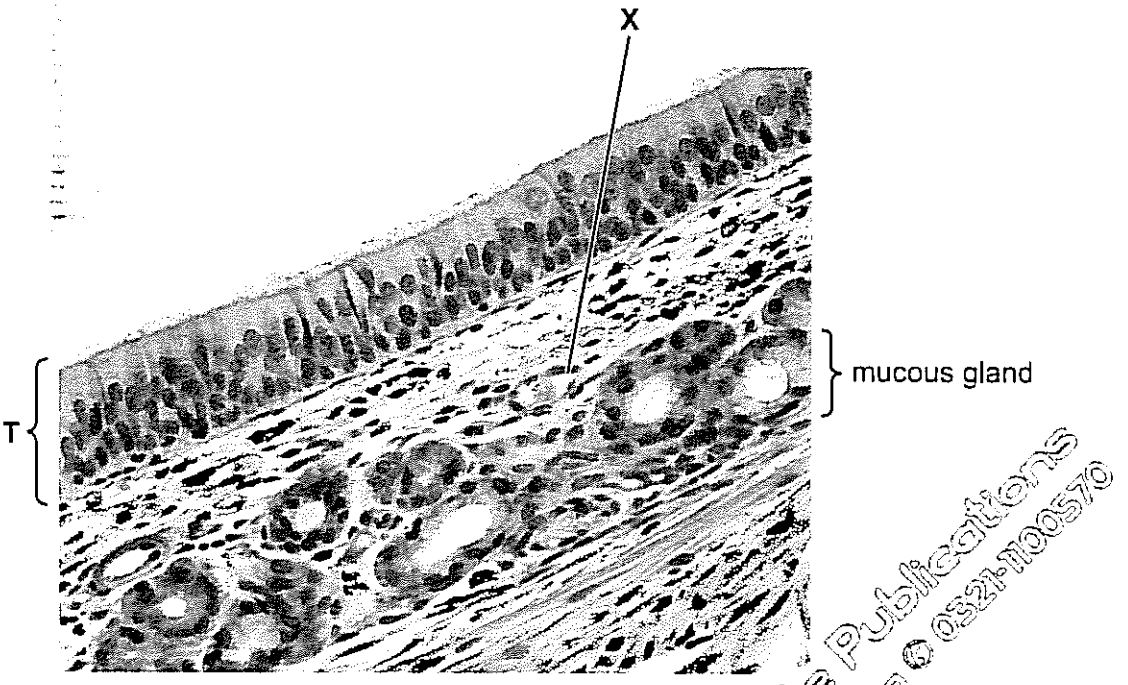


Fig. 1.1

(i) In Fig. 1.1, one of the tissues in the trachea is labelled **T**.

Describe the structural features of tissue **T** visible in Fig. 1.1.

.....

.....

..... [3]

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(ii) Identify structure **X** in Fig. 1.1 **and** outline the features that helped your identification.

structure **X** = ...

.....

..... [3]

4. O/N 21/P22/Q5/c

The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(a) Young children with measles may develop difficulties with breathing. This is made worse if the child is continually exposed to tobacco smoke. Tobacco smoke contains harmful compounds, such as carbon monoxide.

(i) Inhaled tobacco smoke passes through the larynx (voice box) and other structures in the gas exchange system to reach the alveoli.

Complete Fig. 5.1 to list, in the correct sequence, the main structures of the gas exchange system through which the tobacco smoke passes to reach the alveoli.

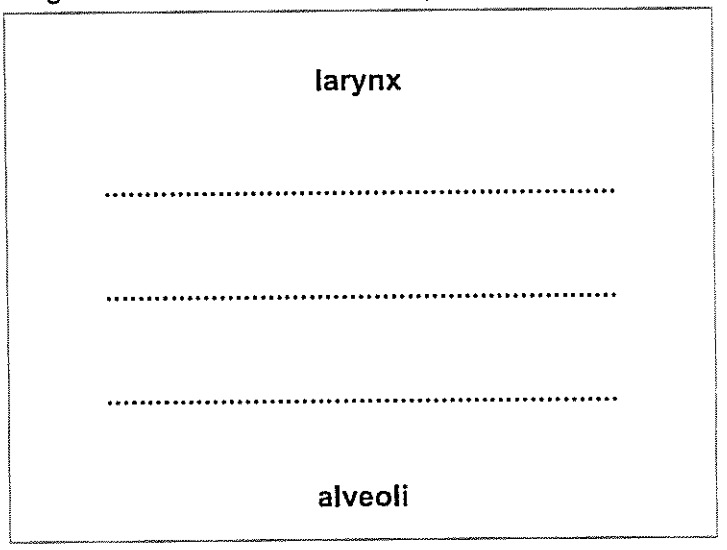


Fig. 5.1

[1]

(ii) State the short-term effects of carbon monoxide on the cardiovascular system.

.....

..... [2]

5. O/N 21/P21/Q2/c

(a) Nicotine is one of the components of tobacco smoke. Nicotine can cross cell surface membranes and enter the bloodstream.

(i) Describe the short-term effects of nicotine on the cardiovascular system.

.....

..... [2]

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(ii) Nicotine is absorbed from the blood plasma into the cells of the capillary wall. Scientists have suggested that nicotine is transported from the blood plasma into these cells using a type of co-transporter mechanism.

Fig. 2.2 shows how nicotine may be transported from the blood plasma into a cell.

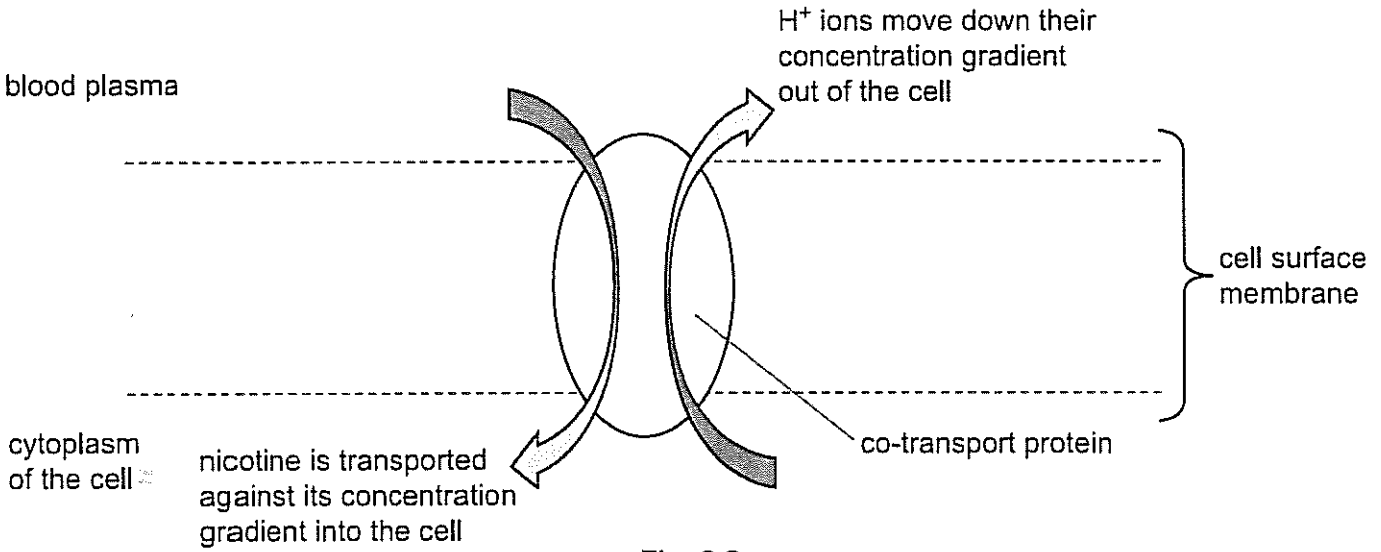


Fig. 2.2

The co-transporter mechanism shown in Fig. 2.2 is different from the co-transporter mechanism that moves sucrose into the cytoplasm of a companion cell in phloem tissue. Outline the similarities **and** differences between the co-transport of nicotine and the co-transport of sucrose.

.....

.....

..... [3]

6. O/N 21/P23/Q6/c

(a) Fibroblast cells produce elastic fibres and collagen fibres in lung tissue.

Describe the function of elastic fibres in lung tissue.

.....

..... [2]

7. M/J 21/P22/Q4

A person who is exposed to tobacco smoke is at greater risk of lung cancer and chronic obstructive pulmonary disease (COPD).

Many people with COPD have both chronic bronchitis and emphysema. These diseases cause changes in the gas exchange system. For example, changes occur in the total lung surface area to volume ratio (SA:V).

(a) Tar in tobacco smoke has a number of effects on the cells lining the gas exchange system.

State the main effects of tar on the cells lining the gas exchange system that are related to lung cancer **and** to chronic bronchitis.

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lung cancer .....

.....

.....

chronic bronchitis .....

.....

..... [3]

(b) A student investigated the effect of SA:V on diffusion.

Agar was prepared with Universal Indicator solution and sodium hydroxide solution. The agar was coloured blue.

Three cubes, **A**, **B**, and **C**, were cut from a solid block of blue agar. Each cube was a different size.

Universal Indicator solution changes to a red colour in the presence of acid.

The student prepared Table 4.1 to show the sizes and SA:V of each cube.

Table 4.1

cube	length of each side / cm	total surface area / cm^2	volume /	SA:V
A	1	6	1	6:1
B	2	24	8	3:1
C	3			2:1

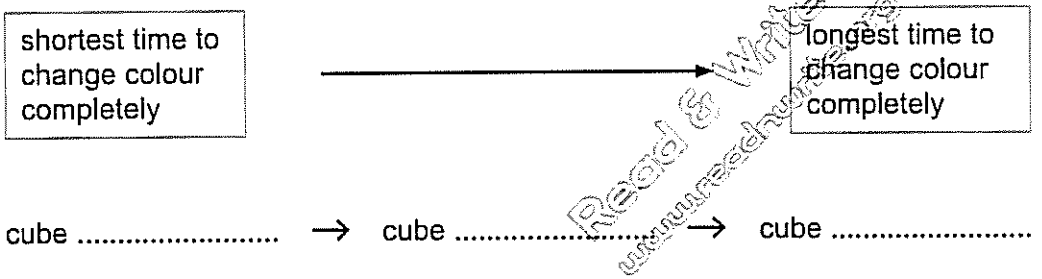
Complete Table 4.1 by:

- writing the correct units for volume
- calculating the total surface area, and volume, of cube **C**. [2]

(c) Cubes **A**, **B** and **C** were placed in a small beaker. At time 0 seconds, dilute hydrochloric acid was added to the beaker to cover the cubes.

The student timed how long it took for each cube to change colour completely.

Complete Fig. 4.1 to show the results that were obtained.



[1]

Fig. 4.1

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(d) Some people with emphysema may be offered lung volume reduction surgery (LVRS), in which diseased lung tissue is surgically removed.

One expected outcome of the surgery is an improvement in total lung surface area to volume ratio (total lung SA:V).

Suggest why there is an improvement in total lung SA:V after the surgery has been carried out.

.....

..... [2]

(e) In humans, blood that becomes oxygenated in the lungs reaches body tissues without coming into contact with blood that is deoxygenated.

Explain how the blood that becomes oxygenated in the lungs is kept separate from blood that is deoxygenated.

.....

..... [2]

8. M/J 21/P23/Q5/c

(a) Chronic obstructive pulmonary disease (COPD) can cause a condition known as pulmonary hypertension. This involves an increase in systolic blood pressure in the right ventricle and in the pulmonary arteries.

Fig. 5.3 is a summary of some of the events that can result from COPD.

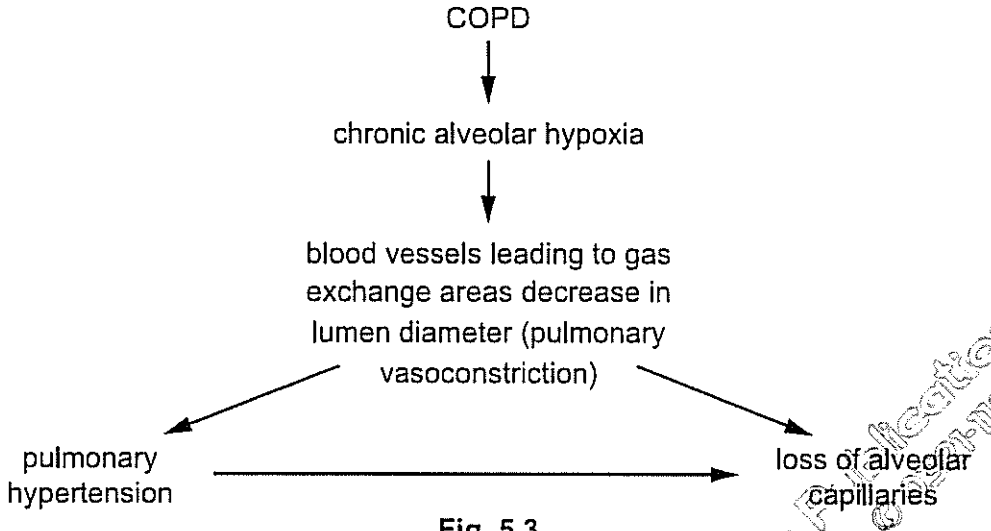


Fig. 5.3

(i) Chronic alveolar hypoxia describes a condition where the partial pressure of oxygen in the gas exchange regions of the lungs is always lower than normal.

Explain how COPD leads to chronic alveolar hypoxia.

.....

.....

..... [3]

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(ii) Explain how the loss of alveolar capillaries affects the functioning of the lungs in a person with COPD.

.....

..... [2]

9. O/N 20/P22/Q3

Fig. 3.1 is a photomicrograph of a section through lung tissue.

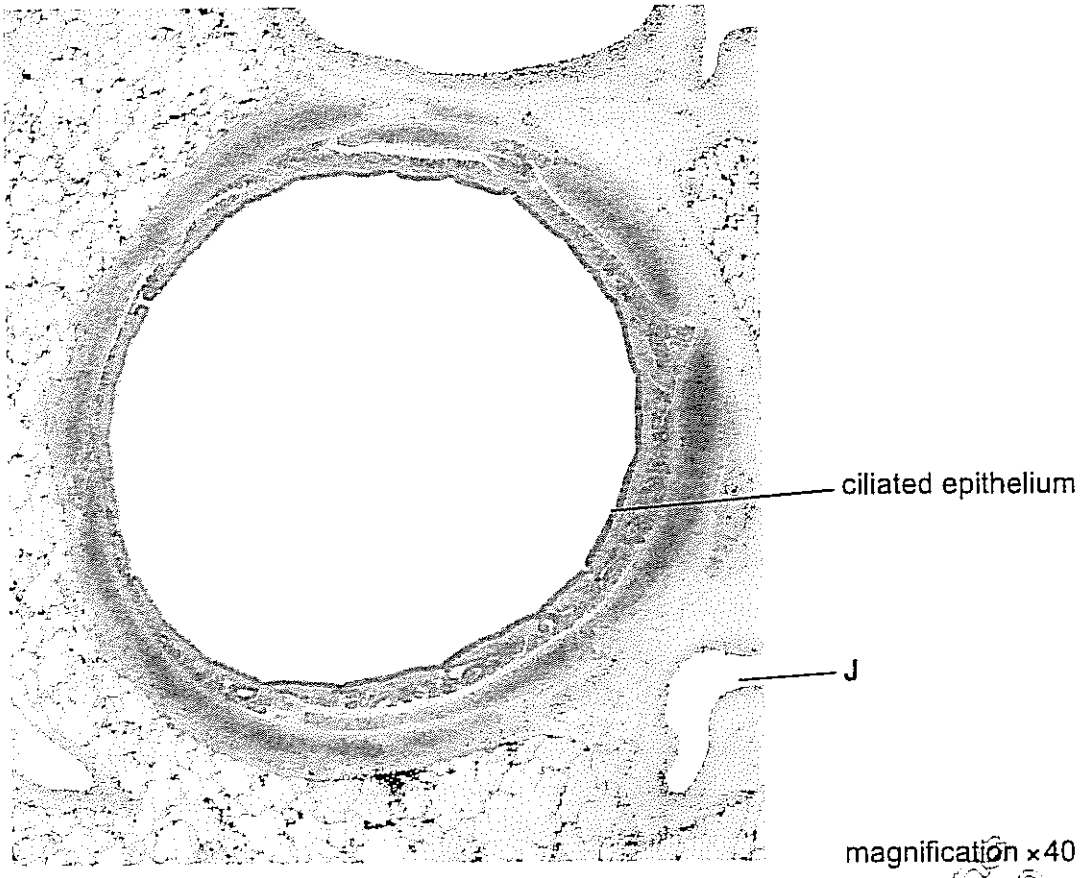


Fig. 3.1

(a) State the feature visible in Fig. 3.1 that identifies the structure in the centre of the image as the bronchus **and** list other visible features that help to confirm this identification.

feature to identify the bronchus .....

other features .....

..... [3]

(b) Identify the structure labelled J in Fig. 3.1.
State the evidence visible in Fig. 3.1 that supports your answer.

.....

..... [2]

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(c) The ciliated epithelium labelled in Fig. 3.1 consists of goblet cells and ciliated epithelial cells. Outline how goblet cells and cilia work together to maintain healthy lung tissue.

.....

..... [2]

10. O/N 20/P21/Q5/a,b(i,ii)

(a) Fig. 5.1 is a photomicrograph of a section through the lungs showing a bronchus and some alveoli.



Fig. 5.1

(i) State the function of tissue **X** labelled in Fig. 5.1.

..... [1]

(ii) Describe how the distribution of tissue **X** in the trachea differs from that shown in Fig. 5.1.

..... [1]

(iii) Describe how the epithelial tissue, **Y**, is adapted for its function.

.....

..... [2]

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(b) Fig. 5.2 is a photograph of two African elephants, *Loxodonta africana*.

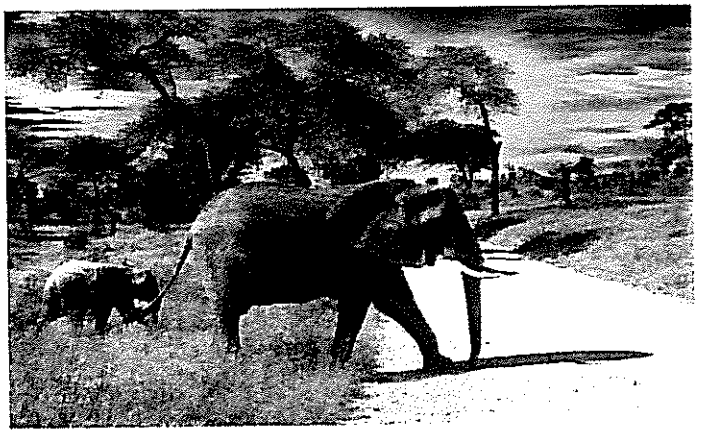


Fig. 5.2

(i) Describe the difference in surface area to volume ratio between the adult elephant and baby elephant shown in Fig. 5.2.

..... [1]

(ii) Suggest why animals such as elephants require a gas exchange system.

.....

.....

..... [3]

11. O/N 20/P23/Q1

Fig. 1.1 shows a section through the human chest. The gross structure of the human gas exchange system is shown.

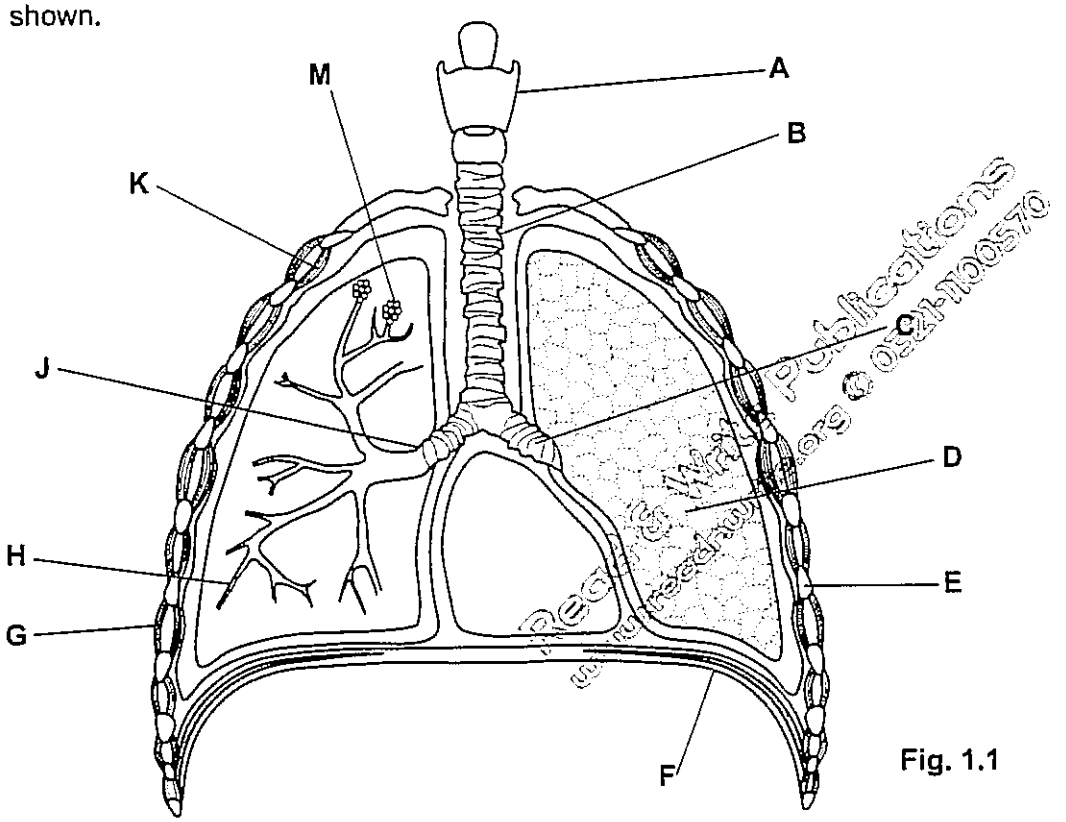


Fig. 1.1

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(a) Descriptions of some parts of the gas exchange system are shown in Table 1.1.

Complete Table 1.1 to:

- state the name of the part described
- write a letter from Fig. 1.1 to identify each part.

Table 1.1

description	name of part of gas exchange system	letter from Fig. 1.1
supported by incomplete (C-shaped) rings of cartilage		
lined by ciliated epithelium and supported by blocks of cartilage		
lined by squamous epithelium		
lined by ciliated epithelium, but not supported by cartilage		

[4]

(b) Tobacco smoke contains a number of compounds which can affect the body.
State the appropriate term that matches each of the statements **A** to **E**.

A The type of chemical that causes mutation of genes that control the cell cycle.

.....

B A component that causes a short-term increase in blood pressure.

.....

C A component that reduces the carrying capacity of haemoglobin for oxygen.

.....

D A component that increases the production and secretion of mucus from goblet cells.

.....

E A component that causes a short-term increase in heart rate.

..... [5]

12. M/J 20/P22/Q4/a,b(i)

Collagen is a major component of the cartilage found in some of the structures of the human gas exchange system. Cells that synthesise and secrete the components of cartilage are known as chondrocytes.

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(a) Fig. 4.1 is a transmission electron micrograph of a chondrocyte.

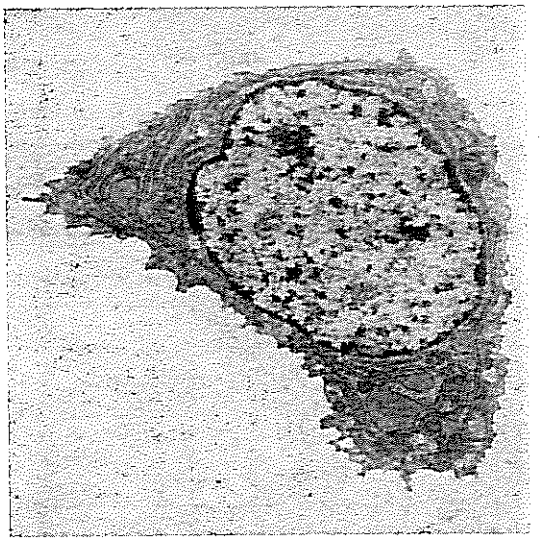


Fig. 4.1

With reference to Fig. 4.1, explain **two** features of the chondrocyte that show how the cell is adapted to its function.

.....

..... [2]

(b) (i) Describe the distribution of cartilage in the human gas exchange system.

.....

..... [2]

13. M/J 20/P21/Q4/a,b,c

Fig. 4.1 shows the site of gas exchange in the mammalian lung.

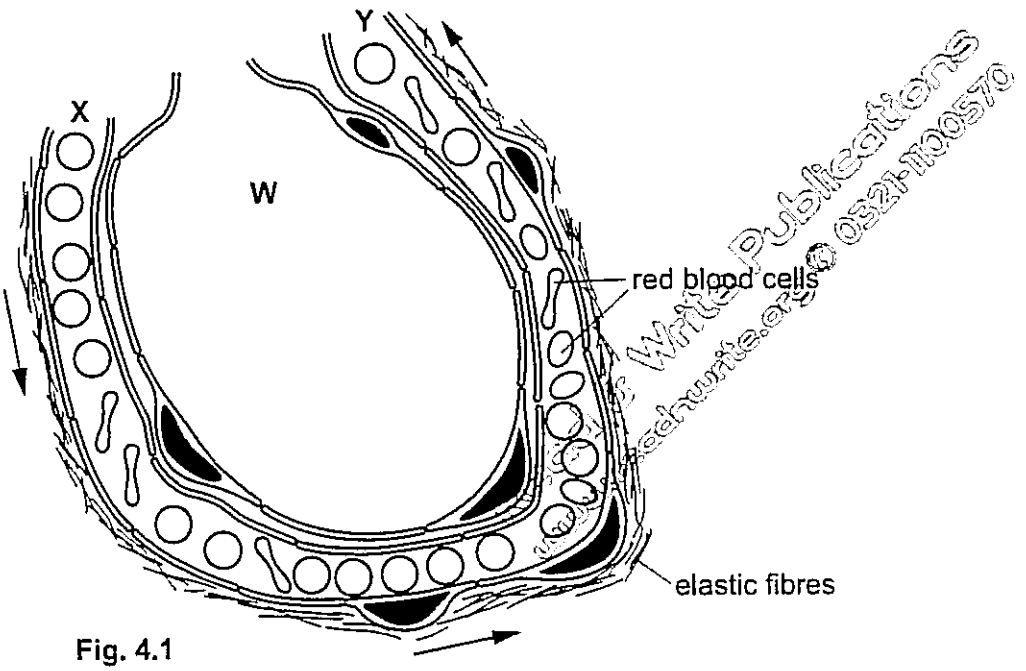


Fig. 4.1

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(a) State **two** ways in which carbon dioxide is transported in the blood.

1 .....

2 .....

[2]

(b) Table 4.1 shows the partial pressures of oxygen (pO_2) and carbon dioxide (pCO_2) at locations **W**, **X** and **Y** in Fig. 4.1.

Table 4.1

partial pressure	locations within tissue		
	W	**X**	**Y**
pO_2 / kPa	13.87	5.33	13.87
pCO_2 / kPa	5.33	6.00	5.55

With reference to Fig. 4.1 and Table 4.1, describe the exchanges that occur as blood flows from **X** to **Y**.

.....

.....

.....

..... [4]

(c) Elastic fibres are present in tissues at the site of gas exchange in the lungs.
Describe the roles of elastic fibres in the gas exchange system **and** in the cardiovascular system.

.....

.....

.....

..... [4]

14. M/J 20/P23/Q3/c

(a) The trachea, bronchi and bronchioles in the gas exchange system require a supply of glucose and oxygen from the blood for the functioning of smooth muscle.
Outline the function of smooth muscle in the gas exchange system.

.....

..... [2]

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15. O/N 19/P22/Q2

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

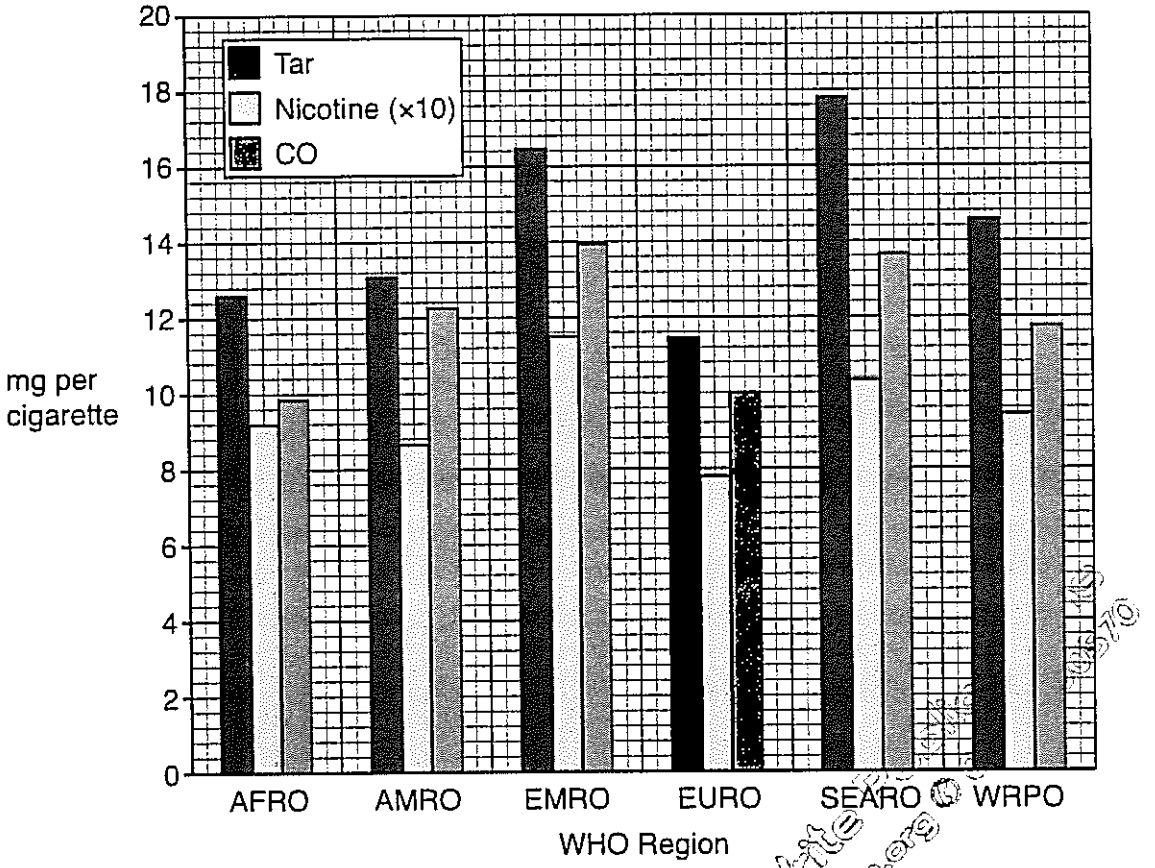


Fig. 2.1

(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.

..... [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.

.....

.....

.....

..... [4]

16. M/J 19/P22/Q2
Some tissues of the gas exchange system include cells that are able to produce and secrete mucins. Mucins are stored in vesicles in these cells, ready for secretion. Once outside the cell, mucins adsorb water to form mucus.

(a) Name the structures in the gas exchange system that produce and secrete mucins.

.....

..... [2]

(b) Mucins are described as glycosylated proteins. The process of glycosylation involves the addition of sugar components after polypeptides are synthesised.
Suggest **one** location in the cell where glycosylation of mucin could occur.

..... [1]

(c) The processes that occur in the production and secretion of mucins are listed.

translation **exocytosis** **glycosylation** **transcription**

Complete Table 2.1 by writing the processes in the correct order in which they would take place.

Table 2.1

first process	
second process	
third process	
fourth process	

[2]

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(d) Chloride ions move out of the mucin-producing cells at the same time as mucin is secreted. Suggest **and** explain how the exit of chloride ions helps the formation of mucus from mucin.

.....

.....

..... [3]

(e) The gas exchange system includes some cells that are able to divide by mitosis. Explain why it is important to have these cells in the gas exchange system.

.....

.....

..... [3]

17. M/J 19/P23/Q2/b

Fig. 2.1 is a photomicrograph showing a transverse section through a bronchus and the surrounding lung tissue.

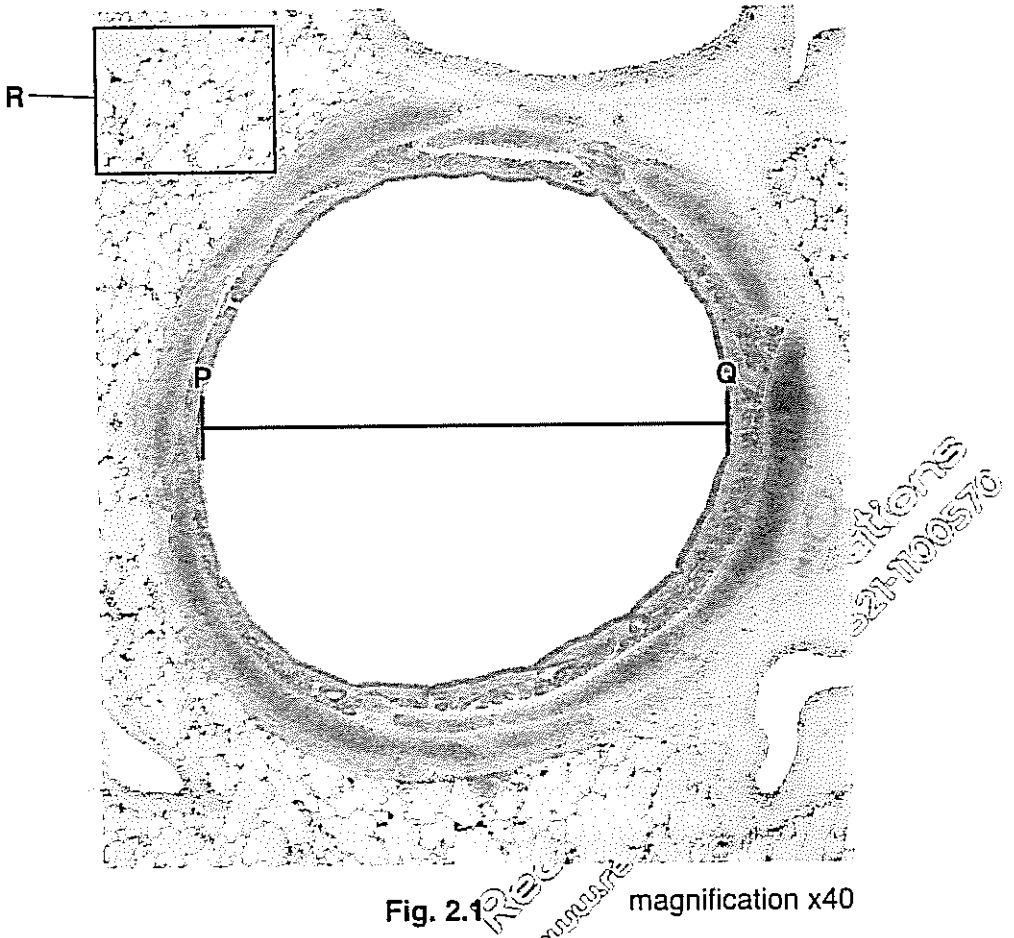


Fig. 2.1 magnification x40

(a) (i) In Fig. 2.1, the area labelled **R** shows a section through some alveoli. Name the tissue that lines the air spaces of the alveoli.

..... [1]

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(ii) Suggest how the alveoli are adapted for gas exchange.

.....

..... [2]

18. O/N 18/P22/Q1

Fig. 1.1**A** is a photomicrograph of healthy lung tissue.
Fig. 1.1**B** is a photomicrograph of lung tissue from a person with emphysema, a chronic obstructive pulmonary disease (COPD). The images are both at magnification ×40.

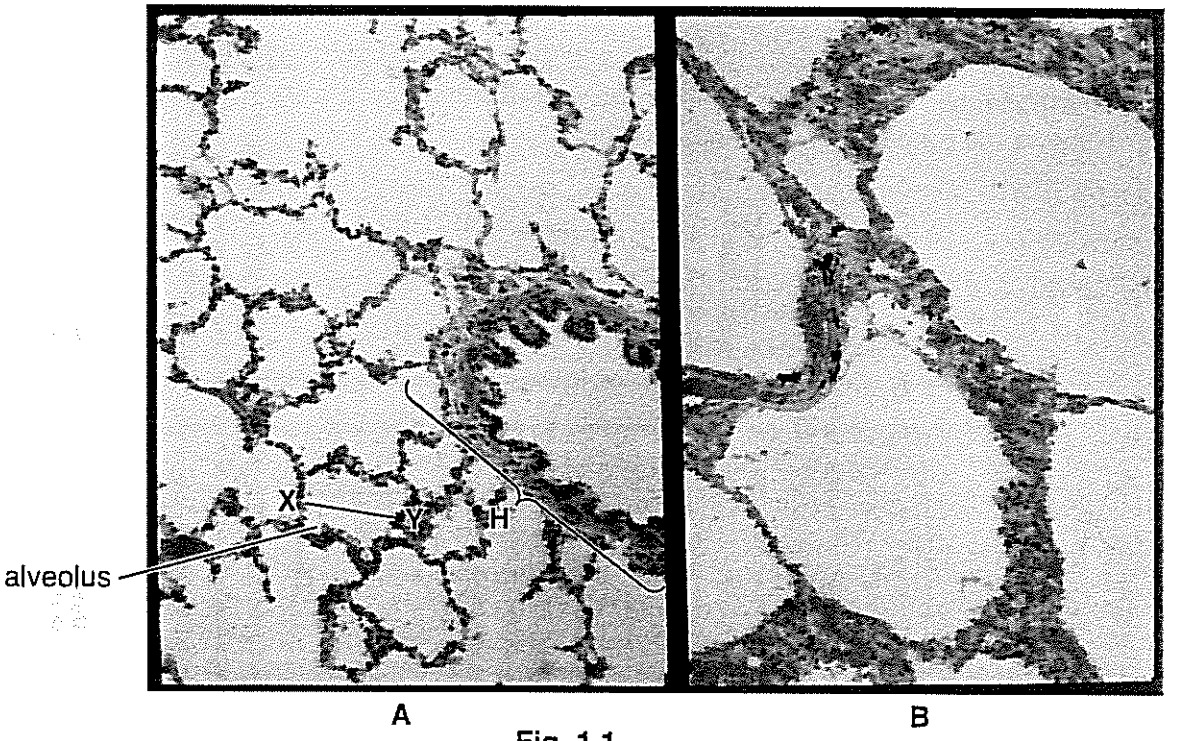


Fig. 1.1

(a) Name the structure labelled **H** in Fig. 1.1**A**.

..... [1]

(b) Calculate the actual diameter of the alveolus at **X–Y**.
Write down the formula and use it to make your calculation.
Give your answer to the nearest whole micrometre (μm).

formula

actual size ..... μm [2]

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(c) Gas exchange in the lungs occurs in the alveoli.
Describe the process of gas exchange in healthy lungs **and** suggest how this compares with gas exchange in the diseased lung shown in Fig. 1.1**B**.

.....

.....

.....

..... [4]

19. O/N 18/P21/Q1/a,b

Fig. 1.1 shows the human gas exchange system.

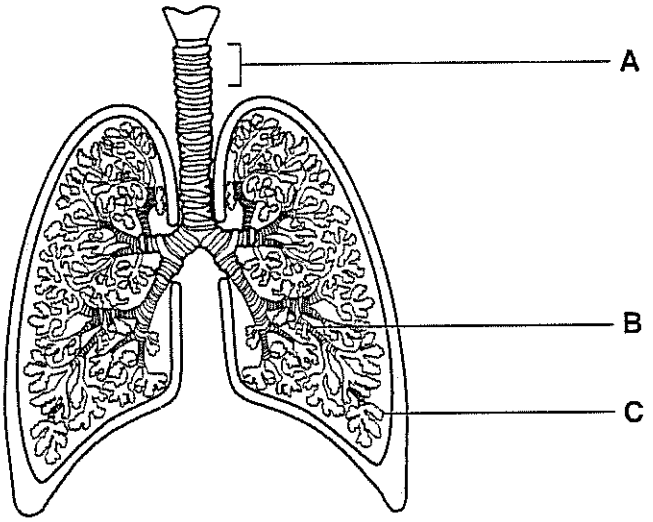


Fig. 1.1

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

A .....

B .....

C ..... [3]

(b) Name a **non-infectious** disease that affects the human gas exchange system.

..... [1]

20. M/J 18/P22/Q5/a

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.

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

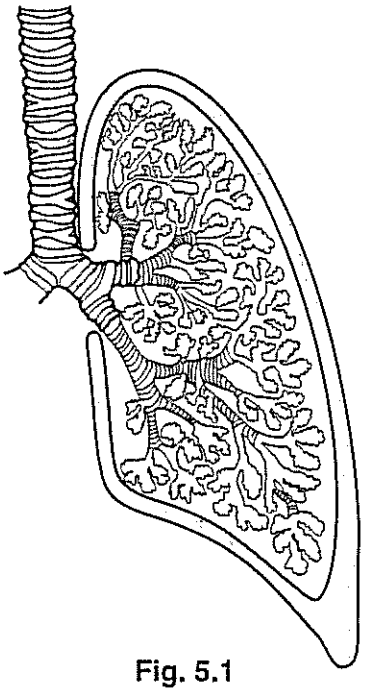


Fig. 5.1

Describe the gross structure of the human gas exchange system.

.....

.....

.....[3]

21. M/J 18/P21/Q4/b

(a) 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.

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The results are shown in Fig. 4.2.

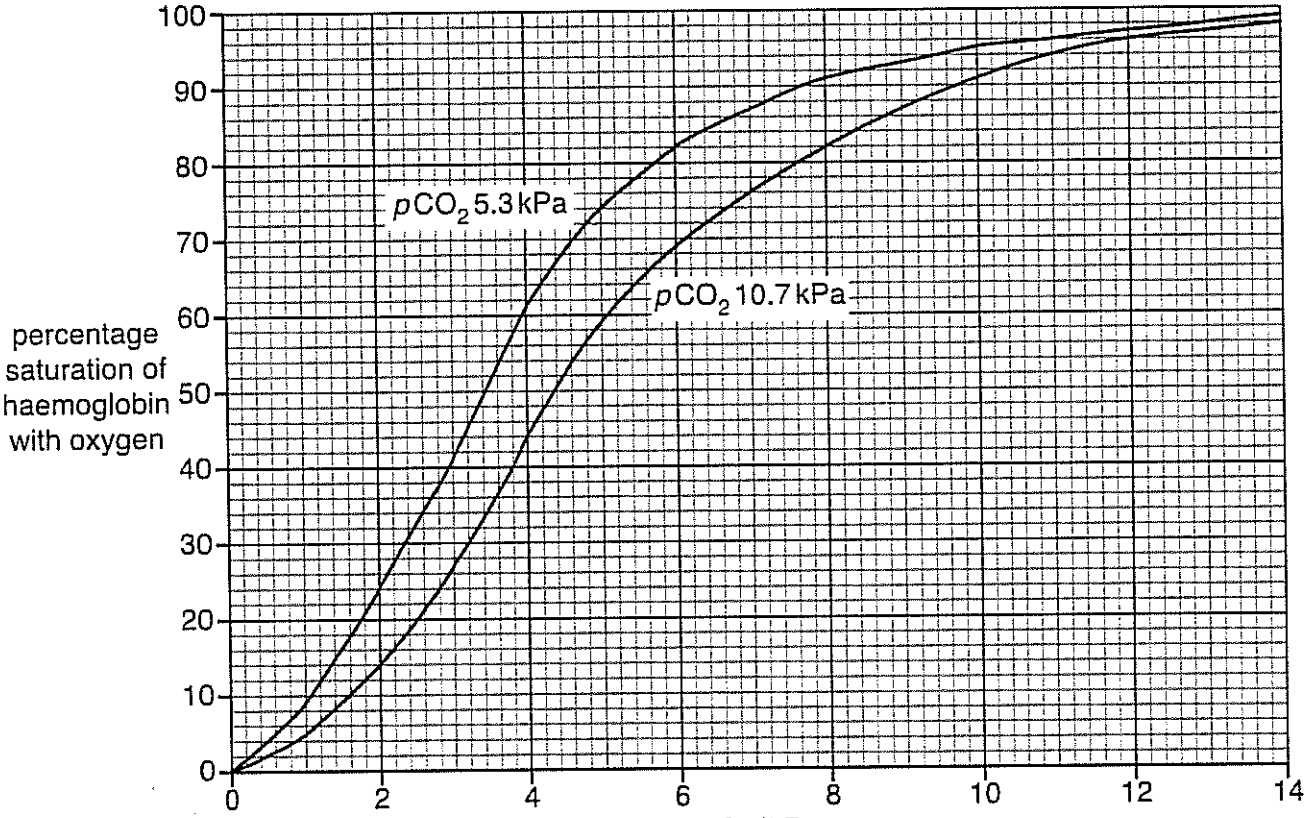


Fig. 4.2

(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]

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

.....

.....

.....

..... [4]

22. M/J 18/P23/Q4/a,b

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.

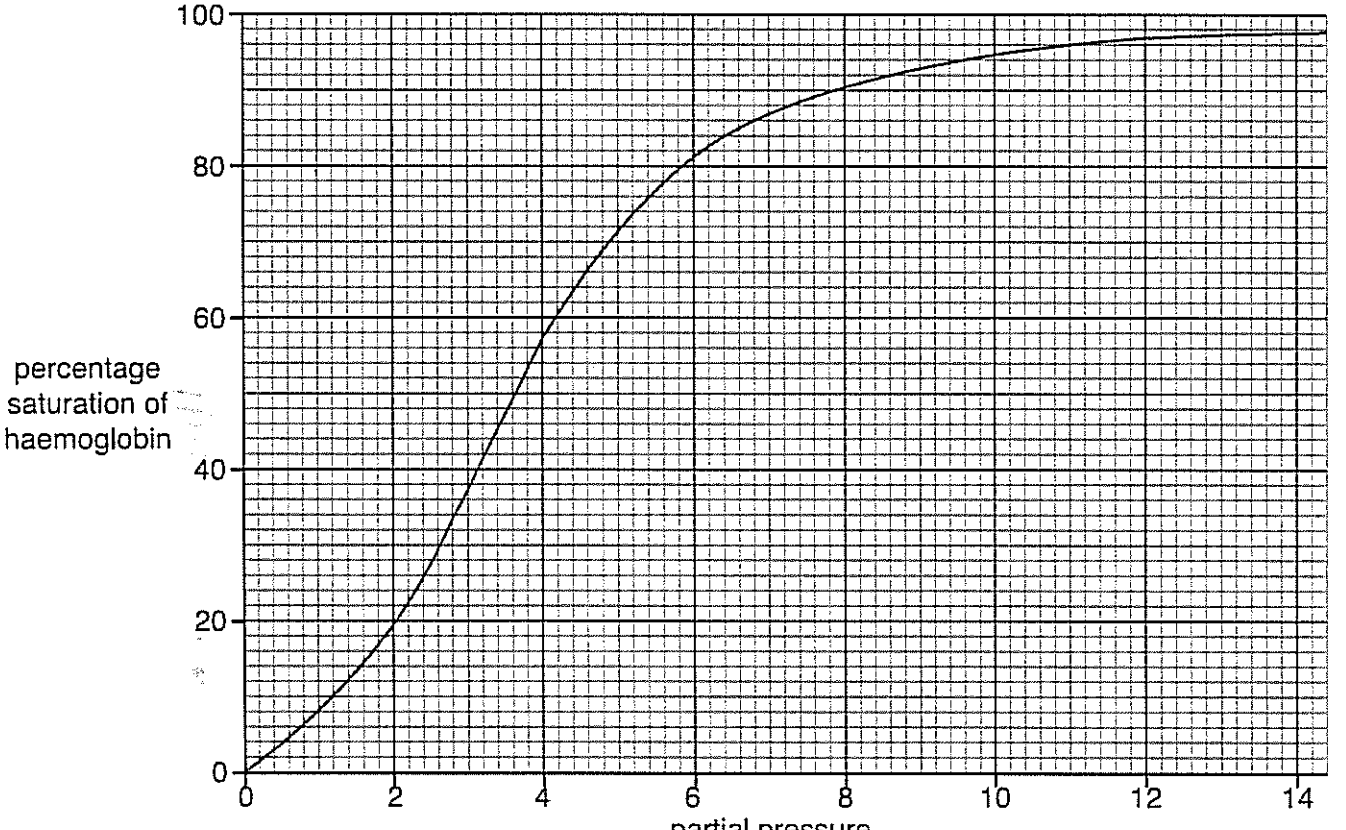


Fig. 4.1

(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.

.....

.....

.....[3]

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23. O/N 17/P23/Q3

Fig. 3.1 shows the structure of an alveolus and surrounding structures in a mammalian lung. The lining of each alveolus is formed by two types of epithelial cell, alveolar type 1 and alveolar type 2.

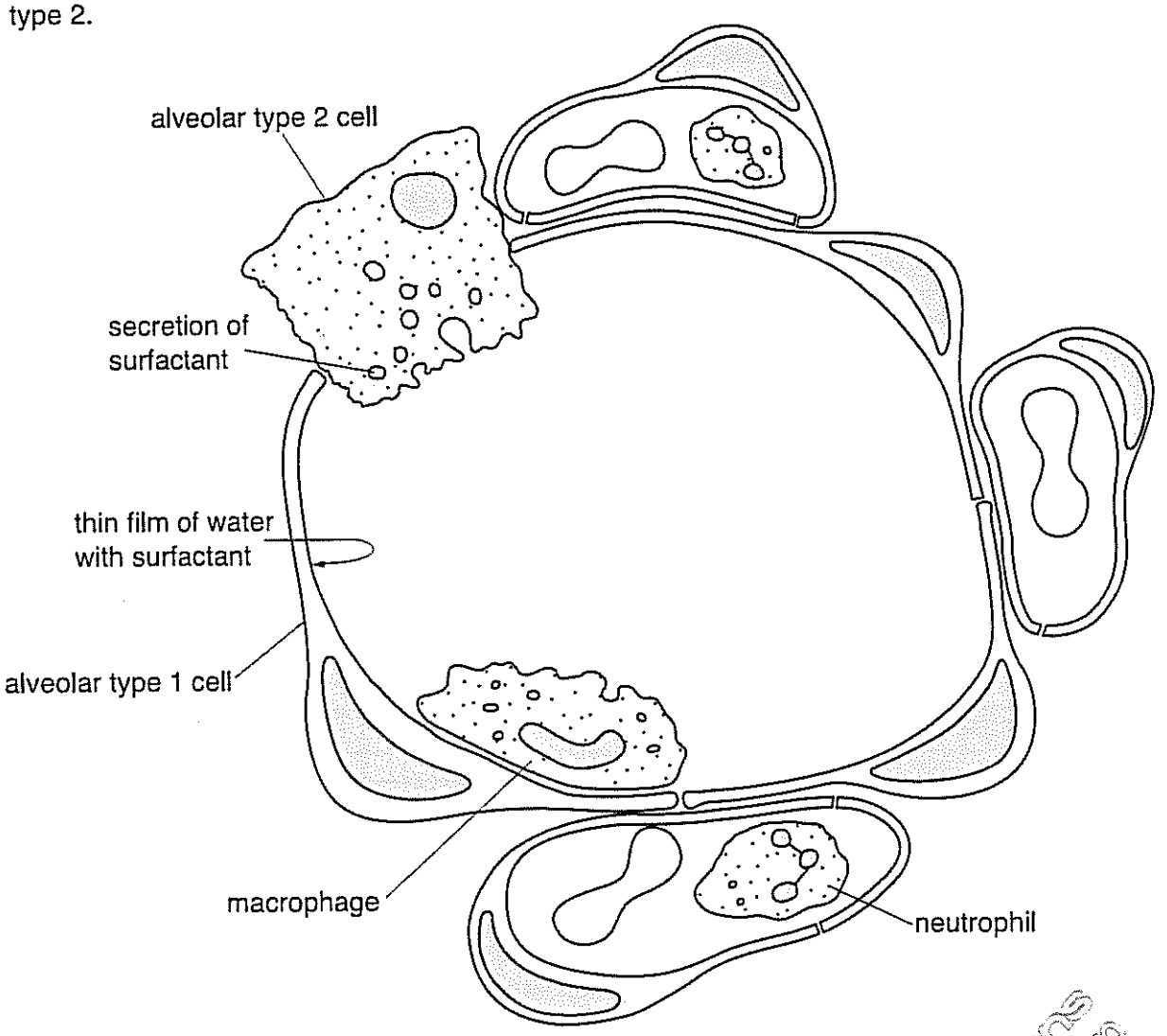


Fig. 3.1 not to scale

(a) Explain how the structure of an alveolar type 1 cell is adapted to its function.

.....

.....[2]

(b) Alveolar type 2 cells secrete pulmonary surfactant into the watery fluid that lines the alveolus. The surfactant reduces the surface tension of the fluid so that the alveolus does not collapse. Pulmonary surfactant is a mixture of phospholipids and proteins. The phospholipids form a monolayer on the surface of the fluid.

Explain how phospholipids interact with water to form a monolayer on the surface of the fluid.

.....

.....[2]

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Macrophages and neutrophils are found in the lungs, as shown in Fig. 3.1.

(c) Describe the role of macrophages in the lungs.

.....

.....

.....[3]

(d) Neutrophils leave the blood and secrete the extracellular enzyme, elastase.

(i) Suggest why neutrophils secrete elastase.

.....

.....[2]

(ii) The protein alpha-1 antitrypsin is produced in cells in the liver and is transported to the lungs, where it inhibits the action of elastase.
Some people produce a different form of this protein that remains within liver cells. These people are at an increased risk of developing emphysema, in which alveolar walls break down. Emphysema is one of the conditions associated with chronic obstructive pulmonary disease (COPD).
Explain why these people are at increased risk of developing emphysema.

.....

.....

.....[3]

24. M/J 17/P22/Q5/a

Some pathogens can enter the human body through the gas exchange system.

(a) The epithelial lining of the gas exchange system is adapted for defence against pathogens.

(i) List the structures in the gas exchange system that have a ciliated epithelial lining.

.....[1]

(ii) Name the cells in the ciliated epithelium that synthesise and secrete mucus.

.....[1]

25. O/N 16/P21/Q6/a,b,c

(a) Complete Table 6.1 to show the features of the human gas exchange system.
Place a tick (✓) where a feature is present and a cross (✗) if a feature is absent.

Table 6.1

	cartilage	cilia	elastic fibres
trachea			
bronchioles			
alveoli			

[3]

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(b) Smoking causes changes to the structure of the lining of the bronchi that make smokers more likely to be infected by bacteria.
Describe these changes and explain how this leads to an increased risk of bacterial infection.

.....

.....

.....
[3]

(c) Haemoglobin binds oxygen in the lungs to form oxyhaemoglobin.
Describe what causes oxygen to be released from the oxyhaemoglobin as blood flows through respiring tissues.

.....

.....

.....

.....[4]

26. M/J 16/P21/Q3
A student studied a transverse section of the trachea of a small mammal. The student drew a plan diagram of the section as shown in Fig. 3.1.

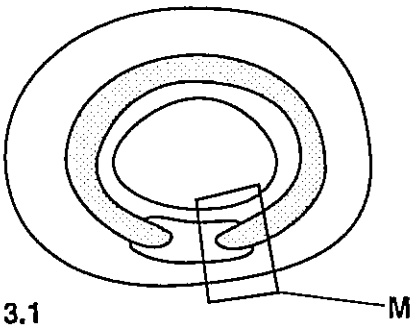


Fig. 3.1

Fig. 3.2 is a photomicrograph of the area labelled **M** in Fig. 3.1.



Fig. 3.2

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(a) Name:

(i) the type of epithelium at **N**

.....[1]

(ii) the structures at **O**

.....[1]

(iii) the tissue at **P.**

.....[1]

(b) Smooth muscle in the trachea and in the bronchi relaxes during strenuous exercise.
Suggest the advantages of relaxing this smooth muscle during periods of strenuous exercise.

.....

.....[2]

(c) The walls of the trachea and bronchi contain elastic fibres.
Elastic fibres are made of bundles of the fibrous protein elastin.

- Each molecule of elastin is a single polypeptide.
- The primary structure contains a large proportion of the amino acid glycine.
- Glycine has a hydrophobic R group.
- Glycine does not occur at regular intervals in the polypeptide.
- The polypeptide forms random coils that change shape as the elastic fibres are stretched and recoil.
- Elastin molecules are joined to each other by many covalent bonds to form a cross-linked network.

Describe two ways in which the structure of a collagen molecule **differs** from the structure of an elastin molecule described above.

1 .....

2 .....
[2]

27. M/J 16/P23/Q1

Fig. 1.1 is a photomicrograph of epithelial cells in the bronchus.

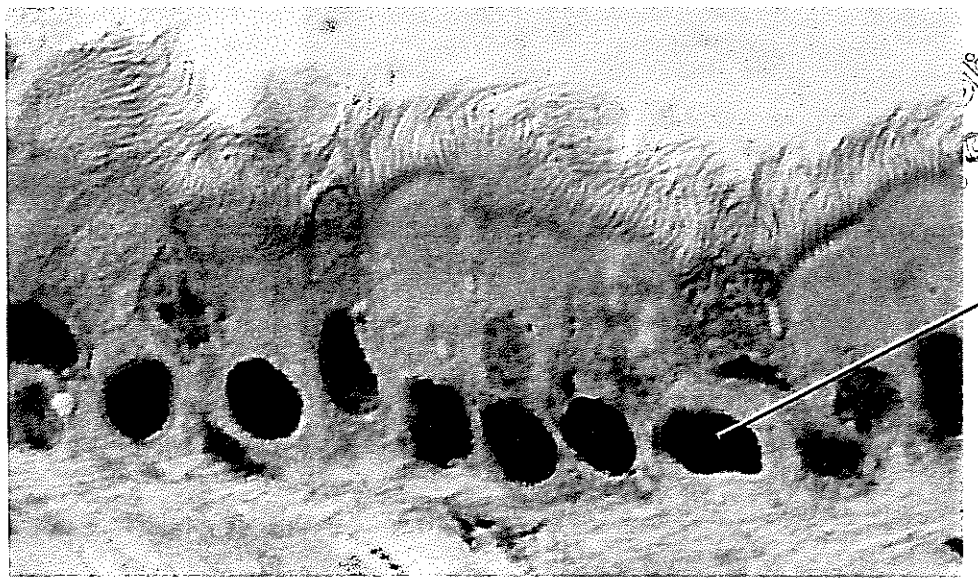


Fig. 1.1

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(a) (i) Write a letter **X** on Fig. 1.1 to show the lumen of the bronchus. [1]

(ii) Name the structure in Fig. 1.1 labelled **A**.

.....[1]

(iii) State **one** feature of the cells, **visible in Fig. 1.1**, which indicates that these are **not** epithelial cells from the alveolus.

.....[1]

(b) Epithelial cells are replaced when they are damaged.

(i) Name the type of cell division used to replace damaged epithelial cells.

.....[1]

(ii) The cells shown in Fig. 1.1 are from a non-smoker.
Smoking causes damage to the epithelial cells of the lungs.
Describe the appearance of the lining of the bronchus in a long-term smoker.

.....

.....

..... [3]

28. O/N 15/P22/Q2/a,b,d,e

Tobacco smoking is known to be associated with atherosclerosis and emphysema.

(a) Outline ways in which tobacco smoking can contribute to atherosclerosis.

.....

.....

..... [3]

(b) Fig. 2.1 is a scan of the lungs of a person with emphysema. One common feature in the damaged areas labelled is a loss of the elastic fibres of the alveoli. Another feature is an increased number of macrophages and neutrophils.

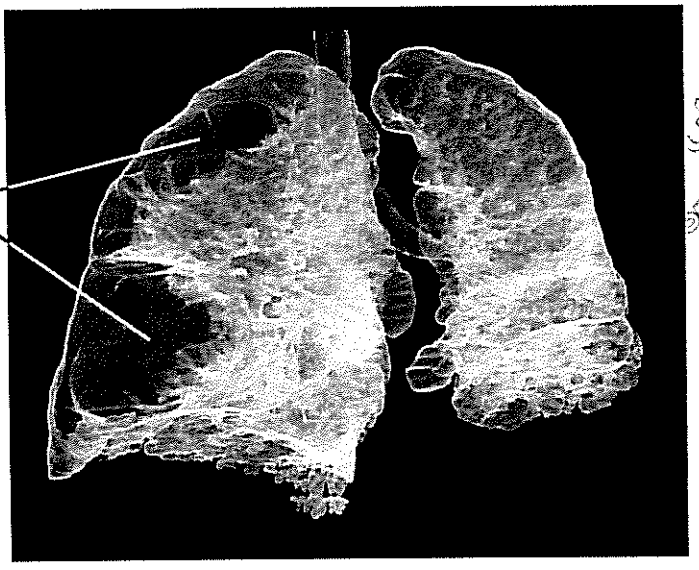


Fig. 2.1

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(i) State the general role shared by macrophages and neutrophils.

..... [1]

(ii) Suggest how the loss of the elastic fibres would cause the enlargement of the lung shown in Fig. 2.1.

.....

..... [2]

(c) There are two inhibitors of elastase that are produced in the body, TIMP-1 and A1AT:

- macrophage elastase is inhibited by TIMP-1
- neutrophil elastase is inhibited by A1AT.

The inhibitors can be inactivated by the elastase enzymes:

- macrophage elastase can inactivate A1AT
- neutrophil elastase can inactivate TIMP-1.

In healthy lungs, the activity of elastase enzymes is regulated. Tobacco smoke can disrupt this regulation.

(i) One effect of tobacco smoke is to cause changes in the structure of A1AT, a competitive inhibitor.
Suggest how structural changes to A1AT will affect its mode of action.

..... [1]

(ii) A1AT is a protein. Some non-smokers have a mutation in the gene coding for A1AT and are at risk of developing emphysema as there is a lack of A1AT in the lung tissue.
Explain why a lack of A1AT in these non-smokers means that they are at risk of developing emphysema.

.....

.....

..... [3]

(d) Tobacco smoke is known to cause increased production of macrophage elastase. *MMP12* is the gene coding for macrophage elastase. Copies of this gene are produced as messenger RNA (mRNA).
Describe how this mRNA is used in translation to produce macrophage elastase.

.....

.....

.....

.....

..... [5]

29. O/N 15/P23/Q5/a

Nicotine and carbon monoxide in tobacco smoke contribute to damage to the cardiovascular system.

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(a) Explain how nicotine and carbon monoxide contribute to damage to the coronary arteries.

nicotine .....

.....

carbon monoxide .....

.....[3]

30. M/J 15/P22/Q2

Fig. 2.1 is a scanning electron micrograph of an area of the trachea showing the presence of *Bordetella pertussis* bacteria.

B. pertussis is the causative organism of a respiratory disease in humans known as whooping cough. The disease is transmitted from person to person in a similar way to tuberculosis (TB).

A symptom that is common to TB and to whooping cough is the production of an excess of mucus.

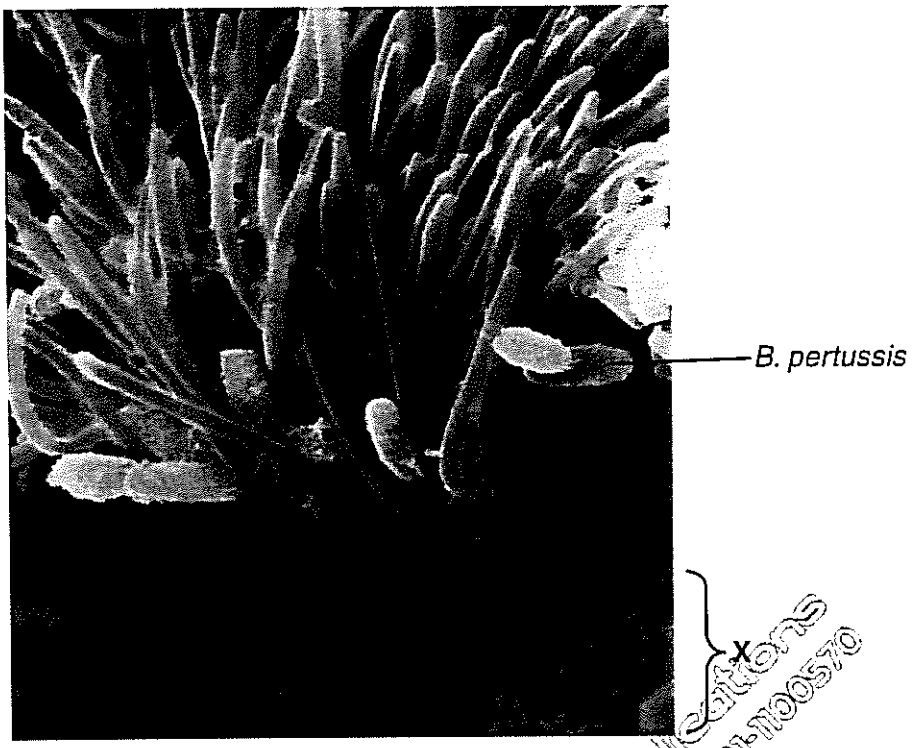


Fig. 2.1

(a) Describe the damage caused by *B. pertussis* that is shown in the area labelled **X** on Fig. 2.1 **and** explain how this will affect the functioning of the epithelial tissue of the trachea.

.....

.....

.....[3]

(b) Goblet cells produce mucus. Name one other structure in the gas exchange system that also produces mucus.

.....[1]

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(c) Suggest how whooping cough is transmitted.

.....

.....[2]

(d) The presence of *B. pertussis* stimulates the production of mucin, a gel-like glycoprotein that is the main component of mucus.
The mucin produced by the cell is packaged into vesicles ready for exocytosis.

(i) The first stage in the production of mucin involves transcription of the gene *MUC5AC*.
Outline the stages occurring in transcription.

.....

.....

.....

..... [4]

(ii) Following translation, the polypeptide formed is modified by the addition of many short chains of monosaccharides in a process called glycosylation.
Suggest where glycosylation occurs in the cell **and** explain why mucin is packaged into vesicles.

.....

..... [2]

(e) Overproduction of mucus is one of the symptoms of chronic obstructive pulmonary disease (COPD).
Describe the signs and symptoms that enable diagnosis of COPD.

.....

.....

.....

.....[4]

31. M/J 15/P21/Q2

Pathogens enter the body in a variety of ways, including through the gas exchange system. The body has several defence mechanisms against the entry of pathogens and their spread throughout the body.

Fig. 2.1 is an electron micrograph of a cross section of the lining of a bronchiole.

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Fig. 2.1

(a) **(i)** Name tissue **X** and cell **Y**.

X .....

Y ..... [2]

(ii) With reference to the structures visible in Fig. 2.1, state three ways in which the lining of the trachea, bronchus and bronchioles provides protection against the entry of bacterial pathogens.

1 .....

2 .....

3 .....

[3]

Fig. 2.2 shows part of the immune response to the first infection by a bacterial pathogen that has entered the body through the lining of a bronchiole. **J** and **K** are stages in the immune response.

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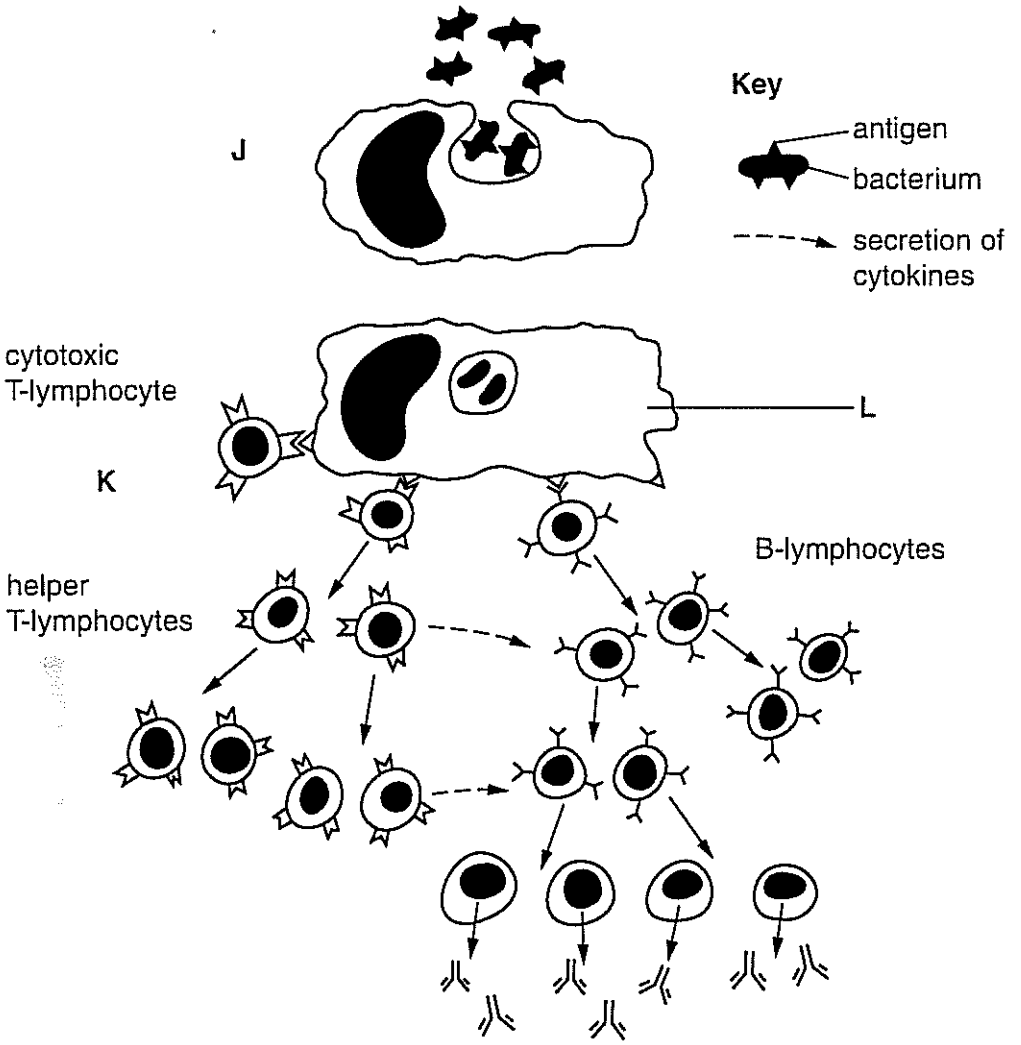


Fig. 2.2

(b) **(i)** State what is happening at stage **J**.

.....[1]

(ii) Explain the role of cell **L** at stage **K** in the immune response.

.....

.....[2]

(c) With reference to Fig. 2.2, explain how the response to a second infection by this bacterial pathogen differs from the first.

.....

.....

.....[3]

(d) There are various ways in which the effectiveness of immune responses can be reduced. Suggest how each of the following reduces the effectiveness of an immune response.

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(i) The number of T-lymphocytes is reduced in a person with HIV/AIDS.

.....[1]

(ii) Some pathogens are covered in cell surface membranes from their host.

.....[1]

(iii) B-lymphocytes do not mature properly and do not recognise any antigens.

.....[1]

32. O/N 14/P22/Q1

Fig. 1.1 is a light micrograph of a section through part of the gas exchange system.

A, **B** and **C** are three different types of tissue.

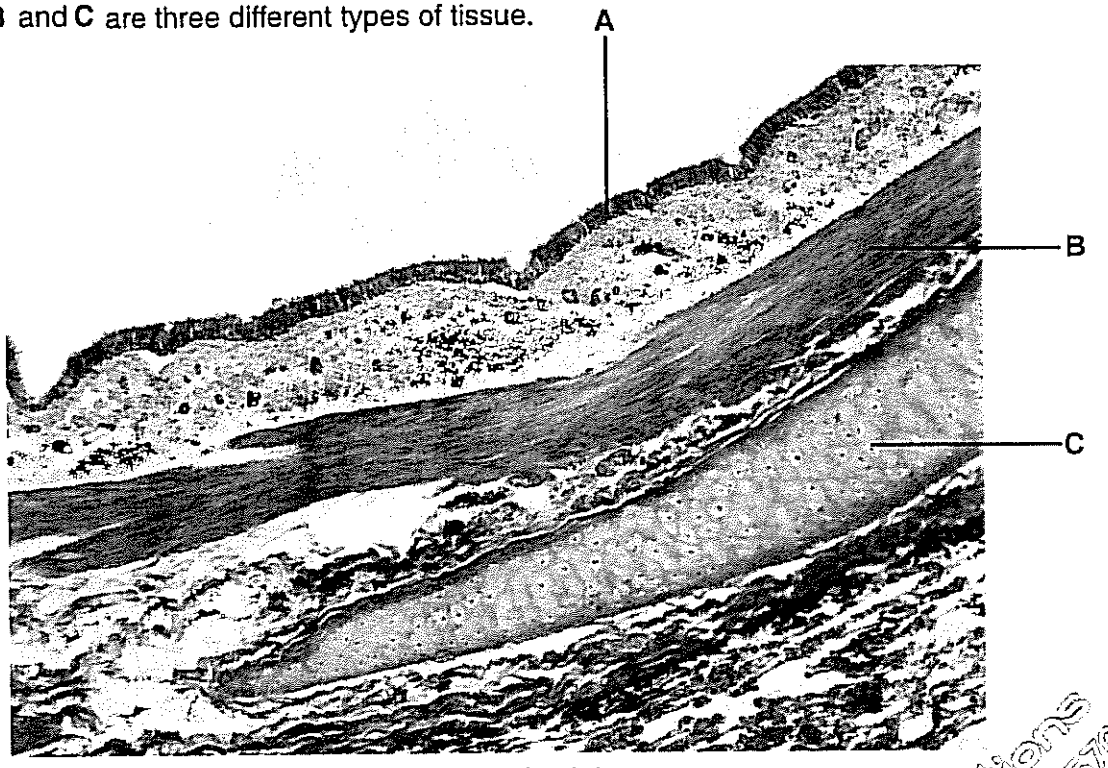


Fig. 1.1

(a) The cell types in tissue **A** have different functions.
Describe how the cell types work together to maintain the health of the gas exchange system.

.....

.....

.....[3]

(b) Suggest why the cells in tissue **B** have many mitochondria.

.....[1]

(c) Name the parts of the gas exchange system where tissue **C** is distributed.

.....[1]

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33. O/N 14/P21/Q3/e,f

(a) People with long-term chronic obstructive pulmonary disease (COPD) usually have blood which is poorly oxygenated during its passage through the lungs. This leads to a constriction of blood vessels in the lungs.
Suggest the likely effect of this on the heart.

.....

.....[2]

(b) Describe the signs and symptoms of COPD that help doctors make an early diagnosis of this condition.

.....

.....[2]

34. O/N 14/P23/Q5

Fig. 5.1 shows a section of lung tissue from a smoker. The image magnification is ×10.

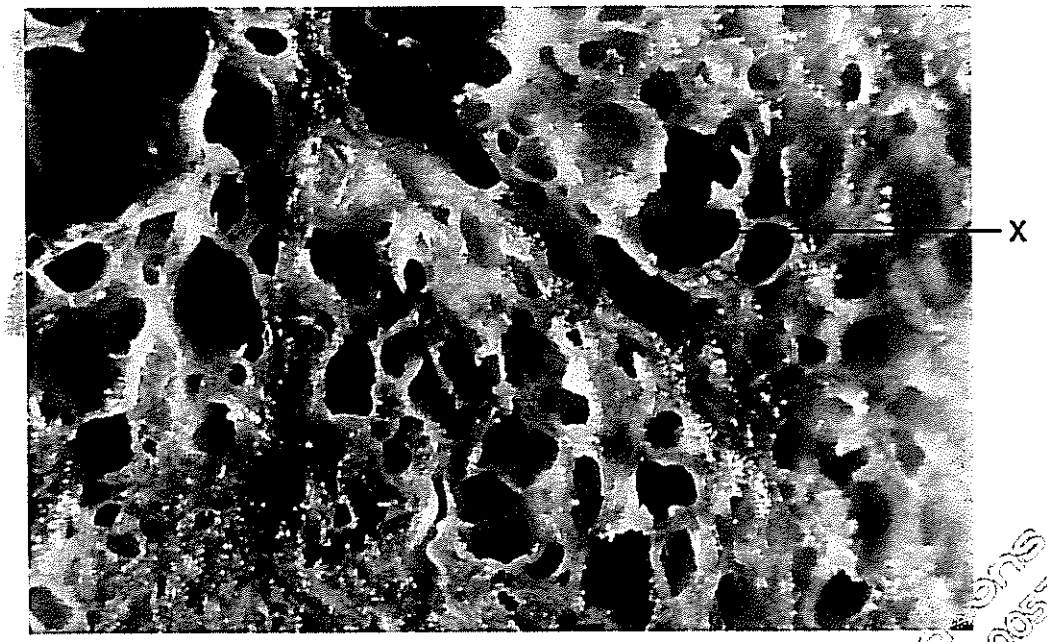


Fig. 5.1

In a smoker, the walls between the gas exchange structures in the lungs can break down, resulting in the damaged features visible in Fig. 5.1. One of these damaged features is labelled **X**.

(a) (i) Name the gas exchange structures which are damaged in Fig. 5.1.

.....[1]

(ii) Name the smoking-related disease resulting in the damaged feature labelled **X** in Fig. 5.1.

.....[1]

(b) Smoking-related diseases may increase the risk of infectious diseases of the gas exchange system.
Describe **and** explain how smoking can increase the risk of these infections.

.....

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.....

.....[3]

(c) From one cigarette, a smoker will inhale between 14 and 20 mg of carbon monoxide. Describe the effects of carbon monoxide on haemoglobin.

.....

.....[2]

35. M/J 14/P22/Q3

(a) Cartilage is present in some parts of the gas exchange system to prevent collapse due to pressure changes during inhalation.
State the parts of the gas exchange system in which cartilage is located.

.....[1]

(b) Fig. 3.1 shows the changes that occur in atmospheric pressure and oxygen partial pressure as altitude changes. The highest altitude at which people live permanently is 5100 m.

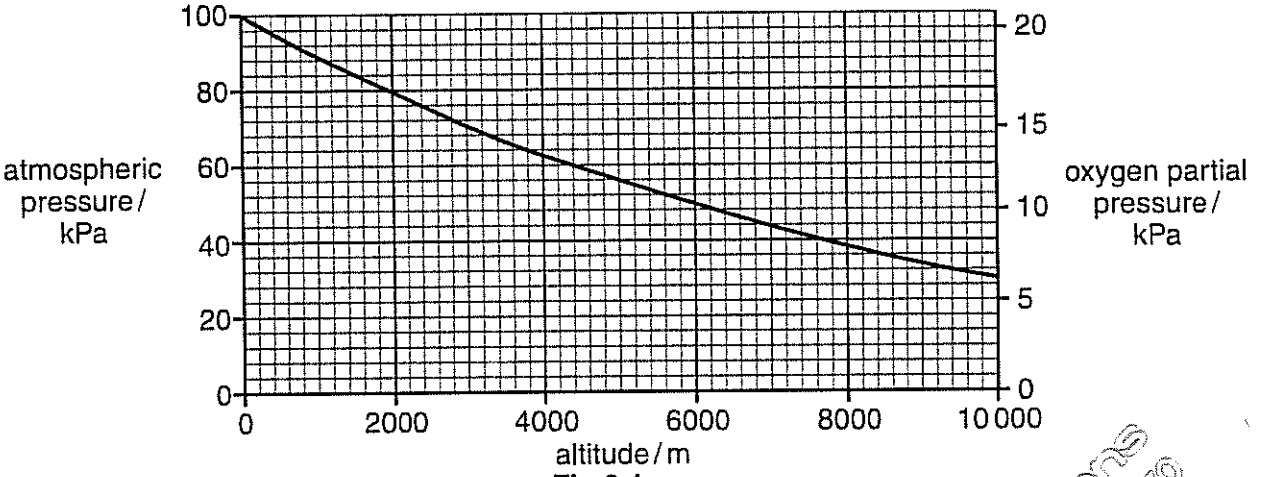


Fig 3.1

With reference to Fig. 3.1:

(i) describe the effect of increasing altitude on both atmospheric pressure and the partial pressure of oxygen

.....

.....[2]

(ii) calculate the change in the atmospheric pressure when a person travels from sea level to an altitude of 3500 m.
Show your working.

answer .....[2]

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(c) When a person travels from 0 m (sea level) to a high altitude, gas exchange in the lungs is affected. A condition known as hypoxia results, where the body tissues do not receive an adequate oxygen supply.

Explain how hypoxia occurs when a person ascends from sea level to a high altitude.

.....

.....

.....

.....[4]

(d) At high altitudes, short-term responses by the body to hypoxia include:

- a decrease in the volume of plasma in the blood
- a decrease in the volume of blood pumped out of the heart per heart beat
- an increase in the heart rate
- an increase in the breathing rate.

(i) Suggest why a decrease in the volume of plasma in the blood may reduce the effects of hypoxia.

.....[1]

(ii) Explain why an increase in the heart rate occurs in response to hypoxia.

.....

.....[2]

(e) People with sickle cell anaemia have a form of haemoglobin that is unable to bind to oxygen efficiently. The cause of the condition is a mutation in the gene coding for the β-globin polypeptide of haemoglobin.

Outline how this mutation can lead to an altered amino acid sequence of the β-globin polypeptide.

.....

.....

.....[3]

36. O/N 13/P21/Q3

(a) Tuberculosis (TB) and chronic obstructive pulmonary disease (COPD) are diseases that affect the lungs.

With reference to TB and COPD, explain how infectious diseases differ from non-infectious diseases.

.....

..... [2]

Macrophages are large phagocytic cells that are found in many tissues including alveolar tissue in the lungs. They provide the main means of defence against pathogens in this tissue.

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Fig. 3.1 is a drawing made from an electron micrograph showing part of a capillary and two alveoli, with a macrophage.

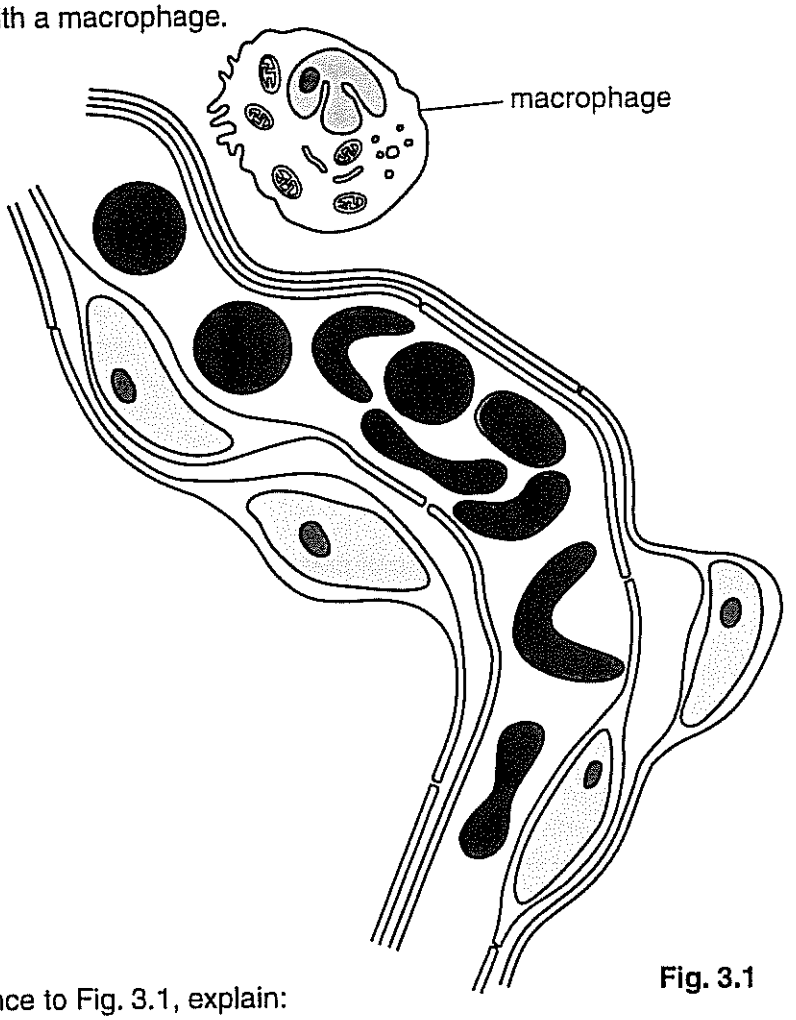


Fig. 3.1

(b) With reference to Fig. 3.1, explain:

(i) how alveoli are adapted for gaseous exchange

.....

.....

..... [3]

(ii) how macrophages function to protect the lungs from becoming infected.

.....

.....

.....

..... [4]

(c) Phagocytes release enzymes that digest proteins. In smokers, this may lead to the large-scale destruction of alveolar walls.
Outline the effects of this destruction on a person's health.

.....

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.....

..... [3]

37. O/N 12/P23/Q3

A study was carried out on a large number of people, some of whom were smokers. The study investigated the link between percentage of deaths due to lung cancer in smokers and their smoking habits. The age at which they started smoking and the number of cigarettes smoked per day were recorded. The results of the study are shown in Fig. 3.1.

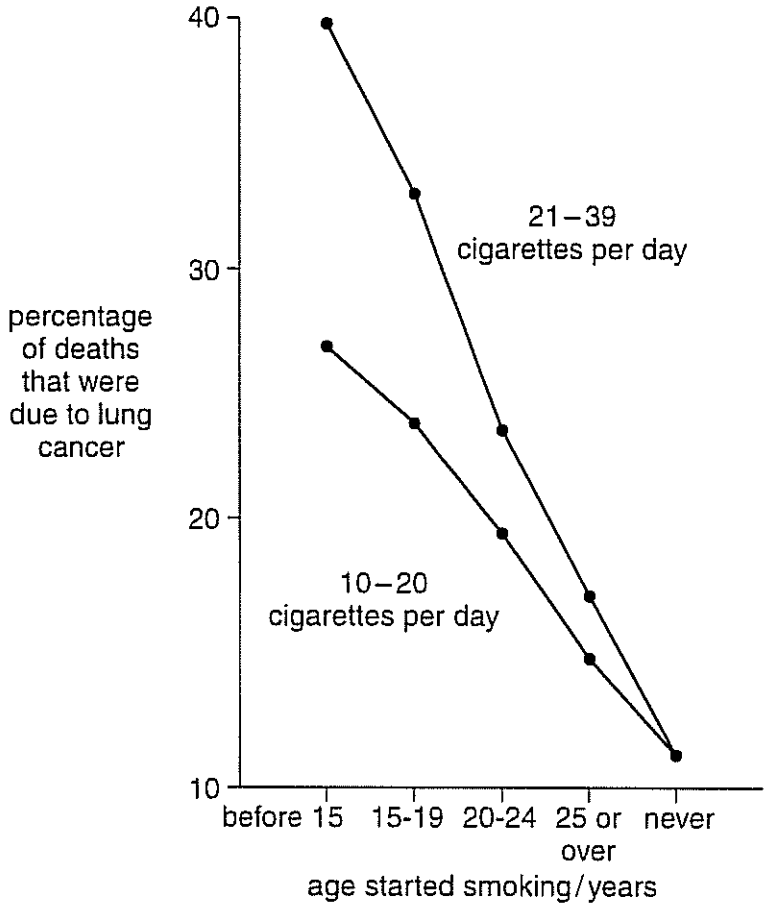


Fig. 3.1

(a) Explain what the results in Fig. 3.1 show about the link between cigarette smoking and percentage of deaths due to lung cancer.

.....

.....

.....

..... [4]

(b) Tobacco smoke contains many substances which are harmful to the body.
Outline the harmful effects on the cardiovascular system of:

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(i) carbon monoxide

.....

..... [2]

(ii) nicotine.

.....

..... [2]

(iii) Describe briefly the effects of tar on the goblet cells and cilia of the trachea.

goblet cells .....

.....

cilia .....

..... [4]

38. M/J 12/P21/Q1

Name as precisely as you can the structure described in each of the following statements.

(a) The blood vessel that transports deoxygenated blood from the heart.

..... [1]

(b) The cell that ingests and digests cell debris and bacteria in the lungs.

..... [1]

(c) The cell that secretes antibodies.

..... [1]

(d) The epithelial cell that secretes mucus in the trachea.

..... [1]

(e) The tissue that prevents the collapse of the trachea during inhalation.

..... [1]

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Answers Section

1. **M/J 22/P22/Q5**

(a) *any **one** from:* **I** too small
presence of ciia ; **A** ciliated, cells / epithelial cells / epithelium
AVP ; e.g. *suggestion that* mucus on surface makes detail not easily seen

(b) epithelium has goblet cells and ciliated epithelial cells ;
A ciliated cells
A two different cell types present
I *ref. to* cell division
ref. to staining ; e.g. use of stains gives different, shades / colours
differential staining
one cell type more neutral / acidic
different parts of cells stain differently
idea of cells have different densities ;
e.g. *idea of* more structures / larger nucleus, gives greater density / AW
R no cell structures *for lighter cell*
I *ref. to* number of cilia
(sectioning may include) more of nucleus so, affects light penetration / makes cell darker
ora
AVP ; *idea of* different components in cells appearing, darker / lighter

(c) *any **three** from:*

A *max two for structure*		**B / cartilage**
smooth muscle / composed of smooth muscle cells **or** no chondrocytes	**or**	no smooth muscle cells **or** has chondrocytes ;
cells close together	**or**	cells, (more) isolated / in gaps / in lacunae
cells, spindle shaped / elongated / AW	**or**	cells (more) rounded / AW ;
AVP structure e.g. not surrounded by, perichondrium / AW contains blood vessels	**or**	surrounded by, perichondrium / AW ; no blood vessels ;
function		
contractile / contracts (and relaxes) **I** recoil **A** bronchi walls contract **R** bronchi contract	**or**	non-contractile ;
changes diameter of airways **A** controls size of lumen	**or**	protective / support ; **A** described e.g. prevents collapse of, bronchus **or** keeps bronchus open

*if incorrectly quotes **A** as the cartilage, use right hand column to allow one mark max (ecf)*

[6]

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2. M/J 22/P21/Q1

(a) **A** – ciliated, epithelium / epithelial tissue ;
B – smooth muscle ;
D – cartilage ;

(b) **1** produce / release / secrete, mucus / mucin ; **R** excrete mucus
*any **two** from:*
2 mucus forms a layer over the (ciliated) epithelium ;
3 traps / sticks to, bacteria / viruses / pathogens / microorganisms / dust / pollen / (fungal) spores / AW ;
4 mucus is, moved / AW, away from alveoli *or* lung tissue / towards back of mouth / AW, by cilia ; **R** 'by ciliated cells'
5 *idea that* mucus prevents (named) pathogens reaching, epithelial cells / alveoli / gas exchange surface ;
A acts as a barrier to (named) pathogens

(c) (i) *pH 7.7* = 72(%)
pH 7.4 = 60(%) ;

(ii) *allow Hb or hb for haemoglobin*
decrease in supply of oxygen to tissues / AW ;
(at lower pCO_2 / increase pH blood) affinity of, haemoglobin, for oxygen is higher
or
haemoglobin is more saturated ora
A less oxygen, released / dissociates / AW, from haemoglobin (than normal)
must be in context of higher affinity in the tissues
or
data quote for difference in saturation of haemoglobin in correct range of pO_2 (within 2–6 $kPaO_2$) ; [9]

3. M/J 22/P23/Q1

(a) bronchi ; **A** bronchus

(b) *any **two** from:*
trachea v alveoli

trachea		*alveoli*
(carries) oxygenated blood **A** (carries) blood with more oxygen	**or**	(carries) deoxygenated blood ; **A** described **A** (carries) blood with, less / little, oxygen **I** no oxygen
lower concentration of carbon dioxide	**or**	higher concentration of carbon dioxide ;
blood at higher pressure	**or**	blood at lower pressure ;
(part of the) systemic circulation **or** branch from the aorta / (originates) from, left ventricle	**v**	(part of the) pulmonary circulation **or** pulmonary artery **or** from right ventricle (of heart) ;

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(c) (i) *allow from, labelled / annotated, diagrams drawn*
*any **three** from:*
ciliated epithelium / ciliated epithelial cells / ciliated cells / cells with cilia ;
detail (of ciliated epithelial cells) ;
e.g. columnar / description
cilia, only facing the lumen / on apical lumen / lining the lumen
I on surface of tissue
goblet cells ;
AVP ; e.g. basement membrane
pseudostratified (epithelium)
large nuclei **I** visible / clear, nuclei
basal nuclei (in goblet cells)
nucleoli visible within nuclei

(ii) blood vessel / capillary / venule ;
plus two from:
presence of red blood cells (in the lumen) ;
endothelium / endothelial cells ;
A flat cells *accept for endothelial cell*
A cells with, prominent / bulging / AW, nucleus
very thin / one cell thick, walls ;
ref. to small size, qualified ; e.g. narrow lumen / comparison to other tissues
alternative
endothelium / endothelial cell ;
plus two from
flat cells ;
cells with, prominent / bulging / AW, nucleus ;
one cell thick ; [9]

4. O/N 21/P22/Q5/c

(a) (i) trachea
bronchus / bronchi
bronchiole / bronchioles ; **A** types of bronchiole

(ii) **A** CO *for carbon monoxide* **A** Hb / hb, *for haemoglobin*
*any **two** from*
1 forms carboxyhaemoglobin ; **A** binds to haemoglobin (permanently)
2 less haemoglobin available to bind oxygen / haemoglobin has higher affinity for carbon monoxide (than for oxygen);
3 reduces, percentage saturation of haemoglobin (with oxygen) / AW ;
A less, oxygen binds to haemoglobin / oxyhaemoglobin forms
I prevents oxygen binding
if mp2 and mp3 not gained allow one mark for statements such as
reduces capacity for binding of oxygen to hb / less oxygen carried by hb / decreases the oxygen carrying capacity of hb
4 decreased quantity of oxygen transported / AW ;
5 damages, endothelium / tunica intima / lining of blood vessels ; [3]

5. O/N 21/P21/Q2/c

(a) (i) *any **two** from:*
increases heart rate ;
increases blood pressure ;
makes platelets stick together / makes blood more likely to clot ;

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damage to, endothelium / endothelial wall / capillary wall ;
reduces blood flow to extremities / ref. vasoconstriction ;

(ii) *any **three** from:*
similarities max 2
both have a (co-)transport protein ;
both involve H^+ / hydrogen ions / protons ;
H^+ move down the concentration gradient / by facilitated diffusion ;
(sucrose and nicotine both) move against the concentration gradient ;
differences max 2
in nicotine transport, H^+ ions and nicotine, move in opposite directions ;
ora for sucrose transport
H^+ ions move from, the apoplast / cell wall, in sucrose transport (from the cytoplasm in nicotine transport) ; AVP ; e.g. ref to ATP [5]

6. O/N 21/P23/Q6/c

(a) *any **two** from:*
either
1 allow alveoli, to stretch and recoil (during inhalation and exhalation)
or
allow, lung (tissue) / named airway, to expand and recoil ;
I 'contract', 'relax' and 'gas exchange' / 'respiration'
2 prevent alveoli, over-stretching / bursting ;
3 recoils to move air out of alveoli ;
A force / expel / push / AW
A alveolar duct [2]

7. M/J 21/P22/Q4

(a) *any three from*
lung cancer to max 2
(tar) is a carcinogen ;
acts as mutagen / causes mutations / described ; **I** mutant cells
e.g. causes changes to sequence of, bases / nucleotides, in DNA
detail ; **I** uncontrolled mitosis
e.g. tumour suppressor genes switched off
protooncogenes to oncogenes / oncogenes switched on
(cell cycle) checkpoints fail to function AW
cell moves from, G0 / inactive state of cell cycle, to G1 phase (for mitosis)
no programmed death / AW
chronic bronchitis to max 2
(tar) paralyses / destroys / damages / AW, cilia ; **I** weakens cilia
A damage to ciliated (epithelial) cells
consequence to cilia action ; *must be related to mp1*
e.g. cilia do not, waft away / AW, mucus
loss of synchronous rhythm of cilia
(tar causes), goblet cells / mucous glands, to, increase in size / enlarge / AW ; **A** (tar / accumulation of mucus, causes) inflammation
more / excess, mucus produced (by, goblet / mucous gland cells) ;
I mucus accumulates

(b) *correct units for volume* cm^3 ;
SA and volume calculation (SA) = 54 (V) = 27 ;

(c) **A → B → C** ; **A** 6:1 → 3:1 → 2:1 **A** 1 → 2 → 3

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(d) *any two from (in emphysema)*
alveolar walls break down / alveoli burst, to, produce one large air sac / give a lower SA:V
or
diseased, tissue / areas / alveoli, has lower SA:V (than healthy tissue) ;
removed tissue has (higher proportion of), large air sacs / diseased alveoli ;
remaining tissue has, healthy / undamaged / functional / only, alveoli ; AW
A volume reduced and functional surface area of lung remains the same
A remaining tissue has higher functional surface area (than before surgery)

(e) *any two from*
1 only oxygenated blood passes through left side of heart **ora**
or
oxygenated blood in left side and deoxygenated blood in right side of heart ;
2 septum in heart separates (oxygenated and deoxygenated) blood ;
3 oxygenated blood is in pulmonary, venules / veins and deoxygenated blood is in, pulmonary arteries / arterioles;
4 (because mixing prevented by) double circulation / double circulatory system / pulmonary and systemic circulations; [10]

8. M/J 21/P23/Q5/c

(a) (i) *emphysema and chronic bronchitis do not need to be named*
any one from must be in context of COPD
less, air / oxygen, able to reach, alveoli / air sacs / gas exchange surface ;
less oxygen able to, diffuse to / AW, capillaries (from, alveoli / air sacs) ;
ventilation impaired / AW ;
any two from effects of chronic bronchitis and emphysema
inflammation (of respiratory airways) ;
build up / accumulation / excess / AW, of mucus
decreased lumen of, trachea / bronchus / bronchioles / respiratory tubes / airways ;
A airway obstruction **I** blocked
A constriction / narrowing
(loss of, elastin / elastic fibres, so) less ability (of alveoli) to recoil ;
alveoli, burst / destroyed **or** alveolar walls break down ;
large(r) air sacs (instead of alveoli) / AW ;
decreased / reduced, SA:V ; *of, alveolar area / gas exchange surface area*
AVP ; e.g. relevant effect of pulmonary hypertension affecting gas exchange

(ii) *any two from*
decreases quantity of, oxygen / O_2, taken into blood / absorbed / transported (back to heart) ; AW
A fewer red blood cells to take up oxygen
A blood less oxygenated
decreases quantity of, carbon dioxide / CO_2, leaving blood / excreted / AW ;
A more carbon dioxide remains in the blood (than normal)
increased, ventilation / breathing, rate ; **R** breathes more deeply
AVP ; e.g. further increase in pulmonary hypertension [5]

9. O/N 20/P22/Q3

(a) irregular / plates / AW, of cartilage ; **A** cartilage not C-shaped rings
other features
*any **two** from:*
smooth muscle ;

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elastic, tissue / fibres ;
mucous glands ;
thick wall / wall many layers ;
large lumen (relative to thickness of wall) ;
large size relative to surrounding alveoli ; I surrounded by alveoli

(b) *evidence must match stated structure*
blood vessel ;
*plus any **one** from:*
presence of tunica media / circular layers of smooth muscle ;
three layers in wall ;
similar to structure on left, which has blood cells ;
not bronchiole, qualified ; e.g. as no ciliated epithelium
not rounded shape / no definite shape
OR
artery ; **A** arteriole
*plus any **one** from:*
small lumen relative to thickness of wall ; **A** small lumen with thick wall
thick, tunica media / muscle layer ;
thick tunica externa ;
OR
vein ;
*plus any **one** from:*
no definite shape / not rounded / not oval / AW ;
large lumen relative to thickness of wall / large lumen and thin wall ;
thin tunica media ;

(c) goblet cells, produce / secrete / AW, mucus to trap, pathogens / AW ;
A dust / dirt / particles etc for AW
cilia, waft / moves / carries / push, mucus, to back of throat / AW ; [7]

10. O/N 20/P21/Q5/a,b(i,ii)

(a) (i) *any **one** from :*
(*when the air pressure lowers inside bronchus*)
holds, bronchus / airway open ; **A** supports, bronchus / airway ;
prevents, bronchus / airway, from collapsing ;

(ii) *idea that* (cartilage arranged as) incomplete / C-shaped, rings in the trachea ;
idea of more regular distribution (of incomplete rings) along the length of trachea ;

(iii) *max 1 if cilia or mucus linked to incorrect cell*
(ciliated epithelial cells have) cilia, to, waft / sweep / AW, mucus, away / up the trachea / AW ;
(goblet cells that) secrete mucus to trap, dust / bacteria / pathogens ;

(b) (i) the larger elephant has a smaller surface area to volume ratio ; **ora**

(ii) *any **three** from:*
are multicellular / have many cells ;
need a large quantity of / enough, oxygen to supply, every cell / all parts of body ;
active so high demand for, oxygen / removal of CO_2 ;
diffusion across body surface is not fast enough (to meet needs) ; AW
long diffusion distance (so diffusion is not fast enough to meet needs) ; [8]

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11. O/N 20/P23/Q1

(a) *one mark per row*
A if *names and labels reversed*

description	name of part of gas exchange system	label from Fig. 1.1
supported by incomplete (C-shaped) rings of cartilage	trachea	B ;
lined by ciliated epithelium and supported by blocks of cartilage	bronchus **A** bronchi	C / J ; **A** C and J
lined by squamous epithelium	alveolus / alveoli	M ;
lined by ciliated epithelium, but not supported by cartilage	bronchiole(s) **I** terminal / respiratory	H ;

(b) **A** mutagen(s) / carcinogen(s) ; **A** tar **A** named carcinogens
B nicotine ;
C carbon monoxide ;
D tar ;
E nicotine ; [9]

12. M/J 20/P22/Q4/a,b(i)

(a) much / AW, rough endoplasmic reticulum / rough ER / RER for, polypeptide / protein / collagen, synthesis ; **A** for translation
many mitochondria provide, energy / ATP, for, polypeptide / protein / collagen, synthesis ;
large nucleus indicates, active cell / (much) transcription ;

(b) (i) *any two from*
in trachea ;
in, bronchus / bronchi ;
if only one correct structure named, allow one qualification mark
trachea
C-shaped / incomplete, rings ;
surround smooth muscle ;
bronchus
plates / irregular ; [4]

13. M/J 20/P21/Q4/a,b,c

(a) *any four from:*
carbaminohaemoglobin ; **A** combined with haemoglobin
hydrogencarbonate ions / HCO_3^- ;
R HCO_3
CO_2 dissolved in the plasma ;

(b) *any four from:*
1. correct direction of movement for oxygen and carbon dioxide ;
e.g. oxygen, moves from, alveolus / **W**, to, capillary / blood / red blood cells, and carbon dioxide moves from, capillary/ blood /plasma to alveolus / blood to **W** ;
2. diffusion of, oxygen / carbon dioxide / respiratory gases ;
A movement down, partial pressure / concentration, gradient
A from high(er), partial pressure / concentration, to low(er), partial pressure / concentration
I along a concentration gradient

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3. use of data from Table 4.1 to support movement of oxygen or carbon dioxide ;
   needs ref. to kPa once
   allow ecf from mp2
4. (diffusion) through, alveolar wall / squamous epithelium ;
5. (diffusion) through, endothelium / capillary wall ;
6. AVP ; e.g. haemoglobin binding oxygen

(c) *any four from:*
alveoli / alveolar walls, stretch / expand, during, inspiration / AW ;
arteries / arterioles / blood vessels, stretch / expand, as blood, volume / pressure, increases ;
stretch to prevent (alveoli / arteries), bursting / rupture / AW ;
A prevent overstretching
recoil during expiration / AW, to help, expel / force out, air ; ***AW** in context of alveoli*
recoil to apply pressure to blood so maintaining blood pressure ; *in context of arteries*
AVP ; e.g. allows trachea / bronchus / bronchioles, to expand during inspiration [10]

14. M/J 20/P23/Q3/c

(a) *any two from*
contraction and relaxation ;
changes diameter of (lumen) of, trachea / bronchus / bronchiole ;
A (contraction causes) constriction
control of air flow (in the bronchioles) ;
AVP ; e.g. changed size of lumen during coughing / forced air out [2]

15. O/N 19/P22/Q2

(a) EMRO and SEARO / Eastern Mediterranean and South-East Asia (Regions)

(b) *max 1 (tar data mark or nicotine makes platelets sticky) if tar / CO also stated*
any two from:
(AFRO) has more nicotine ;
R has more, tar / tar and nicotine / CO and nicotine (*see below)*
nicotine makes platelets sticky / AW ;
A damages endothelial lining (so turbulent blood flow) so increases clotting risk
R if also state tar makes platelets sticky
0.92 and 0.77–0.79 mg (per cigarette) **or**
9.2 v. 7.7–7.9 mg (per cigarette) **or**
(AFRO) 1.3–1.5 mg (per cigarette) higher ;
correctly extracted numerical data for tar is alternative to gain mp 3 ecf
12.5–12.7 v. 11.3–11.5 mg / (AFRO) 1.0–1.4 mg higher

(c) *allow, Hb / hb, for haemoglobin and allow CO for carbon monoxide*
any four from:
1 haemoglobin, has a higher affinity for / binds more readily with, carbon monoxide (than oxygen) ;
A carbon monoxide displaces oxygen from haemoglobin
A carbon monoxide binds to Hb and decreases its affinity for oxygen
2 carboxyhaemoglobin formed ;
3 binding is, (mainly) irreversible / permanent / (more) stable (than oxygen binding) / AW ;
4 decreases saturation of haemoglobin with oxygen (in the lungs) / less haemoglobin available to bind oxygen ;
A less oxyhaemoglobin formed / less oxygen binds to haemoglobin
cigarette smoke:

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5 low concentration of oxygen in inhaled cigarette smoke ;
6 *ref. to* (in airways), narrowed lumen / inflammation / increased mucus / accumulated, mucus ;
A bronchial constriction
7 (so) lower concentration of / less, oxygen, reaching alveolus / in alveolar air
or
(so) less oxygen, diffuses / AW, (from alveolus) into bloodstream / reaches red blood cells / reaches haemoglobin (in red blood cells) ;
R *ref. to* consequence of emphysema
must be in context of mp 5 or 6
8 AVP ; e.g. nicotine causes vasoconstriction and reduces blood supply (to extremities) [7]

16. M/J 19/P22/Q2

(a) mucous gland cells / mucous gland(s) ; **I** mucosa
goblet cell(s) ;
list containing trachea and / or bronchus and / or bronchioles **I** *and allow to two max*
BUT if alveoli stated or incorrect cell types (e.g. ciliated cells) max 1

(b) *any one from:*
Golgi (body / complex / apparatus) ;
rough endoplasmic reticulum ; **A** rough ER / RER **R** SER **I** ER

(c) *two marks to complete table*

first process	transcription
second process	translation
third process	glycosylation
fourth process	exocytosis

allow one mark if transcription first process and exocytosis last process but other two wrong way round
allow one mark if transcription and translation wrong way round and other two correct

(d) *accept symbol Ψ for water potential*
three from:
1 chloride presence outside cell causes water potential (outside cells) to, decrease / become more negative / become lower **or**
chloride leaving cell causes water potential (in cell) to increase / AW ;
2 water potential gradient, created / present (between inside and outside of cell) ;
3 water leaves cell by osmosis (to be taken up by mucin to form mucus) ;
4 from higher to lower water potential / AW ; **R** if term gradient included

(e) *any three from:*
to produce, new / daughter, cells…
1 that are genetically identical ;
2 to replace, old / damaged / dead, cells ; **A** named cells
3 to repair (damaged / injured / diseased) tissue ;
A named tissue
if mp 2 and 3 not gained, allow 1 mark for replacing damaged tissue
4 *ref.to* function ; *in context*
5 AVP ; *idea of* increase in number of cells / growth, to accommodate increase in size of gas exchange system in growing infants / AW [11]

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17. M/J 19/P23/Q2/b

(a) (i) squamous epithelial (tissue) ; **A** pavement epithelial (tissue)

(ii) *any two from:*

(alveoli have) thin wall / wall is one cell thick ; **A** wall composed of thin cells **R** thin membrane **R** thin cell wall

idea of short diffusion distance ;
in context of between alveolar space and, blood / capillary

elastic tissue, qualified ; **A** elastin / elastic fibres
e.g. stretch and recoil for, ventilation / inhalation and exhalation
maintaining steep, diffusion / partial pressure, gradient

(many) alveoli provide a large surface area (for diffusion) ;
I *idea that a single alveolus has a large surface area*

AVP ; surfactant, prevents alveolar collapse / maintains inflation
I *ref. to* moist lining [3]

18. O/N 18/P22/Q1

(a) bronchiole ; **I** respiratory / terminal, before bronchiole

(b) (actual diameter) = image / observed, length, ÷ magnification ;
A (A =) I ÷ M **or** magnification triangle

300 µm ; (12 000 / 40)	**A** 275 µm (11 000 / 40)	**A** 288 µm (11 500 / 40)	**A** 313 µm (12 500 / 40)	**A** 325 µm (13 000 / 40)

(c) *any four from*
in healthy lungs

1 correct direction of movement of <u>both</u> respiratory gases ;
e.g. oxygen from alveolus towards blood and carbon dioxide from blood to alveolus ;
oxygen enters the blood system and carbon dioxide leaves
A red blood cell / haemoglobin, *as ref. to blood*

2 diffusion (of, oxygen / carbon dioxide)
or
movement, down a concentration gradient / from high(er) to low(er) concentration ;
A implied e.g. oxygen enters blood from a high<u>er</u> concentration
I diffusion of gases

3 detail of pathway ; **R** *ref. to* cell walls
e.g. across, alveolar wall / squamous (epithelial) cells across endothelium / capillary wall ;
A squamous cells *in context of capillary* crosses two layers of cells (alveolar wall *and capillary wall)*

comparison healthy with diseased – look for ora

4 higher rate of exchange / increased rate of diffusion / steeper concentration gradient ;
A more oxygen to blood per unit time / more carbon dioxide to alveolus per unit time
I more efficient gas exchange
I better gas exchange / faster diffusion

5, 6 AVP ; ;
e.g. larger surface area (for, gas exchange / diffusion)
shorter diffusion distance
ref. to (greater) ability to, stretch / recoil (for ventilation to maintain gradient) **or** *ref. to elasticity (more v fewer elastic fibres is not sufficient)* [7]

19. O/N 18/P21/Q1/a,b

(a) **A** trachea ; **A** windpipe **I** *ref.* to cartilage rings
B bronchiole ; **I** respiratory / terminal , before bronchiole
C alveoli ; **A** alveolus / air sac / alveolar sac

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(b) *any one from*
lung cancer ;
emphysema ;
chronic bronchitis ;
COPD ;
cystic fibrosis ;
AVP ; e.g. asthma *must be non-infectious* [4]

20. M/J 18/P22/Q5/a

(a) *three from:*
any four named structures ;
mouth / nose / nostrils / nasal passages (count as one structure)
pharynx
larynx
trachea **A** windpipe
bronchus / bronchi
bronchiole / bronchioles
alveolus / alveoli / alveolar ducts / alveolar sacs
lungs
trachea, branches / divides, into (two main) bronchi ;
correct sequence from bronchus (branching) to bronchioles to (end with) alveoli ;
further detail ; ; e.g. trachea has, C-shaped / incomplete rings, of cartilage bronchus has cartilage, plates/AW
diameters of gas exchange structures / respiratory tubes, decrease (towards alveoli) [3]

21. M/J 18/P21/Q4/b

(a) (i) 98 (%) ;

(ii) *four from:*
1 Bohr, shift / effect ;
2 (at any pO_2 on the left of graph) percentage saturation of haemoglobin decreases / haemoglobin releases more oxygen (to muscle tissue) / increases dissociation of oxyhaemoglobin ;
A any comparative data quote for any one value of pO_2 between 1 and 5 kPa
3 (increase in carbon dioxide) increases production of carbonic acid ;
4 increase in hydrogen ions (in red blood cells) ;
5 haemoglobin accepts hydrogen ions / formation of haemoglobinic acid (HHb) ;
A haemoglobin has an affinity for hydrogen ions
6 decreases the affinity between haemoglobin and oxygen ; [5]

22. M/J 18/P23/Q4/a,b

(a) *answers must be in context of oxygen*
three from:
1 diffusion
2 movement, down a, concentration / diffusion, gradient / from high(er) to low(er) concentration ; **A** in terms of partial pressure
3 passive (process) ;
4 through alveolar wall / across alveolar cells / across squamous epithelial cells (of alveolus) / across pavement cells (of alveolus) ;
A squamous cells
5 across, endothelium / endothelial cells / capillary wall ;
A squamous, epithelium / cells (in context of capillary wall)

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6 ref. to diffusion / AW, through the phospholipid bilayer of cell surface membranes / between the phospholipids of the bilayer (of squamous or endothelial cells) ;

(b) (i) 65 / 66 / 67 (%)

(ii) 1 higher partial pressures in lungs / lower partial pressures in (respiring) tissues ;
A correct values / range of values, of kPa
A in alveoli

advantages of differences (higher v lower partial pressure)
only higher partial pressure or lower partial pressure explanation required to gain mark

2 oxygen, binds to v released from, haemoglobin
or
oxyhaemoglobin, is formed v dissociates / AW ;
3 (so) percentage saturation of haemoglobin (with oxygen) high v low ;
4 affinity of haemoglobin for oxygen high v low ;
5 data from Fig. 4.1 to support ;
6 (body), cells / tissues, need oxygen for aerobic respiration ; [7]

23. O/N 17/P23/Q3

(a) (cell) thin / squamous / flat / pavement ;
R cell wall **I** one cell thick
short distance for, diffusion of (named) gases / gas exchange ;
A diffusion between (air in) alveolus and (blood in) capillary

(b) *two from*
phosphate / 'heads', are, polar / hydrophilic **and**, fatty acids / hydrocarbon chains / 'tails', are, non-polar / hydrophobic ; **A** hydrophilic / polar, heads **and** hydrophobic tails
tails, face away from fluid *or* water / project into air ;
A diagram
heads form hydrogen bonds with water ;
max 1 if answer is about a bilayer

(c) *three from*
1 prevention of infections (of, gas exchange system / named part) ;
A in context of a named disease (TB, pneumonia, influenza)
2 prevent (named) pathogen entering, rest of body / blood ;
3 *idea that macrophages* patrol / move around / AW, alveoli / lungs ;
4 (carry out) phagocytosis / endocytosis ;
A are phagocytes
5 engulf / remove / destroy / kill / digest , pathogens ;
6 macrophages are, antigen presenting cells / APCs ;
A description of antigen presentation **A** part of the immune system
7 AVP ; e.g. reduce excess surfactants **I** *ref. to* mucus

(d) (i) *two from*
breakdown / AW, elastin / elastic fibres / elastic tissue ;
makes a pathway, to alveolus / through alveolar wall
or
goes through alveolar wall
or
to reach, respiratory tract / gas exchange surface / air space ;
to reach, pathogens / site of infection, in alveoli / AW / implied ;

(ii) *three from*
1 no / less, inhibition of elastase ;
2 too much / more, elastin / AW, is broken down ;
3 *ref. to* lack of elastin so, no / less, recoil (during expiration) ;

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4 alveoli, over expand / overstretch / increase in size ;
5 alveoli burst ; [12]

24. M/J 17/P22/Q5/a

(a) (i) trachea / windpipe + bronchus / bronchi + bronchiole / bronchioles ;
treat as neutral type of bronchiole
(ii) goblet ; [2]

25. O/N 16/P21/Q6/a,b,c

(a)

	cartilage	cilia	elastic fibres	
trachea	✓	✓	✓	;
bronchioles	×	✓	✓	;
alveoli	×	×	✓	;

(b) *changes max 2*
fewer / no / damaged / AW, cilia ; **A** paralysed / destroyed **R** killed
A ciliated (epithelial) cells destroyed
scar tissue, develops / replaces ciliated (epithelial) cells / AW ;
goblet cells enlarged ;
increased risk max 2
thicker layer / more, mucus traps bacteria ;
mucus not removed (by cilia action) so, (trapped) bacteria remain / longer time for bacteria to infect cells / AW ;
bacteria multiply / bacterial population growth, in mucus (so increases chance of infection) ;

(c) *four from*
oxygen used up in (aerobic) respiration (in tissues) ;
low(er) / decrease in, partial pressure of oxygen / AW ;
allosteric mechanism / described ;
small decrease in partial pressure leads to a large dissociation of oxygen ;
ref. to decrease in haemoglobin affinity for oxygen (so oxygen released) ; AW
high(er) CO_2, partial pressure / AW ;
haemoglobinic acid formation / H^+ combines with haemoglobin (causes oxygen release) ;
AVP ; e.g. H^+ from carbonic acid dissociation
A H^+ results from action of carbonic anyhydrase to form carbonic acid
effects of carbaminohaemoglobin formation [10]

26. M/J 16/P21/Q3

(a) (i) **N** ciliated ; **A** pseudostratified **I** columnar / cuboidal **R** cilia
(ii) **O** mucous glands ; **A** mucus glands / serous glands
(iii) **P** cartilage ;

(b) **I** more air can enter unqualified
1 more air / oxygen, reaches the, alveoli / gas exchange surface ;
2 more gas exchange / greater absorption of oxygen / excretes more carbon dioxide ; AW
A maximises oxygen obtained
3 satisfies increased demand for oxygen / AW ;
4 trachea / bronchi / airways, widen / AW ;
e.g. dilate / expand / enlarge **A** diameter of lumen increases
5 reduces resistance to air flow ; **R** rate of air flow increases

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(c) *collagen has*
three polypeptides / a quaternary structure ;
I more than one polypeptide unqualified
glycine is every third amino acid ; **I** at regular intervals **R** roughly / approximately
(triple) helix / helical (shape) ; **I** regular coils' **R** alpha helix [7]

27. M/J 16/P23/Q1

(a) (i) letter **X** written in space above cilia ; **A** label line into this space
(ii) nucleus ;
(iii) cilia ;
columnar / tall / not flat / not thin ;
nuclei rounded / AW ;
presence of goblet cells ;

(b) (i) mitosis ;
(ii) *presence of any 3 of:*
1 shorter / no / fewer / damaged, cilia ; **A** paralysed
2 undifferentiated / AW, cells ;
3 flattened / squamous, cells / epithelium ;
4 scar tissue ; **A** scar tissue forms
5 enlarged goblet cells ;
6 excess / accumulated / AW, mucus ; **A** excess mucus secreted
7 tar deposits ; **A** description of tar on lining
8 phagocytes ;
9 AVP ; e.g. inflammation (of bronchial lining) [7]

28. O/N 15/P22/Q2/a,b,d,e

(a) **I** *ref. to* other components of tobacco smoke that enter bloodstream
1 contains carbon monoxide and nicotine (which contribute) ;
R if tar also stated
contribution to atherosclerosis
2 damage to / AW, endothelium / (inner) lining / tunica intima / inner wall ;
A also as consequence of increased blood pressure *mp8*
3 increased accumulation of LDLs ; AW *in context of the vessel walls*
A cholesterol / lipids / lipoproteins / fats / triglycerides
4 inflammation ;
5 more / arrival of / attraction of, phagocytes / macrophages / monocytes / neutrophils ;
A leucocytes / white blood cells
A phagocytes, have increased adherence / 'stick' more, to lining
6 phagocytes engulf, LDLs / AW, and die (in situe)
or
formation of / presence, foam cells ;
7 (contributes to) formation of, atheroma / atheromatous plaque ; **A** plaque
I atherosclerosis
features that may have a consequential effect
8 one risk factor (caused by components of smoke) ;
one from:
increased blood pressure *must be in context e.g. adrenalin release owing to nicotine* **I** atheroma increases blood pressure
increased stickiness of platelets (promotes clotting)
thrombus formation / thrombosis / (blood) clotting
increased, (serum) cholesterol / triglyceride / LDL, concentration
decreased, HDL / 'good' cholesterol, concentration
increased, oxidation / reactivity / AW, of LDLs

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(b) (i) phagocytosis ; **A** act as phagocytes
engulf / attack / destroy / AW, pathogens / bacteria / microorganisms ;
A viruses
A act as, antigen presenting cells / APCs
I antigens / foreign organisms / organisms
remove / engulf / AW, foreign substances / dead cells / cell debris / AW ;

(ii) *following inhalation* **I** *ref. to* contract / relax
1 alveoli / air sacs / lungs, over expand / over inflate / over stretch / AW
2 (alveoli have) no / poor, recoil ; **A** do not, rebound
A lungs do not, recoil / deflate properly
3 (alveoli / lungs) cannot return to normal size / remain, (fully) stretched ;
A do not, decrease in size after, stretching / inhalation / AW
4 alveoli / air sacs, do not push out air (effectively) / have trapped air / AW ;
I oxygen trapped

(c) (i) **I** active site of A1AT changes shape / acts as non-competitive inhibitor
R if macrophage elastase stated
cannot bind / not complementary, to active site ; **A** elastase / enzyme
H / temporary, bonds cannot form with active site ;
no longer, prevents entry / binding, of substrate ; **A** (so) substrate can bind

(ii) *consequence must be correctly linked to an event*
1 neutrophil elastase, active / not inhibited / AW ; **A** increase rate of reaction
2 (so) TIMP-1 inactivated ; **A** other / macrophage elastase, inhibitor
3 (so) macrophage elastase, active / functioning / not inhibited / not regulated ;
4 (so) more, macrophage and neutrophil / of both elastases, (to breakdown elastin) ;
5 *ref. to* consequence ; e.g. bursting alveoli / breakdown of alveolar walls / formation one large air sac / decrease in surface area for gas exchange

(d) 1 mRNA, binds / AW, to ribosome ; **A** ribosomal RNA **I** rRNA
A mRNA moves to ribosome
2 tRNA with amino acid (to / at, ribosome) ; **A** aminoacyl / charged, tRNA
3 tRNA / anticodon, specific to an amino acid ; **A** specific tRNA / anticodon for the amino acid
4 *ref. to* start codon; **A** $AUG^{(met)}$ / first codon is AUG / initiator tRNA ;
5 (complementary) base pairing / binding, between anticodon and codon ;
6 first and second tRNAs bind / two tRNAs bound (at a time)
or (tRNAs bring) amino acids, side by side / close ;
7 peptide bond formation ;
8 ribosome moves along, one codon / AW ;
9 next (aminoacyl) tRNA arrives / amino acids added one at a time ;
10 elastase / polypeptide, released when STOP codon reached ;
A process continues until a STOP codon reached
11 AVP ; e.g. *ref. to*, aminoacyl / A, site, and, peptidyl / P, site
small subunit (of ribosome) attaches to mRNA
aminoacyl tRNA synthetase binds amino acid to tRNA
ATP required for tRNA-amino acid binding
peptidyl transferase for peptide bond formation
ref. to, exit / E, site, on ribosome ribosome moves 5' to 3' [15]

29. O/N 15/P23/Q5/a

(a) **I** *ref. to* walls, unqualified **I** *ref. to* vasoconstriction
nicotine

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1 damages the, endothelium / (inner) lining / tunica intima ;
2 increases blood pressure (which can damage the endothelium) ;
3 increases risk of, blood clotting / thrombus formation ;
A thrombosis, **A** increases stickiness of platelets

carbon monoxide
4 damages the, endothelium / inner lining / tunica intima ;
allow even if mp1 given
5 so increases risk of, blood clotting / thrombus formation ;
A thrombosis
6 *idea of* overall reduced oxygen supply to coronary artery walls ;
7 AVP ; e.g. inflammation / (increases risk of) atheroma *or* plaque *or* atherosclerosis [3]

30. M/J 15/P22/Q2

(a) 1 cilia, qualified ; e.g. absent / short / destroyed / smaller / damaged / AW
R cilia killed **R** hairs for cilia **R** mucus damages cilia
A ciliated (epithelial) cells, absent / destroyed / damaged

2 ref. to presence of, scar tissue / scarring ; **BOD** scar
R cilia are scarred (idea is, scar tissue formation / more connective than usual)
note idea of scar tissue in place of, cilia / ciliated epithelium = 2 marks

3 idea of affecting, coordinated movement / synchronous rhythm, (of cilia) ;
A cilia paralysed
A if stated that excess mucus inhibits movement
A ecf if 'hairs' instead of cilia for mp 1

4 mucus, not moved (effectively) / accumulates ;

5 idea that, bacteria / *B. pertussis* / *Bordetella* / pathogens, accumulate (in airways) / are trapped in mucus
A mucus, good growth medium for pathogens / AW

(b) mucous gland ; **A** mucous glands

(c) if another mode of transmission given (e.g. faecal-oral / contact / sexual transmission) = 0 marks for this part-question **I** in unpasteurised milk

1 aerosol / droplet, infection ;
only need to have one of 'infected' / 'uninfected' to gain mps 2 and 3
2 infected / AW, person, coughs / breathes / spits / talks / sneezes ;
3 uninfected / AW, person, inhales / inspires / breathes in, droplets ;
2 / 3 *allow one mark if mps 2 and 3 given with no reference to, infected / uninfected*
4 organism / pathogen / bacteria / *B. pertussis*, in, airborne droplets / droplets in air ;
A without 'airborne' or 'in air' *if mp 2 gained*

(d) (i) 1 DNA / gene / *MUC5AC*, unwinds / AW ; **I** unzips
2 H-bonds break between, (complementary) bases / base pairs / strands ;
I unzips
3 one / a, strand, acts as template / (complementary) copied ;
I ref. to, sense / coding and antisense / non coding
4 ref. to (involvement of) RNA polymerase ;
I ref. to direction of, movement / strand formation
5 (free) complementary RNA nucleotides added ;
A described in terms of correct base-pairs (C with G and A with U minimum)
6 step-by-step / sequentially / AW ;
7 sugar phosphate backbone sealed / phosphodiester bonds formed ;
A sugar phosphate backbone formed
8 (product is) messenger RNA / mRNA ; **A** primary transcript
9 AVP ; e.g. transcription factors required to initiate transcription

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RNA polymerase binds to promoter (sequence)
helicase unwinds
ref. to activated (RNA) nucleotides
ref. to proof reading
(transcription ends at) transcription terminator

(ii) Golgi (body / complex / apparatus) ;
A RER / rough ER / rough endoplasmic reticulum
one of
2 transport / movement, to cell (surface) membrane (from Golgi) ;
A through cytoplasm (for Golgi or RER)
A transport to Golgi *if RER given in mp1*
3 ref. to bulk transport, across cytoplasm / to cell surface membrane ;
4 ref. large size and difficulty of movement across, cell / cell surface membrane ;
5 it, functions extracellularly / is released to the outside of the cell / is secreted ;
I ref. to exocytosis *as it is in the question*

(e) 1 shortness of breath / dyspnea / difficulty breathing / restriction of airflow ;
A rapid breathing **R** heavy breathing
2 chronic / persistent / AW, cough / coughing ; **I** cough, blood / mucus
A constant coughing **A** smoker's cough
3 chest tightness ; **A** chest pain **R** heart pain
4 wheezing ;
5 fatigue / weakness ;
6 difficulty, when exercising / with physical activity / with mobility ;
7 more prone to / frequent, chest / respiratory / named, infections ;
8 barrel (shaped) chest ;
9 cyanosis (blue, face / fingers)
10 AVP ; e.g. weight loss / anorexia
swollen, ankles / feet
not excess mucus as this is in the question [16]

31. M/J 15/P21/Q2

(a) (i) **X** – (ciliated) epithelium ;
Y – red blood cell / erythrocyte ;

(ii) cilia beat to move mucus (up the bronchiole / towards the mouth / away from the lungs / AW) ;
mucus as a barrier to entry into (epithelial) cells ;
mucus traps, pathogens / bacteria / microbes ; *accept in context of goblet cells*
capillary / blood vessel, brings, phagocytes / macrophages (to engulf bacteria) ;

(b) (i) **J** – phagocytosis / endocytosis / described in terms of engulfing *or* forming phagosome ;

(ii) digestion of bacteria / described ;
to destroy bacteria / pathogen ; **A** to prevent spread through the body
antigen, presentation / display on cell surface ;
idea of selection of specific, B cells / T cells ;
A recognition / binding of / activation of, appropriate B / T cells

(c) 1 faster ;
in context of whole secondary response
2 memory cells;
in context of production during the first response
3 *idea that* there are many more cells specific for this pathogen ;
4 (so) increases chances of encountering pathogens more quickly / AW ;
5 fast(er) production of, B lymphocytes / plasma cells / antibodies / helper (T) cells / cytotoxic T cells / cytokines ;

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6 greater concentration of antibodies (in, blood / lymph) *or*
greater numbers of, B / plasma, cells ;
A more, antibodies / plasma cells / B cells

7 pathogen, removed / killed, faster ;

8 person does not become ill / no symptoms ;
A pathogen does not, spread through the body / infect cells / AW

(d) (i) little / no / slower / weak, immune response ;
stated function of T-lymphocytes, does not occur / occurs slowly ;
e.g. release of cytokines / stimulating macrophages / stimulating B cells / killing infected cells
high susceptibility to infectious diseases ;
R 'fighting disease'

(ii) pathogen **not** recognised, as non-self / foreign ;
pathogen is recognised as self ; **A** non-foreign
ignore antigen concealment

(iii) no, antibodies / plasma cells / memory (B) cells, produced ;
no humoral response ;
no antigen presentation by B cells ; [14]

32. O/N 14/P22/Q1

(a) *mp 1 for naming the cell types in the epithelium*
cell names not required for mps 2 and 4

1 goblet cells and ciliated epithelial cells ; **A** ciliated cells
goblet cells

2 produce / **AW**, mucus ; **R** ciliated cells produce mucus

3 mucus, traps / **AW**, pathogens / **AW** ;
treat, dust / particles, as neutral unless qualified
e.g. allergens / asbestos dust *can be credited*
ciliated (epithelial) cells

4 cilia / ciliated cells waft / move mucus to back of throat / away from lungs / to be swallowed ;
A away from alveoli / gas exchange system
R goblet cells waft
R *idea that cilia present all the way to the stomach*
R *idea that whole ciliated cells move*

(b) *in context of smooth / involuntary muscle*
need a large supply of / **AW**, ATP / energy ;
so able to synthesise large supply of ATP ; **R** energy
energy / ATP, for muscle / contraction ;

(c) bronchi / bronchus, and trachea ; [5]

33. O/N 14/P21/Q3/e,f

(a) increase in power of contraction ; AW
increase in (systolic) blood pressure ;
strain on right ventricle/right ventricle does not function efficiently ;
growth of muscle in/right ventricle increases in thickness ;
insufficient oxygen to, heart/cardiac, muscle ;
heart failure/heart attack ;

(b) persistent/AW, cough ;
cough produces much mucus ;
wheezing ;
rapid breathing/difficulty breathing/breathlessness ;
bluish colour to the skin ;
recurrent chest infections/frequent colds *or* 'flu/AW ;

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barrel-shaped chest ;
chest pains ; **R** heart pains
fatigue/weakness, (with exercise) ; [4]

34. O/N 14/P23/Q5

(a) (i) alveoli ; **A** alveolus/aveoli
(ii) emphysema ; **A** emphasema etc.

(b) damage/paralyse/destroy/inhibit, cilia/ciliated epithelium ;
goblet cells, enlarge/produce more mucus ;
mucus, accumulates/not swept away (by cilia) ;
bacteria/pathogens, can multiply in mucus/AW ; **A** grow in mucus
I mitosis
bacteria/pathogens, not removed ;
increased time available to infect cells ;
AVP ; e.g. increased permeability of alveolar walls to pathogens depressed
antigen-presenting ability of lung macrophages

(c) CO, binds to/combines with/joins with, haemoglobin ;
A forms carboxyhaemoglobin
I carbaminohaemoglobin
binding is irreversible/carboxyhaemoglobin is stable/AW ;
R carbaminohaemoglobin is stable
haemoglobin, cannot become fully saturated with oxygen/has a lower affinity for oxygen/carries less oxygen/AW ; **A ora**
R 'carries no oxygen' [7]

35. M/J 14/P22/Q3

(a) trachea and, bronchi/bronchus ; **A** windpipe *for trachea*
R *if* bronchioles *also included*

(b) (i) (as altitude increases), both of them/atmospheric pressure and oxygen partial pressure, decrease ;
(one) correct comparative data quote ;
altitude and pressure, with units once, for either atmospheric pressure ***or*** *oxygen partial pressure*
non-linear decrease ; **A** almost linear decrease
decrease in oxygen partial pressure proportionate to decrease in atmospheric pressure ;

(ii) difference of/reduction of, 34 kPa ;;
A 33/35 kPa
A – 34/35/33, kPa
A 33/34/35% decrease for two marks only if evidence of kPa in working
100 kPa at sea level – 66 kPa at 3500 m ***A*** *65/67kPa*
one mark only if correct answer but no units/kPa
one mark if correct values taken from graph but no subtraction carried out
one mark if 3500 m value read as 63 kPa, so answer stated as 37 kPa

(c) *lower, atmospheric pressure/partial pressure of oxygen so*
lower partial pressure of/less/**AW**, oxygen in, alveolar/inspired/inhaled, air;
A breathed in *for inspired*
A less oxygen goes into lungs
decreased, diffusion/concentration/pressure, gradient ;
between, alveolus/alveoli, and capillary ;
less/**AW**, oxygen, enters/**AW** (pulmonary) capillaries/the blood ;
A less/**AW**, oxygen, transported/**AW**, by, haemoglobin/red blood cells/ blood (to tissues)

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(so) percentage saturation of haemoglobin is lower ;
A haemoglobin is less saturated
A fewer molecules of/less, oxygen combine with haemoglobin
(as) haemoglobin has lower affinity (for oxygen than at sea level) ; **AW**
A *ref. to* effect of 2,3 DPG
allow correct explanation in terms of oxygen dissociation curve
ref. to insufficient red blood cells to compensate ;
ora e.g. more red blood cells, need to be/will be, produced

(d) (i) greater concentration of/(proportionately) more/**AW**, red blood cells (through pulmonary capillaries per unit time)/**AW** ;
A haemoglobin for red blood cells
increases, the haematocrit/the percentage of red blood cells to the total blood volume/**AW** ;

(ii) more, blood/red blood cells, flowing to lungs (per unit time) ;
A blood flows faster to lungs
to maximise oxygen uptake (from alveoli)/takes in more oxygen/**AW** /compensates for lack of oxygen ;
more blood pumped through, systemic circulation (per unit time)/rest of body/to tissues/**AW** ; **A** blood flows faster *for more blood*
compensates for the lowered plasma volume
or
ref. need to, maintain supplies of required substances/remove waste/prevent decrease in pH ;
allow named required substances e.g. glucose/oxygen/amino acids
allow named waste substances e.g. carbon dioxide

(e) 1 nucleotide/base, sequence of, DNA/gene, changed/**AW** ;
A new allele (formed)

2 base substitution (mutation)/(DNA) thymine replaced by adenine/(DNA is) CTC to CAC/CTT to CAT (template codon) ;
this cannot be used for mp 1 as well

3 altered/changed, mRNA codon ; *(allow codons)* **A** *idea of different mRNA*
R altered genetic code

4 (mRNA codon is) GAG to GUG/GAA to GUA ;

5 glutamic acid, substituted/replaced/AW, by valine ; **A** glutamate
A glu *and* val

6 tRNA/anticodon, with different amino acid (to ribosome) ;
A tRNA with different anticodon

7 **AVP** ;
e.g.amino acid substitution at position 6
valine, hydrophobic/**AW** (R-group)
glutamic acid, polar/**AW** (R-group) [15]

36. O/N 13/P21/Q3

(a) *max 1 if no ref. to TB and COPD or if correct definitions given and ref. to TB/COPD incorrect (TB is an infectious disease, COPD non-infectious)*
TB caused by, a pathogen/*Mycobacterium*/*M. tuberculosis*/*M. Bovis* ; ora *for* COPD
A microorganism/bacterium/bacteria **I** virus/fungus/protoctist
A infectious disease is caused by a pathogen ora
TB is/COPD is not, transmissible/communicable/can be passed from one organism to another ; *allow detail of TB transmission e.g. droplet infection / in contaminated milk*
A infectious disease is transmissible ora
COPD caused by, damage to/irritation of, lung tissue ; AW
accept relevant ref. to tobacco smoking

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(b) (i) 1 lining / epithelium / wall, is thin / one cell thick / squamous ;
I thin interstitium
R cell walls of alveoli
R alveoli are one cell thick
R endothelium / membrane
2 (so) short diffusion distance / only diffuse through two cells ;
3 (collectively / many, so) large surface area for diffusion ;
R an alveolus has a large surface area
I high SA:V ratio / increase SA
4 surrounded by / many / network of, capillaries ;
I good blood supply
5 red blood cells are very close to air (in alveoli) ;
6 (so) maintain, diffusion / concentration / partial pressure, gradient(s) ;
7 elastin / elastic fibres, allow(s) alveoli to, increase in volume / expand / stretch / stop bursting / recoil ;
I alveoli are elastic
R contract

(ii) *allow microorganisms or named type of microorganism or infectious agent for pathogens*
1 recognise, non-self / foreign, antigens, (on pathogen) ;
2 receptors (on macrophage) bind antigens (on pathogen) ;
3 (or), pathogen / AW, adheres / 'sticks', to (cell surface) membrane ;
4 infolding of (macrophage cell surface) membrane around / engulf / phagocytosis of, pathogen ; **R** engulf antigen
5 vacuole / vesicle / phagosome, forms ;
6 ref. to lysosomes ;
7 hydrolytic / digestive / named, enzymes ;
e.g. lysozyme / protease / nuclease
A pathogen broken down by enzymes
8 hydrolysis of named compound(s) ;
9 ref. to destroying / killing, pathogen ;
10 ref. to antigen presentation ;
accept idea even though does not occur in alveoli

(c) 1 emphysema ;
2 (alveolar walls broken down so) less surface area for, gas exchange / diffusion ;
A impaired / AW, gas exchange / diffusion
3 difficulty in breathing / restriction in air flow / shortness of breath, wheezing / rapid breathing ;
4 blood is less well oxygenated / less oxygen reaches, tissues / muscles ;
5 any two other, signs / symptoms ;;
6 e.g. lethargy / tiredness / fatigue / constraints on mobility or activity
wheezing
persistent / AW, coughing
chest tightness ; **R** chest pain
more prone to / frequent, chest / respiratory, infections
A more frequent colds / influenza ('flu)
weight loss
swollen, ankles / feet
increase in thickness of, right ventricle / right side of heart
increase in blood pressure in pulmonary artery [12]

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37. O/N 12/P23/Q3

(a) *look at quoted data to confirm qualitative statements if unclear*

1 people who never smoked have the lowest percentage of deaths (due to lung cancer) ;
must be comparative
for age

2 *either*
the younger / earlier the person starts smoking the higher the percentage of deaths
or
the older / later the person starts smoking the lower the percentage of deaths (due to lung cancer) ;
for number of cigarettes per day

3 *either*
increasing / AW, the number of cigarettes smoked per day increases the percentage of deaths
or
decreasing / AW, the number of cigarettes smoked per day decreases the percentage of deaths ;
different 'start' ages for the two types of smokers

4 highest percentage deaths is for those with an early start and smoke, 21–39 (cigarettes per day) / the most / AW ;

5 greatest difference in percentage deaths occurs in those that start smoking early ; **ora**

(b) (i) 1 forms carboxyhaemoglobin ;
2 reduces affinity of Hb for oxygen / Hb has higher affinity for CO than for oxygen ;
ignore 'picks up CO rather than oxygen', if mp3 is given then allow
3 reduces quantity of oxygen transported (in blood) / AW ;
R prevents
4 damages lining of arteries ;
A promotes / AW, atheroma / atherosclerosis / plaque

(ii) raises, heart rate / blood pressure ;
reduces diameter of arterioles ;
decreases blood flow to body extremities ;
increases 'stickiness' of platelets / promotes, blood clotting / thrombosis ;

(iii) *goblet cells*
enlarge / swell up ;
A become bigger / dilate
R inflamed
produce more / excess, mucus ;
A lots of
AVP ; e.g. any cellular detail such as more mitochondria / Golgi bodies or vesicles
cilia:
paralysis / destruction ;
A damages **R** kills ***ignore*** 'tar coats...'
no / less beating / sweeping (action) / moving mucus ;
R in context of moving air [12]

38. M/J 12/P21/Q1

(a) pulmonary artery ; **A** pulmonary arteries

(b) phagocyte / macrophage ;
A neutrophil / polymorphonuclear leucocyte **R** PMN
R leucocyte / white blood cell unqualified
R any incorrect qualification

(c) B-lymphocyte / (effector) B (cell) / plasma (cell) ; **R** lymphocyte alone
R effector cell unqualified

(d) goblet (cell) ;

(e) cartilage ; ignore plates / rings [5]

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Unit 10

INFECTIOUS DISEASE

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

Editorial Board

Syllabus

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Unit 10: Infectious Disease

1. M/J 22/P22/Q2

Cholera is a life-threatening and infectious disease caused by the bacterium *Vibrio cholerae*. One of the symptoms of the disease is severe diarrhoea.

V. cholerae O1 and *V. cholerae* O139 are the two forms of the pathogen that are associated with cholera epidemics (large outbreaks). These two forms have different antigens that can be detected.

(a) If an outbreak of cholera is suspected but not confirmed, a standard home treatment for diarrhoeal diseases can be used immediately to help prevent severe illness as a result of dehydration. If cholera is the cause of the disease, this standard treatment also helps to prevent a larger outbreak of the disease.

(i) Outline the standard treatment that can be used for suspected cholera cases.

.....

..... [2]

(ii) Suggest **and** explain why this treatment can help to prevent a larger outbreak of cholera.

.....

..... [2]

(b) Rapid diagnostic testing (RDT) can be used to diagnose cholera by detecting the presence of *V. cholerae*. One type of RDT involves using a dipstick that contains mobile and immobilised monoclonal antibodies.

Monoclonal antibodies (mAbs) are specific in their action.

Fig. 2.1 shows a simplified diagram of an RDT dipstick that can be used to distinguish between *V. cholerae* O1 and *V. cholerae* O139. A faecal sample from a person with suspected cholera is collected and added to a reagent solution to form the test mixture.

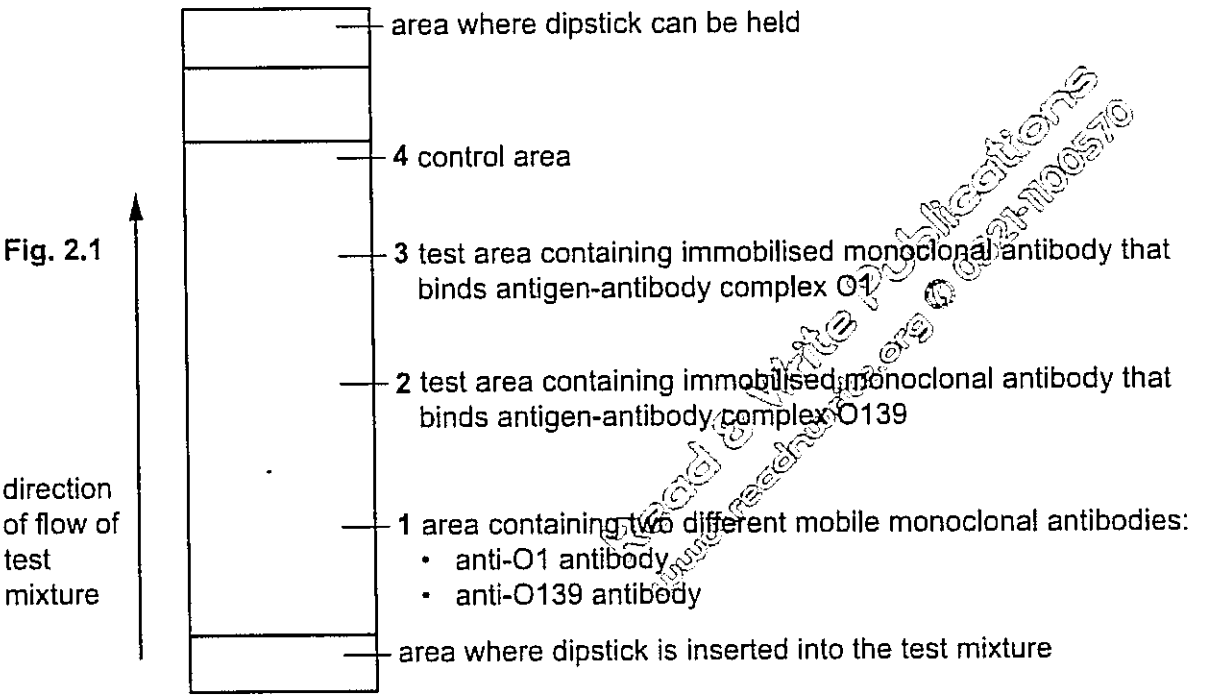


Fig. 2.1

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The test mixture moves up the dipstick through area **1**. The mobile monoclonal antibodies are attached to tiny gold particles. If these antibodies collect in test area **2** or **3**, a coloured band becomes visible.
A coloured band that becomes visible in area **4** confirms that the test strip is working and that the results are valid.

(i) Explain how the structure of the monoclonal antibodies in the dipstick allows them to be specific in their action.

.....

..... [2]

(ii) Fig. 2.2 shows the results for samples taken from two different people, A and B, who are suspected of having cholera.

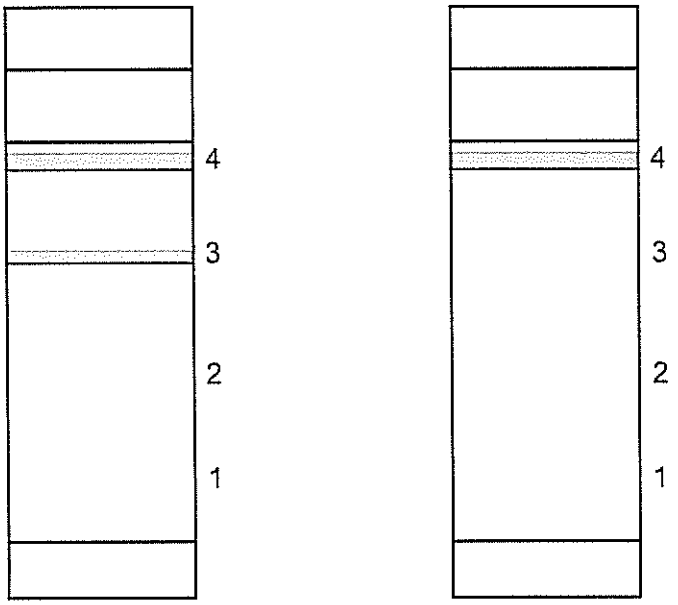


Fig. 2.2

With reference to Fig. 2.2, state and explain the conclusions that can be drawn from the results of the RDT dipsticks for each person.

.....

.....

..... [3]

(c) Table 2.1 shows the results of an investigation to evaluate the effectiveness of an RDT dipstick in diagnosing cholera.
Samples taken from 156 people were tested using a dipstick and compared to the results obtained by culturing the pathogen in a laboratory for accurate identification.

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Table 2.1

	number of test results		
	using culture techniques (to obtain accurate identification)	using dipstick	
		correct diagnosis	incorrect diagnosis
positive results for cholera	102	97	5
negative results for cholera	54	32	22

(i) With reference to Table 2.1, calculate the percentage chance of an RDT dipstick correctly confirming that a person with cholera has the disease.

[1]

(ii) Using an RDT dipstick to diagnose cholera is much cheaper than culturing the pathogen and requires less technical skill.
Suggest **one** additional advantage of using an RDT dipstick, rather than culture techniques, to diagnose cholera.

..... [1]

2. M/J 22/P21/Q5

(a) Infectious diseases are caused by pathogens and are described as transmissible diseases.
Explain what is meant by the term transmissible.

..... [1]

(b) *Vibrio cholerae* is the bacterium that causes cholera.
Fig. 5.1 is a transmission electron micrograph of *V. cholerae*.



Fig. 5.1

A student wanted to know the actual length of the flagellum shown in Fig. 5.1.
State the information that is needed so that the student can calculate the actual length of the flagellum.

.....

..... [2]

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(c) Table 5.1 shows data on large outbreaks of cholera that occurred in seven countries in 2019. The case-fatality rate is the number of deaths as a percentage of the number of cases.

Table 5.1

country	number of cases of cholera	number of deaths from cholera	case-fatality rate /%
Cameroon	1 307	55	4.2
DR Congo	29 087	501	1.7
Haiti	684	3	0.4
Kenya	5 150	39	0.8
Somalia	9 968	50	0.5
Sudan	346	11	3.2
Yemen	2 260 495	3767	

(i) Complete Table 5.1 by calculating the case-fatality rate for Yemen. [1]

(ii) Suggest why large outbreaks of cholera occurred in the countries listed in Table 5.1, but there were very few cases in most other countries.

.....

.....

.....

.....

..... [5]

3. O/N 21/P22/Q3/a,b

Baculovirus is a virus that kills some of the insect pests of major crops. When the virus is released to the outside of the insect body, it is contained within stable, protective structures known as polyhedrons.

The main component of the polyhedron is a protein molecule, polyhedrin.

Polyhedrons can be sprayed onto plants as a bioinsecticide. They are ingested by feeding insect larvae and once inside the insect gut they break down to release the virus.

(a) Explain why the term infectious disease can be used to describe the effect of baculovirus on insects.

.....

..... [2]

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(b) Suggest **and** explain the conditions present in the insect gut that can cause the breakdown of polyhedrons.

.....

..... [2]

4. O/N 21/P22/Q5/b

The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(a) Describe how measles is transmitted.

.....

.....

..... [3]

5 . O/N 21/P21/Q3/a,b,d

Cholera is an infectious disease caused by the bacterial pathogen *Vibrio cholerae*

(a) Describe how *V. cholerae* is transmitted from an infected person to an uninfected person.

.....

..... [2]

V. cholerae releases a toxin called choleragen. Choleragen is a protein molecule made up of six polypeptides (subunits).

(b) Fig. 3.1 is a ribbon diagram of a molecule of choleragen.



Fig. 3.1

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Describe what is shown by the part of the molecule labelled **T**.

.....

.....

..... [3]

(c) The World Health Organization states that most cases of cholera can be treated with oral rehydration therapy. To reduce the risk of antibiotic resistance developing, antibiotics are only recommended for the most serious cases.
Discuss the consequences of the development of antibiotic resistance in *V. cholerae*.

.....

.....

.....

..... [4]

6. O/N 21/P23/Q5
Measles is a highly infectious disease. The World Health Organization (WHO) has coordinated a programme for controlling this disease by using vaccination.

(a) (i) Name the pathogen that causes measles.

..... [1]

(ii) Explain how the measles pathogen is transmitted.

.....

.....

..... [3]

(b) Fig. 5.1 shows the number of cases of measles globally each month between January 2015 and March 2019.

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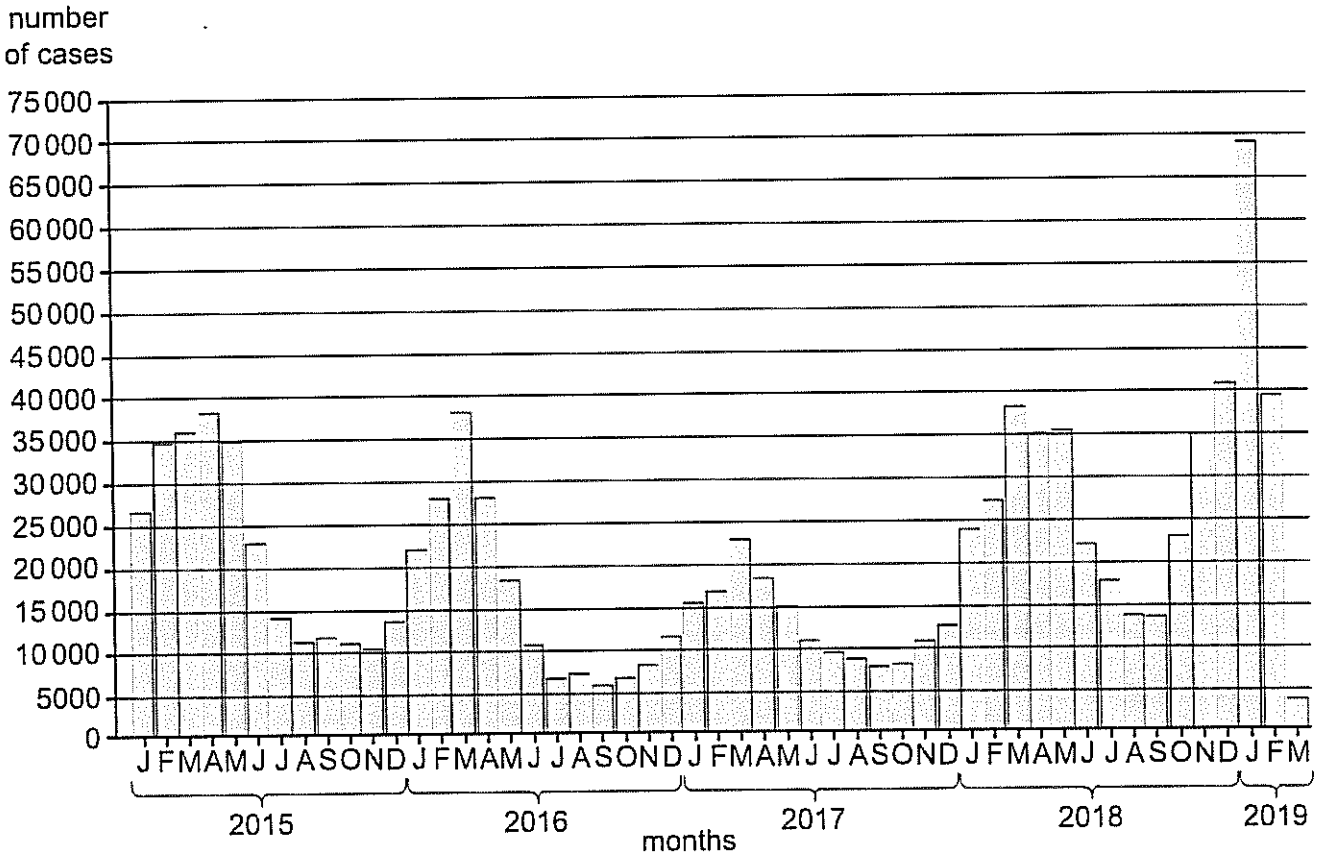


Fig. 5.1

Describe the pattern of measles cases as shown in Fig. 5.1.

.....

.....

..... [3]

(c) Explain why measles has **not** yet been eradicated even though a vaccine has been available since the 1960s.

.....

.....

.....

..... [4]

7. M/J 21/P21/Q5

Much success was made in reducing the number of cases of malaria between 2000 and 2015.

(a) Explain how malaria is transmitted.

.....

..... [2]

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(b) Diagnostic test strips for malaria contain monoclonal antibodies. The test strips detect antigens produced by the pathogens that cause malaria.

Fig. 5.1 shows stages in the production of monoclonal antibodies. The information in three of these stages is incomplete.

Complete Fig. 5.1.

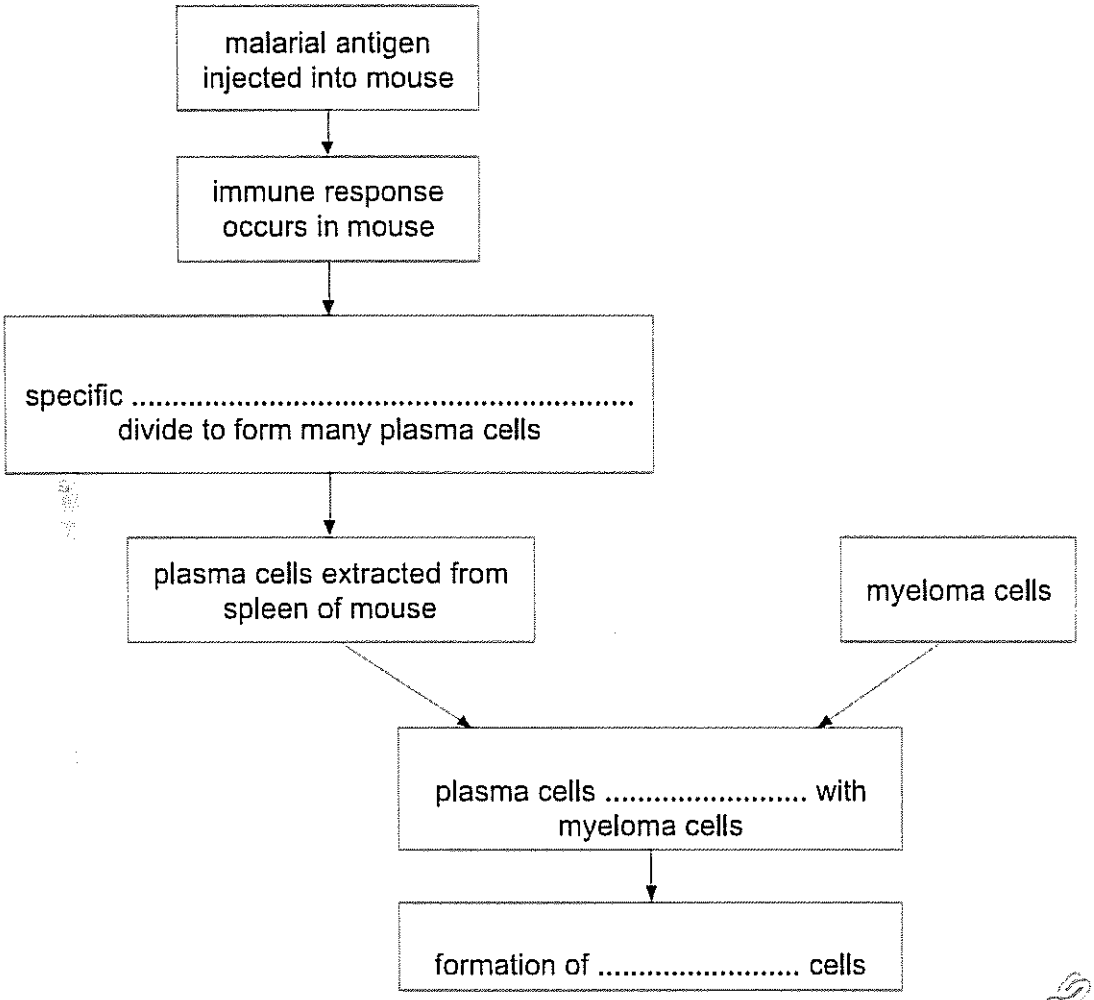
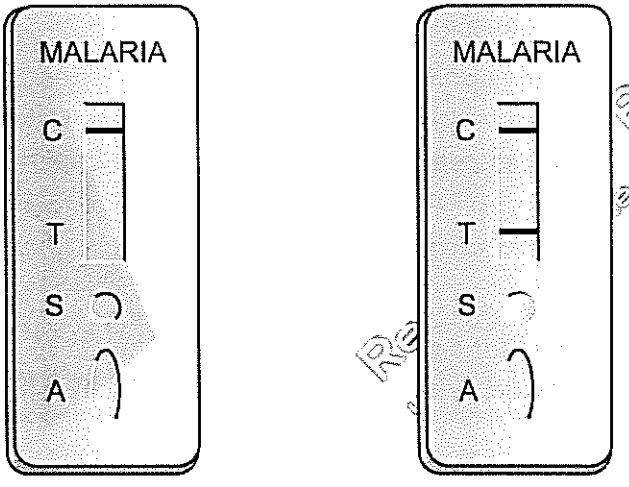


Fig. 5.1

(c) Fig. 5.2 shows two diagnostic test strips for malaria. [3]



negative result positive result

Fig. 5.2

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- A sample of blood from a person suspected of having malaria is put into the well labelled **S**.
- A buffer solution is put into the well labelled **A**.
- The buffer solution moves the blood towards the results window.
- A line at position **C** indicates that the test is working correctly.
- A line at position **T** indicates a positive result for malaria.

State **three** advantages of using test strips for malaria, such as those shown in Fig. 5.2.

1 .....

2 .....

3 ..... [3]

(d) The highest number of cases of malaria occur in sub-Saharan Africa and South-East Asia. Discuss the factors that determine the global distribution of malaria.

.....

.....

.....

.....

..... [5]

8. M/J 21/P23/Q2/a,b,c,d

Smallpox, measles and HIV/AIDS are infectious diseases caused by different viruses. These different viruses share some structural features.

(a) State **one** structural feature that would confirm that a pathogen is a virus.

..... [1]

(b) The virus that causes smallpox belongs to a different genus to the virus that causes measles. Name the viruses that cause these diseases.

smallpox .....

measles ..... [2]

(c) Explain why antibiotics, such as penicillin, **cannot** be used to treat measles.

.....

..... [2]

(d) Antibiotics may be prescribed for a person with HIV/AIDS.
Suggest why antibiotics may be prescribed for a person with HIV/AIDs.

..... [1]

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9. O/N 20/P22/Q2/a

The treatment for people with active tuberculosis (TB) lasts six months and involves a combination of antibiotics. This is usually very effective if the person has a susceptible (non-resistant) strain of *Mycobacterium tuberculosis*, the causative organism of TB.

Table 2.1 summarises one recommended treatment strategy that involves a combination of antibiotics.

Table 2.1

antibiotic	length of treatment	mode of action of antibiotic
rifampicin (R)	6 months	enters bacterial cells and inhibits protein synthesis
isoniazid (H)	6 months	prevents the synthesis of cell wall components known as mycolic acids
ethambutol (E)	first two months	prevents mycolic acids from being added to the cell wall
pyrazinamide (Z)	first two months	prevents the synthesis of fatty acids

(a) Susceptible strains of *M. tuberculosis* will be killed using any one of the antibiotics listed in Table 2.1. However, combination treatment is preferred as it is one method that can be used to reduce the impact to society of antibiotic resistance.

With reference to Table 2.1, explain how combination treatment for TB can help to reduce the impact of antibiotic resistance compared to single antibiotic treatment.

.....

.....

.....

..... [4]

10. O/N 20/P21/Q3/b

(a) The endocardium is a thin layer of tissue lining the chambers of the heart. A serious condition called endocarditis results if bacteria infect this tissue.

Endocarditis is treated with a combination of antibiotics. This increases the effectiveness of the treatment and reduces the risk of antibiotic resistance in bacteria.

Table 3.1 shows the action of two antibiotics used together to treat endocarditis.

Table 3.1

antibiotic used in treatment	action of antibiotic
gentamicin	binds permanently to the bacterial ribosomes
penicillin G	inhibits an enzyme involved in cell wall synthesis

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(i) With reference to Table 3.1, explain why treating endocarditis with a combination of gentamicin and penicillin G reduces the risk of developing antibiotic resistance.

.....

..... [2]

(ii) Describe how the bacteria that cause endocarditis could become resistant to gentamicin.

.....

.....

..... [3]

11. O/N 20/P21/Q4/a

(a) Fig. 4.1 is a scanning electron micrograph of a section of a plant cell wall. In living plant tissue cytoplasmic strands form part of structure **W**.

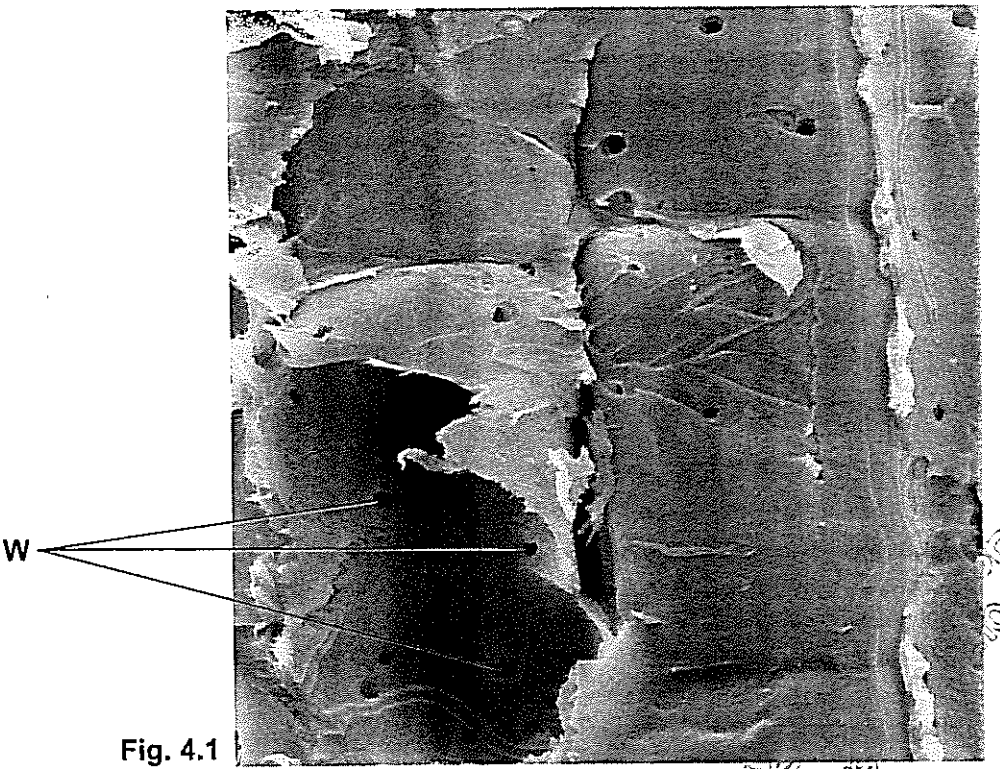


Fig. 4.1

(i) Identify the structures labelled **W** in Fig. 4.1.

..... [1]

(ii) Describe the function of structure **W**.

.....

..... [2]

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12. O/N 20/P23/Q4/a

Antibiotic sensitivity tests can be carried out to choose appropriate antibiotics to use for treatment of bacterial diseases.

A researcher carried out an antibiotic sensitivity test using two pathogenic bacteria, **X** and **Y**.

The researcher prepared two Petri dishes containing agar.

- A culture of each bacterium was spread over the surface of the agar.
- Filter paper discs containing antibiotics were placed on the surface of the agar in each dish.
- The Petri dishes were incubated at 25 °C for two days.

The results of the test using three antibiotics, **P**, **Q** and **R**, are shown in Fig. 4.1.

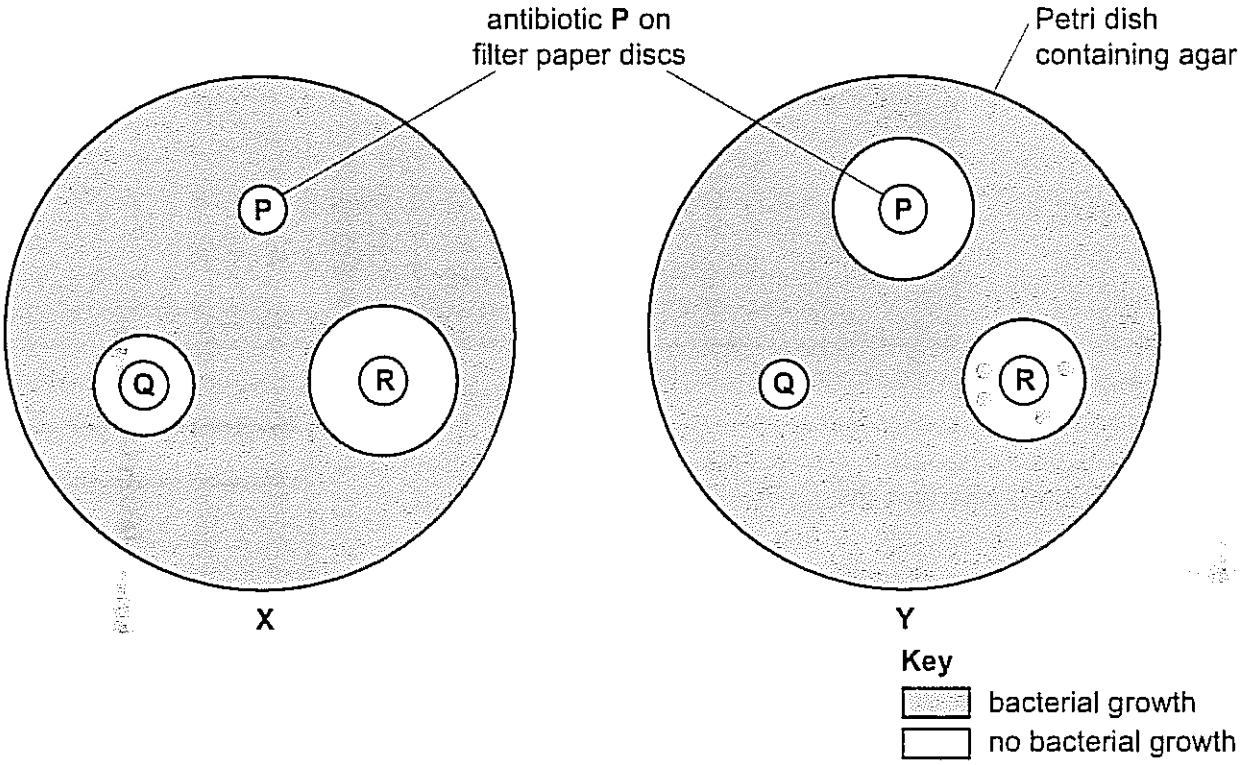


Fig. 4.1

(a) (i) State the most effective antibiotic to treat infections of bacterium **X** and bacterium **Y**.

bacterium **X** .....

bacterium **Y** ..... [1]

(ii) Suggest why bacterium **Y** had a different sensitivity to each of the three antibiotics.

.....

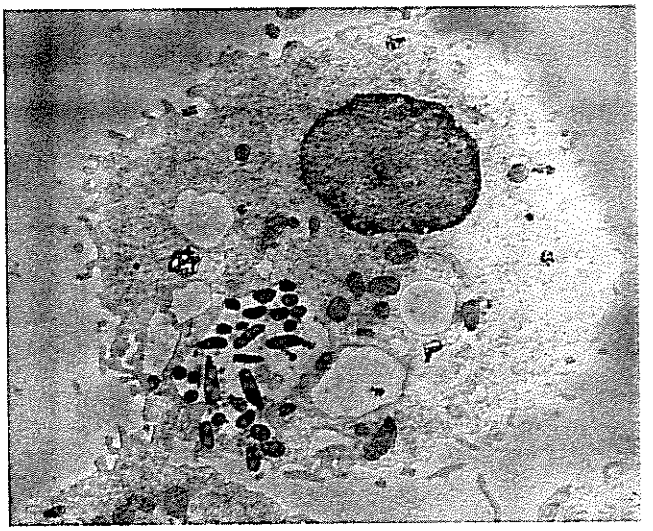
..... [2]

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13. M/J 20/P21/Q5/a

The vaccine used to control tuberculosis (TB) is known as Bacillus Calmette-Guérin (BCG). The vaccine contains live bacteria that have been selected so that they do not cause disease in humans. Fig. 5.1 shows a macrophage that is in the process of engulfing the bacteria in the vaccine.



magnification ×4400

Fig. 5.1

(a) (i) Name the pathogen that causes TB.

..... [1]

(ii) Describe how this pathogen is transmitted.

.....

..... [2]

14. M/J 20/P23/Q2/a,b

In 2016, the highest number of cases of malaria and deaths caused by the disease were in sub-Saharan Africa. In many areas of sub-Saharan Africa, malaria is endemic (continually present) and people are at high risk of becoming infected with the *Plasmodium* pathogen.
In high risk areas it is recommended that:

- homes are provided with insecticide-treated nets (ITN)
- the surfaces inside homes where *Anopheles* mosquitoes may rest are sprayed with insecticide. This is known as indoor residual spraying (IRS).

(a) Explain how the use of ITN and IRS can help break the transmission cycle of malaria.

.....

.....

..... [3]

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(b) Fig. 2.1 shows the proportion of the population in sub-Saharan Africa at risk of malaria that is protected by using IRS or ITN, or both, in the years 2010 to 2016.

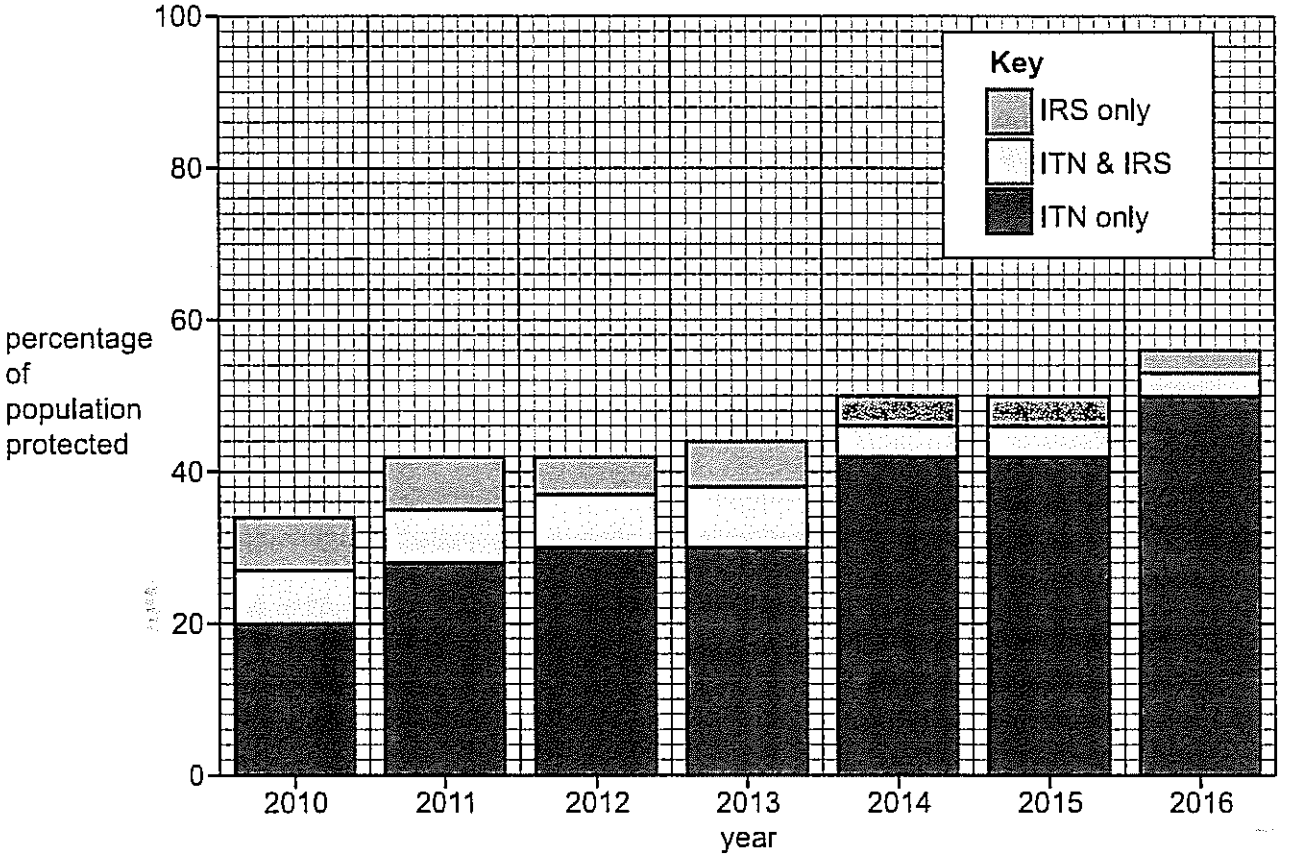


Fig. 2.1

The main trend in Fig. 2.1 shows that there is an increase in the percentage of the population protected over time.

(i) State **one** other trend shown in Fig. 2.1.

..... [1]

(ii) Explain why the main trend shown in Fig. 2.1 could be a concern for the World Health Organization.

..... [1]

(iii) With reference to Fig. 2.1, suggest a reason for the difference in trends shown for ITN only compared with IRS only.

..... [1]

15. O/N 19/P22/Q5/a,b,c,d

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.*

..... [1]

(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.

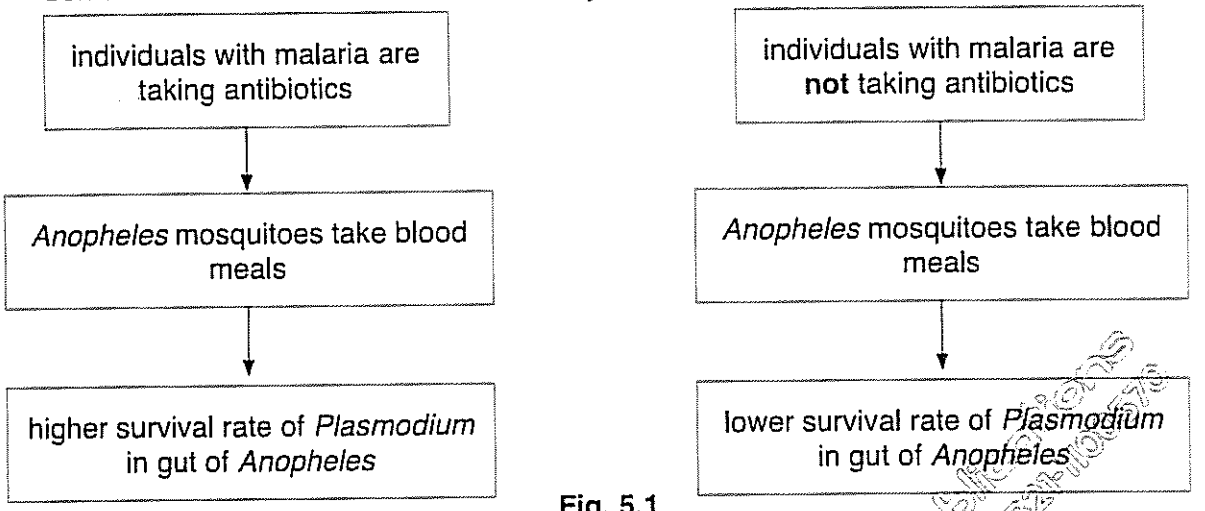


Fig. 5.1

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.

.....

.....

..... [3]

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16. O/N 19/P21/Q2

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

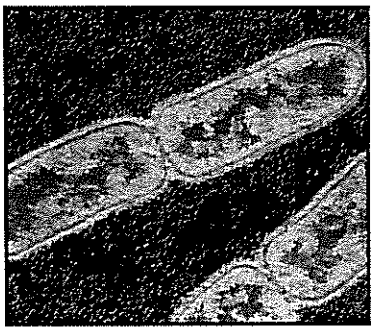


Fig. 2.1

(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]

(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.

.....

.....

..... [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).

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

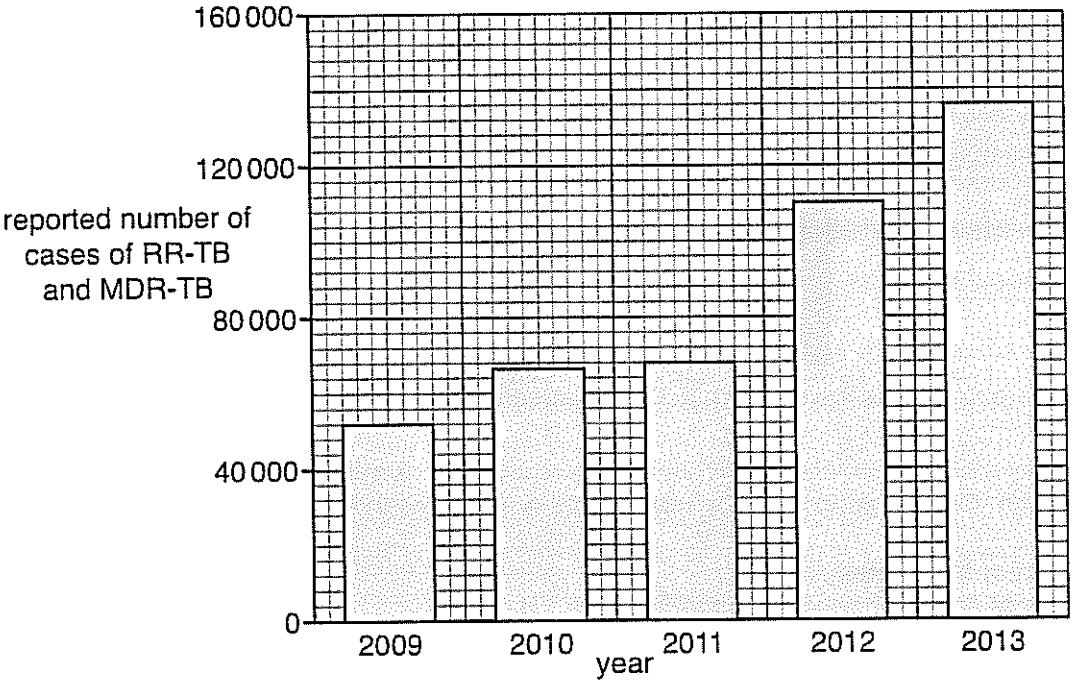


Fig. 2.2

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

.....

..... [2]

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

.....

.....

.....

..... [4]

17. M/J 19/P22/Q4

The bacterium *Vibrio cholerae* is the causative organism of the infectious disease cholera. *V. cholerae* has structural features typical of all bacterial cells. It also has a flagellum for movement.

(a) Fig. 4.1 is an outline drawing of *V. cholerae*.

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Complete Fig. 4.1 by drawing **and** labelling the structures found in *V. cholerae*.

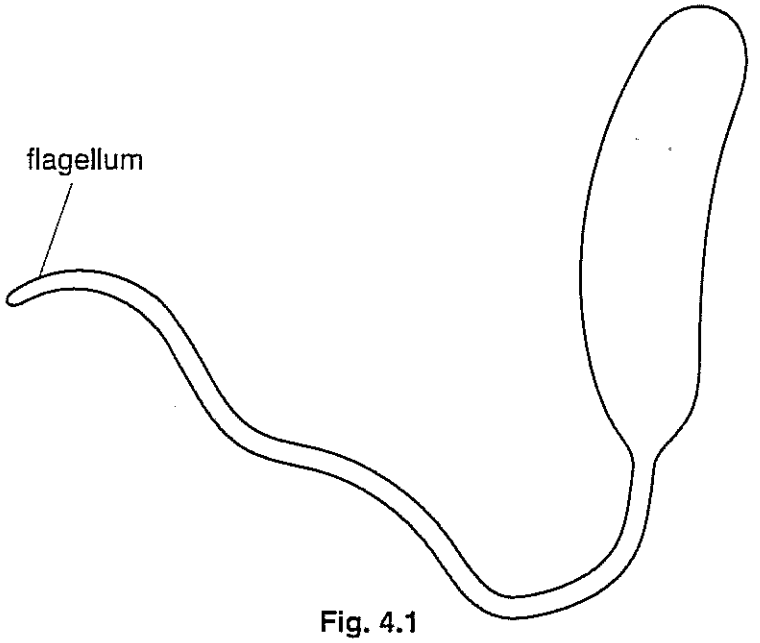


Fig. 4.1 [4]

(b) The World Health Organization (WHO) collects data about cholera from the 194 countries that are members of the World Health Assembly (WHA).
In 2015:

- there were cases of cholera in 42 of the member countries of the WHA
- the total number of cases of cholera reported was 172454
- there were deaths as a result of cholera in 23 of these countries
- the total number of deaths from cholera reported was 1304.

The case fatality rate for cholera is the proportion of cases of cholera that results in death within a particular time period.
A country with cases of cholera that are properly treated should have a case fatality rate of less than 1%.

(i) Calculate the case fatality rate for the 42 member countries of the WHA for 2015.
Give your answer to the nearest 0.1%.

case fatality rate = ... % [1]

(ii) Many of the 23 countries reporting deaths from cholera in 2015 had a case fatality rate of less than 1%.
However, two of the 23 countries had case fatality rates greater than 5%.
Suggest **two** explanations for the higher case fatality rate in these two countries.

.....

..... [2]

(c) In 2010, the country of Haiti experienced a major earthquake. This led to an outbreak of cholera.

(i) Explain why an earthquake may lead to a cholera outbreak.

..... [1]

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(ii) Fig. 4.2 shows data about cholera collected by WHO over a period of 8 years, from 2008 to 2015. These data include:

- the total number of cases of cholera for each year
- the number of countries in each year that had cases of cholera.

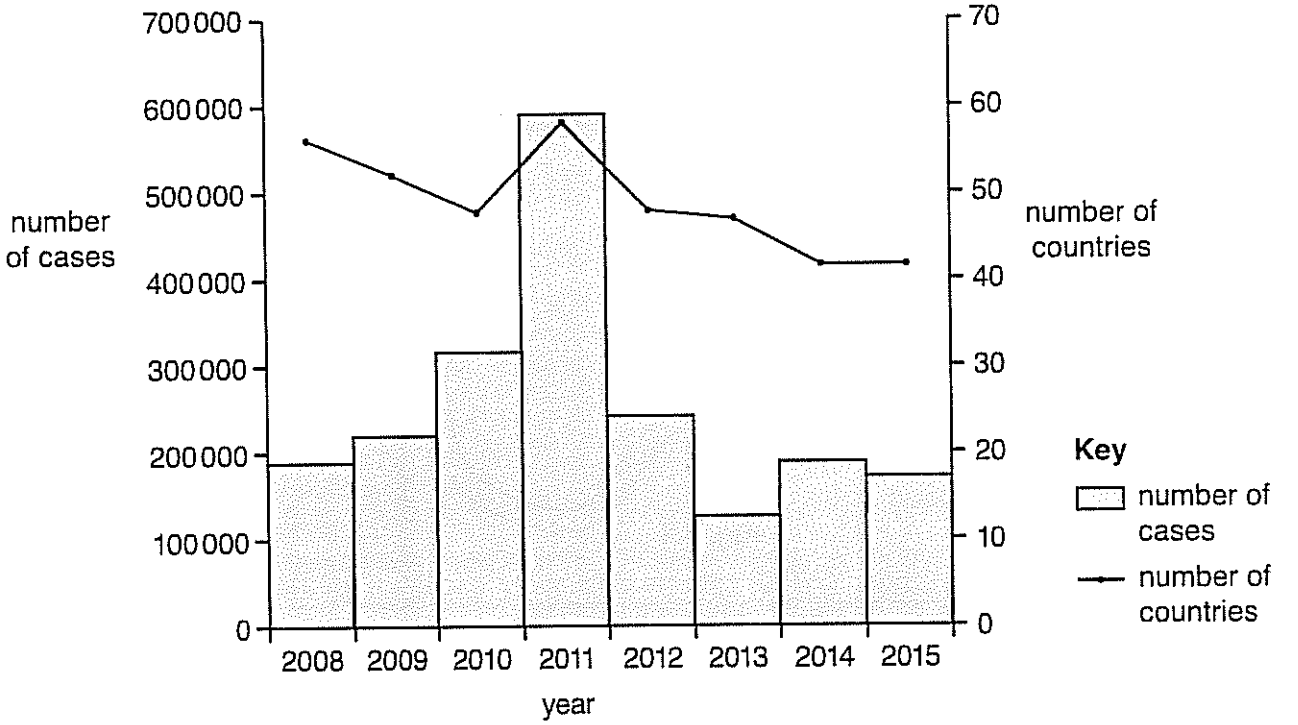


Fig. 4.2

Comment on the trends shown in Fig. 4.2.

.....

.....

..... [3]

18. M/J 19/P23/Q3

Cholera is an infectious disease caused by the bacterium *Vibrio cholerae*. The pathogen causes disease by disrupting the activity of the epithelial cells in the human intestine.

(a) Complete Table 3.1 to compare the structure of *V. cholerae* and an epithelial cell from the human intestine.

Use a tick (✓) to indicate the presence of the structure.

Use a cross (✗) to indicate the absence of the structure.

The first row has been completed for you.

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Table 3.1

cell structure	*V. cholerae*	epithelial cell from the human intestine
cell wall	✓	✗
cell surface membrane		
ribosomes		
large permanent vacuole		
organelles surrounded by a double membrane		

[4]

(b) Describe the methods that can be used to prevent the spread of cholera.

.....

.....

.....

.....

..... [5]

(c) The World Health Organization has suggested that people with HIV/AIDS take a longer time to recover from cholera and are at an increased risk of death from cholera.

The human immunodeficiency virus (HIV) only infects certain types of cell. These cells have CD4 receptor proteins in their cell surface membrane. Helper T-lymphocytes have CD4 receptor proteins.

(i) Fig. 3.1 is a diagram of HIV showing the glycoprotein gp120.

This glycoprotein is embedded in a membrane envelope which surrounds the viral protein coat.

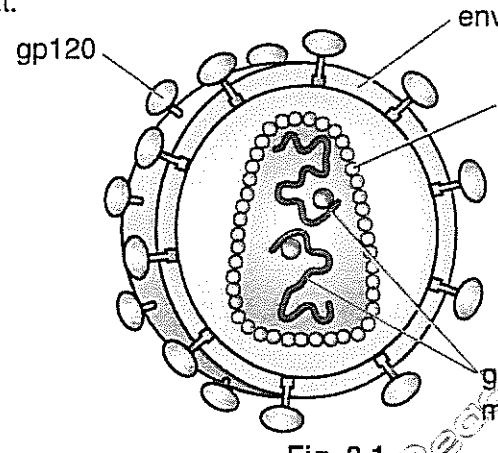


Fig. 3.1

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The glycoprotein gp120 is important in allowing HIV to only infect certain types of cell.

Suggest the role of gp120.

.....

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..... [2]

(ii) People with HIV/AIDS have a low helper T-lymphocyte count.
Explain how a low helper T-lymphocyte count could reduce the body's ability to produce antibodies against *V. cholerae*.

.....

..... [2]

19. O/N 18/P22/Q4/b,c

Viruses share common structural features. Some viruses, such as human immunodeficiency virus (HIV), also have an outer envelope as part of their structure.
HIV can remain in a dormant state within infected immune system cells for many years. A person diagnosed as HIV-positive (HIV+) has the virus but does not have symptoms of HIV/AIDS.

The chances of an HIV+ person developing HIV/AIDS can be greatly reduced with a drug treatment programme known as anti-retroviral therapy (ART).

(a) In 2010, the World Health Organization (WHO) published recommendations for the treatment of pregnant women living with HIV. This includes both HIV+ women and women who have developed HIV/AIDS.
The publication recommended that **all** pregnant and breastfeeding women living with HIV should be provided with ART.
Fig. 4.1 shows the number of pregnant women living with HIV, and the number of these receiving ART, between 2005 and 2013, in low and middle income countries.

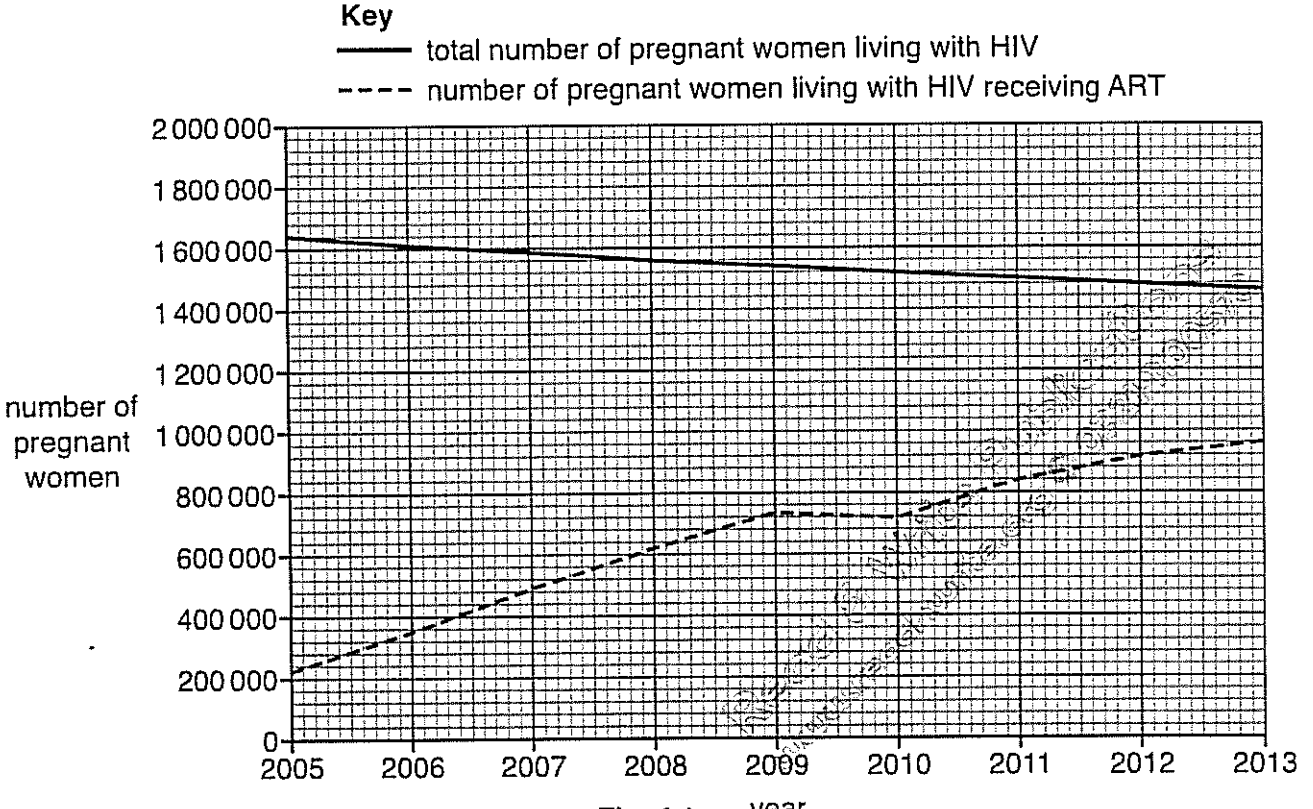


Fig. 4.1

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(i) From the data in Fig. 4.1, it can be calculated that 13% of pregnant women living with HIV received ART in 2005.
Calculate the percentage of pregnant women living with HIV that received ART in 2013.

answer = ... % [1]

(ii) Describe the trends shown in Fig. 4.1.

.....

.....

..... [3]

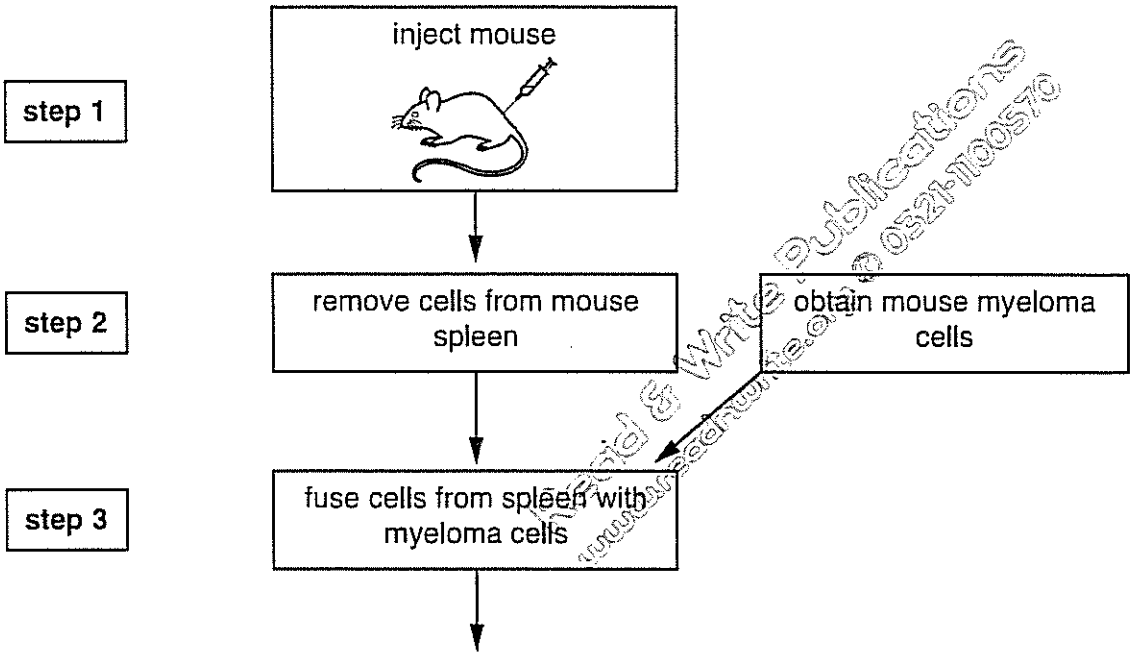
(iii) Suggest **and** explain the global importance of providing ART to all pregnant and breastfeeding women living with HIV.

.....

.....

..... [3]

(b) In a person who has been infected with HIV-1, the most common strain of HIV, a sample of blood can be tested for the presence of the virus.
One test that can only be used in the early stages of infection involves a monoclonal antibody specific for p24, a structural protein present in the virus.
Fig. 4.2 is a flow chart outlining the steps in the production of anti-HIV p24 monoclonal antibody.



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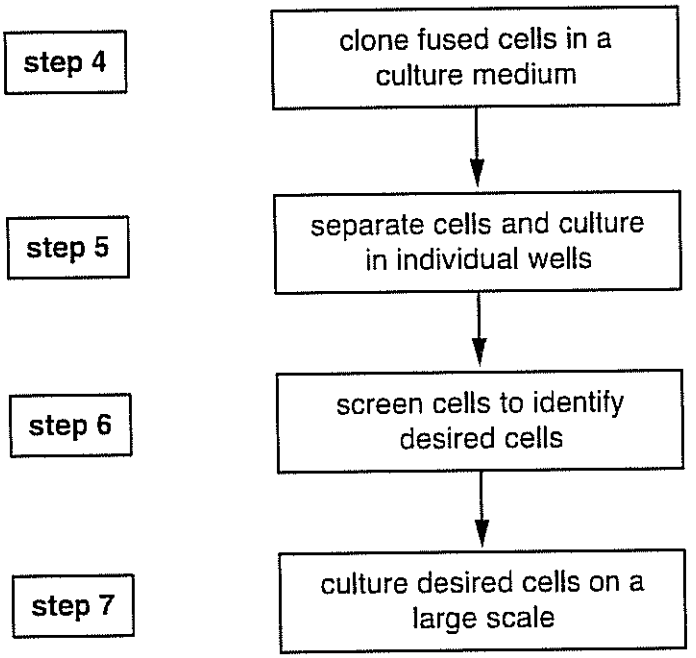


Fig. 4.2

(i) State what is being injected into the mouse in **step 1**.

..... [1]

(ii) Explain why several weeks, rather than several days, separates **step 1** and **step 2**.

..... [1]

(iii) State **one** feature of the myeloma mouse cells, used in **step 3**, that is essential for this production process.

..... [1]

(iv) Name the fused cells formed in **step 4**.

..... [1]

(v) Suggest why **step 6** is necessary.

..... [1]

20. O/N 18/P21/Q1/c,d,e

(a) Malaria is an infectious disease.
Name the pathogen that causes malaria.

..... [1]

(b) There are a number of vaccines being developed to help control the spread of malaria.
Explain why vaccination programmes have **not** been able to eradicate malaria.

.....

.....

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..... [3]

(c) Fig. 1.2 shows the distribution of malaria in the Americas in 2012.

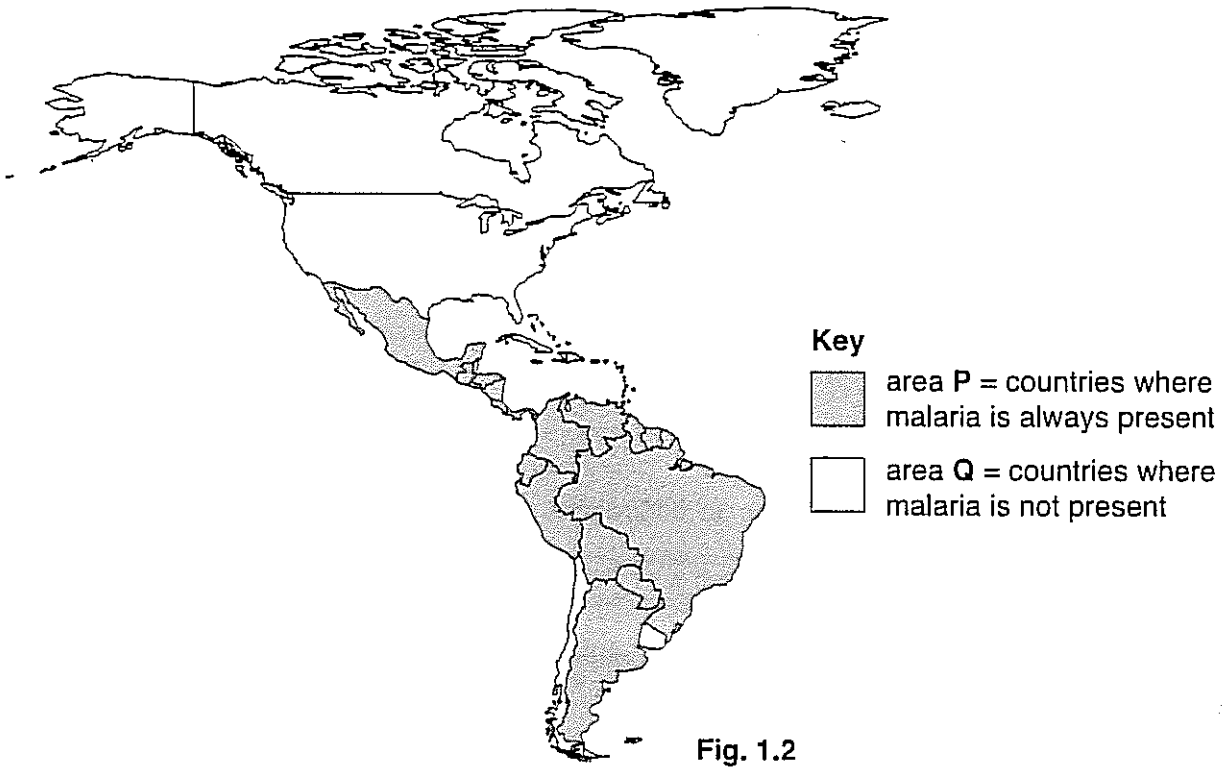


Fig. 1.2

Suggest the factors, **other than** lack of vaccines, that could be restricting the distribution of malaria to area **P**.

.....

.....

.....

..... [4]

21. O/N 18/P23/Q5

The bacteria that cause tuberculosis (TB) can be found in many parts of the body including the lungs.

(a) (i) State the name of the bacterium that causes TB.

..... [1]

(ii) The presence of the pathogen in the lungs attracts phagocytes to the area of infection. The phagocytes release elastase, which digests elastin.

Many people with TB feel tired all the time.

Suggest **and** explain how the effect of phagocytes on tissues in the lungs leads to people feeling tired all the time.

.....

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.....

..... [3]

(b) Discuss the **biological** factors and **social** factors that make TB a difficult disease to control.

.....

.....

.....

.....

..... [5]

22. M/J 18/P22/Q3/a

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*.

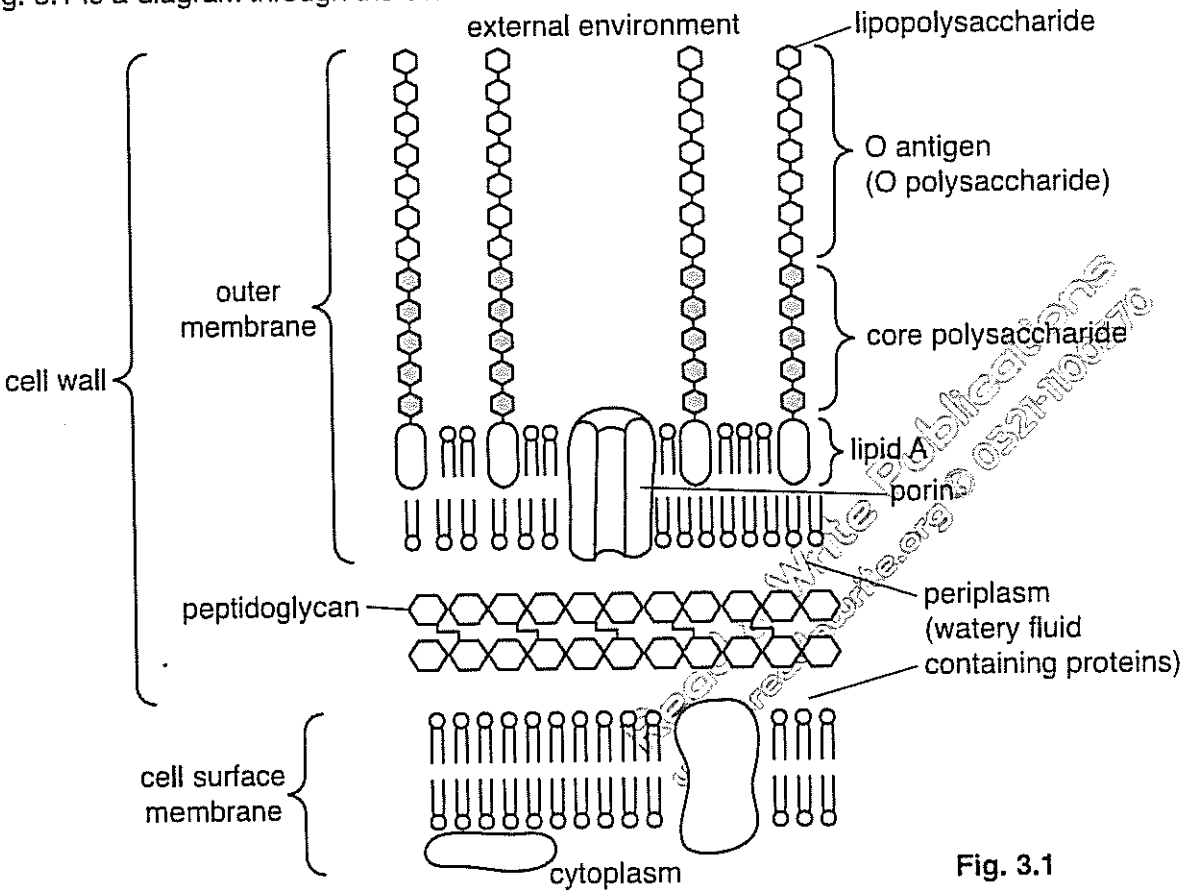


Fig. 3.1

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(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.*

.....

.....

..... [3]

23. M/J 18/P22/Q5/b,c,d
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) 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.

.....

..... [2]

(b) 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.

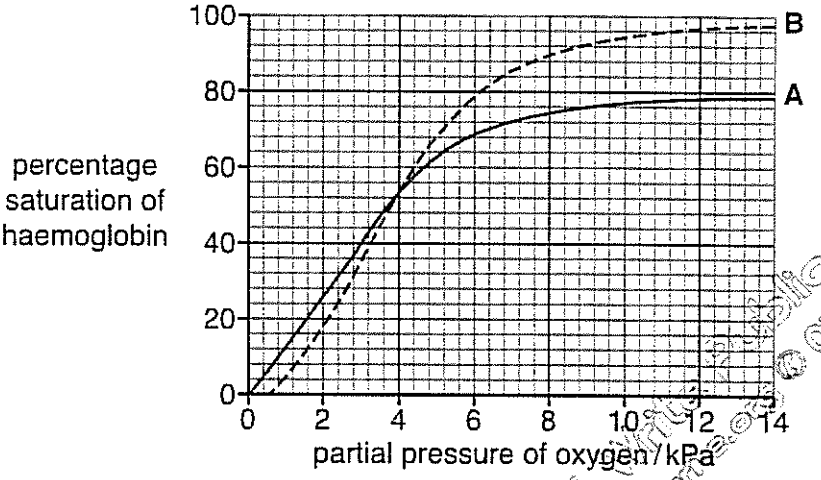


Fig. 5.2

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]

(c) 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*.

.....

.....[2]

24. M/J 18/P22/Q6

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.

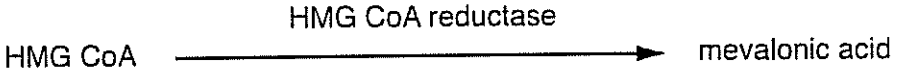


Fig. 6.1

Explain how mevinolin inhibits the enzyme HMG CoA reductase.

.....

.....

.....[3]

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

.....

.....[2]

25. M/J 18/P23/Q6/a

(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

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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]

26. O/N 17/P22/Q4

Fig. 4.1 is a transmission electron micrograph of the bacterium that causes cholera, *Vibrio cholerae*. The flagellum shown in Fig. 4.1 allows movement of the bacterium within the gut and may also function to help it to bind to an intestinal epithelial cell. The organism does not enter the cell but the toxin it releases can enter and cause damage. Large quantities of water, chloride ions and sodium ions are lost from the cell.

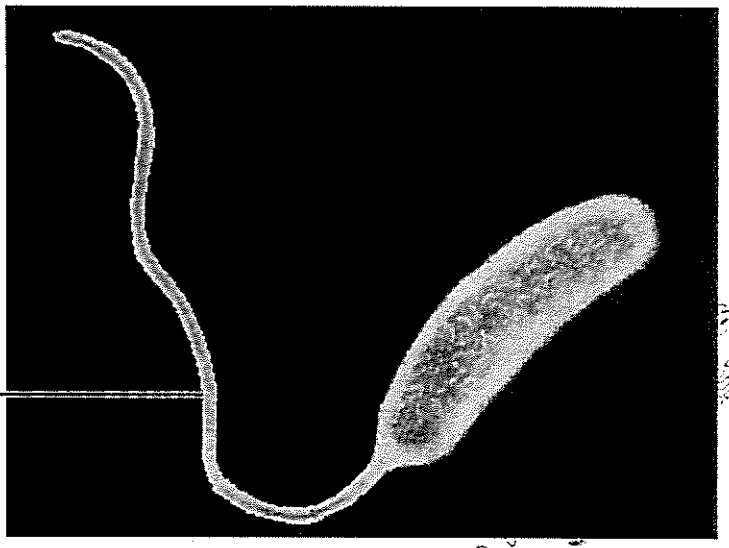


Fig. 4.1

People with symptoms of cholera have severe watery diarrhoea and as a result can become very dehydrated.

(a) Explain how a loss of chloride ions and sodium ions from the intestinal epithelial cell will cause a loss of water from the cell.

.....

..... [2]

(b) The main treatment for cholera is oral rehydration therapy (ORT) using oral rehydration salts (ORS). This involves drinking a solution of electrolytes (mineral ions) and glucose.

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Fig. 4.2 summarises the movement of glucose and sodium ions across an intestinal epithelial cell.

Fig. 4.2 includes three different types of cell surface membrane proteins:

- SGLT1 is a cotransporter protein
- GLUT2 and Na^+/K^+ pump are two types of carrier protein.

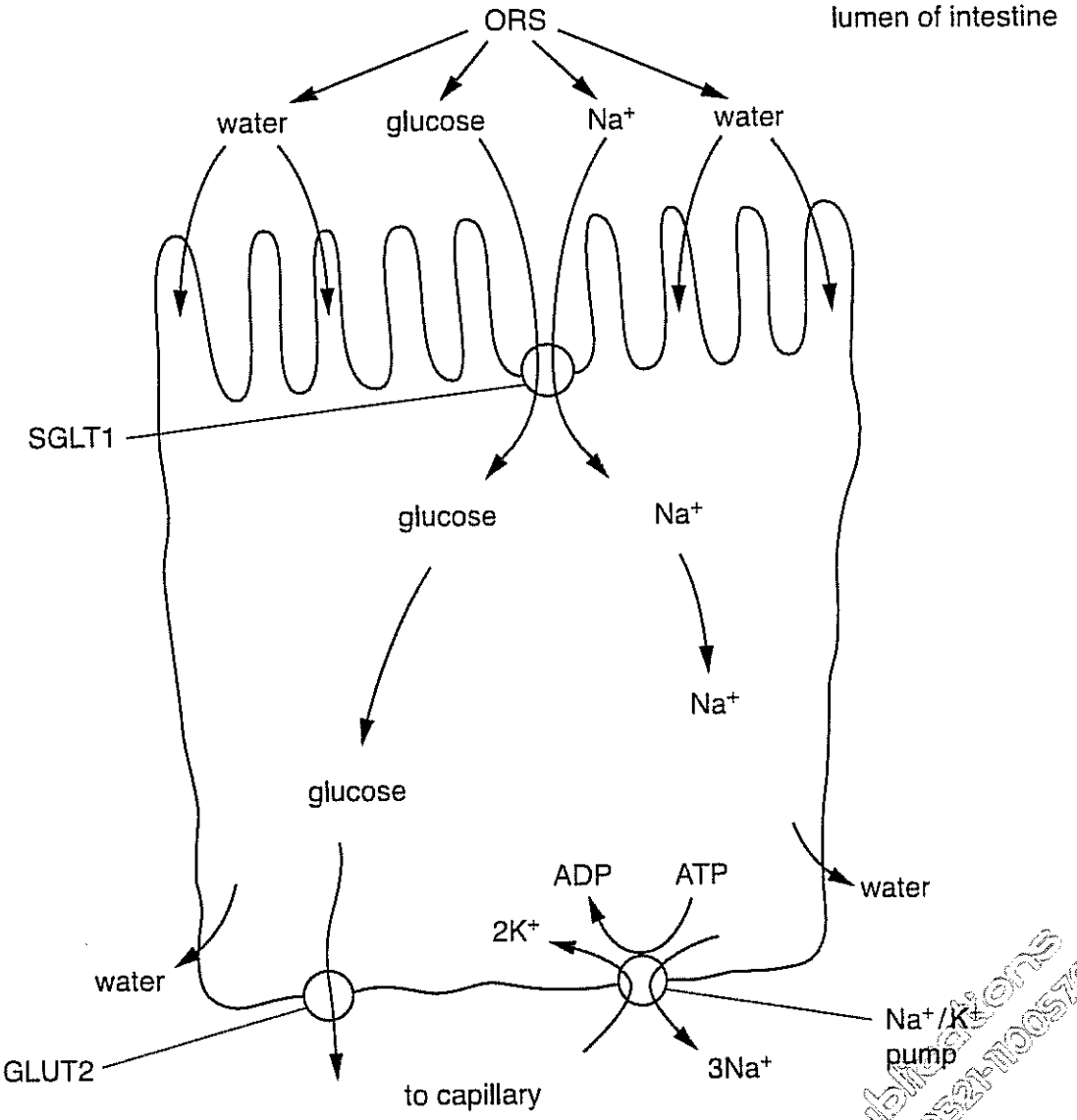


Fig. 4.2

The first rehydrating solution developed for the treatment of cholera did not contain glucose. Using ORS, patients absorb a higher concentration of sodium ions and there is an increase in water uptake.

- outline the transport mechanisms that result in the movement of glucose and sodium ions across the intestinal epithelial cell
- suggest how the movement of glucose and sodium ions increases water uptake by the cell.

.....

.....

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.....

..... [4]

(c) In severe cases of cholera, the rehydrating solution is given intravenously, as a drip directly into a vein.

Suggest **one** reason why the rehydrating solution is given as a drip directly into a vein rather than into an artery.

..... [1]

In very severe cases of cholera, antibiotics are also prescribed. The preferred antibiotic for treatment of cholera is a single dose of doxycycline, a form of tetracycline antibiotic.

(d) Tetracycline binds to a ribosomal subunit.

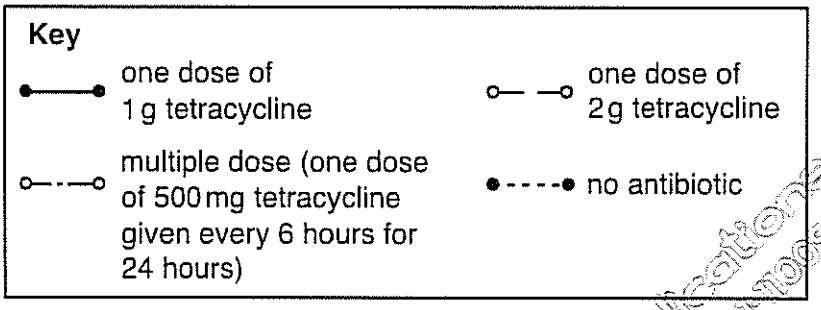
Suggest what effect this will have on the metabolism of *V. cholerae*.

..... [1]

(e) A study was carried out to compare the effectiveness of the antibiotic tetracycline in the treatment of 118 patients with cholera. The patients were divided into four different treatment groups:

- Group **A**, given one dose of 1 g tetracycline
- Group **B**, given one dose of 2 g tetracycline
- Group **C**, given a multiple dose (one dose of 500 mg tetracycline every 6 hours for 24 hours)
- Group **D**, no antibiotic given.

Following treatment, the volume of diarrhoea collected from each patient was measured every 16 hours for 128 hours. Fig. 4.3 shows the mean volume collected for each group.



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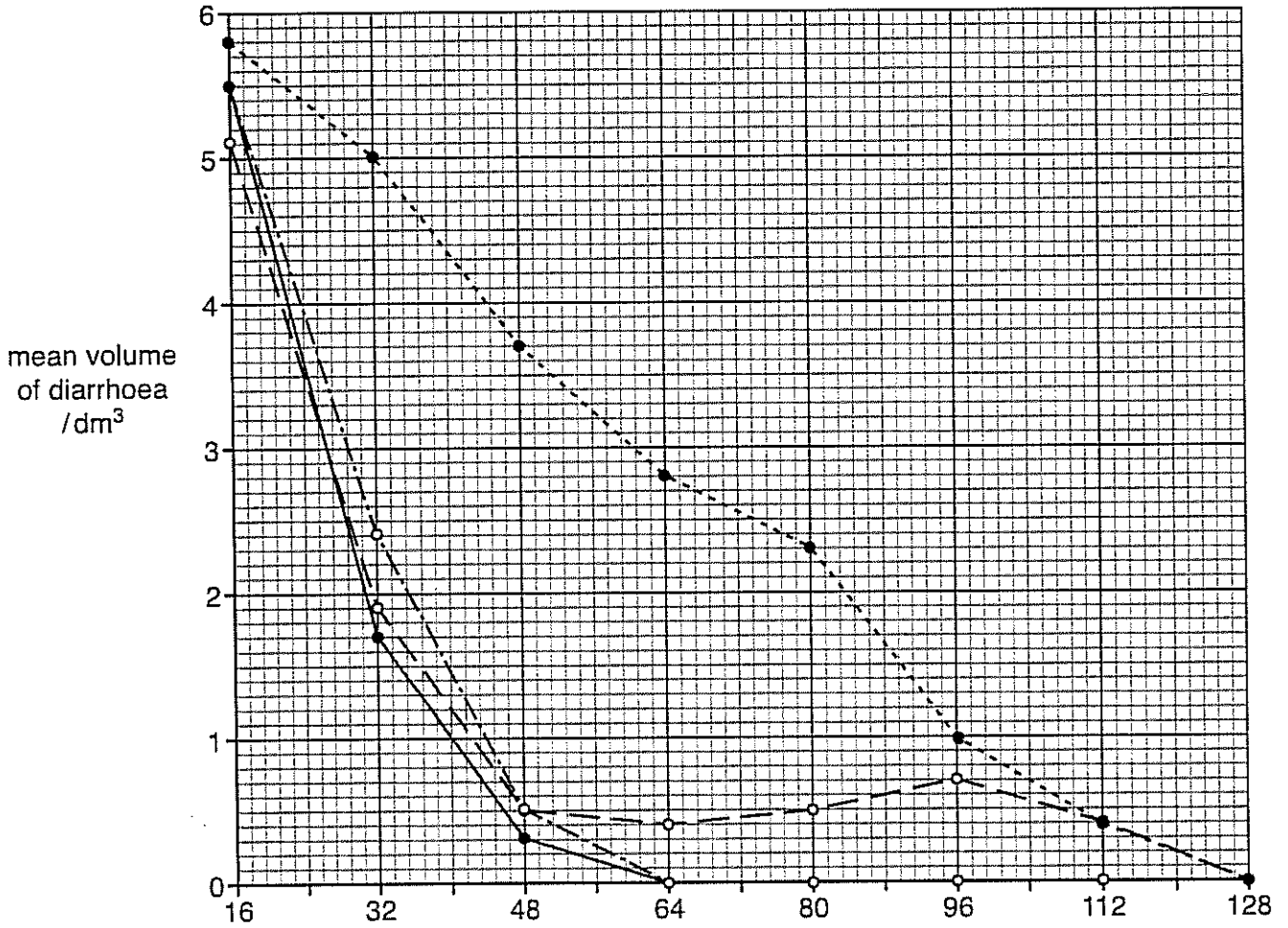


Fig. 4.3

(i) Describe the trends shown in Fig. 4.3.

.....

.....

.....[3]

(ii) Explain whether the results support, or do not support, treating very severe cases of cholera with tetracycline.

.....

.....[2]

(f) Some strains of *V. cholerae* are antibiotic resistant.
Explain why this means that medical practitioners prefer to treat cholera with a single dose of antibiotic, rather than a multiple dose of the same antibiotic.

.....

..... [2]

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(g) Most people who have recovered from cholera rarely become ill again from the disease. In these people, antibodies have been identified that will bind either to the cholera toxin, or to the bacterial flagellum, or to the main bacterial cell.

Explain why the antibodies are different, each one specific to its target.

.....

.....

..... [3]

(h) Evidence suggests that newborn babies of mothers who have had cholera have immunity to the disease.

State **precisely** the type of immunity these babies are likely to have.

.....[1]

27. O/N 17/P21/Q3

Cells of the immune system function to protect the body against infectious diseases.

(a) (i) Name the type of cell that produces antibodies.

.....[1]

(ii) The virus that causes the infectious disease influenza has two antigens, **H** and **N**. Antibodies are produced in response to an infection by this virus. The antibodies are specific for either antigen **H** or for antigen **N**.

Describe how the structure of an antibody molecule allows it to be specific for **one** antigen, such as **H** or **N**.

.....

.....

..... [3]

(b) Cholera is a disease caused by a bacterial pathogen.

(i) Name the pathogen that causes cholera.

.....[1]

(ii) Describe how the pathogen that causes cholera is transmitted.

.....

..... [2]

(c) Viruses that infect bacteria are called bacteriophages. Some bacteriophages that infect the cholera pathogen cause lysis of the bacterium.

(i) Suggest what happens to the structure of a bacterial cell to cause lysis.

.....

..... [2]

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(ii) Some scientists believe that bacteriophages could be used to treat people who are infected with cholera.
Suggest the properties of the bacteriophages that would make this possible.

.....

..... [2]

(iii) Antibiotics can be used to treat people with cholera.
State why antibiotics are **not** effective against measles.

..... [1]

28. O/N 17/P23/Q4

Malaria is a disease transmitted by a vector.

(a) (i) State the name of the pathogen that causes malaria.

.....[1]

(ii) State the name of the vector that transmits the pathogen.

.....[1]

In 2014, the World Health Organization (WHO) estimated that 3200 million people were at risk of malaria. This was almost half of the world population in 2014.
Table 4.1 shows the number of cases of malaria and the number of deaths from malaria between 1998 and 2013. The table shows numbers for all the countries of the world and for the countries in the WHO African region.
The table also shows the numbers in the African region as percentages of the numbers for all countries.

Table 4.1

year	number of cases of malaria in millions		cases in the African region as a percentage of all countries	number of deaths from malaria in thousands		deaths in the African region as a percentage of all countries
	all countries	African region		all countries	African region	
1998	272.9	237.6	87.1	1110.0	961.0	90.1
2003	236.0	186.6	79.1	872.0	800.0	91.7
2008	225.1	181.0	80.4	747.0	677.0	90.6
2013	198.0	158.4	80.0	584.0	525.6	90.0

(b) Describe the trends shown in Table 4.1.

.....

.....

..... [3]

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(c) Suggest reasons why the number of cases of malaria and the number of deaths from malaria changed between 1998 and 2013.

.....

.....

..... [3]

(d) Malaria is very difficult to control even though there is improved understanding of the disease.

Explain why malaria is very difficult to control.

.....

.....

.....

..... [4]

29. M/J 17/P22/Q5/b,c,d

Alveolar macrophages are cells of the immune system. They have an important role in defence against respiratory infections.

(a) The infectious lung disease, pneumonia, can be caused by *Streptococcus pneumoniae*.

Most healthy people inhaling air containing these bacteria do **not** become ill because of the action of the alveolar macrophages.

Outline the mode of action of an alveolar macrophage in response to the presence of *S. pneumoniae*.

You may use diagrams with notes to help your answer.

.....

.....

.....[3]

Irritants in tobacco smoke can contribute to emphysema, one of the chronic obstructive pulmonary disorders (COPD). In emphysema, the alveoli lose their ability to recoil on expiration and can burst.

(b) Suggest how the structure of the alveolar wall changes so that an alveolus bursts.

.....

..... [2]

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(c) Some alveolar cells produce a surfactant that helps to prevent the collapse of alveoli on exhalation. Too much surfactant decreases the efficiency of gas exchange in the alveoli.

A glycoprotein known as GM-CSF is released by some cells of the immune system when there is too much surfactant in the alveoli. Excess surfactant is then broken down by alveolar macrophages.

Receptors for GM-CSF are on the cell surface membranes of alveolar macrophages.

Explain how maintaining the correct quantity of surfactant in the alveoli is the result of a cell signalling mechanism.

.....

.....

.....

.....[4]

30. M/J 17/P21/Q6/a(i)

Cholera bacteria release the toxin, choleragen, when they are in the intestine.

(a) (i) Name the bacterium that is the pathogen of cholera.

.....[1]

31. M/J 17/P23/Q3

(a) Name the causative organism of tuberculosis (TB).

.....[1]

(b) Fig. 3.1 shows the number of deaths from TB and the number of new cases of TB from 1925 to 2010 in Canada.

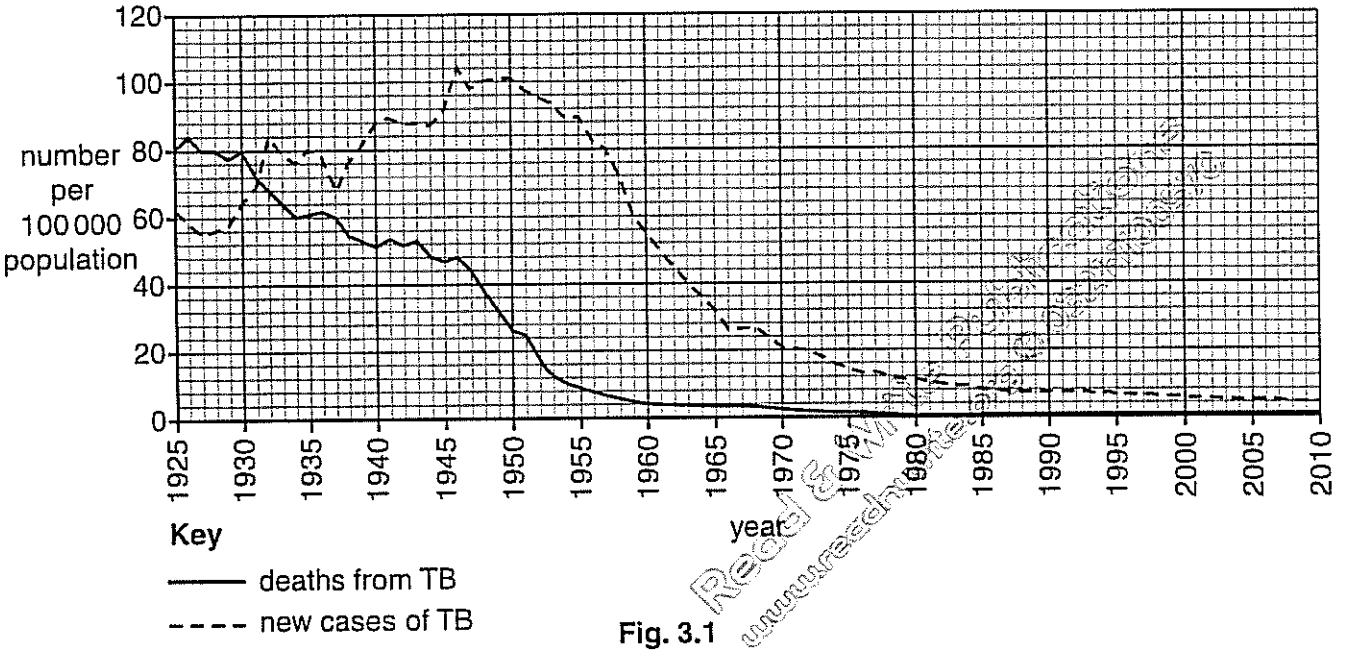


Fig. 3.1

The vaccine for TB was introduced in Canada for widespread use from 1948.

Antibiotics, such as streptomycin, were introduced in Canada from 1940.

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Use the information in Fig. 3.1 to comment on the effect of the introduction of the vaccine and antibiotics on the number of new cases and deaths from TB.

.....

.....

.....

.....

..... [5]

(c) In 2010, Swaziland had one of the highest death rates from TB in the world.
Swaziland also had a high number of new cases of HIV infection in its population in 2010.
People who are infected with HIV are described as HIV+ and people who are **not** infected with HIV are described as HIV–.
Table 3.1 shows the number of deaths from TB in Swaziland in 2010.

Table 3.1

HIV status	number of deaths from TB per 100 000 population
HIV+	400
HIV–	91

Using the information in Table 3.1, suggest why the number of deaths per 100 000 population of people who are HIV+ is much higher than that in people who are HIV–.

.....

.....

..... [3]

32. O/N 16/P22/Q5
A disease can be described as infectious or non-infectious.

(a) Lung cancer is a non-infectious disease.

(i) Explain the term *non-infectious disease*.

non-infectious .....

disease ..... [2]

(ii) In a person with lung cancer one or more healthy cells undergo changes to produce cancerous cells that can form a tumour.
Suggest **and** explain the cellular changes that occur in the development of lung cancer.

.....

.....

.....

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..... [4]

(b) Fig. 5.1 is a summary of some infectious diseases.

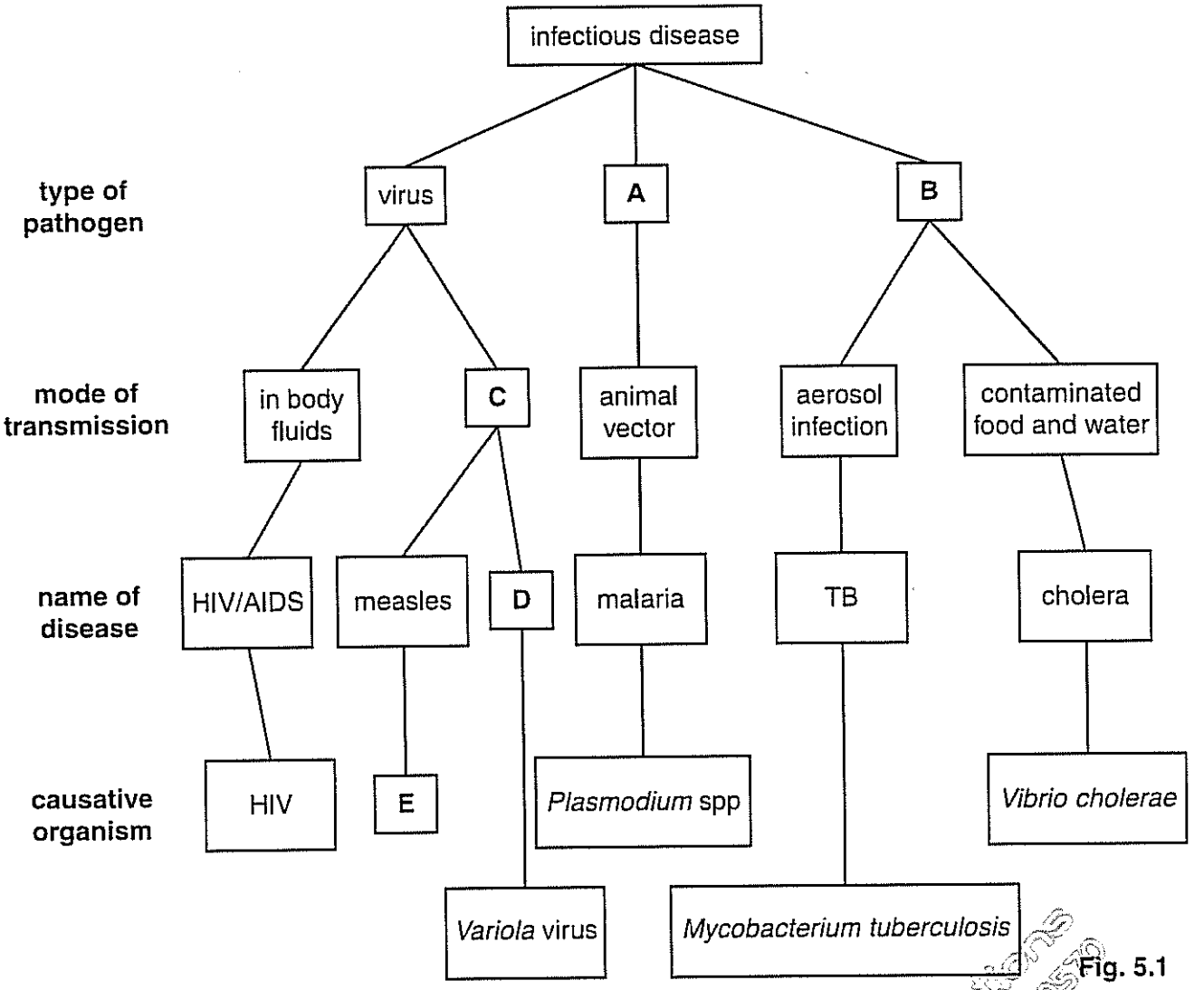


Fig. 5.1

Use the information in Fig. 5.1 to answer parts **(i)** to **(iv)**.

(i) Name the type of pathogen represented by **A** and **B**.

A .....

B ..... [2]

(ii) State the mode of transmission represented by **C**.

..... [1]

(iii) Name the disease represented by **D**.

..... [1]

(iv) Name the causative organism represented by **E**.

.....[1]

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(c) Explain how vaccination can control infectious diseases.

.....

.....

..... [3]

33. O/N 16/P21/Q4/a,c

(a) (i) Name the bacterium that causes cholera.

..... [1]

(ii) Describe how cholera is transmitted from an infected person to an uninfected person.

.....

..... [2]

(iii) Suggest **and** explain why cholera outbreaks are common after natural disasters.

.....

..... [2]

(b) Some of the strains of bacteria that cause cholera are resistant to more than one antibiotic (multiple resistance).
Discuss the consequences of multiple resistance for health authorities.

.....

.....

.....

..... [4]

34. O/N 16/P23/Q6

Measles is a highly infectious disease.

(a) Name the pathogen that causes measles.

..... [1]

The number of cases of measles is reported to the World Health Organization (WHO) by countries throughout the world so that global data are collected.
Fig. 6.1 shows the global data collected between January 2008 and December 2012.

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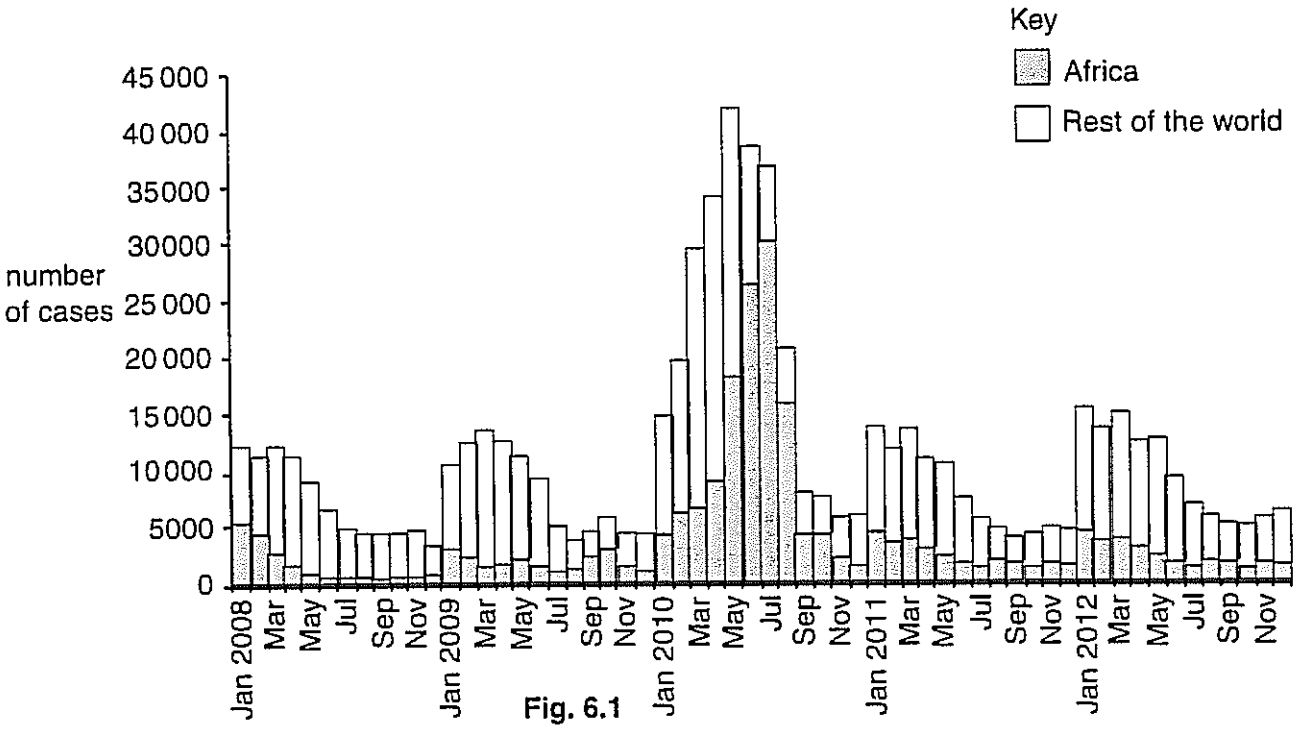


Fig. 6.1

(b) Use the data in Fig. 6.1 to describe the pattern shown in the number of cases of measles reported to the WHO between January 2008 and December 2012.

.....

.....

..... [3]

(c) The WHO is coordinating a vaccination campaign to reduce the number of cases of measles. Between seven to ten days after receiving the vaccination for measles the concentration of antibodies in the blood begins to increase.

Describe what happens in the body after the injection of a measles vaccine until the concentration of antibodies in the blood begins to increase.

.....

.....

.....

..... [4]

(d) Explain why countries that have established vaccination programmes still have cases of measles.

.....

..... [2]

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35. M/J 16/P22/Q3/a

Globally, measles is an important disease that mainly affects children. Many deaths from measles occur in children under five years of age.

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Table 3.1 shows the population of six countries in Africa in 2009 and the number of cases of measles per 100 000 people for the four years 2009 to 2012.
All six countries are classified as low-income countries.

Table 3.1

country	population in 2009	number of cases per 100 000 people			
		2009	2010	2011	2012
Central African Republic	4 266 000	0.26	0.05	15.31	3.12
Chad	11 371 000	1.45	1.66	71.60	0.96
Eritrea	5 558 000	1.48	0.89	0.81	3.16
Ethiopia	84 838 000	1.39	4.86	3.64	4.74
Gambia	1 628 000	0.00	0.12	0.00	0.00
Niger	15 303 000	5.23	2.34	4.67	1.59

(a) (i) The actual number of cases of measles in Chad in 2009 was 165 and in Eritrea was 82. Calculate the actual number of cases of measles in Ethiopia in 2009.
Show your working.

[2]

(ii) Use the data for Chad, Eritrea and Ethopia to explain the advantages of showing the data in Table 3.1 as number of cases of measles per 100 000 people rather than the actual number of cases.

.....

.....

..... [3]

36. M/J 16/P21/Q1
Table 1.1 shows features of three infectious diseases: malaria, tuberculosis (TB) and cholera.
Complete Table 1.1.

Table 1.1

feature	malaria	tuberculosis	cholera
name of pathogen	..... *falciparum*	*Mycobacterium tuberculosis*	....
type of organism	.....	bacterium	.....

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method of transmission	....	....	drinking water and food contaminated with human faeces

[6]

37. M/J 16/P23/Q5/d

(a) Other drugs such as isoniazid are also used in the treatment of TB.
Some bacteria are now resistant to more than one of these drugs. These bacteria are known as multi-drug resistant (MDR) bacteria.
Outline the steps that can be taken to reduce the impact of drug resistance in bacteria.

.....

.....

..... [3]

38. O/N 15/P22/Q5/a,b,c

Diseases can be infectious or non-infectious.

(a) Explain the difference between an infectious and a non-infectious disease.

.....

..... [2]

Malaria is an infectious disease caused by *Plasmodium*. *Plasmodium* requires two hosts to complete its complex life cycle. One of the hosts is the *Anopheles* mosquito, which acts as a vector of malaria.

Transmission of malaria occurs when females of some species of *Anopheles* take blood meals from humans infected with *Plasmodium*, and then feed on uninfected individuals.

Both male and female *Anopheles* mosquitos have piercing and sucking mouthparts. The female mosquito is shown in Fig. 5.1.

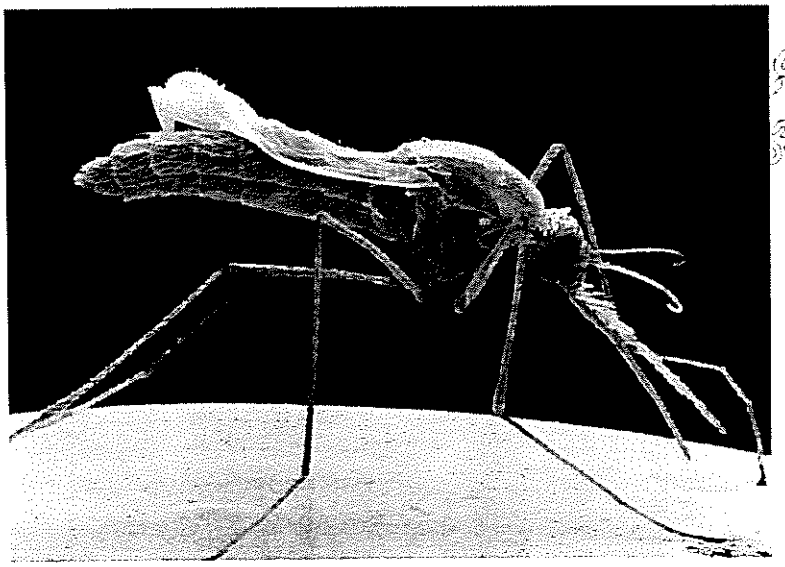


Fig. 5.1

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(b) The blood meals are a good source of protein for *Anopheles* for the production of eggs. Explain why blood is a good source of protein.

.....

..... [2]

(c) Fig. 5.2 shows the global distribution of those species of *Anopheles* that are able to act as hosts for Plasmodium.

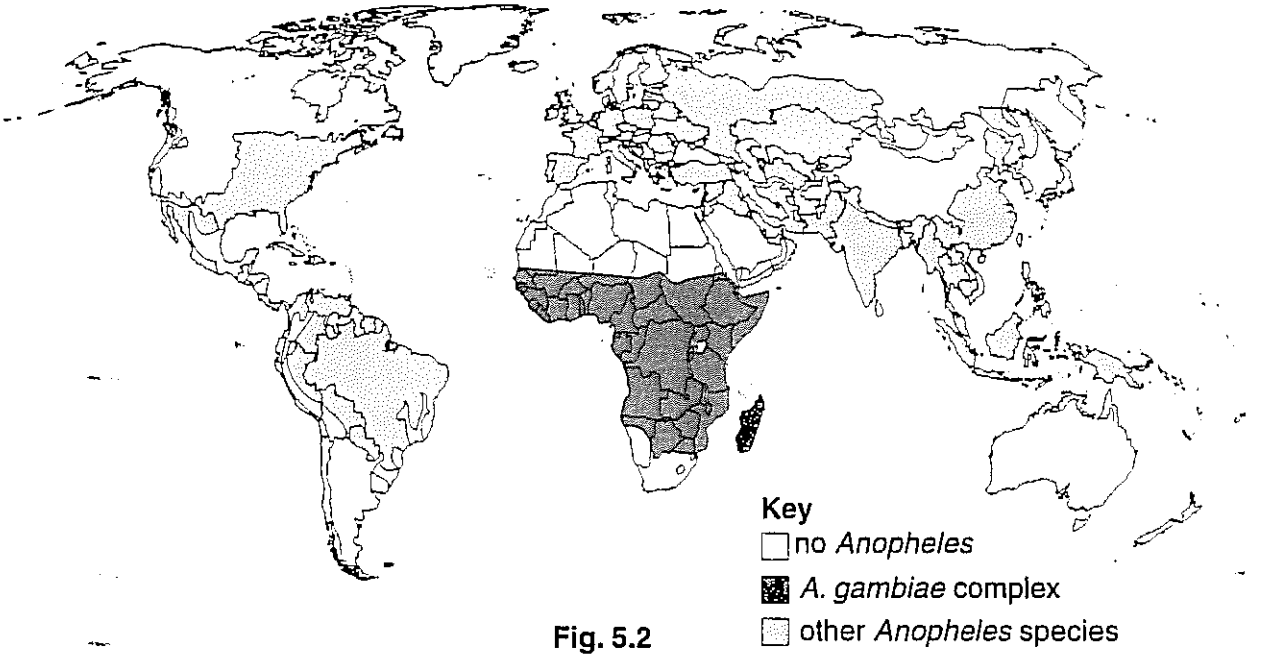


Fig. 5.2

(i) Describe **and** explain the difference between the global distribution of *Anopheles* shown in Fig. 5.2 and the global distribution of malaria.

.....

.....

..... [3]

(ii) The distribution of *Anopheles* shown in Fig. 5.2 includes over forty different species that are vectors of malaria. The areas with the highest number of cases of malaria are also the areas where *Anopheles gambiae* occurs. *A. gambiae* is responsible for most of the transmission of the disease in these areas.

Suggest why *A. gambiae* is responsible for most of the transmission of *Plasmodium*.

.....

.....

.....

[3]

39. O/N 15/P21/Q5/a,b,c,d

(a) State the name of the causative organism (pathogen) of measles.

..... [1]

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(b) Describe how the measles pathogen is transmitted.

.....

.....[2]

(c) The measles pathogen contains a single stranded RNA molecule and no DNA.
The cells that the measles pathogen infects contain double stranded DNA molecules.
State two **other** ways in which the RNA in the measles pathogen differs from the DNA in the infected cells.

1. .....

2. ..... [2]

(d) The measles pathogen must carry out RNA replication to make new RNA molecules for the new pathogens. This happens inside the infected cell.
The pathogen carries its own enzyme for RNA replication, but no other enzymes.
Explain why the measles pathogen cannot use an enzyme from the cell to carry out RNA replication.

.....

..... [2]

40. O/N 15/P23/Q3/c

The enzyme catalase is found in many plant and animal tissues.
The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism. The reaction is:

$$2H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2H_2O$$

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *Anopheles gambiae*, an important vector of malaria. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.
The results are shown in Fig. 3.1.

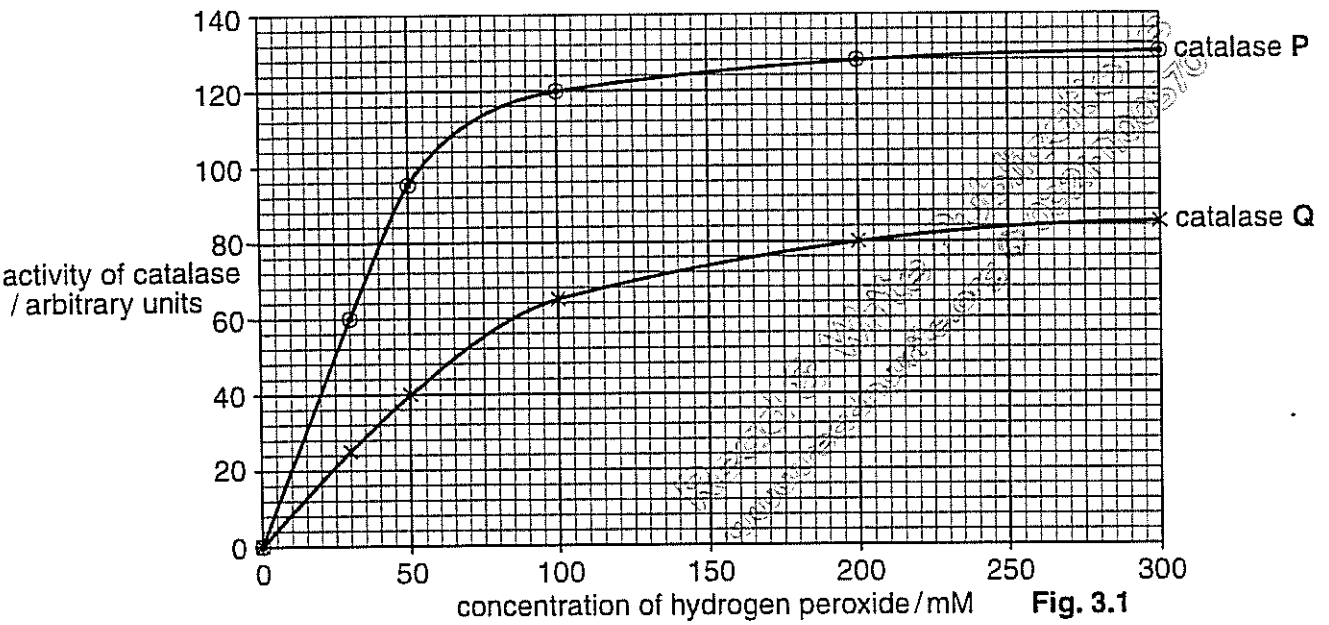


Fig. 3.1

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(a) Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.
The researchers allowed female mosquitoes to feed on blood. They found that female mosquitoes with only catalase **P** produced more eggs than those with only catalase **Q.**
Suggest why there is a difference in egg production between the two types of *A. gambiae.*

.....

..... [2]

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Answers Section

1. M/J 22/P22/Q2

(a) (i) *any **two** from:*
oral rehydration (salts / solution / therapy) ; **A** ORS / ORT
A rehydration therapy if *ref. to* 'drinking' stated within response
solution of / water with, glucose and salts ;
A named example for salts e.g. sodium / potassium / citrate / chloride
AVP ; e.g. antibiotics / doxycycline / tetracycline / furazolidone / choramphenicol / sulfaguanidine (*standard treatment in some countries*)
zinc treatment (*standard treatment for children in some countries*)
ref. to isolation

(ii) *any **two** from:*
decreases, recovery time ; **A** cured more quickly
I helps recovery / reduces severity of disease
reduces time of / stops, diarrhoea production (containing pathogen) ;
less likely to / AW, contaminate water ;
reduced transmission of pathogen ; AW e.g. breaks transmission cycle

(b) (i) *allow antibody or mAb or Mab for monoclonal antibody*
I *ref. to* receptor **I** active site **I** combines / bonds
*any **two** from:*
specific / different, *(Vibrio* / pathogen) antigen-binding sites / binding sites for antigen ; **R** if antibody described as enzyme **A** (each) mAb binds to a, specific / particular, *(Vibrio* / pathogen) antigen
(each mAb has) specific / different, tertiary structure / variable region(s) / primary structure / sequence of amino acids ;
binding site and antigen have complementary shapes ;

(ii) *allow antibody or mAb or Mab for monoclonal antibody*
*any **three** from:*
1 person **A**, has cholera O1 / is infected with *V. cholerae* O1
and person **B**, does not have cholera ;
A *ref. to* person **A** testing positive for cholera O1 and person **B** testing negative to cholera
2 tests are, valid / working, because, controls / bands 4, shows bands ;
*person **A**, band / colour in area 3 because*
3 anti-O1 (mobile) antibody binds (specific antigen on) *Vibrio* O1 ;
A antigen-antibody (complex) 01 formed
4 antigen-antibody (complex) O1 binds to immobilised antibody *ref. to* area 3 ;
R if stated as, band / colour, in area 2
5 person **B** (in test area 2 and 3) no bands form / no colour / no change, because no antibody binds with antigen / no antigen-antibody complexes formed ;

(c) (i) 95 / 95.1 (%) ; **R** 95.0%

(ii) **I** *ref. to*, cheaper / no need for (highly) trained personnel / easier to use / easier to obtain results / accurate
R more accurate
*any **one** from:*
quicker to, obtain result / to do the test ; **A** less time consuming
can carry out test in a greater variety of places / AW ;
e.g. can be done at home
less labour intensive ; AW e.g. only needs one person / can do it yourself
easier to test more people at one time / AW ;

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portable ;
AVP ; e.g. *idea of* easier to transport or distribute (to reach more people)
ref. to, safer / less risk, from pathogen
available to more people (*consequence of cheaper*)
suggestion that dipsticks are able to identify different, forms / strains [11]

2. M/J 22/P21/Q5

(a) (pathogen / causative organism is) transferred / passed on / AW, (from infected) to an uninfected, person / organism ;
I disease
I from one person to another *unqualified*
I spread

(b) *any **two** from*
information needed
1 magnification of, image / (electron) micrograph / Fig. 5.1 ; A scale bar
I magnification of (electron) microscope
2 length of flagellum (in, image / Fig. 5.1) ; I width / diameter / size
3 *formula* actual length of flagellum = measured length of flagellum divided by magnification ; A A= I / M **or** magnification triangle

(c) (i) 0.2

(ii) *large outbreaks of cholera in countries shown in Table 5.1 accept ora*
*any **five** from:*
I *ref. to* poverty, unqualified
1 civil disturbance / (civil) war ;
2 named natural disaster ; I famine / drought
3 lack of, uncontaminated / AW, drinking water ;
A examples e.g. no piped water supply / no bottled water / no water treatment
4 *ref. to* sewage, qualified ;
e.g. no sewage treatment A examples e.g. no separation of drainage from homes and water supplies / contamination of water supplies with human faeces
5 poor sanitation ; *credit only if mp3 or mp4 are not awarded*
6 *ref. to* poor personal hygiene / described example ;
7 eating contaminated foods ; e.g. crops irrigated with contaminated water / seafood harvested from contaminated seawater
8 slow(er) / no / little, diagnosis ;
9 slow(er) / no / little, treatment / healthcare / medical facilities ;
10 oral rehydration, (salts / therapy), not, provided / available ; A named example of oral rehydration
11 antibiotics not, provided / available ;
12 vaccine not provided / vaccine not available / reluctance to be vaccinated / ref to anti-vaccination campaigns ;
13 poor, understanding of / education about, prevention / treatment / precautions ;
14 AVP ; e.g. difficult to reach people living in, rural / remote / dangerous, areas
lack of trained professionals
antibiotic resistance
ref. to people bringing in cholera from elsewhere [9]

3. O/N 21/P22/Q3/a,b

(a) *any **two** from:*
infectious
(baculovirus) is a pathogen / causative organism (of disease) ;
(baculovirus) is transmitted (from one insect host to another) / transmissible ;
allow a description of transmission, e.g. transfer of, virus / pathogen, from, insect to insect

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/ organism to organism
I spread **R** person to person / plant to plant
disease
idea of causing ill-effect on insect, e.g. causes, harm / damage / loss of functioning / ill health / death ; **A** illness

(b) *any **two** from:*
(highly) alkaline / acidic (conditions) ; **A** (very) low / high, pH
disruption of, hydrogen / ionic, bonds, of (polyhedron) proteins / polyhedrins ;
(presence of) digestive enzymes / hydrolytic enzymes / hydrolases ;
R if stated as within lysosomes *but allow detail of enzyme action ecf*
detail ; e.g. extracellular enzymes / proteases / peptidases
peptide bonds broken **A** amide bond for peptide bond
optimum pH ; *must be in context of enzyme presence* [4]

4. O/N 21/P22/Q5/b

(a) *any **three** from: penalise once if incorrect, pathogen / type of organism*
aerosol infection / droplet infection / ref. to airborne droplets ;
in context of droplets containing, pathogen / virus
infected person, exhales / expires / breathes out / coughs / sneezes / AW, (airborne droplets) ;
(airborne droplets) breathed in / AW, by, uninfected / healthy, person;
idea of transmitted when uninfected person touches an infected surface and puts fingers into, mouth / nose ;
R contact *without qualification* [3]

5. O/N 21/P21/Q3/a,b,d

(a) *one mark for infected person with contaminated faeces*
faeces / sewage, contaminates, (drinking) water / cooking utensils / vegetable plots / crops / food ;
one mark for uninfected person
drinking contaminated water / eating food washed in contaminated water ;
R infected food or water ;
A faecal-oral route *for two marks*

(b) *any **three** from:*
secondary structure ;
alpha / α, helix ;
bonding
hydrogen bonding ;
further detail ;
e.g. between NH and CO of different amino acids four, amino acids / places, ahead
hydrogen of the NH and oxygen of the CO

(c) *any **four** from:*
(resistant) (*Vibrio cholerae*)is not killed by the antibiotic ;
A can still reproduce
inability to treat people with cholera using antibiotics ;
prolonged periods of illness ;
(so) increased risk of spread / AW ;
increased death rate from cholera ;
transfer of antibiotic resistance (alleles) to, other species of bacteria / other strains of *V.cholerae* ;
development of multiple resistance in other species of bacteria ;
inability to treat other bacterial diseases ;
increased death rate from other bacterial diseases ;
need to research alternative antibiotics ;
AVP ; [9]

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6. O/N 21/P23/Q5

(a) (i) Morbillivirus ;

(ii) *any **three** from:*

1 (pathogen is transmitted) in airborne droplets / as an aerosol ;
A droplet infection / aerosol infection

2 breathed / sneezed / coughed / AW, out by infected person ;

3 (droplets) breathed in by, healthy / uninfected, person ;

4 touching surface with virus and, breathing into lungs / puts fingers in, nose / mouth ;

(b) *any **three** from:*

1 increase and decrease / fluctuates / AW ;
A between 2015 and 2019, over some of the years or just one year
A increase, decrease and then increase for any one year 2015 to 2018

2 use of data to support mp1 ;

3 numbers for January 2019 are, highest / higher than other years
or
numbers for March 2019 are, lowest / lower than other years ;

4 use of data to support mp3 ;

(c) *ignore* mutation and vaccine evasion / vaccine resistance
ignore refs to cost
*any **four** from:*
transmission and susceptibility (from mp1 to mp7)

1 infected person can infect many people / spreads easily in crowded conditions ;

2 measles spreads to children before they are vaccinated ;

3 vaccine cannot be given soon after birth because of passive immunity ;

4 immunisation rates do not reach 100% / ref to difficulty in reaching herd immunity / herd immunity is not achieved;

5 herd immunity needed for protection of, unvaccinated people / babies ;

6 some people have, no / poor, response to vaccine ;
A vaccine not always effective

7 *ref. to* malnutrition / *ref. to* lack of vitamin A ;

reasons for low immunisation rates (from mp8 to mp12)

8 difficult to reach all people, with example ;
e.g. in rural areas
areas of poor housing in big cities

9 collapse of vaccination programmes as a result of war / AW ;

10 lack of, trained professionals / health facilities ;

11 many children do not receive boosters ;

12 reluctance to be vaccinated / *ref. to* anti-vaccination campaigns / ref to MMR *or* triple vaccine / lack of awareness about beneficial effects of vaccine / *ref. to* cultural *or* religious reasons / AW ;

13 AVP ; *(for either section of the answer)*
e.g. *ref. to* any specific difficulty with contact tracing
ref. to thermostability of vaccine and maintaining a cold chain
migrants, with measles / from an area with an outbreak of measles [11]

7. M/J 21/P21/Q5

(a) 1 vector is female *Anopheles* (mosquito) ;

2 mosquito / (female) *Anopheles*, takes blood from infected person ; **I** 'bites' alone

3 (vector / mosquito / *Anopheles*) inserts / AW, saliva / anticoagulant, with, pathogen / *Plasmodium* / parasite, into (blood of) uninfected person ;
R if incorrect type of pathogen

(b) B-lymphocytes / B-cells ;
fuse / combine / join / merge / AW ;

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R hybridise / bind / bond

hybridoma ;

(c) *any three from*

1 results are accurate (rely on monoclonal antibodies) ;
2 results are obtained quickly / diagnosis is quick ;
3 low cost / cheap ;
4 does not need highly trained medical professional / easy to read / easy to use / AW ;
5 does not need specialised equipment ;
6 easily, transported / distributed (in bulk) ;
7 can ensure appropriate treatment is given immediately malaria is confirmed ;
8 reduces unnecessary use of antimalarial drugs (just in case) ;
9 (a small area for S so) only a small sample of blood needed ;
10 AVP ;
e.g. can identity different species of *Plasmodium*

I *ref. to* line C and working correctly

(d) ***ignore*** *ref. to* sickle cell anaemia

any five from

habitat of Anopheles *mosquito*

1 tropical / warm and humid / AW, climate / regions ;
A in context of global warming (increases life span of *Anopheles*)
2 in areas where, *Anopheles* (mosquito) / vector, occurs ;
3 *Anopheles* mosquitoes only live in humid conditions ;
4 warm temperatures for, development / growth, of, parasite / *Plasmodium* (in vector / mosquito) ;
5 warm temperature for, development / growth, of mosquito larvae ;
6 mosquitoes require bodies of, still / AW, water for breeding ;
A ponds, puddles, lakes, swamps
7 mosquitoes require places where there is sufficient rainfall ;
8 low altitude ;

resistance

9 insecticide / repellent, resistance of mosquitoes ;
10 drug resistance of parasite ;

prevention

11 in countries / areas, where, prevention / control measures, are not implemented by, governments / health authorities;
12 further detail e.g. any example of a, prevention / control measure that is not used or not implemented fully;

immunity

13 immunity to malaria in human population (limits distribution) ;

people

14 migration of infected people from areas (with high rates of malaria) ;
15 high rates of HIV infection ;

[13]

8. M/J 21/P23/Q2/a,b,c,d

(a) **I** *ref. to* features that are absent e.g. no cellular structure

any one from

nucleic acid core ;
either DNA or RNA ; **I** ref. to, single / double, stranded
protein coat / capsid ;
A *idea of* (outer covering) made of capsomeres

(b) *(smallpox) Variola* ;
(measles) Morbillivirus ;

(c) *allow, virus / viruses, for Morbillivirus*

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I penicillin doesn't act on viruses
any two from

1 penicillin only acts on bacteria (and measles is caused by a virus) ;
A prokaryotes
2 *Morbillivirus* does not have, cell walls / murein / peptidoglycan ;
3 *Morbillivirus* does not have, transpeptidases / the enzyme that is inhibited (by penicillin) ;
A *idea of* not possessing the enzyme that is acted upon by penicillin
4 *Morbillivirus* does not grow / penicillin (only) acts on growing cells / AW ;
A when cell wall is, growing (larger) / getting bigger
5 *Morbillivirus* does not have cellular structure / *Morbillivirus* is acellular / penicillin only acts on cells ;

(d) to treat / to cure / may have / prone to / to prevent / AW, infectious diseases / infections / AW ;
e.g. bacterial / opportunistic / secondary, disease(s) / infection(s) **A** to kill bacterial pathogens
A to treat (some) fungal diseases
R viral disease / HIV infection
do not award if a mix of viral and bacterial diseases stated [6]

9. O/N 20/P22/Q2/a

(a) *any* ***four*** *from:*

1 (in combination treatment) antibiotics (in Table 2.1), act at different targets / have different modes of action / AW ;
A comparison of any two antibiotics from Table 2.1
A suggestion of how two antibiotics have different ways of killing
2 *idea that* if resistance / mutation, occurs / exists, unlikely to be against all antibiotics / other antibiotics should still be effective ;
3 (in combination treatment) if resistance / mutation, occurs / exists, all bacteria will (still) be, killed / destroyed / AW ;
A no bacteria remain to develop resistance / no reservoir of resistant bacteria
4 antibiotic resistance, not / less likely to be, spread to affect people because no bacteria surviving (with combination treatment) ; AW
5 long treatment time / 6 months, with, combination treatment / AW, increases chance of killing all bacteria
or
long treatment time with a single antibiotic not effective in killing all bacteria if, resistance develops / a mutation occurs ;
6 AVP ; e.g.
combination treatment (is likely to) eliminate bacteria more quickly (so less chance of resistance occurring)
resistance to different antibiotics involves more genes so less chance of resistance occurring
gene for antibiotic resistance has more chance of being passed on if using single antibiotic (and not all killed) ora
if using single antibiotic (and not all killed) more chance of being passed on (to other bacteria) by horizontal / vertical / AW, transmission ora [4]

10. O/N 20/P21/Q3/b

(a) (i) *idea of* using both antibiotics makes sure all bacteria are killed ;
if, resistance against one antibiotic occurs then, the other antibiotic will be effective / bacteria still susceptible to the other antibiotic
or
if, some bacteria are less susceptible to one antibiotic, then, the other antibiotic will be effective / bacteria still susceptible to the other antibiotic ;

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*any **one** from:*
antibiotics / gentamicin and penicillin G, have different sites of action / AW ;
A suggestion of how the antibiotics have different ways of killing
ref. to mutations, qualified ;
e.g. need two mutations to occur to be resistant to both antibiotics probability / AW, of these two mutations occurring in
the same bacterium is very small mutations must be in different genes

(ii) *any **three** from:*
course of antibiotic is not completed ;
less susceptible bacteria survive ; **A** not all bacteria destroyed
replication / population growth, increases chance of mutation ;
ref. to random mutation, ref to gene / allele, for resistance to gentamicin ;
suggestion of outcome of different mutations ;
e.g. changed ribosome structure so gentamicin cannot bind enzyme to breakdown gentamicin
ref. to transmission of allele for resistance ;
e.g. vertical transmission / described
horizontal transmission / described (conjugation / transformation)
e.g. frequency of allele for resistance increases in the population ;
when antibiotic next prescribed
antibiotic in the environment is the selection pressure / resistant bacteria selected for / susceptible bacteria selected against ; [5]

11. O/N 20/P21/Q4/a

(a) (i) plasmodesmata ;

(ii) *any **two** from:*
ref. to connecting two cells ; *in context of connecting cytoplasm*
(facilitate) movement of substances between cells ; **A** named substances
ref. to symplast pathway ;
cell to cell communication / passage of cell signalling molecules ;
AVP ; e.g. removes the need to cross the partially permeable cell surface membrane (when moving between cells)
increases the rate of movement of substances between cells [3]

12. O/N 20/P23/Q4/a

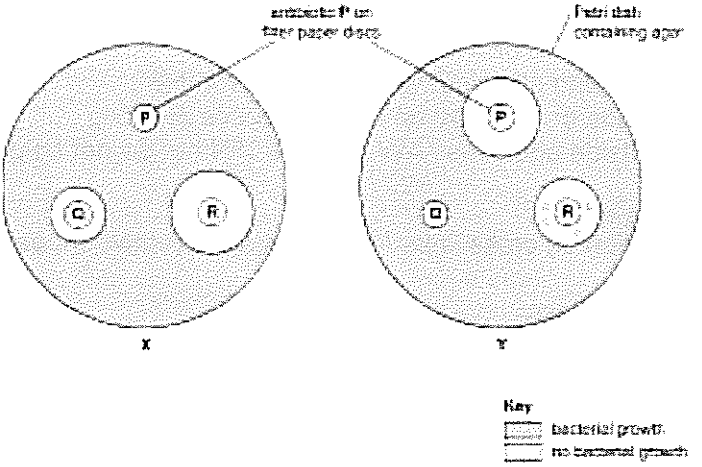
(a) (i) **X – R**
and
Y – P ;

(ii) *any **two** from:*
mp1** = resistance with ref. to **P / Q / R
Y, is resistant to **Q** / has no resistance to **P** ;
A Y has some resistance to (antibiotic) **R**
***mp2** = antibiotics used at different concentrations*
(antibiotic) **R** may, have different concentration / be less effective, compared with **P** ;
***mp3** = reason for resistance*
ref. to gene(s) for resistance (on plasmids)
or
Y has, cell wall / cell membrane, that prevents entry of antibiotic **Q**
or
Y has enzyme that breaks down, **Q / R** ;
***mp4** = action of antibiotics*
idea that antibiotics have, different / specific, target(s) / AW ;
A any example of process inhibited by antibiotic, e.g.
cell wall synthesis

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transcription
translation
DNA replication
cell surface membrane function
synthesis of folic acid
mp5 = AVP ;
e.g. *idea that* **P** may be bacteriocidal / (antibiotic) **R** is bacteriostatic
e.g. *idea that* gene for resistance to antibiotic **R** passed by, vertical / horizontal, transmission



[3]

13. M/J 20/P21/Q5/a

(a) (i) <u>*Mycobacterium tuberculosis*</u> or <u>*Mycobacterium bovis*</u> ;

(ii) *max1 if no reference to, infected / uninfected*
airborne droplets, breathed / sneezed / AW, out by infected person ;
breathed in / inhaled / inspired, by uninfected person ;
or
in context of M. bovis only
contaminated meat / unpasteurised milk, from infected, cattle / cows ;
ingested by uninfected person ; [3]

14. M/J 20/P23/Q2/a,b

(a) *allow mosquito for <u>Anopheles</u> throughout*
allow pathogen for <u>Plasmodium</u> throughout
any three from
role of *Anopheles* in transmission cycle ; e.g. *Anopheles* is, a vector of *Plasmodium* / *Anopheles* passes *Plasmodium*
infected person to uninfected person
insecticide on nets and on surfaces
kills *Anopheles* before it can take <u>blood</u> from an infected person ;
kills *Anopheles* before it can transfer <u>blood</u> with *Plasmodium* to uninfected person ;
presence of nets
protect people, when sleeping / at time when *Anopheles* is, active / feeding ;
general
prevent *Plasmodium* from completing its life cycle ; AW
AVP ; *idea of* reducing population size of mosquitoes
use of different insecticides on net and IRS to avoid insecticide resistance

(b) (i) *any one from*
increase in the use of ITN over time ;
decrease in the use of IRS only ;

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proportion of population protected by ITN only has increased;

(ii) *any one from*
increase is not steep enough, to make a large enough difference / so disease will still be able to spread ;
a large proportion of the population is still at risk, so people will still contract the disease ;
A figures from Fig. 2.1
WHO targets may not be met, so hindering progress in the fight against malaria ; AW
AVP ; e.g. suggests that the, provision of / distribution of / access to, ITN is not adequate ;

(iii) *any one suggestion from*
ITN more effective in control than IRS ;
more cost effective to provide ITN ;
lack of personnel to carry out work required for IRS ;
ref. to insecticide on net may be more effective at killing ;
AVP ; e.g. outside agencies / AW, provide ITN but do not help with IRS [6]

15. O/N 19/P22/Q5/a,b,c,d

(a) **1** prevents formation of, cross links / cross linkages (between, peptidoglycan / murein, chains) ;
A peptide cross links
A links between, murein / polymer, chains
I peptide bonds
I formation of peptidoglycan
R if cellulose chains stated
2 (penicillin) inhibits, transpeptidase action / enzyme involved in forming cross links ;
A alternative correct names for transpeptidase
3 weakens cell wall ;
A cell wall unable to withstand (turgor) pressure
A cell wall loses strength
R idea that penicillin, punches / makes, holes, to weaken
4 (cell), lysis / bursts / ruptures / AW (so bacterium killed) ;
5 acts, on growing bacteria / when bacteria are increasing in size (when cell wall needs to be synthesised) ;
I growing, wall / peptidoglycan chains

(b) *(Plasmodium / P.),* ovale */* falciparum */* malariae */* vivax *; correct spelling*
I *if Plasmodium is written after the species name*
if more than one given, all must be correct

(c) *any one valid suggestion:*
male does not, need protein for egg production / produce eggs ;
R larvae
I male does not reproduce
male does not have mouthparts for piercing skin ; AW
e.g. no 'needle' to pierce skin (to suck blood)
adult male does not feed ;
adult male feeds (only) on, plants / nectar ;
blood is toxic to males ;
can't detect presence of, humans / mammals ;
male does not produce anticoagulant (for blood) ;

(d) *accept mosquito or vector for* Anopheles
accept, pathogen / parasite, for Plasmodium
max 2
1 *idea that* individuals / people, taking antibiotics for bacterial diseases will pass on antibiotics to *Anopheles* when it feeds ;
e.g. blood taken by *Anopheles* contains antibiotics

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2 (so) antibiotics kill bacteria (in *Anopheles* gut) ;
must be in context of gut bacteria
3 decreased / no, competition between, *Plasmodium* and (gut) bacteria (so more *Plasmodium* survives) ;
4 higher survival of *Plasmodium* makes effective (*Anopheles*) immune response more difficult ; AW
(so Anopheles more likely to pass on Plasmodium)
max 2
I ref. to antibiotic resistance
5 use of antibiotics may increase, incidence / number of cases of, malaria ;
6 and **7** *two marks for* examples of what doctors need to consider ;
e.g. need to balance antibiotic intake with increased risk of malaria transmission
idea that do not want to stop people taking antibiotics / antibiotics needed to fight (bacterial) infections
treat for malaria before giving antibiotics for (non-serious / non-life threatening) bacterial infections
only prescribe antibiotics that have, no / low, impact on bacteria in *Anopheles* (gut)
(consider) avoiding use of antibiotics to treat malaria
8 AVP ;
e.g. need to research which antibiotics have this effect look for alternatives to antibiotics to treat bacterial infections [8]

16. O/N 19/P21/Q2

(a) (i) *Mycobacterium tuberculosis*
or
Mycobacterium bovis ;

(ii)

artificial active immunity	✓ ;
artificial passive immunity	
natural active immunity	
natural passive immunity	

(b) (i) *three from*
changes the tertiary structure / shape of active site, of , enzyme / RNA polymerase ;
active site no longer complementary to, RNA nucleotides / substrate ; AW
RNA nucleotides not joined / mRNA not synthesised ; **A** transcription does not occur
translation prevented ; **A** described, **I** polypeptide / protein synthesis prevented
AVP ; *ref. to* other roles of RNA polymerase not occurring, e.g. does not bind to DNA, double helix does not unwind

(ii) *two from*
(from 2009 to 2013) overall increase in number of cases (of RR-TB and MDR-TB) ;
use of data to support overall trend ;
ref. to large increase between 2011 and 2012 / 2013
or
very little change between 2010 and 2011 ;

(iii) *four from*
overuse of, antibiotics / rifampicin
or
example of over use ; e.g. taking for viral infection, over prescribing for bacterial infection

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people not completing course of antibiotics ;
reservoir of bacteria remains ;
ref. to mutation ;
any detail of the mutation ; e.g. protein produced has a changed binding site
bacteria with resistance, survive / selected for
or
only bacteria sensitive to antibiotic are, killed / selected against ;
A antibiotic acts as a selection pressure
bacteria reproduce and pass on, gene / allele, for resistance to offspring
or
vertical (gene) transmission ;
(alleles for resistance to antibiotics transferred by) horizontal (gene) transmission / described ;
frequency of resistance, gene / allele, increases in the bacterial population ; [11]

17. M/J 19/P22/Q4

(a) *max 3* if any membrane-bound organelles drawn inside cell e.g. nucleus, Golgi body, mitochondrion, lysosome, ER, a large vacuole
BUT **I** vesicle / small vacuoles
I detail of cell wall / cell surface membrane around flagellar area
four from:
cell wall ; *must add another line to diagram* **R** cellulose cell wall
cell (surface) membrane ; **A** plasma membrane
label line to the inside of cell wall
I if outer line labelled as cell membrane
DNA ; **A** bacterial chromosome / nucleoid *as label*
allow one or two circular molecules (circle, loop, ball of string, tangled)
R *if obviously linear*
R if label includes, histones / histone proteins / chromatin
R if nuclear, envelope / membrane, shown
R if nucleolus shown or labelled
ribosomes ; **R** 80S ribosomes
shown as, dots / small spheres
cytoplasm / cytosol ;
plasmid ; *smaller than DNA, circular*
AVP ; e.g. 70S / smaller / 17–20 nm, *for ribosome*
murein / peptidoglycan (for cell wall – allow even if cell wall label not added)
pilus /pili *drawn as external hair-like structure(s)*
basal granule *at base of flagellum*
capsule drawn to outside *(some do have a capsule)*

(b) (i) 0.8 % ; **R** 0.80 %

(ii) *any two from:*
delay in / no, diagnosis ;
delay in / no, treatment / therapy ;
A feature of, oral rehydration, treatment /solution **A** ORT / ORS
e.g. lack of supply of ORT
unwillingness by health workers to give ORT
greater belief in herbal remedies
thinking drug treatment is sufficient
lack of clean water to make up ORT solution
no rehydration programmes
I improper treatment / treatment not effective
ref. to no / lack of, antibiotic therapy ; e.g. lack of supply of / less efficacious (AW) antibiotics used / less supervision in taking full dose

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ref. to antibiotic resistant strains ;
idea that already have a weak immune system / malnourished ;
A may have HIV/AIDS (hence weak immune system)

(c) (i) *any one from:*
damaged sanitation system / poor sanitation following earthquake ;
I poor sanitation unqualified
damage to, sewage treatment plants / water purification plants ; AW
(contaminated) sewage contaminates drinking water ; **I** pollution
A water becomes contaminated
lack of purified drinking water; **A** lack of, clean / treated / safe / bottled, water
AVP ; no, proper / safe, disposal of sewage

(ii) *any three from:*
1 2011, peak in / highest / AW, number of, cases / countries / countries and cases ;
A decrease, increase in 2011, decrease *for countries*
A increase to 2011 and decrease *for cases*
2 (2010 outbreak in) *ref. to* Haiti and epidemic (so high number of 2011 cases) ;
3 *ref. to* spread of disease to countries neighbouring Haiti (hence increase in countries in 2011) ;
4 overall / generally / AW, decrease in number of countries with cases of cholera
or
2008 54–56 countries and 2015 41–43 countries, with ref. to decrease ;
decrease, peak at 2011 / increase in 2011, decrease is mp1 only
5 suggestion for trend in decrease in number of countries ;
e.g. improved infrastructure for sewage / water treatment
improved health education to prevent spread
providing piped (treated) water
6 2008–2010 number of cases increased and number of countries decreased ;
7 AVP ; e.g. lowest / AW, number of cases in 2013
R if also state that 2013 is lowest for countries
similar number of countries in 2008 and 2011 but, approx 3× / much higher / stated values, number of cases in 2011 [11]

18. M/J 19/P23/Q3

(a) *one mark each row*

cell structure	*V. cholerae*	epithelial cell from the human intestine
cell wall	✓	✗
cell surface membrane	✓	✓;
ribosomes	✓	✓;
large permanent vacuole	✗	✗;
organelles surrounded by a double membrane	✗	✓;

(b) **I** better sanitation unqualified
I *ref. to* unclean water
any five from :
ref. to treat drinking water ;
A clean / sterilised / chlorinated / safe / bottled / boiled
A *ref. to* water treatment plants

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provide sewage treatment plants ; **A** treat waste water / containment of sewage / provide latrines (in temporary camps);
ref. to keeping sewage and (drinking) water sources separate ;
A examples e.g. avoid swimming downstream of sewage outlets
avoid defaecating near rivers used for washing
water treatment plants upstream of sewage disposal
bury faeces
ref. to vaccination / providing vaccines ;
ref. to education in ways to prevent spread ;
ref. to (encourage) hand washing ;
ref. to food hygiene ; e.g. use of clean cooking utensils / covering food to prevent flies landing / washing food in treated water / cook food thoroughly / peel fruit and vegetable washed in (suspected) contaminated water
discourage use of human faeces for fertiliser / use fertiliser other than human faeces / do not irrigate plant food with contaminated water;
control breeding of, vectors / flies ;
rapid diagnosis ;
rapid treatment (for earlier recovery to minimise risk of spreading) ;
ref. to oral rehydration, salts / therapy ;
use of antibiotics ;
ref. to isolation / quarantine ;

(c) (i) to, bind / attach / AW, HIV / virus / pathogen, to, host cell / T-lymphocyte / T-cell ;
(because it) binds / is complementary, to, CD4 receptor proteins / AW ;
ref. to binding leads to, entry of virus into cell / endocytosis / fusion of viral envelope with host cell (surface) membrane;

(ii) *ref. to* less cytokine (released) ; *in context of fewer helper T-lymphocytes*
any one from:
(so) fewer B-lymphocytes divide by mitosis / AW ; **A** humoral response decreased
(so) fewer B -lymphocytes stimulated to differentiate into plasma cells / AW ;
(so) fewer plasma cells to, produce / secrete antibodies ; [13]

19. O/N 18/P22/Q4/b,c

(a) (i) one value in the range 64% – 68% ;
((940 000 – 980 000) ÷ (1 440 000 – 1 480 000)) × 100

(ii) *allow women for pregnant women and therapy / treatment, for ART*
any three from
1 (slight) decrease in (total) number of women living with HIV and (overall) increase in number of women living with HIV receiving ART ;
2 slight decrease / plateau / AW, between 2009 to 2010, in number of women living with HIV receiving, ART / therapy ;
3 proportion / percentage cover(age), of women receiving ART increases (in time period);
A calculated values (approx. 13% to 66%)
A number of women receiving ART increases more steeply than decrease in number of women living with HIV
4 data to support mp1 or 2 ; *mp1 two years and, two values / manipulated data, for either curve mp2 two values, 2009 compared to 2010* **or** *manipulated data allow ± 20 000 for extracted values*

(iii) *in context of pregnant and breastfeeding women who are living with HIV*
any three from
1 *ref. to* mother to child transmission ; *in context of HIV transmission*
A (because) HIV can be passed from mother to baby
A decreases HIV transmission during, pregnancy / labour / birth / breastfeeding

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A reduces, number / proportion, of babies born with HIV (so fewer die)
I stops transmission *(as this is in context of global transmission this implies in all cases)*
I makes babies immune to HIV / AW or gives passive immunity
allow idea that ART may be passed across, placenta / breastmilk, to baby and so provide(short-term) protection against any HIV transmitted from mother

2 reduces number of, HIV positive women becoming ill (with HIV /AIDS) /women with HIV/AIDS dying from the disease ;
A opportunistic infections / named examples e.g. TB

3 example of reduces spread of HIV ;
in any correct context other than HIV mother to child
e.g. child may grow up without HIV and will not pass on
mother less likely to pass on to partner

4, 5 examples of, social / economic, effect ;;
e.g. (healthy women) can contribute to work force
can be main carer if partner has died (*idea that* children not orphaned)
overall financial savings
e.g. if infants are not born with HIV then no lifelong ART required
ART may be less costly than treating HIV/AIDS
makes breastfeeding safer when no other options exist to feed babies
HIV negative children will become next workforce generation
all women throughout world receive same treatment

(b) (i) (HIV) antigen / p24 ; **A** capsid protein / capsomere(s) / protein coat **R** HIV

(ii) (time needed) so, immune response / clonal expansion / production of B-lymphocytes / production of plasma cells, can occur ;
A B-cells / splenocytes
R plasma cells need to multiply
I *ref. to* antibody production

(iii) *any one from*
immortal / long-lived ;
able to replicate / capable of cell division ;
uncontrolled cell division, can grow / survive, in cell culture ;
cannot grow on, HAT / hypoxanthine-aminopterin-thymidine / step **4**, (culture) medium ;
A do not have gene coding for ability to grow on HAT

(iv) hybridoma ;

(v) *any one from*
(check cells for) production / AW, (by hybridoma cells) of, anti-HIVp24 antibody / antibody against p24 ;
A the antibody / monoclonal antibody
A check cells, contain / have / AW, desired antibody / AW
idea that only want cells that produce desired antibody / do not want cells that produce different antibodies / need to remove cells that don't produce the antibody ;
waste of, money / resources, to culture other cells / if no antibody produced ; [12]

20. O/N 18/P21/Q1/c,d,e

(a) *Plasmodium, falciparum / vivax / ovale / malariae* ;

(b) *any three from*
pathogen
(because) four / several, different, causative species / AW, (with different antigens) ;
(pathogen has) many antigens as it is eukaryotic / many genes coding for antigens ;
ref. to mutation changing antigens ;
pathogen has different stages of life cycle (within human) with different antigens ;
I *ref.* to antigenic shift

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antigenic concealment / pathogen spends part of life cycle within host cells / AW ;
A short time in blood plasma
vaccine
ref. to more than one type of vaccine needed ;
suggestion that antigens used have not given the strongest immune response ;
vaccination programme
ref. to only trial programmes ;
A programmes not global
ref. to not achieving herd immunity / not enough people (successfully) vaccinated ;
detail ;
e.g. lack of willingness to be vaccinated
lack of trained people to give vaccines
poor nutrition and poor immune response

(c) *allow* *mosquitoes / vectors, for Anopheles*
pathogen / parasite, for Plasmodium
any four from (max 1 for list of factors without explanation)
assume in context of comparison with area **Q**
ref. to a suitable climate for *Anopheles*, e.g. tropical / subtropical / hot and humid ;
presence of *Anopheles* species which carry *Plasmodium* ;
ref. Anopheles breeding sites present / (many) water sources (suitable for breeding) ;
difficulty in controlling / lack of control, of *Anopheles* breeding sites ;
AW, e.g. stagnant water not drained
lack of / cannot afford, spraying with, insecticide / pesticide / repellents ;
insecticide-resistant forms of *Anopheles* exist ;
lack of / insufficient use of, mosquito nets ;
mosquito nets not impregnated with insecticide ;
lack of, artemisinin drugs / drugs to treat disease ;
drug-resistant forms of *Plasmodium* exist ;
idea of *Plasmodium* requiring temperatures of approximately 20 °C (in vector) ;
A area **P** has temperature / conditions for survival of *Plasmodium*
ref. to difficulties in diagnosing disease (so delay / no treatment) ;
e.g. lack of diagnostic tests lack of trained personnel
AVP ;;
e.g. some countries in area **Q** have *Anopheles* but control is good,
ref. to feature of *Anopheles* species present in area **P**
feed at all times during the day
feed only on humans
good host for reproduction of *Plasmodium*
poor education so people don't know how to protect themselves from malaria [8]

21. O/N 18/P23/Q5

(a) (i) *Mycobacterium, tuberculosis / bovis* ;

(ii) *any three from*
1 phagocytes / macrophages / neutrophils / elastase, breaks down / weakens, alveolar walls ;
2 (reduced elastin so) alveoli cannot stretch and recoil / alveoli overstretch ;
3 alveoli burst / one large air sac formed ;
4 surface area (for gas exchange) is reduced ;
5 less oxygen absorbed by blood / reduced oxygen supply (to tissues) / not enough oxygen for (aerobic) respiration / AW ;

(b) **R** cost
any five from
1 *Transmission* ;
e.g. aerosol / droplet, infection
I airborne

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A lack of pasteurised milk
overcrowded, housing / living conditions / AW
migration / travel, from areas with high rates of TB
reservoir of infection in people not, diagnosed / not treated

2 *HIV / immunodeficiency* ;
e.g. infection with HIV may activate (dormant) TB (pathogen)
immunodeficiency / AW, makes people more susceptible to TB
intravenous drug taking increases risk of, immunodeficiency / HIV

3 *Diagnosis is difficult* ;
e.g. TB (pathogen) remains dormant / symptomless carriers
limited access to health care for diagnosis / AW
idea that contact tracing is difficult

4 *Treatment* ;
e.g. treatment is long term / treatment may not start early enough
people may not finish the course of treatment
limited access to health care for treatment

5 *Acquired resistance* ;
e.g. bacterium / TB (pathogen), develops resistance to, antibiotic(s) / drug(s)
multi-drug resistance / MDR-TB / XDR-TB

6 *Vaccination* ;
e.g. vaccine may not always be effective in providing protection
difficult to achieve herd immunity
concerns / misconceptions, about vaccination
limited access to vaccination (programmes)
poor (immune) response in people who are malnourished
poor thermostability of vaccine

7 *Education* ;
e.g. limited education / low awareness, about prevention for general population
limited education / low awareness, for health care professionals [9]

22. M/J 18/P22/Q3/a

(a) **A** antibiotic for penicillin throughout
three from:
1 (penicillin) weakens / AW, the <u>cell wall</u> ;
I punches holes / holes made
2 (penicillin) acts, on growing cells / when cell wall being synthesised (during growth) ;
3 inhibits / binds to / AW, enzymes / transpeptidases (for cross linkage formation) ;
I ref. to synthesis of peptidoglycan
4 prevents formation of cross, links / linkages (between, peptidoglycan / murein, molecules) / AW ;
suggestions why antibiotic is less effective on Gram negative
5 outer membrane, prevents / interferes with / protects from / AW, entry (of penicillin) ;
A idea of, more difficult / further, to reach peptidoglycan layer
6 proteins in outer membrane may pump out antibiotic ;
A presence of efflux pumps
7 enzymes may be present (in periplasm) to degrade antibiotic / AW ;
8 suggestion that antibiotic cannot cross hydrophobic region of (outer) membrane ;
9 AVP ; e.g. proportionately, less / lower concentration of, penicillin
reaches murein for, enzyme / transpeptidase, inhibition [3]

23. M/J 18/P22/Q5/b,c,d

(a) *two from:*
blood pressure, decreases / returns to normal ;
platelets no longer sticky / risk of thrombosis decreases /
risk of blood clotting decreases ;

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endothelial repair (more likely to be) successful ;
A endothelium no longer damaged
A decreased risk of, atheroma / atherosclerosis
I less fatty deposits
heart rate, decreases / returns to normal ;
I heartbeat decreases
AVP ; e.g. increased peripheral circulation / AW
blood vessels, not / less, constricted
A less vasoconstriction
A blood vessel (lumen) diameter increases / vasodilation occurs

(b) *four from:*
assume from point of view of giving up smoking unless stated otherwise
in lungs / at high partial pressures of oxygen
1 (so) more oxygen taken up by haemoglobin / haemoglobin more saturated (with oxygen) / AW ;
A haemoglobin has, increased / normal, affinity for oxygen
2 before and after data / calculated difference in data, to support, from 10 kPa ;
3 carbon monoxide no longer binding to haemoglobin / AW ;
A carboxyhaemoglobin no longer forming / ora with ref. to smoking
A haemoglobin has a higher affinity for CO than oxygen
4 more (sites on) haemoglobin available to take up oxygen ;
in respiring tissues
5 more oxygen dissociates from (oxy)haemoglobin / AW, at, lower partial pressures / below 4 kPa / in (respiring) tissues (after stopping) ;
A haemoglobin less saturated (with oxygen)
A haemoglobin has, less / decreased, affinity for oxygen
6 before and after data / calculated difference in data, to support ;
7 ref. to increase in allosteric effect / regains ability for conformational change / AW ;
health benefits after stopping
8 more / sufficient, oxygen to, transport / deliver to, tissues / body
or
more oxygen to reach (respiring) tissues ;
A less, tired / fatigued
A more able to, do work / carry out exercise / be mobile
R more energy unless qualified with link to aerobic respiration

(c) *two from:*
non-infectious
not from a pathogen ; **A** bacteria / viruses / fungi *for pathogens*
A from lifestyle
A tar / carcinogen in smoke, causes mutation (in cells of lung)
cannot be passed onto another person / not transmissable / AW ;
disease
abnormal condition (affecting an organism) / condition that reduces the effectiveness of the functions of the organism / AW ; [8]

24. M/J 18/P22/Q6

(a) *three from:*
same / similar, shape as, HMG CoA / substrate ;
<u>complementary</u> (shape) to active site (shape) ;
binds / attaches / fits into / active site (of, enzyme / HMG CoA reductase) ;
HMG CoA / substrate, cannot bind (to active site) ;
A no / few, enzyme/substrate complexes form
mevalonic acid production, decreases / stops ; **I** product not made
AVP ; e.g. increase in mevinolin concentration increases inhibition / ora

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(b) *two from:*
treatment of disease
I *statements about locating or diagnosis of disease*
specific / targeted, therapy / treatment ;
A specific to diseased, cells / tissue
A examples
bind to / recognition of, receptors / antigens, on cell surface (of diseased cells) ;
kill the cell by stimulating the immune system / AW ;
A correct immune responses e.g. stimulates phagocytosis / activates B-cells
attach, radioactive substance / drug (to treat / kill diseased cells) / AW ;
treat infectious diseases / bind to (antigens on) pathogens /
recognition of antigens on pathogens ; A viruses
I bacteria *unless stated that they cause disease*
allow examples such as treatment of ebola or rabies or tetanus
(by immunising with antibody) [5]

25. M/J 18/P23/Q6/a

(a) **A** HIV / AIDS, measles, smallpox ;
B cholera, tuberculosis ;
C cholera ;
D malaria ; [4]

26. O/N 17/P22/Q4

(a) *two from*
(loss of ions) increases / AW, water potential within cell ; **ora, A** Ψ for water potential, **I** *ref. to* solutes / solute potential
water moves out of cell, down water potential gradient / from high(er) to low(er) water potential ; **R** from high to low water potential gradient
(out) by osmosis / through the partially permeable membrane ; **A** selectively permeable membrane **I** osmotic gradient

(b) *four from*
capillary side sodium ions
1 sodium ions out (of cell), by active transport /with use of ATP ; **A** sodium ions pumped out
2 (so) lowers concentration of sodium ions within cell **or** sodium ion concentration gradient, set up / maintained ;
intestinal lumen sodium ions and glucose
3 sodium ions enter by facilitated diffusion ; **A** diffusion / high to low concentration, through, SGLT1 / cotransporter **I** glucose enters by facilitated diffusion
4 glucose, cotransported with sodium ions into cell (through SGLT1) ; **A** sodium ions cotransported with glucose **A** glucose enters by secondary active transport, **A** *idea of* glucose only able to enter if moving with sodium ions (i.e. sodium drives the process)
5 (cotransport means) glucose enters against concentration gradient ;
capillary side glucose
6 glucose out of cell (towards capillary) by facilitated diffusion ; **A** by diffusion if stated through, membrane protein / GLUT2
water uptake from lumen
7 (higher concentrations of) sodium ions / glucose / solutes, within cell lowers water potential ;
8 water follows, sodium ions / glucose / solutes (osmotically) **or** so water enters cell (down water potential gradient); *must have idea that it follows inward movement of solutes*

(c) *any one valid e.g.(if not stated artery or vein, assume vein)*
high(er) pressure of artery (will not allow drip)

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or
artery may be deeper to reach to insert needle for drip / easier to find vein **A** vein more, visible / superficial
or
greater risk / more complications / greater blood loss, associated with intra arterially AW

(d) *one from*
no / reduced, polypeptide / protein, synthesis
or
mRNA not translated/ no translation / reduced translation ; **A** detail of translation e.g. tRNA cannot bind **R** DNA not translated
no / few, enzyme-catalysed reactions ;

(e) (i) *three from*
1 volume / AW, decreases over time for all groups ;
2 *compared to no antibiotic* antibiotic groups, steep(er) / faster, decrease to, 32 / 48 hours ;
3 *idea that* diarrhoea, stops / is 0 dm^3, at / after, 64 hours, for one dose 1 g / **A**, **or**, multiple dose / **C** ; **A** recovers after 64 hours / AW
4 after 48 hours, one dose 2 g / **B**, fluctuation / decreases then (slight) increase then decrease / AW ;
5 no antibiotic / **D**, higher volumes diarrhoea than antibiotics (to approx. 110h) **or** no antibiotic / one dose 2 g / **B**, took 128 hours (for diarrhoea) to, reach 0 dm^3 /stop ;
6 multiple dose / **C**, higher volumes than, **A** (all readings) / **B** (to 48 hours) **ora or A** has steepest decrease *in context of 16–32 hours or overall*

(ii) *alternative ways to refer to decrease in volumes of diarrhoea may be in terms of recovery, destroying bacteria, decreasing loss of glucose and salts*
two from
support treatment
there is a difference between antibiotic and no antibiotic treatment **or** fast(er) decrease in volume of diarrhoea with antibiotics / AW **or** (generally) faster recovery with antibiotics ; **I** *ref. to* one dose 2 g use of Fig. 4.3 to support ;
e.g.
use (1 dose) 1 g or multiple dose
time, to recover / reach 0 dm^3, is halved
use of numerical data from Fig. 4.3
does not support treatment
(in all cases) volume decreased to, same level / zero **or** all patients recovered ;
use of Fig. 4.3 to support ;
e.g.
by 128 hours all patients 0 dm^3
one dose of 2 g same trend from 112 hours as no antibiotic
one dose of 2 g patients relapse after 64 hours
one dose of 2 g took 128 hours (for recovery)
not able to say
limited information available / small number of patients ;
ref. to one dose of 2 g antibiotic ; e.g. does not reach 0 dm^3 until same time as no antibiotic
also see arguments above – allow once only here or for does not support

(f) *answer may be from point of view of single dose or multiple dose*
allow AW – note mp 3 is for starting with susceptible bacteria and mp 4 is for starting with resistant bacteria

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penalise once if use virus throughout

	single dose	multiple dose	
1	easier to be sure patient has taken complete dose	course may not be completed	;
2	if (bacteria are all susceptible and) treatment completed, all bacteria killed / no reservoir of bacteria	treatment may not be completed so some (susceptible) bacteria survive	;
3	(susceptible so) no bacteria survive to, mutate / become resistant	(bacteria replicating so) increased chance of, mutation / becoming resistant	;
4	*idea that* (if resistance is already present) single stronger dose has greater chance of killing resistant bacteria	weaker dose spread over time, resistant bacteria, more likely to survive / have less chance of being killed	;
5	(if all killed with single dose) *idea that* resistance not transferred (if all killed) e.g. no vertical / horizontal, transmission *this could be suggested as follow up to mp 2 / 4*	if resistant / if develop resistance, this could be transferred **A** vertical / horizontal, resistance	;
6	AVP e.g. one dose may mean, no / less, antibiotic enters environment (in faeces) (more effective so) bacteria passed out for shorter time, so reduces risk of transmission (of pathogen) *idea that* multiple low dose antibiotics may increase mutagenesis *suggestion that* if resistant and not killed by antibiotic, there may be less of an effect on (good) gut bacteria with single dose		;

[19]

(g) *three from*
1 *ref. to* different antigens (in context of, flagellum / whole cell / toxin) ;
A *ref. to* epitopes instead of antigens
2 specificity ; *in correct context (B-lymphocytes / plasma cells / antibodies /antigen binding sites)*
3 detail of B-lymphocytes ; e.g. specific B-lymphocytes activated (by each different antigen)
A clonal selection form
plasma cells that release specific antibody, **A** B-lymphocytes release specific antibody
4 detail of antibody ; **I** *ref. to* receptor
e.g. antibody complementary (shape) to antigen, antigen binding sites on antibody, variable regions different for each antibody

(h) passive natural / natural passive ;

27. O/N 17/P21/Q3

(a) (i) B-lymphocyte / plasma cell ;
A B-cell / white blood cell / lymphocyte / leucocyte / **R** beta / β, cells
R T-lymphocyte / macrophage / neutrophil

(ii) *three from* **I** ref. to receptor
1 antibody complementary (shape) to antigen ; **I** matching shape
2 *idea that* variable regions different for each antibody ;
3 (specific) antigen / H / N, binding sites (on antibody) ;
if mp 2 and 3 not gained, allow one mark for antigen binding regions
4 sequence of amino acids / primary structure, varies between antibodies / gives specificity;
5 *ref. to* difference in, primary structure / amino acid sequence, leading to different, tertiary structure / 3-D shape ;
6 *ref. to* R group interactions between antibody and antigen ;

(b) (i) *Vibrio cholerae* ; **I** bacterium

(ii) faecal–oral route ;;
if mode of transmission not named, allow description
infected person
faeces / sewage, contaminates, (drinking) water / cooking utensils / vegetable plots / crops / food **A** diarrhoea *for faeces* **R** (human) waste unqualified

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or
ref. to houseflies landing on contaminated faces ;
uninfected person
eating contaminated food / using contaminated utensils / drinking contaminated water ;
A bacteria enters water in context of drinking **R** infected food or water **I** handling contaminated food
need ref. to contaminated once only

(c) (i) cell wall, breaks / damaged / AW **A** cell wall becomes thinner
or
cell wall weakened ;
plus one from
detail of change to cell wall e.g. cross links break down, quantity of murein / peptidoglycan, decreases
or
cell membrane, breaks / AW
or
increase in water in cell (so increase in turgor pressure) / AW ;

(ii) *two from*
infect only, *V. cholerae* / cholera bacteria AW
or
do not, infect human cells / infect humans ; **A** do not harm human cells
do not give side effects / allergic responses, (to humans) ;
able to replicate inside *V. cholerae* (to produce more bacteriophage for treatment) ;
ref. to remaining, active / infective / AW, with delivery method used / within gut ;

(iii) *antibiotics*
only effective against bacteria / not effective against viruses
or
do not act on structures possessed by, (measles) virus / *Morbillivirus* **A** named structure e.g. protein coat
or
act on structures that viruses do not have **A** named structure e.g. murein cell wall
or
only act on, living / growing, cells
or
may not be able to reach virus inside (host) cell ; AW [12]

28. O/N 17/P23/Q4

(a) (i) *Plasmodium* , *ovale* / *falciparum* / *malariae* / *vivax* ;

(ii) *Anopheles* / anopheline ;

(b) *either*
1 numbers of cases have decreased in, all countries / Africa
or
number of deaths have decreased in, all countries / Africa ;
2 cases in Africa as a percentage of all countries decreases and, remains constant / reaches a plateau / (small) fluctuations / down + up + down ;
3 deaths in Africa as a percentage of all countries, remains constant / fluctuates (a little) ;

(c) *three from*
1 example of control of breeding of, vector / mosquitoes ;
e.g. drainage of stagnant water / sterile males / aerial spraying of insecticide / oil on water / fish in water / *ref. to* bacteria
2 example of reduction of contact between vector and humans ;
e.g. bed nets (impregnated with insecticide) / insect repellents

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3 earlier, identification of cases / treatment of malaria ;
4 use of (new) drugs to, prevent transmission / prevent spread / treat malaria ;
A development of new drugs for malaria
5 better, awareness of / education about, transmission / control methods ;
6 AVP ; e.g. targeting people at risk (e.g. pregnant women / high drug-resistant areas
better screening of blood for transfusion
I *better access to, healthcare /AW, without further qualification*

(d) **A** mosquito for *Anopheles*
four from
1 no vaccine ; **A** no effective vaccine
2 any problem in developing a vaccine ;
e.g. *Plasmodium* is eukaryotic / antigens differ in different life stages / intracellular parasite / antigenic concealment / different stages in life cycle
3 drug resistance in *Plasmodium* ;
4 any example, e.g. chloroquine / artemisinins ;
5 insecticide resistance in *Anopheles* ;
6 any example, e.g. DDT / dieldrin / pyrethroids ;
7 *ref. to* conditions for breeding of *Anopheles* ;
8 problems with, funding research / AW ;
9 cost of, drugs / insecticides, to government / health authorities / individuals ;
10 people with HIV / AIDS are at high(er) risk than others ;
11 lack of knowledge / lack of education / 'fatalism' / AW ;
12 inaccessibility of some regions to healthcare ;
13 infected people not, identified / diagnosed ;
14 AVP ;
e.g. migration of people with malaria to places without malaria (such as countries where it has been eliminated) [12]

29. M/J 17/P22/Q5/b,c,d

(a) *D = accept points from diagram*

1D recognition / AW / binding / attachment, (of macrophage) to, bacterium / *S. pneumoniae* / (bacterial) antigen ;
A detects / identifies
(D) must label, bacteria / S. pneumoniae, or macrophage and show bacterium attached

2 endocytosis / phagocytosis ;

3D described ; e.g. engulfing / enveloping / pseudopodia surround phagocytic / endocytotic, vacuole formed **A** phagosome **A** vesicle

4D fusion of lysosome(s) (to vacuole) ; *(D) must label lysosome*

5D breakdown / destruction / digestion / AW, of bacterium / *S. pneumoniae* ;
A kills *(D) annotated on diagram*

6D *ref. to*, hydrolytic / digestive, enzymes ; **A** named digestive enzymes
must be in context of lysosome (D) labelled as such

(b) elastin broken down / elastic fibres damaged ;
A elastic fibres broken down
A less, elastin / elastic fibres
detail e.g.
(alveolar) wall becomes overstretched / AW
weakened (alveolar) wall / AW e.g. cannot withstand higher pressure
bursts on inhalation ;
(bronchioles collapse) on exhalation, trapped / remaining, air bursts alveoli

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(c) *accept (the) glycoprotein for GM-CSF throughout*

1 (excess surfactant) stimulates immune system cells ;
2 release / secretion, of, GM-CSF ; **I** produce
3 GM-CSF is a signal **or** GM-CSF is a signalling, molecule / protein / glycoprotein ; **A** messaging molecule
4 binds to / combines with / AW, (cell surface membrane) receptors (on alveolar macrophages);
5 *ref. to* specificity ;
A described as GM-CSF receptor complementary shape for GM-CSF
6 leads to / sets off / triggers / AW, response (in the cell) / removal of surfactant ;
in context of macrophage **A** stimulates
7 detail ; e.g. triggers secondary messenger
activates enzymes / enzyme cascade
signal transduction
phosphorylation events [9]

30. M/J 17/P21/Q6/a(i)

(a) (i) *Vibrio cholerae* ; [1]

31. M/J 17/P23/Q3

(a) *Mycobacterium tuberculosis / Mycobacterium bovis* ; *correct spelling*

(b) 1 deaths decrease to zero / new cases fall to 4 per 100 000, (in 2010) ;
A other values that confirm decrease
(after introduction of antibiotics)
2 deaths relatively constant / approx. 52 per 100 000, until 1943–6 (*accept any in range*) ;
A for a few years
A *idea that* rate of decrease not improved
3 number of new cases initially stops increasing / plateaus ;
4 (overall) number of new cases increases before decreases ;
5 data to support mp 3 or 4 ; e.g. 88–90 per 100 000 (1940–44) rises to / drops from, 104 per 100 000 in 1946 ;
(after introduction of vaccination)
6 no change in trend of decrease in deaths / deaths continue to decrease ;
7 decrease from 36–40 per 100 000 (in 1948) ;
8 short plateau / 100 per 100 000 (until 1950), in new cases, then decreases ;
9 antibiotics may not have been in widespread use at first ; **ora**
10 vaccine, reduces spread / gives (herd) immunity ;
11 *ref. to* decrease less steep initially as time needed to build up herd immunity ;
12 AVP ; e.g. suggestion why increase in new cases after introduction of antibiotics
suggestion why cases have not decreased to zero
not possible to tell relative effect of vaccine v antibiotic

(c) some people who are HIV+ will have developed HIV / AIDS ;
HIV / AIDS weakens immune, system / response ; **ora**
allow **ecf** *for HIV+ people*
detail of why immune response weakened ;
people with HIV / AIDS, prone to opportunistic diseases ;
A TB is an opportunistic disease
A more susceptible to, diseases / TB
(Table 3.1 shows that) a greater proportion / AW, people die of TB if they are HIV+ ;
AW e.g. greater chance of dying from TB if HIV+

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dormant TB more likely to become the active form in, HIV+ people / people with HIV / AIDS ; AW

AVP ; a high proportion of deaths from HIV / AIDs is due to TB mortality
HIV+ people do not respond well to treatment for life-threatening diseases
inability to pay for treatment for all conditions for HIV+ people [9]

32. O/N 16/P22/Q5

(a) (i) *non-infectious to max 1*
not caused by a pathogen ; **A**
not, communicable / transmissible ; **A** not passed from one living, organism / person, to another AW
disease to max 1
R *if in context of an infectious disease*
abnormal condition (affecting an organism) / condition that reduces the effectiveness of the functions of the organism / lack of good health / AW ;

(ii) *four from*
1 *ref. to* mutation ;
2 further detail ; e.g.
change in sequence of, nucleotides / bases, of, DNA / gene
tumour suppressor gene, switched off / stops functioning / alters / AW
formation of oncogene
proto-oncogene altered
3 uncontrolled, mitosis / cell division / cell replication ; AW
4 *ref. to* changes to checkpoints / coordination of cell cycle lost ;
A cell does not, receive / respond to, signals (to stop dividing)
5 loss of function / lack of differentiation / lack of specialisation / AW ;
allow loss of function idea if referring to the mass of cells
6 other detail of, tumour cell / cellular changes ;
e.g. immortal / no apoptosis / no programmed cell death
no contact inhibition / grows to invade healthy tissue / AW
more protein synthesised (for growth)
(release cell signalling molecules for) vascularisation / blood vessel formation
changed size compared to normal cell size
telomeres do not shorten / AW

(b) (i) **A** = protoctist ; **A** protoctista, protist(a), protozoa(n), sporozoa(n)
B = bacterium ; **A** bacteria

(ii) aerosol infection / droplet infection ; **A** described **A** airborne droplets
A direct contact ; **A** *description in this context,* e.g. body contact

(iii) smallpox ;

(iv) *Morbillivirus* ;

(c) *three from*
1 vaccination, gives (active) immunity / stimulates an immune response ;
must be in context of active artificial immunity
2 detail ; e.g. primary immune response
clonal, selection / expansion (specific, B / T, lymphocytes)
formation of antibodies
formation of memory cells
artificial active (immunity)
3 secondary (immune) response, when, pathogen / antigen, present
or

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presence of antigen / pathogen, gives, faster response / higher antibody production / AW ; **R** disease (for antigen / pathogen)

4 (effects of vaccination / immunity) long-lived / AW ;
A memory cells remain (in circulation) for a long time

5 herd effect ;

6 explained ; e.g. sufficient, (successfully) vaccinated / immune, so, susceptible / non-vaccinated, people protected

7 stops the transmission cycle ;
A less people with disease so reduces spread

8 AVP ; *ref. to* ring vaccination [14]

33. O/N 16/P21/Q4/a,c

(a) (i) *Vibrio cholerae* ;

(ii) **R** if other modes of transmission listed
ref. to 'infected' and 'uninfected' not required (as in question) but statements must be in correct context

I polluted water

one mark for infected person
passed in, faeces / stools / sewage ; **R** waste, unqualified

one mark for uninfected person
ingests / eats, contaminated, food / crops
or
drinks / ingests, contaminated, water / liquids ;
A uses utensils washed in contaminated water / AW

if above 2 mps not gained, one mark for
idea of (infected person) sharing drinking bottles / utensils (with uninfected person)

two marks for
faecal-oral, route / transmission ;;

(iii) **A** poor sanitation *once only for mp 1 or 3*
two from
1 damage to, sewers / drains / foul water systems ;
2 (so) mixing of sewage and drinking water ;
3 (contaminated) water supplies cannot be treated ;
A water (for drinking) from untreated (contaminated) sources
4 *ref. to* spread by flies exposed to, contaminated faeces / untreated sewage ;
5 *idea of* people in high density temporary accommodation facilitating spread ;
6 unable to practice good hygiene ; **A** examples e.g. lack of soap
restrictions on (treated) water for cleaning
7 unable to thoroughly cook foods ;
8 need to share (contaminated) water containers / cooking pots / AW ;
9 disruption to health care facilities / AW ; **A** example
e.g. lack of ORT (so higher proportion of infected people)
10 AVP ; e.g. increased risk of malnutrition linked to increased risk of disease

(b) *four from*
1 risk of, further spread / wider epidemic, (from people still infected) ; AW
2 reduces chance of succesful treatment / higher death rates ;
3 increased, treatment / hospitalisation times ; **A** takes longer to treat
A more complex treatment
4 increased costs of treatment / strain on health budget / AW ;
5 risk of, further resistance / resistance to all antibiotics ;
6 fewer antibiotics left that are effective ;

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A risk that no antibiotics will be left to successfully treat

7 need to find, new antibiotics / alternative treatment ;
A difficulty in finding new treatments / AW

8 (so) cost of research ; *allow cost once*

9 AVP ; e.g. strain on, resources / health personnel, to treat other diseases
need to identify type of resistance so that effective treatment is given
education, qualified [9]

34. O/N 16/P23/Q6

(a) *Morbillivirus* ; **A** *Morbilivirus / Morbili virus / morbillivirus*

(b) *three from*

1 number of cases fluctuates (between 2008 to 2012 / in all years) ;
2 number of cases (much) higher in 2010 ;
3 epidemic lasted longer in 2010 ;
4 highest peak is 42 000 – 43 000 in 2010 ; **R** 45 000 **A** 30 000 – 35 000 in Africa
5 numbers are higher at beginning of each year (than at end) ;
6 five, outbreaks / peaks / epidemics / AW ; **A** four as no data before Jan 2008
7 numbers of cases in rest of world are greater than in Africa in every year except 2010 ; **ora** numbers of cases in Africa were less than in the rest of the world in every year except 2010

(c) **I** *the term primary immune response*
I *any ref. to, T cytotoxic / T killer cells*
four from

1 antigen presentation ;
2 clonal selection / described ;
3 clonal expansion / described ;
4 B-lymphocytes / B cells, develop / AW, into plasma cells ;
5 plasma cells, secrete / produce / AW, antibody ;
6 any correct ref. to T helper cells ;

(d) **I** virus mutates / different strains *(as one vaccine is effective)*
two from

1 measles introduced by people who caught the disease when abroad ;
A any e.g. tourists / visitors / travellers / returning tourists / migrants / displaced people
2 *idea that* herd immunity, needs to be >90% / is not 100% ;
A herd immunity not achieved
3 some people in these countries have not been vaccinated ;
A too young to receive vaccine / refusal of vaccination / live in remote places / war zones / AW ;
4 some people do not respond to the vaccine ; **A** people have weak immune system / malnutrition
5 some people do not receive booster(s) ;
6 (reconstituted) vaccine is not thermostable / difficult to maintain the cold chain ; [10]

35. M/J 16/P22/Q3/a

(a) (i) 1179 ;;

one mark *if not to the whole person e.g. 1179.24 / 1179.2* **or**
if calculation correct but answer incorrect
e.g. 1.39 × 848.38 **or** 1.39 × (84 838 000/100 000) **or**
if no calculation to check but answer given as 1180

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(ii) **1** provides information about / AW, proportion / percentage, (of population) affected / AW ;

2 to, make (valid) comparisons / compare ; *between countries / in one country over time*

3 provides information about severity of disease ; AW

4 population size, taken into account / different for different countries / changes over time in a country ;
do not need 'size' if 'use of 'population' is in correct context

5 *idea that* countries with larger populations will usually have more cases / higher number of cases may just mean larger population of country;

6 AVP ; gives guidance about whether the disease is, spreading / becoming an epidemic / dying out (in one country) *in context of over time*
idea that number of cases per 100 000 are, standardised / normalised, values

7 use of data to support ; *only two of Chad, Eritrea or Ethiopia where comparisons between countries stated* I *ref. to* other countries

(2009) actual cases and standardised cases

comparison (2009) to support mp 5 population size and actual cases

stated values of similar number of cases per 100 000 and populations of different sizes

countries compared, number of cases per 100 000 for any stated year, with comment about severity

number of cases per 100 000 for one country over time, with comment about severity / spreading / dying out / control / AW [5]

36. M/J 16/P21/Q1

must have correct spellings of Plasmodium *and* Vibrio cholera

feature	malaria	tuberculosis	cholera
name of pathogen	*Plasmodium* ;	*Mycobacterium tuberculosis*	*Vibrio cholerae* ;
type of organism	protoctist / protoctistan ; **A** protist / protozoan / sporozoan	bacterium	bacterium ; **A** bacteria
mode of transmission	by, a vector **or** (feeding or biting by) *Anopheles* / mosquito ;	via, (airborne) droplets / aerosol(s) (infection) ;	drinking water and food contaminated with human faeces

[6]

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37. M/J 16/P23/Q5/d

(a) *points can be general or TB specific*

1 prescribing / take, antibiotics, only when (absolutely) necessary ;
2 ensure, correct / effective, antibiotic(s) prescribed / used ;
3 complete course / follow instructions for use, of antibiotics ; **A** *ref. to* DOTS
4 patients to, use only antibiotics prescribed / not use leftover antibiotics at a later date / AW ;
5 *ref. to* monitoring situation to check if antibiotic is effective ;
6 use other antibacterials ;
7 develop new, drugs / antibiotics ;
8 ensure / improve, knowledge of, healthcare professionals / public ; AW
9 reduce / control, antibiotics in, agriculture / animals used for food ;
10 reporting patterns of antibiotic resistance / AW ;
11 *ref. to* breaking transmission cycle / described example ; e.g. vaccines good hygiene in hospitals
12 break transmission cycle of resistant bacteria ; e.g. quarantine
13 AVP ; e.g. WHO Global Plan Stop TB
14 *further detail of mp1 or mp2* ; e.g. only prescribe wide-spectrum antibiotics when narrow spectrum not known [3]

38. O/N 15/P22/Q5/a,b,c

(a) *assume response refers to infectious unless otherwise stated*
caused by a pathogen ; **ora A** microorganism / microbe
transmissible / communicable / passed from one, organism / person, to another ; **ora**
examples to support explanation
two examples of pathogen types ; *two of:*
bacterium / bacteria
virus / viruses
fungus / fungi
protoctist **A** protozoa
example of non-infectious, disease / category ;
e.g. genetic disorders / named (e.g. sickle cell anaemia / cystic fibrosis)
cancer / named cancer (e.g. lung)
degenerative disease / named (e.g. chronic bronchitis, emphysema / COPD / coronary heart disease) lifestyle / AW

(b) (red blood cells contain) haemoglobin ;
plasma proteins ; **A** plasma contains proteins
named protein in blood plasma or within (red / white) cells ;
e.g. fibrinogen / albumin / globulin / antibodies / (protein) hormone / enzyme / transport proteins / membrane proteins
R steroid hormone / named steroid hormone

(c) (i) not all countries with *Anopheles* have malaria / example using Fig. 5.2 ;
e.g. (although, Anopheles / vector, shown as present),
no / few, cases (of malaria) in, North America / Europe
(although, *Anopheles* / vector, occurs elsewhere) malaria, only / mainly, in subtropical and tropical areas ;
explanations:
Plasmodium / parasite / pathogen, not present in all areas where *Anopheles* is located / AW ;
conditions (where *Anopheles* located) not always suitable for life cycle of, *Plasmodium* / parasite / pathogen ;
some, areas / countries, have eradicated the disease (but still have the vector) ;

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AVP ; e.g. some countries have better prevention methods against malaria
AVP ; some countries have effective treatment for malaria
I vaccination

(ii) *assume ref. to A. gambiae unless stated otherwise*
occurrence
1 (in Africa) wide distribution / large numbers ;
2 occurs where high density of humans ;
3 occurs (in climate) where *Plasmodium* is, present / able to survive ; AW
A e.g. *idea of* Plasmodium requiring temperatures above approx. 20 °C where *A. gambiae* is also present
well adapted **or** *better adapted than other mosquito vectors*
4 better adapted to complete life cycle / lays eggs in large variety of habitats / can withstand (more) polluted waters / larvae able to eat a wide variety of food ;
5 short(er) life cycle / long(er) breeding season ; **A** reproduces quickly
6 withstands, dry / drier, conditions / larger temperature variation / higher temperatures ; **I** better adapted to climate
7 (more) resistant to, pesticides / insecticides ; **R** immune
feeding
8 feed mainly / AW, on human blood ;
9 takes, large(r) / more frequent, blood meals ;
10 takes blood meal / bites / feeds, at night (when humans less able to notice) ;
11 mouthparts, well adapted for feeding on humans / can penetrate clothing;
as host for Plasmodium
12 good host for / very susceptible to, parasite / *Plasmodium* ;
AVP ; e.g. able to migrate to find hosts
quick to adapt to changing human habitation
better adapted to find (human) hosts
females live for longer
A. gambiae present in Africa, where, malaria control is difficult [10]

39. O/N 15/P21/Q5/a,b,c,d

(a) Morbillivirus ;

(b) *must have one ref. to either infected or uninfected to gain max*
aerosol, infection / route ; **A** droplet infection **I** *ref. to* contact
infected person, sneezes / coughs / talks / spits, to release airborne droplets;
inhaled by, uninfected / healthy, person ;

(c) RNA nucleotides ;
contains uracil ; **A** no thymine
ribose (instead of deoxyribose) ;
no (double) helical structure ;
AVP ; e.g. small enough to pass through nuclear pores ;

(d) cell has no enzyme for RNA replication ;
ref. to enzyme specificity ;
RNA polymerase (in cell) uses DNA template / not RNA template / AW ; [7]

40. O/N 15/P23/Q3/c

(a) 1 increased, metabolic rate / protein metabolism (after feeding) means, increased / more, hydrogen peroxide (produced) ;
2 *idea that* less effective, catalase / **Q**, means, more hydrogen peroxide remains / less hydrogen peroxide broken down ; **ora**

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more hydrogen peroxide from increased metabolism is broken down faster in ***P*** *= 2 marks*

3 hydrogen peroxide, interferes with / is damaging to / AW, egg production ;

4 AVP ;

I *ref. to* oxygen production and use in aerobic respiration [2]

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Unit 11

IMMUNITY

A Level
Biology Paper 2
Topical Workbook
Article Number: 212

Editorial Board

Syllabus

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Unit 11: Immunity

1. **M/J 22/P21/Q2**
B-lymphocytes are activated to form plasma cells during immune responses.
Fig. 2.1 is a drawing of a plasma cell made from a transmission electron micrograph.

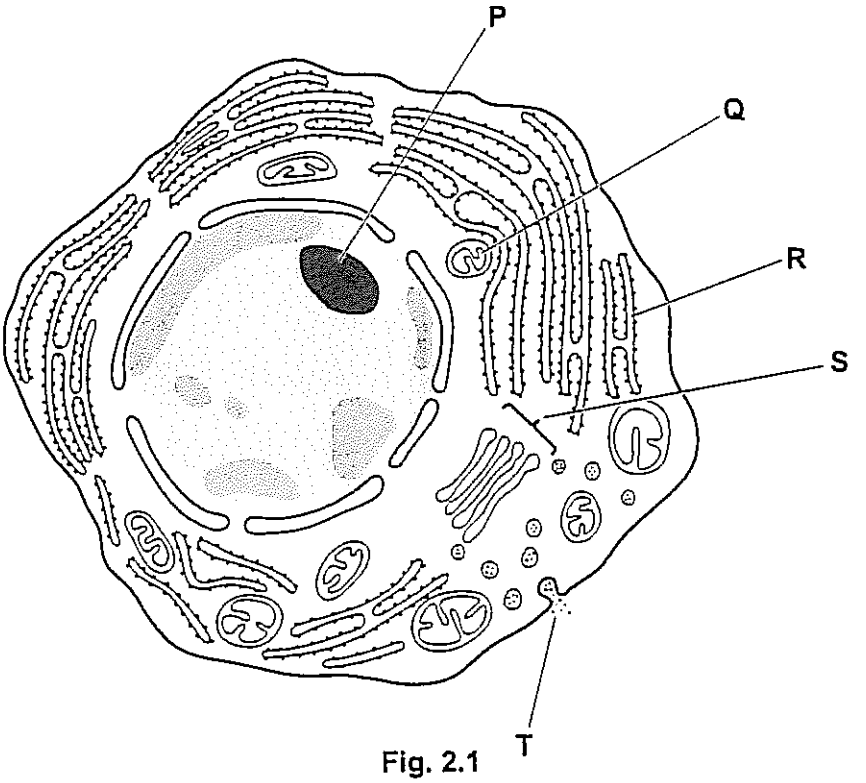


Fig. 2.1

(a) (i) State the name of the process that is occurring at **T**.

..... [1]

(ii) Complete Table 2.1 to show the names and functions of the cell structures labelled **P**, **Q**, **R** and **S** in the plasma cell shown in Fig. 2.1.

Table 2.1

cell structure in Fig. 2.1	name of cell structure	function of cell structure in plasma cell
P		
Q		
R		
S		

[4]

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(b) Plasma cells can be used in the commercial production of some monoclonal antibodies. The method of production is known as the hybridoma method.
Outline the steps in the production of monoclonal antibodies by the hybridoma method.

.....

.....

..... [3]

(c) Antibodies can be collected from human blood donors and used to treat people that may have been infected with a pathogen. This prevents them becoming ill with the disease.
Explain why this treatment does not prevent people becoming ill if they are infected again with the same pathogen.

.....

.....

.....

..... [4]

2. M/J 22/P23/Q4

There are many different forms of *Vibrio cholerae*, a bacterium that is found naturally in aquatic environments. The bacterium is motile (can move) and uses a cell structure known as a flagellum to allow it to move through water.
Fig. 4.1 is a drawing of four cells of one form of *V. cholerae*.

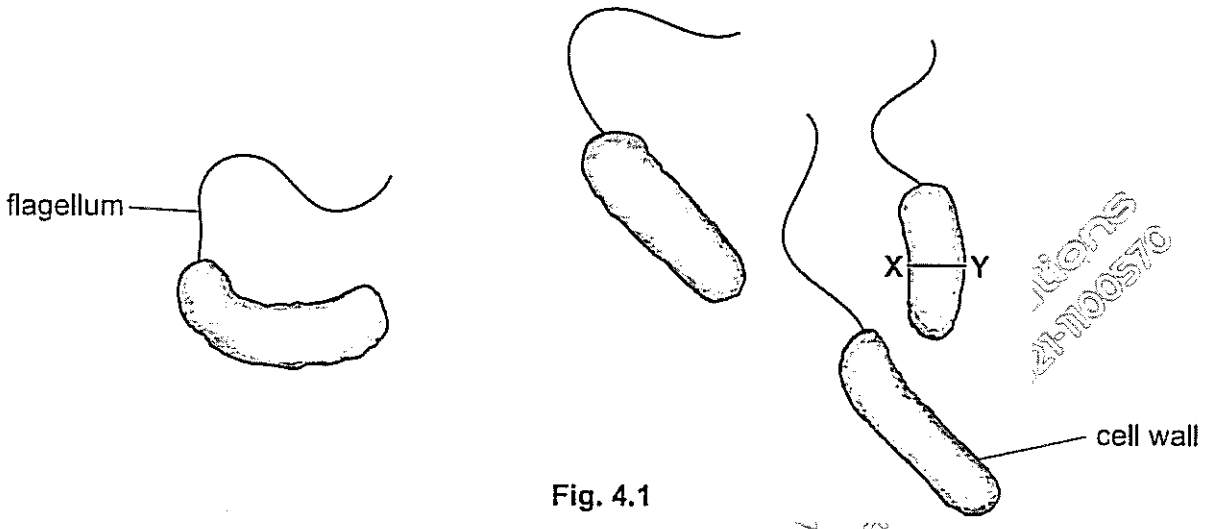


Fig. 4.1

Two main forms of *V. cholerae*, O1 and O139, are able to colonise the small intestine and cause cholera. These two forms are able to produce a toxin, choleragen, which causes the symptoms of diarrhoeal disease. Mutant *V. cholerae* that lack flagella are less able to cause disease.

(a) The magnification of the diagram shown in Fig. 4.1 is ×32 000.
Calculate the actual width **X–Y** in Fig. 4.1 in nanometres (nm) **and** give your answer to the nearest 10 nm.
Complete Fig. 4.2 to show the formula you will use to make your calculation.

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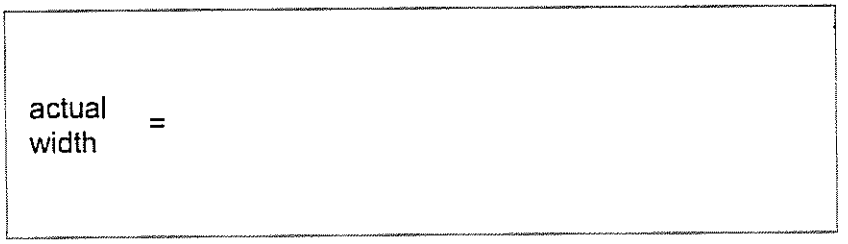


Fig. 4.2

answer = ... nm [2]

(b) State the term used to describe disease-causing organisms, such as the bacterium *V. cholerae*.

..... [1]

(c) Outline **one** way in which an uninfected person may become infected by *V. cholerae*.

..... [1]

(d) Choleragen is produced after *V. cholerae* has penetrated (passed through) the mucus lining and attached to intestinal epithelial cells.

Choleragen is composed of two subunits:

- subunit **A** consists of one polypeptide
- subunit **B** consists of five identical polypeptides
- the polypeptide in subunit **A** is different from the polypeptides in subunit **B**.

Two genes, *ctxA* and *ctxB*, are needed to produce choleragen. Only one strand of the DNA forming gene *ctxA* is involved in the production of subunit **A**. Only one strand of the DNA forming gene *ctxB* is involved in the production of subunit **B**.

Explain why only one strand of the DNA of each gene is involved in the production of the subunits.

.....

.....

..... [3]

Monoclonal antibodies (mAbs) can be designed to act against components of the cell wall of *V. cholerae*. The cell wall has an outer membrane with lipopolysaccharide (LPS) molecules, shown in Fig. 4.3.

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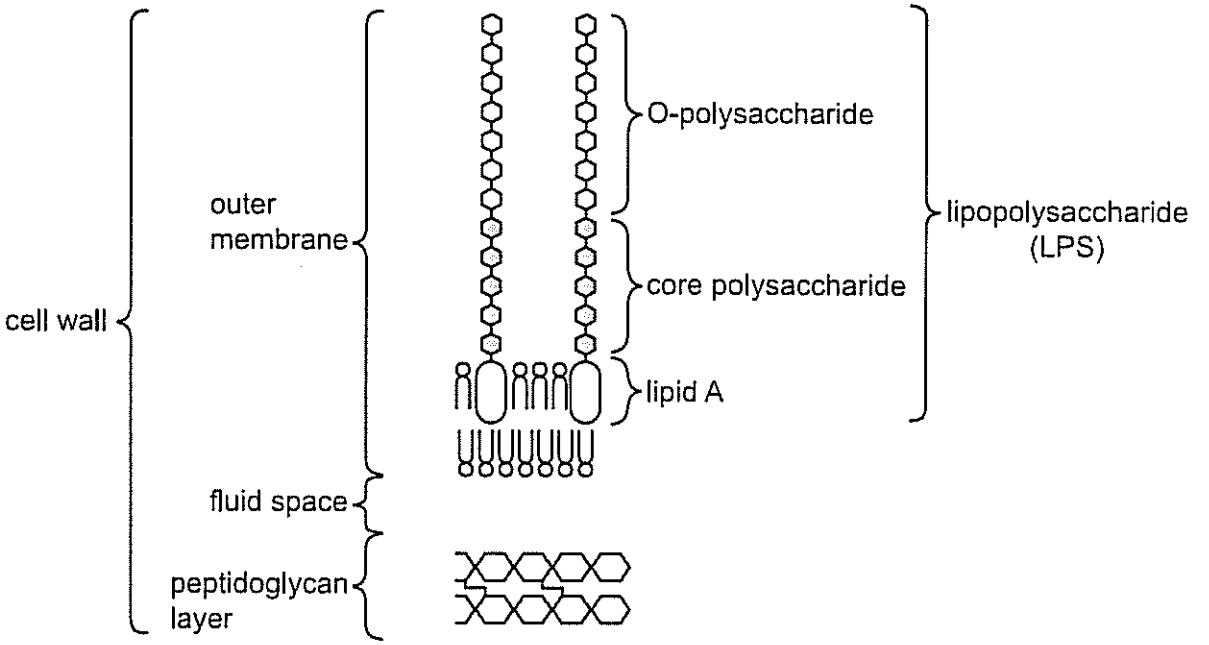


Fig. 4.3

The core polysaccharide and the lipid A components of the LPS molecules are the same in *V. cholerae* O1 and *V. cholerae* O139. However they have different O-polysaccharides.

There are also different types of *V. cholerae* O1 and these have different O-polysaccharides.

(e) Laboratory tests were carried out using two different monoclonal antibodies that had been designed and produced to act against the LPS of bacterial cultures of *V. cholerae* O1:

- mAb 2D6 acts against the O-polysaccharide
- mAb ZAC-3 acts against the core polysaccharide and lipid A components.

(i) Explain why the mAb ZAC-3 produced against the core polysaccharide and lipid A components will not act against the O-polysaccharide of the LPS molecules.

.....

..... [2]

(ii) The results of the tests showed that both mAbs were effective in causing agglutination (clumping) of bacteria and in preventing their motility. This suggests they may be useful for preventing cholera and for treating the disease.
Discuss whether mAb 2D6 and mAb ZAC-3 may be useful for preventing cholera **and** for treating the disease.

.....

.....

.....

..... [4]

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3. O/N 21/P22/Q5/d,e

The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(a) Smallpox is a disease that has been eradicated with the help of a global vaccination programme. Measles has not been eradicated, even though there is a global vaccination programme.

Fig. 5.2 is a graph showing the estimates of number of deaths from measles globally, between 2000 and 2017, for people who have **not** been vaccinated.

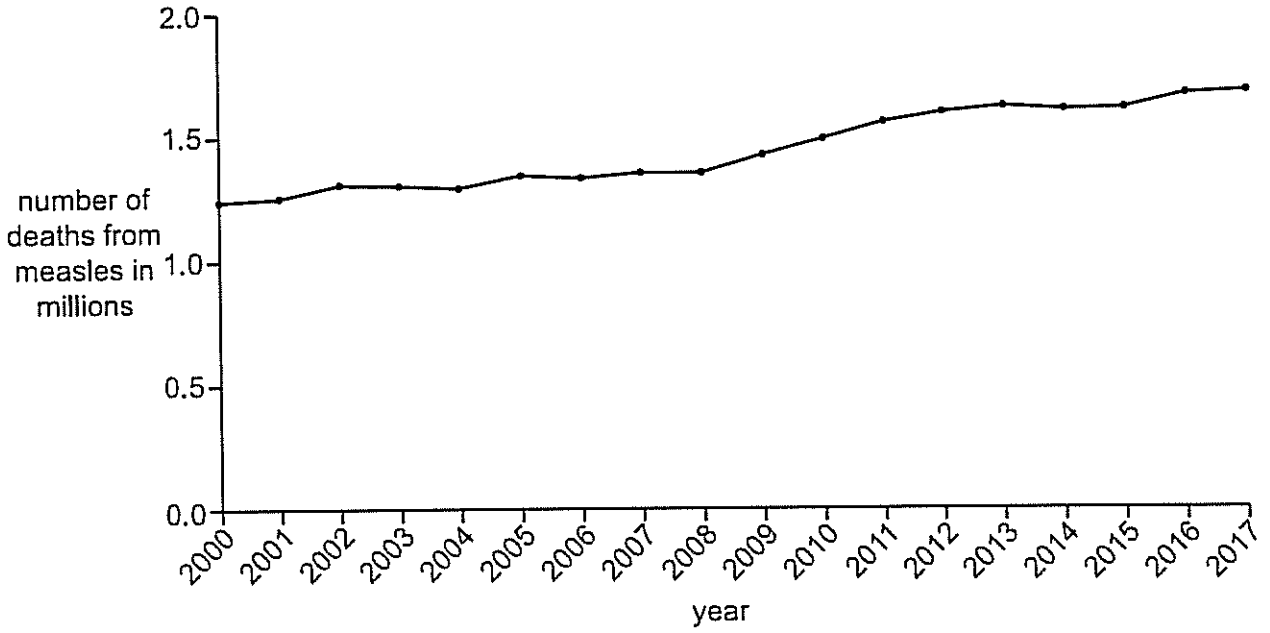


Fig. 5.2

(i) State the trend shown in Fig. 5.2 between 2000 and 2017.

..... [1]

(ii) Suggest reasons for the trend shown in Fig. 5.2.

.....

.....

..... [3]

(b) A child with leukaemia is at high risk of developing measles even though the child has a high white blood cell count **and** has been vaccinated against the disease.

Explain why this child is at high risk of developing measles.

.....

..... [2]

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4. O/N 21/P21/Q3/c

Cholera is an infectious disease caused by the bacterial pathogen *Vibrio cholerae*.

(a) Vaccination can be used to prevent the spread of cholera. The vaccine used contains part of the choleragen molecule and also contains dead cells of *V. cholerae*.

(i) Phagocytes play an important role in the immune response to a vaccine. Phagocytes contain many lysosomes.

Describe the function of lysosomes in phagocytes.

.....

..... [2]

(ii) Suggest the advantage of having a vaccine that includes dead cells of *V. cholerae* and part of the choleragen molecule.

.....

..... [2]

5. M/J 21/P22/Q6

The diseases myasthenia gravis (MG) and HIV/AIDS both involve disorders of the immune system.

(a) The cause of MG involves a response by B-lymphocytes.

Explain why MG is called a disorder of the immune system.

.....

..... [2]

(b) Studies have indicated that T-lymphocytes are involved in stimulating the B-lymphocyte response that causes MG.

Research has been carried out on a vaccine that will provide a person with **active immunity** against these T-lymphocytes and B-lymphocytes.

Suggest **and** explain how this vaccine will provide a person with active immunity against the T-lymphocytes and B-lymphocytes responsible for causing MG.

.....

.....

..... [3]

(c) Many people who are living with HIV (infected with HIV) develop tuberculosis (TB). If a person does not have any symptoms of TB, one preventive measure is to prescribe antibiotics. This reduces the overall number of cases of TB and deaths from TB.

State the **disadvantage** of prescribing antibiotics as a preventive measure against TB.

..... [1]

(d) Fig. 6.1 is a summary of some of the statistics published by UNAIDS (Joint United Nations Programme on HIV and AIDS) about HIV and HIV/AIDS for the year 2017.

The figures shown in Fig. 6.1 for 2017 are estimated.

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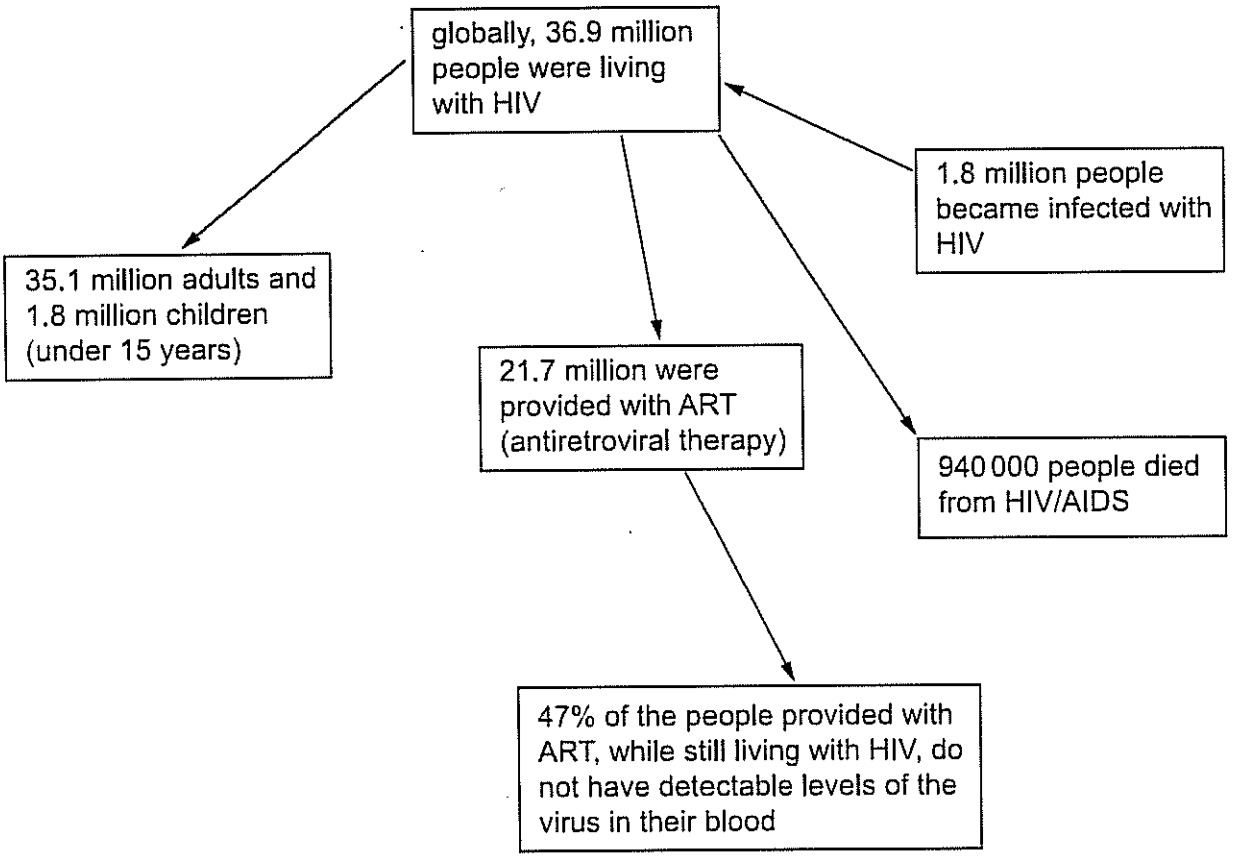


Fig. 6.1

One other statistic published by UNAIDS indicated that, in 2017, only 75% of the estimated 36.9 million people living with HIV knew that they had been infected with the virus.
With reference to the information in Fig. 6.1, discuss the importance of this statistic.

.....

.....

..... [3]

6. M/J 21/P23/Q2/e

Smallpox, measles and HIV/AIDS are infectious diseases caused by different viruses. These different viruses share some structural features.

(a) Smallpox is the only infectious disease of humans that has been globally eradicated. This eradication was due mainly to a successful global vaccination programme. Most people who were given the vaccine gained immunity to the disease.
A student correctly listed four reasons for the success of the global vaccination programme for smallpox. These reasons are listed in Fig. 2.1.

- The virus did not mutate.
- A live virus, closely related to the smallpox virus, was used in the vaccine.
- The vaccine was freeze-dried and so was thermostable (heat stable).
- The vaccine was easy to administer (give), so little training was required.

Fig. 2.1

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(i) Discuss how the reasons listed in Fig. 2.1 contributed to the success of the eradication of smallpox.

.....

.....

.....

..... [4]

(ii) Table 2.1 lists four types of immunity.
Complete each row of Table 2.1 with a tick (✓) or a cross (✗) to summarise the types of immunity gained by a person who received the smallpox vaccine.

Table 2.1

type of immunity	gained (✓) not gained (✗)
active immunity	
artificial immunity	
natural immunity	
passive immunity	

[1]

7. O/N 20/P22/Q4/c,d

In the immune system, a plasma cell develops from an activated B-lymphocyte. Mature plasma cells synthesise and secrete antibody molecules.

(a) Clonal expansion also results in the production of memory B-lymphocytes.
Explain the importance of clonal expansion **and** the production of memory B-lymphocytes in providing protection for a person against an infectious disease.

.....

.....

..... [3]

(b) Myasthenia gravis is an example of a disease where the immune system fails to distinguish between self and non-self.
Explain what is meant by this statement.

.....

..... [2]

8. O/N 20/P21/Q6/b

(a) Immunotherapy is a form of treatment for cancer which aims to stimulate the immune system to destroy tumour cells.
One form of immunotherapy for cancer uses a vaccine which contains one specific type of TSA.

(i) Describe how vaccination with a specific type of TSA could lead to the destruction of tumour cells by T-lymphocytes in the body.

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.....

.....

..... [3]

(ii) Vaccines that contain tumour cells instead of a TSA are being developed for use during immunotherapy. Tumour cells are removed from a patient's body and used in a vaccine for the patient.
Suggest **one** advantage and **one** disadvantage of using a patient's tumour cells in a vaccine rather than a TSA.

advantage .....

disadvantage ..... [2]

9. O/N 20/P21/Q4/b

(a) Viruses can infect plant cells.

(i) Outline the key structural features of a virus.

.....

..... [2]

(ii) Many plant viruses can travel through the plant to enter companion cells in the phloem tissue. The viruses then travel with assimilates in the phloem sap to other areas of the plant.
Explain the mechanism that allows assimilates and viruses to travel through phloem sieve tubes to other areas of the plant.

.....

.....

.....

.....

..... [5]

10. O/N 20/P23/Q4/b

Antibiotic sensitivity tests can be carried out to choose appropriate antibiotics to use for treatment of bacterial diseases.
A researcher carried out an antibiotic sensitivity test using two pathogenic bacteria, **X** and **Y**.
The researcher prepared two Petri dishes containing agar.

- A culture of each bacterium was spread over the surface of the agar.
- Filter paper discs containing antibiotics were placed on the surface of the agar in each dish.
- The Petri dishes were incubated at 25 °C for two days.

The results of the test using three antibiotics, **P**, **Q** and **R**, are shown in Fig. 4.1.

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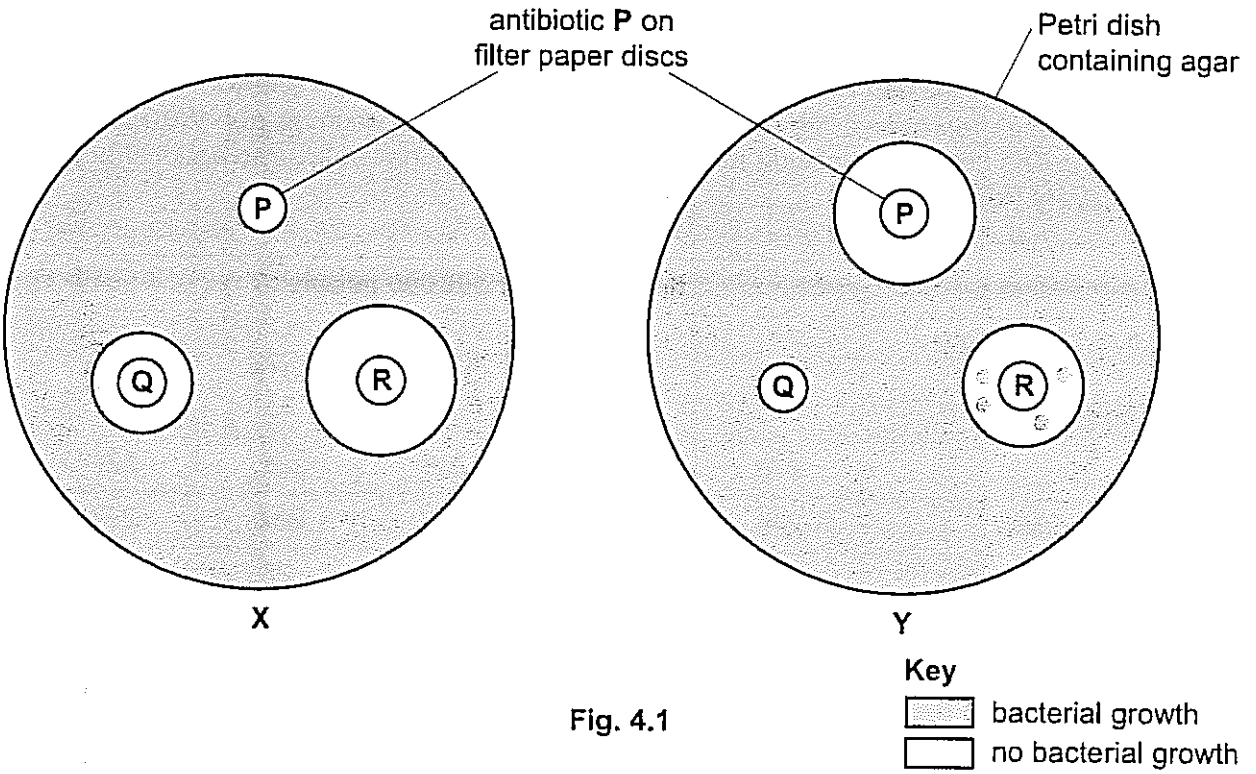


Fig. 4.1

(a) Explain how the use of vaccines in the control of infectious diseases differs from the use of antibiotics.

.....

.....

..... [3]

11. M/J 20/P22/Q3

The Bacillus Calmette-Guérin (BCG) vaccine is the only vaccine used to provide protection against the infectious bacterial disease tuberculosis (TB). Most countries of the world have a BCG vaccination programme.

(a) TB is most commonly transmitted from person to person by aerosol infection. The causative organism is present in airborne droplets.

Name the species of causative organism of TB commonly passed from person to person by aerosol infection.

..... [1]

(b) In general, the countries that do not have a BCG vaccination programme are high-income countries that have a low number of cases of TB. In most of these countries, the vaccine is given only to babies and children at high risk of developing TB.

Suggest **one** reason why a child in a country with a low number of cases of the disease could be at a high risk of developing TB.

..... [1]

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(c) Countries are classified by the World Bank into one of four income groups.

Table 3.1 shows the estimated incidence of TB for 2012 to 2016 for these income groups. The incidence represents the number of new cases of TB occurring per 100 000 people in one year. The new cases include the number of cases that have occurred again after a period of recovery (relapse TB).

Table 3.1

	incidence per 100 000 people				
year / income group	2012	2013	2014	2015	2016
low	253	244	238	231	224
lower middle	244	240	236	232	227
upper middle	84	81	78	76	74
high	14	13	13	12	12

Describe the patterns and trends shown in Table 3.1.

.....

.....

..... [3]

(d) There is evidence that the BCG vaccine has also provided protection against the disease leprosy.

Leprosy is caused by a bacterium that is closely related to the bacteria that cause TB.

Suggest why the BCG vaccine can also provide protection against leprosy.

.....

..... [2]

(e) A baby can gain artificial active immunity to TB after having the BCG vaccine. A baby can also gain natural passive immunity to TB.

State the differences between **artificial active** immunity and **natural passive** immunity.

.....

.....

..... [3]

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12. M/J 20/P22/Q6/c

The mitotic cell cycle in dividing cells is very carefully controlled.

(a) Vincristine has been used in the treatment of certain types of leukaemia.

Fig. 6.1 is a photomicrograph of a blood smear of a person with one form of leukaemia, which affects lymphocytes.

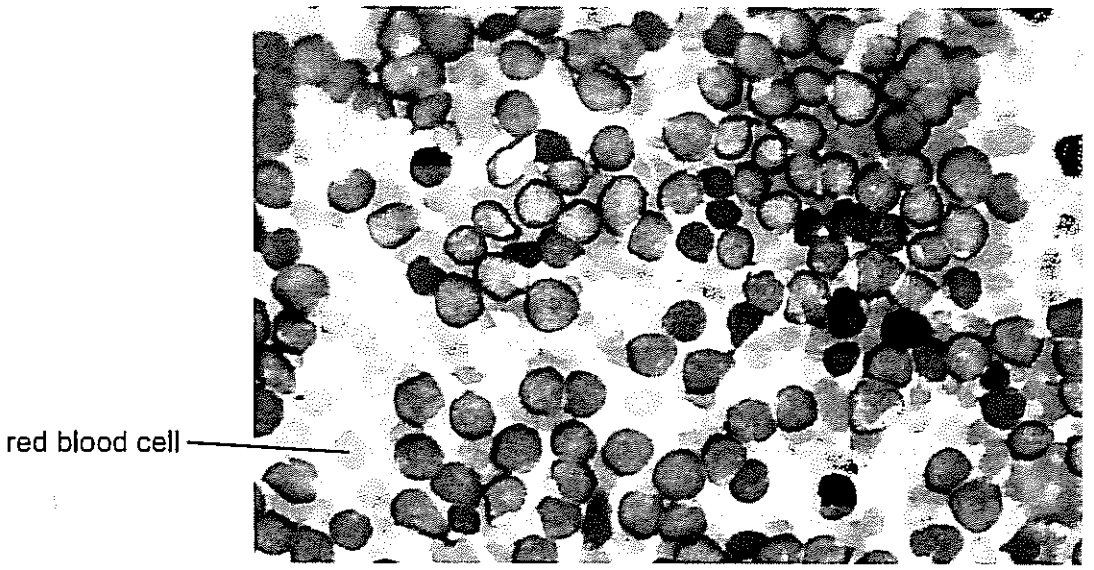


Fig. 6.1

Describe how:

- the blood smear shown in Fig. 6.1 differs from a blood smear of a healthy person
- the lymphocytes in a person with leukaemia, such as those shown in Fig. 6.1, differ from those of a healthy person.

blood smear differences .....

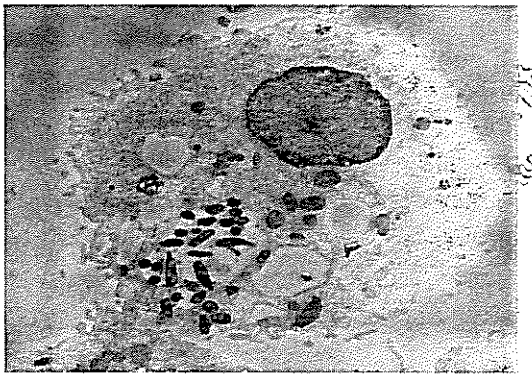
lymphocyte differences .....

..... [3]

13. M/J 20/P21/Q5/b,c,d

The vaccine used to control tuberculosis (TB) is known as Bacillus Calmette-Guérin (BCG). The vaccine contains live bacteria that have been selected so that they do not cause disease in humans.

Fig. 5.1 shows a macrophage that is in the process of engulfing the bacteria in the vaccine.



magnification ×4400

Fig. 5.1

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(a) Describe the events that occur in the body after the macrophage has engulfed the bacteria until the production of antibodies in response to the BCG vaccine.

.....

.....

.....

.....

..... [5]

(b) Vaccines, such as BCG, stimulate the formation of memory cells.
Explain the role of memory cells in the body's defence against the TB pathogen.

.....

.....

..... [3]

(c) Suggest why vaccination with BCG has not yet eradicated TB.

.....

.....

..... [3]

14. M/J 20/P23/Q2/c,d

In 2016, the highest number of cases of malaria and deaths caused by the disease were in sub-Saharan Africa. In many areas of sub-Saharan Africa, malaria is endemic (continually present) and people are at high risk of becoming infected with the *Plasmodium* pathogen.
In high risk areas it is recommended that:

- homes are provided with insecticide-treated nets (ITN)
- the surfaces inside homes where *Anopheles* mosquitoes may rest are sprayed with insecticide. This is known as indoor residual spraying (IRS).

(a) In a primary immune response, antibodies against *Plasmodium* are produced within one to two weeks following infection. In some people, the pathogen is eliminated and the concentration of antibodies in the circulation decreases over time.
Infection again by *Plasmodium* with the same antigens causes a secondary response that also involves antibody production.
State **and** explain how the antibody response following a second infection will differ from the primary immune response.

.....

.....

..... [3]

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(b) In malaria, the production of antibodies is beneficial to recovery, whereas in the disease myasthenia gravis the production of antibodies is harmful.
Explain why the production of antibodies in a person with myasthenia gravis is harmful.

.....

..... [2]

15. O/N 19/P22/Q5/e

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) 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.

.....

.....

.....

..... [4]

16. O/N 19/P21/Q5/a,b(i)

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.*

.....

..... [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.

.....

.....

..... [3]

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17. O/N 19/P23/Q5

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.

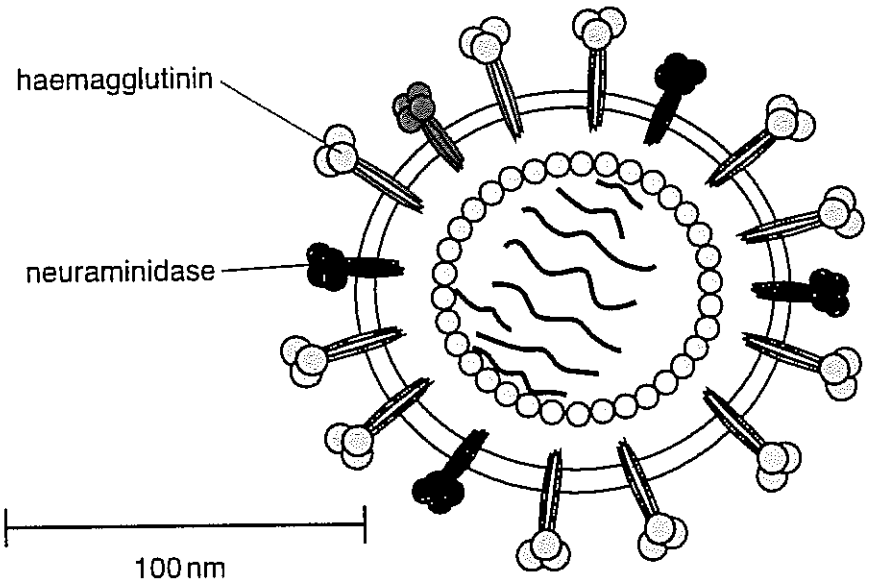


Fig. 5.1

(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.

.....

.....

..... [3]

(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.

.....

.....

..... [3]

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

1 .....

2 ..... [2]

18. M/J 19/P21/Q1/b

(a) Fig. 1.2 is a transmission electron micrograph of a hybridoma cell.

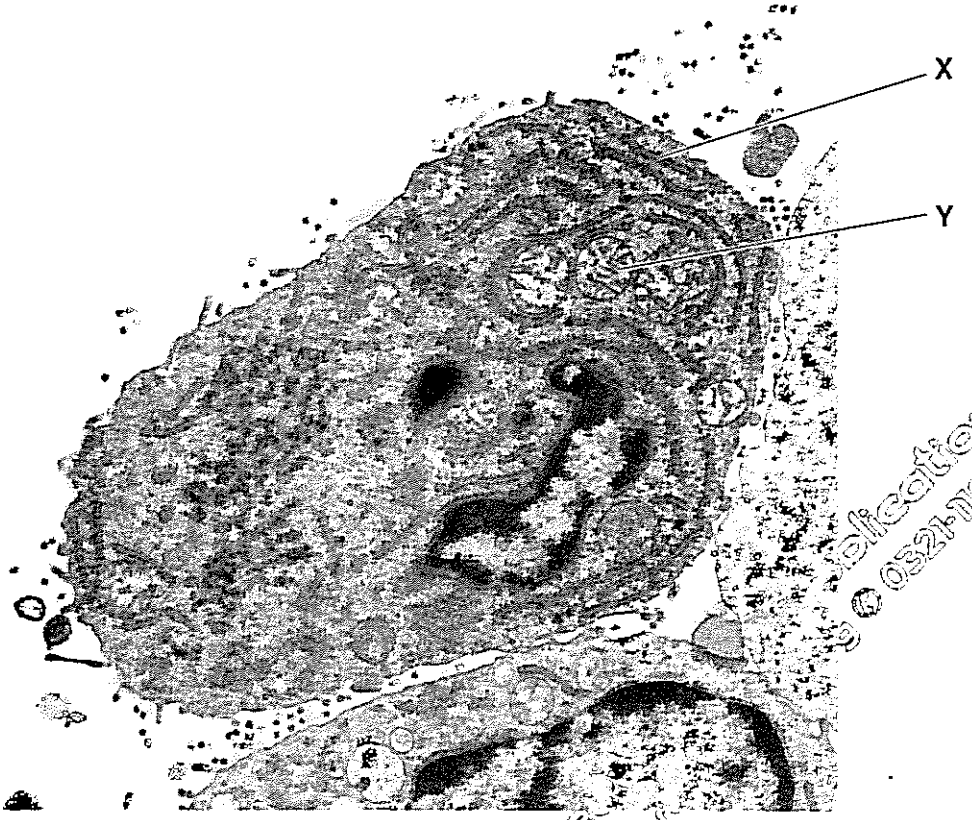


Fig. 1.2

(i) The hybridoma cell in Fig. 1.2 synthesises and secretes molecules of a monoclonal antibody.

State the roles of the structures labelled **X** and **Y** in the production of antibody molecules in the hybridoma cell.

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X .....

Y ..... [2]

(ii) The hybridoma method for the production of monoclonal antibodies involves a number of stages. One of these stages is the formation of hybridoma cells.

Outline the stage in which hybridoma cells are formed.

.....

.....

..... [3]

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

.....

.....

..... [3]

19. O/N 18/P21/Q4/b,c,d

(a) Some epithelial cells in the kidney release the protein vascular endothelial growth factor (VEGF). This protein is a cell signalling molecule that stimulates cell division in endothelial cells in blood vessels.

(i) State what occurs during interphase to prepare a cell for division.

.....

..... [2]

(ii) Explain how a cell signalling molecule, such as VEGF, can lead to a response in a cell.

.....

..... [2]

(b) Uncontrolled cell division may result in a tumour. Tumour cells in the kidney respond to VEGF. Kidney cancer can be treated with monoclonal antibodies. These monoclonal antibodies bind to VEGF.

Outline the hybridoma method for the production of monoclonal antibodies that will target the VEGF protein.

.....

.....

.....

..... [4]

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(c) Monoclonal antibodies used as a treatment need to be given more than once. Repeated treatment can cause side effects to the person or can become less effective.

Suggest why repeated treatment with monoclonal antibodies may have these effects.

..... [1]

20. M/J 18/P22/Q3/c(ii)

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*.

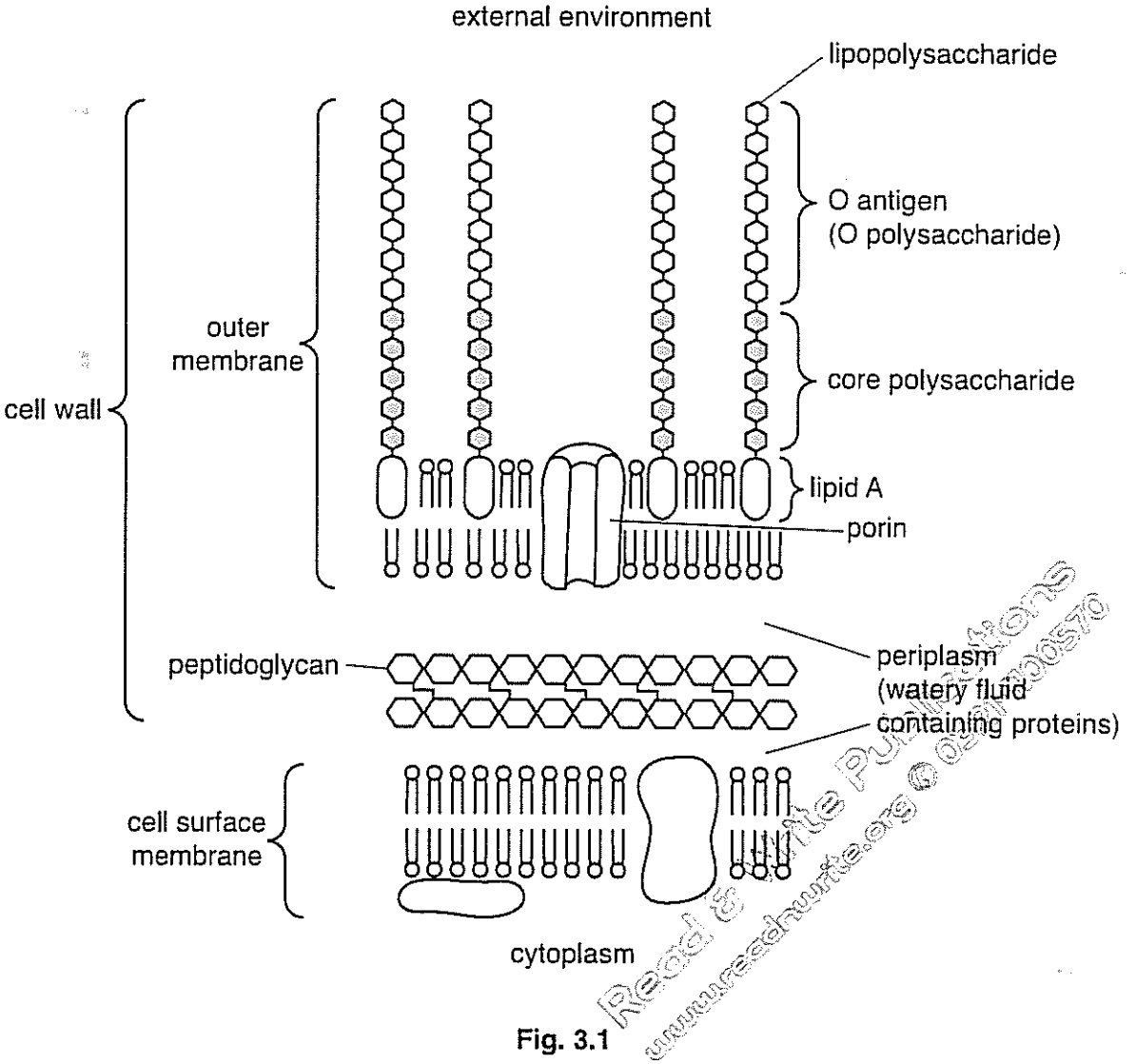


Fig. 3.1

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(a) 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) 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.

.....

.....

..... [3]

21. M/J 18/P21/Q5

(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.

.....

.....

.....

.....

..... [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.

.....

.....

..... [3]

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

.....

..... [2]

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22. M/J 17/P21/Q3

Fig. 3.1 is a diagram that shows the structure of an antibody molecule.

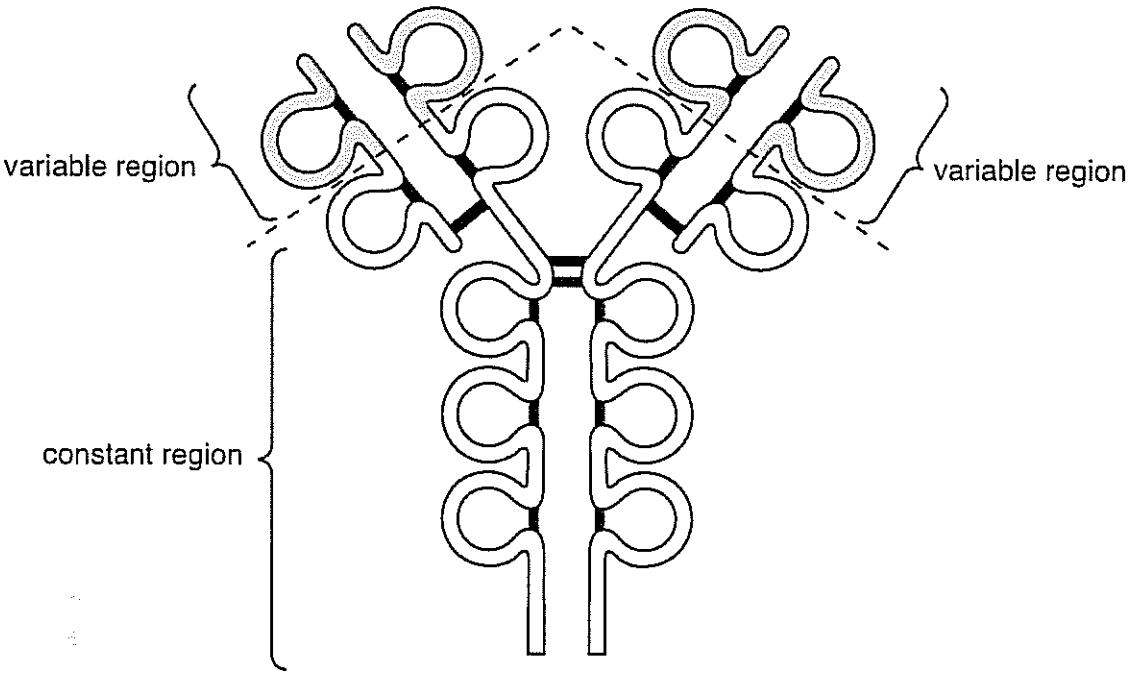


Fig. 3.1

(a) State why the antibody molecule shown in Fig. 3.1 has quaternary structure.

.....[1]

(b) (i) Use Fig. 3.1 to explain how the structure of the variable region of an antibody molecule is related to its function.

.....

.....

..... [3]

(ii) State the role of the constant region of an antibody.

.....[1]

(c) Monoclonal antibodies are used both in diagnosis and in treatment of disease.

(i) Outline how monoclonal antibodies are produced.

.....

.....

.....

..... [4]

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(ii) Suggest the advantages of using monoclonal antibodies in diagnosis of disease.

.....

.....[2]

23. M/J 17/P21/Q6/b,c,d,e

Gangliosides are glycolipids that bind choleragen. These glycolipids are found on many cell surface membranes.

When choleragen is released from the bacteria in the intestine, it binds to gangliosides on epithelial cells and enters these cells as shown in Fig. 6.1.

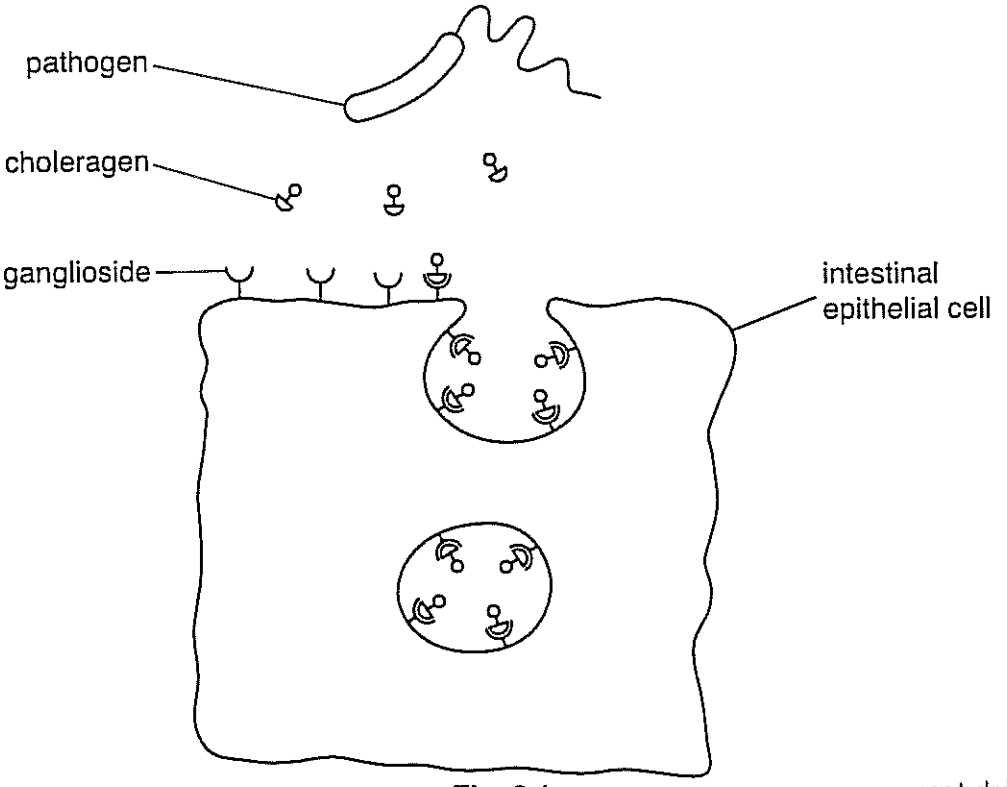


Fig. 6.1 not drawn to scale

(a) Suggest how choleragen interacts with gangliosides on intestinal epithelial cells.

.....

.....[2]

(b) Name the process by which choleragen enters the intestinal epithelial cell as shown in Fig. 6.1.

.....[1]

Once inside the cells choleragen is activated. One effect is to increase the movement of chloride ions through channel proteins out of cells.

(c) Suggest **and** explain the likely consequences on the intestinal epithelial cells of the loss of chloride ions through the channel proteins.

.....

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.....[2]

(d) Health authorities recommend that antibiotics, such as tetracycline, are **only** to be used for treating people with severe cases of cholera.
Explain why it is recommended that antibiotics should **not** be given to people with mild cases of cholera or to protect people from cholera.

.....

.....

.....[3]

24. O/N 16/P22/Q6/b,c

The development of stem cells to become neutrophils occurs in several stages. Some of these stages are capable of cell division.
Fig. 6.2 is a summary of neutrophil development. Some details of cellular structure are included.

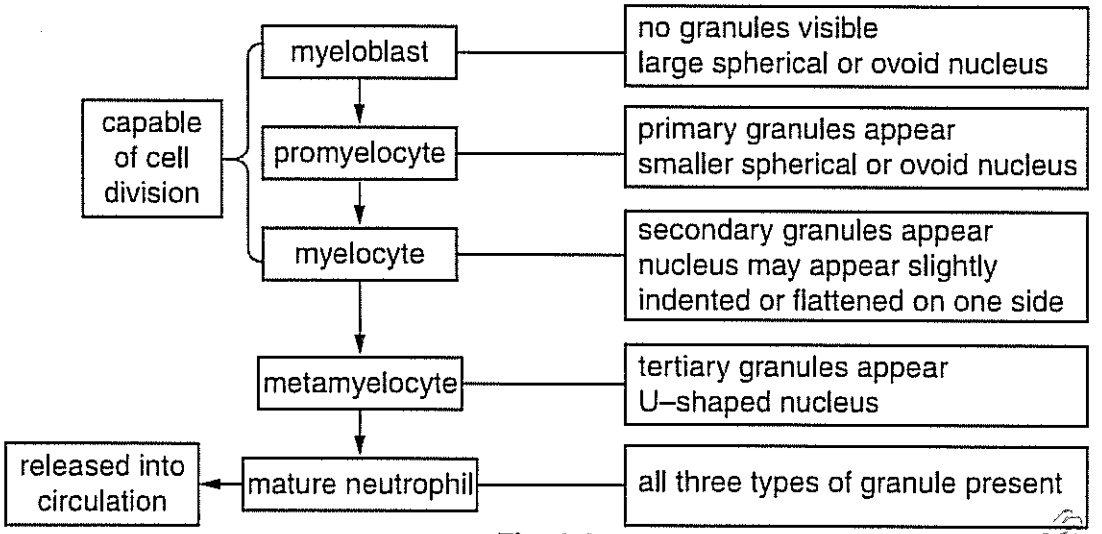


Fig. 6.2

All three types of granule indicated in Fig. 6.2 are membrane-bound cell structures containing hydrolytic enzymes. Each type of granule contains a different group of enzymes and other chemicals that enable the neutrophil to carry out its role.

(a) (i) State the location in the body where development and maturation of the neutrophil occurs.

.....[1]

(ii) Describe the shape of the nucleus in the mature neutrophil.

.....[1]

(iii) State the alternative name of the cell structures described in Fig. 6.2 as "granules".

.....[1]

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(b) (i) Primary granules contain proteins known as defensins. These bind to cell surface membranes of bacteria and form very small pores in the membrane.
Suggest how defensins contribute to the role of the neutrophil in killing bacteria.

.....

..... [2]

(ii) Secondary granules contain lysozyme. This is an enzyme that breaks bonds in peptidoglycan molecules.
Explain how the action of lysozyme will lead to the destruction of the bacterial cell.

.....

..... [2]

25. O/N 16/P21/Q5

(a) Monoclonal antibodies (MAbs) have been used in the treatment of some non-infectious diseases.
MAbs can be designed to bind to a protein on diseased cells, so causing their destruction by cells of the person's immune system.

(i) Name the part of an antibody molecule that will bind to a protein on diseased cells.

..... [1]

(ii) Suggest how the binding of monoclonal antibody to the diseased cells causes their destruction by cells of the person's immune system.

.....

.....

.....

..... [4]

(b) Myasthenia gravis is an auto-immune disease.
Explain the term *auto-immune disease.*

..... [1]

26. M/J 16/P22/Q3/b,c,d,e

Fig. 3.1 shows the percentage of children vaccinated against measles over a ten year period from 2003 to 2012.

- The percentage vaccinated represents children under one year of age who have been given at least one dose of the vaccine against measles in the given year.
- The data are for the six African countries shown in Table 3.1.

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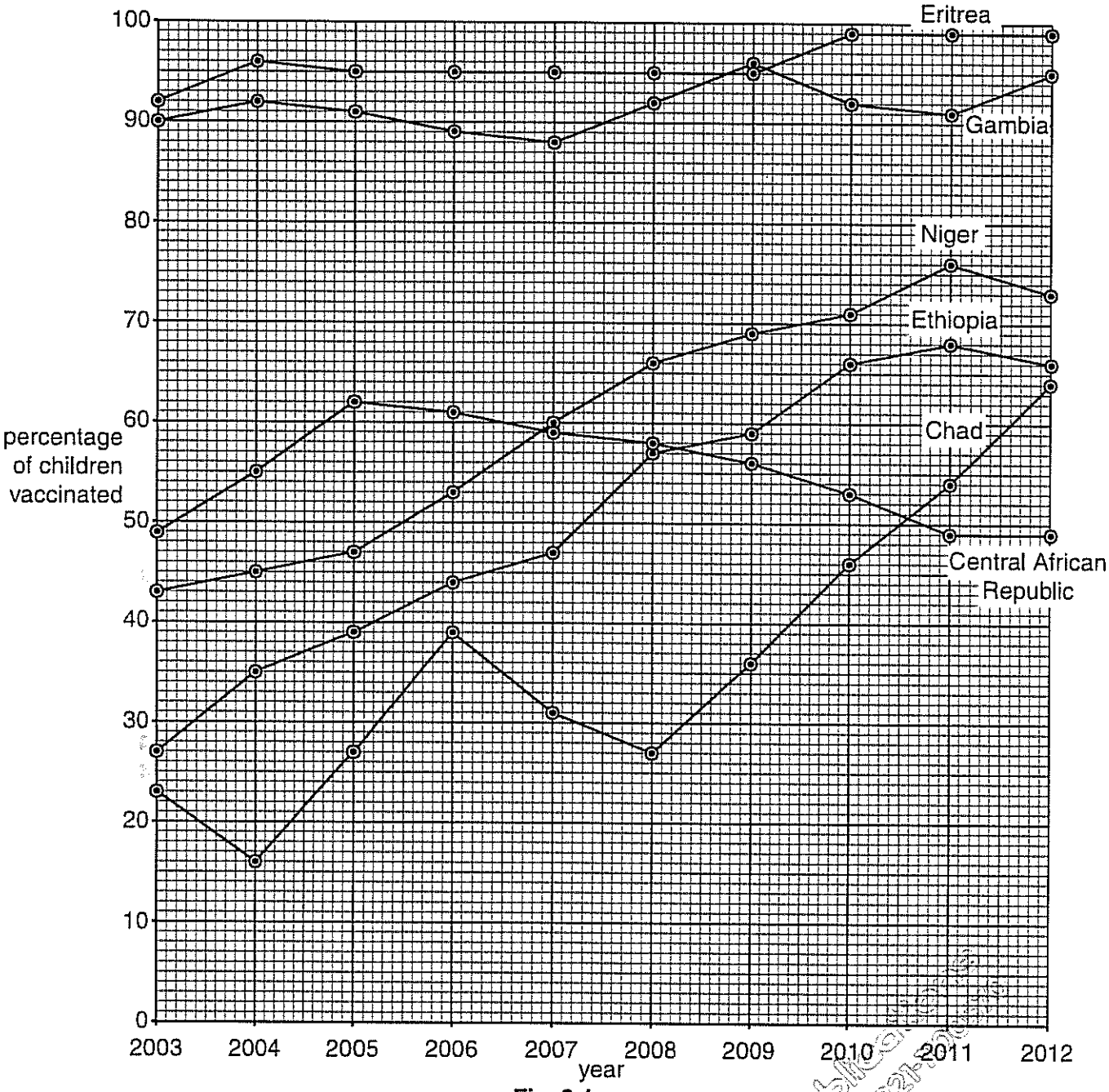


Fig. 3.1

(a) Vaccination is known to protect populations against infectious diseases. Some of the data in Table 3.1 (on page 4) and Fig. 3.1 (on page 6) support this statement. Describe the data that support this statement **and** comment on the data that do **not** support this statement.

.....

.....

.....

.....

[4]

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(b) The successful eradication of smallpox involved an intensive global vaccination programme. It is hoped that the same can be achieved with measles.

Outline **two** features, apart from cost, of the smallpox eradication programme that may have made it easier to eradicate than measles.

.....

..... [2]

(c) State precisely the type of immunity gained by receiving a measles vaccine.

..... [1]

(d) Planning the prevention and control of measles using a vaccination programme means that financial costs must be considered.

State two examples of these costs.

1 .....

2 .....

[2]

27. M/J 16/P21/Q2/b,c

Macrophages synthesise intracellular enzymes.

Fig. 2.1 is a summary diagram of events that occur in a macrophage.

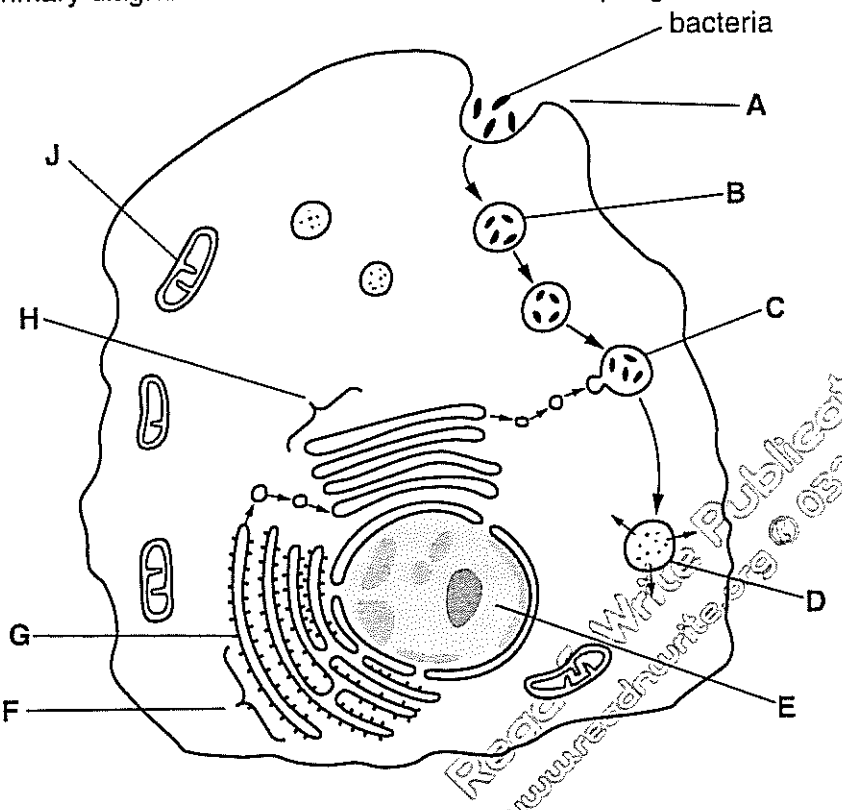


Fig. 2.1

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(a) Describe what happens to the bacteria between **C** and **D**.

.....

.....

.....[3]

(b) Macrophages are antigen presenting cells (APCs). Antigens from pathogens such as the bacteria shown in Fig. 2.1 are presented to helper T-lymphocytes as shown in Fig. 2.2.

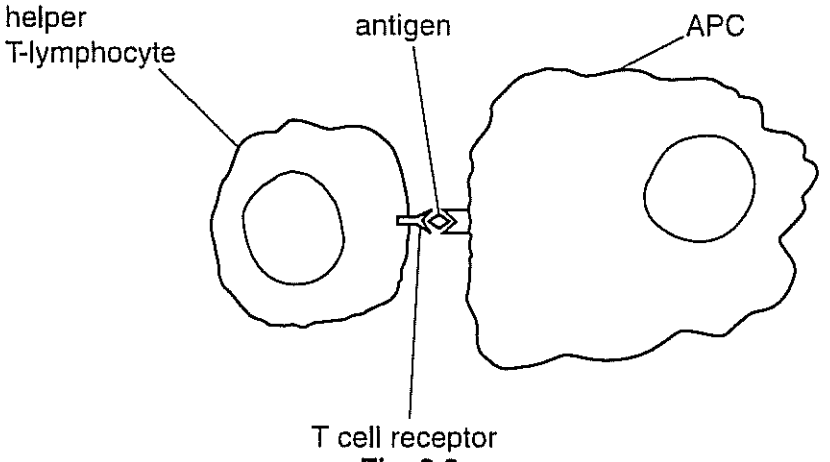


Fig. 2.2

Very few helper T-lymphocytes respond to the presence of APCs by binding in the way shown in Fig. 2.2.
Suggest why this is so.

.....

.....[2]

28. M/J 16/P23/Q3

Rheumatoid arthritis (RA) is a disease of the joints in the human body.

(a) RA is classed as an auto-immune disease where the immune system treats some self antigens as non-self.

Explain what is meant by the term *non-self antigens*.

.....

.....

.....[3]

(b) The symptoms of RA include inflammation of the joints which causes pain and difficulty in movement of the joint.

The inflammation is triggered by a chemical known as TNF-α, produced by macrophages.

One approach to the treatment of RA is by the use of monoclonal antibody against TNF-α.
Fig. 3.1 is a diagram of an antibody molecule.

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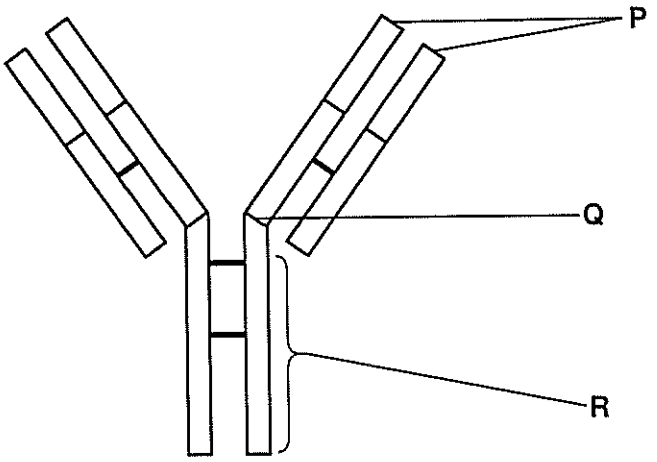


Fig. 3.1

(i) Name the parts of the antibody molecule labelled **P**, **Q** and **R**.

P .....

Q .....

R ..... [3]

(ii) Name the type of bonds that hold the polypeptide chains together in the antibody structure.

..... [1]

(c) (i) Outline how monoclonal antibody against TNF-α is produced.

.....

.....

..... [3]

(ii) Suggest how monoclonal antibody against TNF-α can reduce the symptoms of RA.

.....

..... [2]

29. M/J 16/P23/Q5/a,b,e

Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*.

(a) Describe how TB is transmitted.

.....

..... [2]

(b) Streptomycin was the first antibiotic used to treat TB.

During the first few years after the introduction of streptomycin treatment, an increasing number of *M. tuberculosis* bacteria developed resistance to streptomycin.

Outline how this happened.

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.....

.....

.....

..... [4]

(c) Explain why antibiotics can be used to treat bacterial infections and not viral infections.

.....

..... [2]

30. O/N 15/P21/Q5/e

(a) The outer part of the measles pathogen contains an antigen called the H-protein. This antigen appears on the surface of cells infected with the measles pathogen.

Describe the role played by T-lymphocytes in a primary immune response to an infection by the measles pathogen.

.....

.....

.....

.....

..... [5]

31. O/N 15/P23/Q1/b,c,d

(a) Antibodies are glycoproteins.

State what is meant by the term glycoprotein.

..... [1]

(b) The genes responsible for antibody production are found on different chromosomes, such as chromosomes 2 and 14 in humans.

Explain how one antibody molecule is the product of more than one gene.

.....

..... [2]

(c) Describe **and** explain how the structure of an antibody molecule is related to its functions.

.....

.....

.....

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..... [4]

32. M/J 15/P22/Q5

(a) Natural immunity and artificial immunity can both be acquired in a passive or in an active manner.

Table 5.1 shows information about immunity acquired by two individuals, **P** and **Q**.

Complete Table 5.1.

Table 5.1

description of event	outcome for the individual	production of memory cells / yes or no	type of immunity acquired by individual
individual **P** is injected with a live, weakened disease-causing organism	individual **P** does not become ill from the disease and has long-lasting protection from the disease	.....	....
individual **Q** is injected with antibody against a specific disease-causing organism	individual **Q** does not become ill from the disease but is ill with the disease a year later	.....	....

[2]

Fig. 5.1 is a light micrograph of a sample of blood. Cell **X** is a phagocyte.

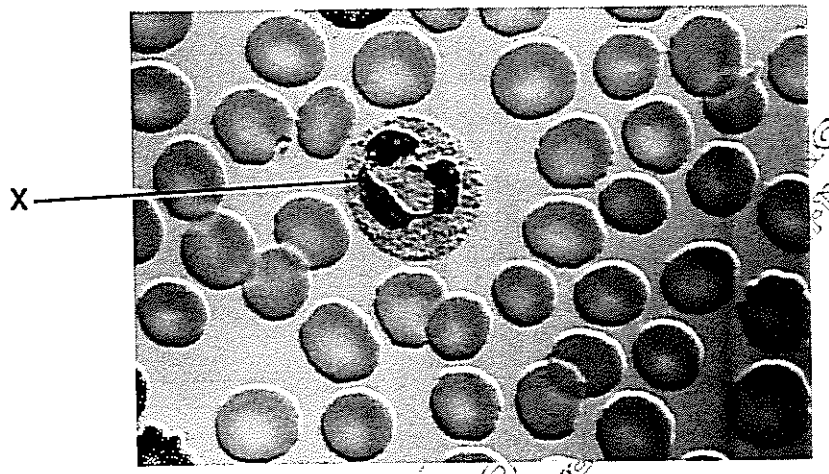


Fig. 5.1

(b) State the origin of the blood cell labelled **X**.

[2] .....[1]

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(c) Phagocytes play an important role when an immune response is initiated against cancerous tumour cells.

(i) Suggest how phagocytes can recognise the difference between healthy body cells and cancerous tumour cells.

.....

..... [2]

(ii) Outline briefly how a tumour forms.

.....

..... [2]

33. M/J 15/P21/Q2/b,c,d

Fig. 2.2 shows part of the immune response to the first infection by a bacterial pathogen that has entered the body through the lining of a bronchiole. **J** and **K** are stages in the immune response.

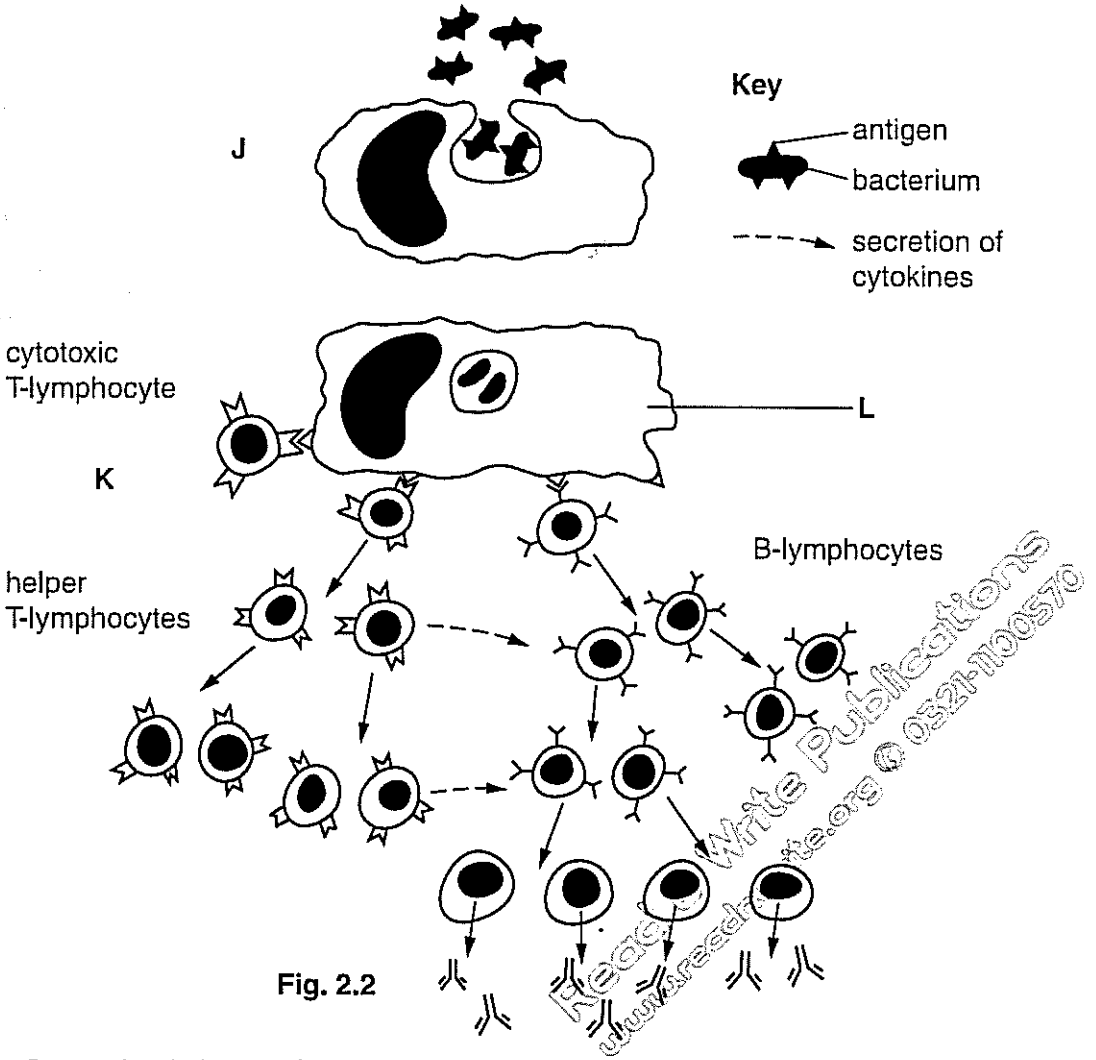


Fig. 2.2

(a) (i) State what is happening at stage **J**.

.....[1]

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(ii) Explain the role of cell **L** at stage **K** in the immune response.

.....

.....[2]

(b) With reference to Fig. 2.2, explain how the response to a second infection by this bacterial pathogen differs from the first.

.....

.....

.....[3]

(c) There are various ways in which the effectiveness of immune responses can be reduced. Suggest how each of the following reduces the effectiveness of an immune response.

(i) The number of T-lymphocytes is reduced in a person with HIV/AIDS.

.....[1]

(ii) Some pathogens are covered in cell surface membranes from their host.

.....[1]

(iii) B-lymphocytes do not mature properly and do not recognise any antigens.

.....[1]

34. M/J 15/P23/Q3/c,d,e,f

(a) Smallpox was the first disease to be eradicated by vaccination. The vaccine was effective for up to 10 years after one dose and did not require boosters within this time.
Name the causative organism (pathogen) of smallpox.

.....[1]

(b) When a person received the smallpox vaccine, the numbers of plasma cells specific for the smallpox pathogen were measured from blood samples taken over a period of 35 days.
Fig. 3.2 shows how the numbers of smallpox-specific plasma cells changed during 35 days after vaccination.

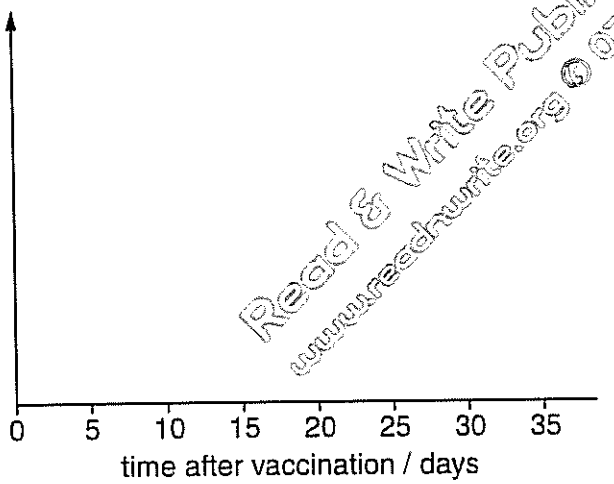


Fig. 3.2

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Fig. 3.2 shows that the number of smallpox-specific plasma cells increases and then decreases within 35 days of vaccination.

Explain how a single dose of this vaccine can provide immunity for up to 10 years when the plasma cells are short-lived.

.....

.....

.....[3]

(c) State two reasons why the vaccination programme was successful in eradicating smallpox.

1 .....

2 .....

[2]

(d) State the type of immunity provided by the smallpox vaccine.

.....[1]

35. O/N 14/P22/Q4/b

(a) Vaccination helps to prevent the spread of infectious diseases by stimulating an immune response in individuals against specific pathogens, such as Morbillivirus, the virus that causes measles.

(i) Suggest two reasons why measles vaccination programmes may fail to prevent epidemics.

1. .....

2. ..... [2]

(ii) Outline the response produced by **B-lymphocytes** on exposure to Morbillivirus in an individual **who already has immunity** to measles.

.....

.....

..... [3]

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36. M/J 14/P22/Q5

B-lymphocytes have antibodies located on their external surface. When B-lymphocytes become plasma cells they then secrete antibodies.

Fig. 5.1 shows how the enzyme papain digests an antibody to obtain three fragments.

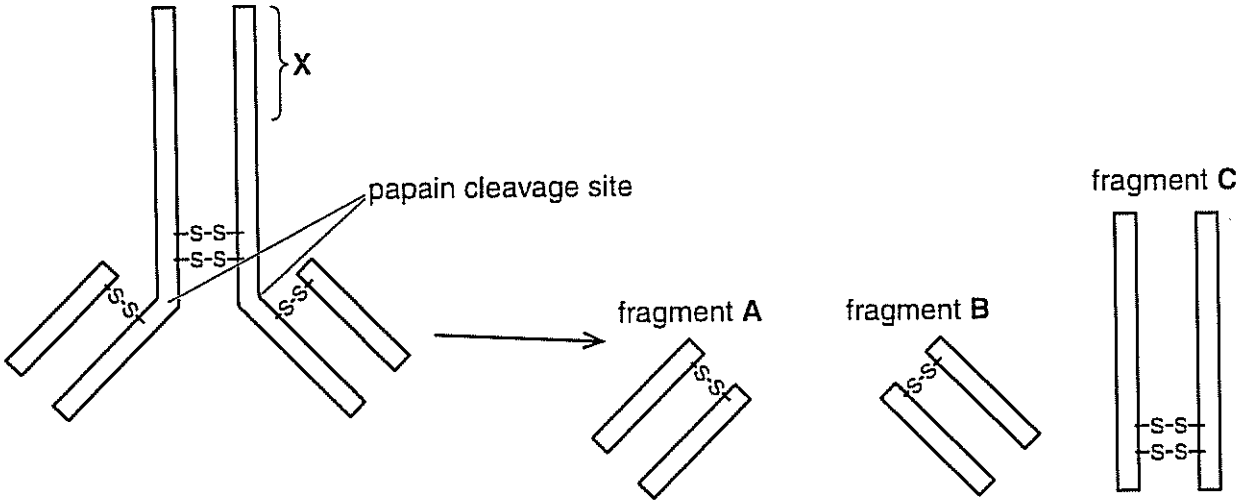


Fig. 5.1

(a) Fig. 5.1 shows the location of the region where papain acts.
State **one** role of this region in the intact antibody molecule.

.....[1]

(b) The three fragments, **A**, **B** and **C** still retain their ability to function.
State the function of:

(i) fragments **A** and **B**

.....[1]

(ii) fragment **C**.

.....[1]

(c) The region labelled **X** in Fig. 5.1 is hydrophilic in antibodies that are secreted by plasma cells, whereas in antibodies located on the surface of B-lymphocytes, region **X** is hydrophobic.
Suggest reasons for this difference.

.....

.....[2]

(d) Papain is a globular protein with a tertiary structure but no quaternary structure.

(i) State how many polypeptides there are in a molecule of papain.

.....[1]

(ii) Explain how the tertiary structure of the protein results in papain being globular.

.....

.....[2]

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37. M/J 14/P21/Q4

B-lymphocytes respond to the presence of a non-self antigen by dividing as shown in Fig. 4.1.

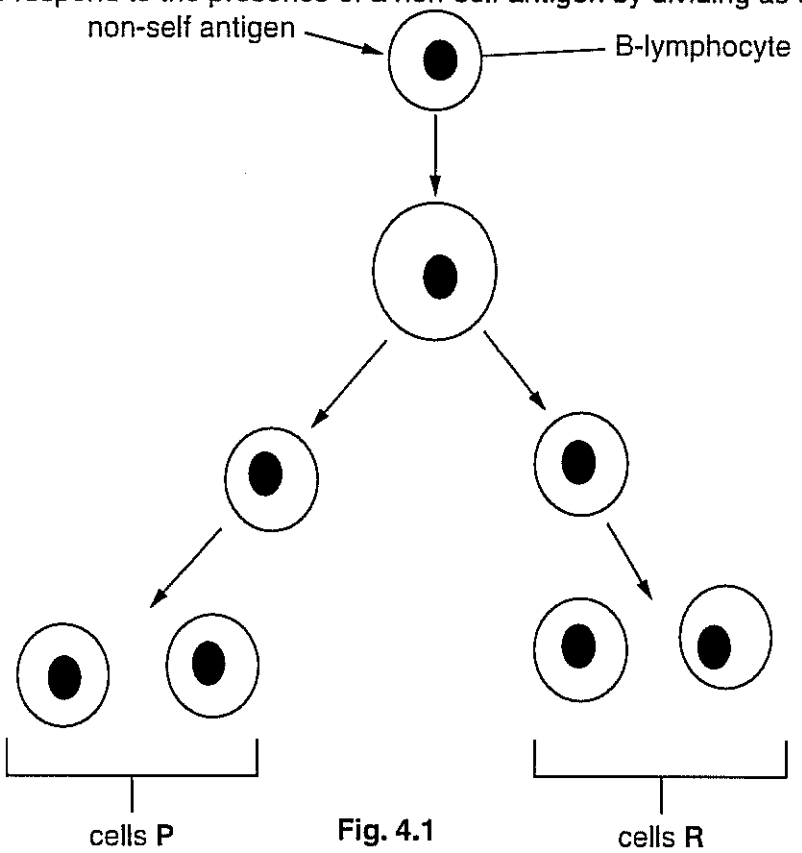


Fig. 4.1

(a) (i) Explain what is meant by the term *non-self antigen*.

.....

..... [2]

(ii) Outline how B-lymphocytes recognise non-self antigens.

.....

..... [2]

The cells labelled **P** on Fig. 4.1 continue to divide to give rise to many cells that differentiate into short-lived plasma cells. The plasma cells release antibody molecules.

(b) (i) Outline how plasma cells produce antibody molecules.

.....

.....

.....

..... [4]

(ii) Describe how antibody molecules are released from the plasma cell.

.....

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..... [2]

(c) The cells labelled **R** on Fig. 4.1 divide to give more cells that do not differentiate into plasma cells. These cells have an important role in the immune system.
Explain the role of these cells.

.....

.....

..... [3]

The mass of DNA in the cells shown in Fig. 4.2 was determined. The results are shown in Fig. 4.2.

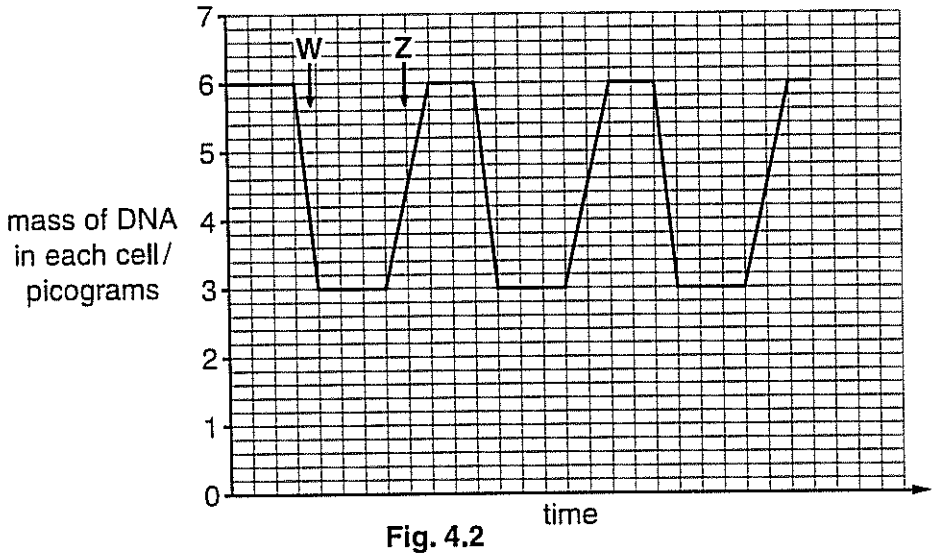


Fig. 4.2

(d) State what happens at **W** and **Z** to change the mass of DNA in each cell.

W .....

Z .....[2]

(e) Acute lymphoblastic leukaemia (ALL) is a cancer of B-lymphocytes. It is very rare in adults, but more common in children. A study in 2009 found that exposure to tobacco smoke in the home may put children at risk of developing ALL.
Suggest how smoking by adults in the home may put their children at risk of cancers, such as ALL.

.....

.....

.....[3]

38. O/N 13/P22/Q6

(a) Nicotine, in cigarette smoke, is highly addictive. A nicotine vaccine has been developed to try and reduce the effects of addiction. The vaccine stimulates an immune response to produce antibodies that bind to the nicotine molecule. Fig. 6.1 is a diagram of an antibody molecule. On Fig. 6.1:

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- label **three** structural features that enable an antibody molecule to carry out its function.
- next to each label, state the function of the feature.

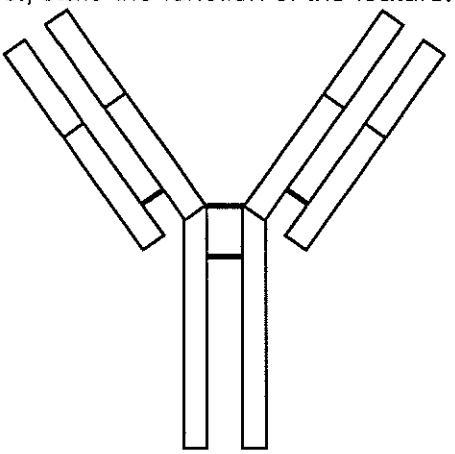


Fig. 6.1 [3]

(b) Nicotine has an effect on the cardiovascular system, such as making platelets sticky, so causing blood to clot. This increases the risk of thrombosis and reduces blood flow. Outline **other** effects of nicotine on the cardiovascular system.

.....

.....

..... [3]

39. O/N 13/P23/Q1

Fig. 1.1 is a diagram of an antibody molecule.

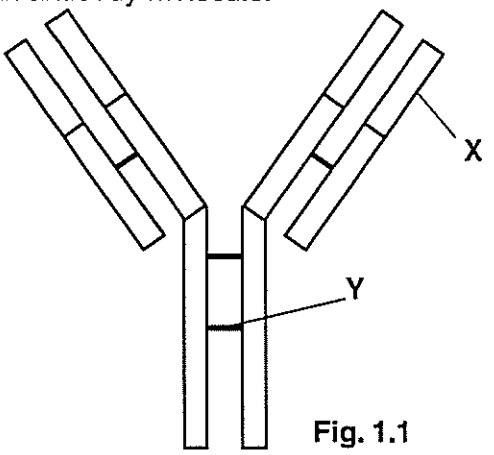


Fig. 1.1

(a) (i) Name the part labelled **X**.

..... [1]

(ii) Name the bond labelled **Y**.

..... [1]

(iii) The antibody molecule in Fig. 1.1 has quaternary structure.
Explain the meaning of the term *quaternary structure* as applied to proteins.

..... [1]

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(b) When a pathogen enters the body, a primary immune response occurs. This response includes the production of antibodies.
Describe the stages in the immune response that lead to antibody being produced against a specific antigen.

.....

.....

.....

..... [4]

(c) Vaccination was used in the eradication of smallpox.
Explain, in terms of antigens, why it has not been possible to do the same for malaria.

.....

..... [2]

40. M/J 13/P21/Q2

(a) Explain how the virus that causes measles is transmitted.

.....

..... [2]

(b) Antibodies against measles are produced by plasma cells during an immune response.
Fig. 2.1 shows a diagram of an antibody molecule.

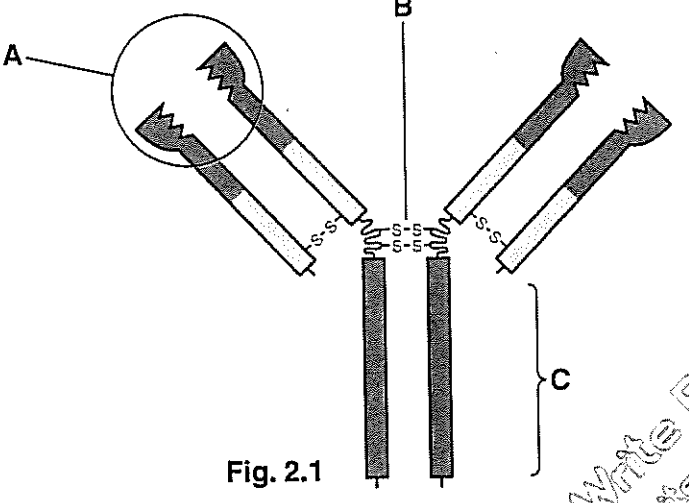


Fig. 2.1

Explain the functions of the parts labelled **A**, **B** and **C**.

(i) A .....

..... [2]

(ii) B ..... [1]

(iii) C ..... [1]

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Answers Section

1. M/J 22/P21/Q2

(a) (i) exocytosis ;

(ii) ***one*** *mark per row*

cell structure in Fig. 2.1	name of cell structure	function of cell structure in plasma cell
P	nucleolus	production / assembly, of (sub-units of) ribosomes ; A manufacture, ribosomal RNA / rRNA / transfer RNA / tRNA
Q	mitochondrion	R *if answer refers to, ATP / energy, for aerobic respiration* aerobic respiration ; A oxidative phosphorylation A provide, ATP / energy A produce / AW, ATP
R	rough endoplasmic reticulum R rough ER / RER / ribosome	protein / antibody, synthesis / transport ; A synthesis of, polypeptide(s) / heavy and light chains A (post-translational) modification of, polypeptide / protein / antibody *allow example* A forms (transport) vesicles
S	Golgi body A Golgi, complex / apparatus	I lipids (post-translational) modification of, polypeptide / protein / antibody *allow example* **or** packaging, qualified ; e.g. packaging of antibodies / protein, into vesicles A formation of, vesicles / (primary) lysosomes

(b) *any* ***three*** *from:*

1 (named) small mammal, injected / AW, with antigen ;
2 immune response occurs (over several weeks) ; **A** immune response described
3 plasma cells / B-lymphocytes / B-cells / splenocytes, extracted from spleen ;
4 plasma cells / activated B-lymphocytes / activated B-cells, fused with, myeloma / tumour / cancer / AW, cells (to form hybridomas) ;
5 AVP ; e.g. hybridoma cells separated (into wells) to produce clones screening / selection / AW, for hybridomas producing desired, (monoclonal) antibodies / Mabs *ref. to* large scale production

(c) *any* ***four*** *from:*

1 (artificial) passive immunity ; **R** natural
2 no immune response ; **I** primary / secondary
3 *idea that* antibodies are, broken down / degraded / destroyed (in the body / blood) ; **R** 'antibodies die'
4 no long-term / only short-term / only temporary, immunity ; **A** no formation of immunological memory
5 memory cells not produced ; **A** memory cells only produced, in active immunity / during an immune response / after presentation of antigen
6 AVP ; e.g. *ref. to* no, clonal selection / clonal expansion / antibodies produced [12]

2. M/J 22/P23/Q4

(a) image length ; **A** magnification triangle
magnification

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250 (nm) ; (8 mm)
A 220 (for 7 mm)
A 230 (for 7.5 mm)
A 270 (for 8.5 mm)
A 280 (for 9 mm)

(b) pathogen ;

(c) ingests / drinks / AW, contaminated water / water containing the pathogen / food washed in contaminated water / contaminated food ;

A examples of accidental ingestion e.g. swimming in contaminated rivers
A faecal / oral, transmission

A bacteria / *Vibrio*
R if described as virus

(d) A mRNA or messenger RNA

*any **three** from:*
(one strand only needed) to form mRNA / mRNA is single-stranded ;

(m)RNA is, used / needed, to produce, subunit (s)/ polypeptide(s) ;

(only) one strand (of DNA) is the, template / transcribed, strand ;

idea that (complementary) copying / transcribing, other DNA strand would not result in, desired / AW, mRNA / polypeptide ;

(e) (i) *any **two** from:*
I receptor I active site

(mAbs) specific/ different, antigen binding sites / binding sites for antigen ;
A (each) mAb binds to a, specific / particular, antigen
R if antibody described as an enzyme

(each mAb has) specific/ different, tertiary structure / variable region(s) / primary structure / sequence of amino acids ; binding site and antigen have complementary shapes

or

ZAC-3 complementary shape to core polysaccharide and lipid A

or

2D6 complementary shape to O-polysaccharide ;

(ii) *any **four** from:*
yes
general points
(agglutination / motility prevented, so)
bacteria less able to, penetrate mucus / attach to intestinal epithelial cells / colonise intestine / AW ; A *idea that* fewer bacteria able to, attach / colonise intestine less / no, choleragen / toxin, released ;

bacteria passed out in faeces not able to cause disease in others / AW ;

ref. to phagocytosis more effective;e.g. macrophages stimulated to carry out phagocytosis

prevention / treatment
(to prevent disease) needs to be given, at early stages / before colonising (intestine) ;

passive immunity / passive vaccine ;
must be in context of treatment or immediate protection
idea that in addition to immune response (so increased effect) ;
e.g. acts beside, immune system / immune system cells
acts before the immune response can become effective

ref. to quicker recovery (if a person has cholera) ;

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useful when, there is antibiotic resistance / antibiotics cannot be given ;
specific mAb
mAb ZAC-3 may be more effective for cholera caused by, wider range of *V. cholerae* / AW;
mAb ZAC-3 may be useful if exact form of *V. cholerae* not known ;
mAb 2D6, needs to be targeted against specific *V. cholerae* forms
/ may not be effective against other *V. cholerae* forms ;
A not all forms of *V. cholerae* were tested in lab
AVP ; e.g.
(only) short-term protection / not active immunity / not long term
ref. difficulty in delivering mAbs to intestine
e.g. may be, digested / destroyed, as pass through gut
need to find a way to get mAbs to the intestine
if given intravenously need to pass through to gut lumen
may be able to prevent multiplication of bacteria
mAbs have been used successfully for other diseases [13]

3. O/N 21/P22/Q5/d,e

(a) (i) (steady) increase in number of (estimated) deaths (from measles, over time / from 2000 to 2017) ;

A (relatively) constant then (steady) increase in number of (estimated deaths over time)

(ii) *any **three** from*: **I** ref. to cost or mutations

1 as (global) population increased, higher, number / proportion, of unvaccinated ; **ora**

2 *ref. to* HIV link to measles ;
e.g. increase in number of people living with HIV increases spread of measles
increase in cases of HIV / AIDS, measles can be an opportunistic disease **R**
spread of HIV / AIDS weakened immune system in people with HIV / AIDS so measles more likely to occur (in unvaccinated)

3 less / no, herd immunity (so increased chance of getting measles) ;
A *ref. to* larger, number / proportion, unvaccinated will increase risk of spreading disease
context is community

4 one example of a difference between unvaccinated versus vaccinated ;
e.g. risk of death from measles is higher in unvaccinated
unvaccinated do not have, (artificial active) immunity / memory cells *context is individuals*

5 suggestion as to why fewer people are vaccinated ;
e.g. reluctance, of parents to get child vaccinated
reluctance because of, cultural / religious, beliefs
difficulty in obtaining vaccine *in context of remote communities*
collapse of vaccination programmes in some countries / AW
lack of, trained trained professionals / health facilities, to deliver vaccine
lack of education about benefits of vaccine / AW

6 suggestion as to why measles cases (and so deaths) may increase ;
e.g. (greater proportion of people) malnourished / lack vitamin A
(greater proportion of people) living in, overcrowded / poor, conditions
I overcrowded countries
measles is easily spread (with increase in population) **A** very infectious
measles is more easily spread in overcrowded conditions

7 example of spread (of measles) owing to movement of people between countries ;
e.g. (unvaccinated) people with measles arriving to a country and spreading disease
unvaccinated people travelling to countries with the disease, catching measles and taking it back home people arriving with measles to countries with low vaccination rates

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8 AVP ; e.g. ref. to, no / any specific difficulty for, contact tracing
lack of, isolation / quarantining
poor epidemiological records so authorities cannot react to outbreaks
improved, recording / reporting, of deaths over the time period

(b) *any **two** from:*
(high count owing to), cancerous / uncontrolled mitosis of, white blood cells ;
A malignant cells **A** uncontrolled division
white blood cells (in child with leukaemia) cannot, function (in immunity) / protect / example of function ; **A** undifferentiated / unspecialised
(so) weakened immune system (and more likely of developing measles) ; AW
vaccination is, less effective / not effective / gives weak immune response ;
secondary immune response, does not occur / too slow (after vaccination) ;
AVP ; has memory cells but clonal expansion, does not occur / is faulty [6]

4. O/N 21/P21/Q3/c

(a) (i) *any **two** from:*
break down / digest / hydrolyse / AW, pathogen / foreign material / AW ;
ref. to containing hydrolytic / digestive / named, enzymes ; **A** hydrolases
fuse with the, phagosome / phagocytic vacuole / AW ;

(ii) *any **two** from:*
cells are dead so cannot, cause disease / reproduce / AW ;
only part of a choleragen molecule, so no toxic effect ;
recognised by / trigger clonal selection of, more than one type of B-lymphocyte ;
stimulates production of different antibodies ;
stimulates the production of more than one type of memory cell / AW ;
ref. to immune system cells can respond to bacterial cells and the toxin produced ;
AVP ; e.g. different antigens on the surface of the cells [4]

5. M/J 21/P22/Q6

(a) *any two from*

1 (MG is an) autoimmune, disease / disorder / condition ; **A** autoimmunity
R autoimmune system

2 (disease in which) failure to distinguish / AW, between self and, non-self ;
A between self and, non-self / foreign, antigens

3 (so, at neuromuscular junctions) ref. immune response occurs against / antibody produced against, self-antigens / receptors qualified (see list);
A antibodies, bind to / block / attack / AW
examples of receptors
cell surface
muscle cell
ACh / neurotransmitter
neuromuscular junction
postsynaptic

4 *idea that* defective lymphocytes not destroyed (during development) ;

(b) *max 2 if wrong context*
e.g. vaccine contains, foreign antigens / antigens of pathogen / pathogen / antibody to bind to lymphocytes any three from:

1 vaccine contains antigens ; *in context of antigens of defective, T-lymphocytes and B-lymphocytes (accept antibody of defective B-lymphocyte as AW antigen)*

2 stimulates an immune response ;

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3 detail ; e.g. macrophages and antigen presentation / AW
ref. to specific lymphocytes involved
clonal selection of lymphocytes
recognition by / activation of, lymphocytes
clonal expansion of lymphocytes
production of plasma cells in context of B-lymphocytes
production of memory cells
T-helper cells produce cytokine

4 antibody produced against (defective), T-lymphocytes / B-lymphocytes / antibody (that binds ACh receptors) ; in context of primary or secondary response
R if context is related to the vaccine containing antibody

5 memory cells, remain / give long-lasting effect / AW ;

6 memory cells allow secondary immune response to (defective) lymphocytes (newly produced);

(c) any one from
antibiotic resistance, qualified ; A drug for antibiotic
e.g. increases risk of antibiotic resistance developing
may cause / could lead to problems of, antibiotic resistance
an antibiotic resistant bacterial strain may develop
R if, immune / immunity, included
R antibiotic resistance / mutation, in, TB / disease / people / virus

mutation(s) occur in bacteria which, make antibiotics ineffective / prevent antibiotic action ;
A mutation occurs which may make bacteria resistant

AVP ; e.g. ref. to development of, DR-TB / MDR-TB / XDR-TB
(if latent bacteria become active)

(d) max 2 if not in context of the statistic stated (using only Fig. 6.1) mps 2 -8 only
points are in context of people who do not know
any three from

1 9.2 million do not know that they are, living / infected with, HIV ; ora
27.7 million people know risk to themselves

2 not accessing, ART / treatment ;
A only people who know will access ART
A if tested, can access ART

3 high(er) viral, loads / levels (compared to many on ART); ora
idea of no control over presence of virus in body

4 greater risk of, developing / dying from, HIV/AIDS / HIV-related diseases ; ora
A AIDS for HIV / AIDS
R HIV
context could be, no ART / higher viral loads / no treatment of HIV-related diseases
risk to others

5 greater risk of transmitting, virus / HIV ; ora
includes placental transmission
R HIV/AIDS or AIDS
context could be, higher viral load / not practising prevention

6 detail of prevention that may not be practised ; ora
e.g. are sharing contaminated needles
are donating blood
are breastfeeding
are not, practising safe sex / using condoms / AW

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7 (may develop opportunistic infection so) greater risk of spreading infectious diseases ; consequence for, health care / authorities

8 problems with increase in infection within a population ; **ora**
e.g. increased cost of, care / medication
increased pressure on medical staff
reduction in size of labour force

9 *ref. to* testing for HIV ; **R** testing for HIV/AIDS
e.g. indicates more, education / advertising, needed to encourage testing
indicates more testing required / focusing on at risk groups

10 AVP ; *issues for authorities other than mp 8 and 9*
e.g. if people do not know status, no contact tracing can occur
focus efforts on countries where a high proportion do not know HIV status
authorities provide free condoms to try and reduce overall transmission [9]

6. M/J 21/P23/Q2/e

(a) (i) *allow ref. to, cheaper / low cost, related to relevant mp once only*

any four from

did not mutate to max 2

1 same vaccine could be used (everywhere / for many years) ;
A no need to manufacture different vaccines
in context of ease of, administering / planning / production

2 (so) a person was protected for, a long time / life / each exposure (to virus) ;
AW e.g. same virus so vaccinated person did not become ill on repeated exposure
A reduced / no, risk of vaccine becoming ineffective
A long-lasting immunity *once only for mp2 or mp4*
I more effective vaccine

3 no, research / trials / development, required for new vaccine(s) ;
in context of pre-mass production

live and closely related to max 2

4 (closely related so) same antigens / (gives the desired) immune response / antibodies produced / memory cells produced / memory cells remain ;
A long-lasting immunity *once only for mp4 or mp2*

5 live virus (replicates, so), gives a strong(er) immune response ;
A better immunity than inactive virus
R natural active immunity

6 no need for boosters ;

7 *ref. to* not smallpox virus, so fewer health and safety issues (at all stages of development and use); e.g. could not get ill from smallpox
A not smallpox virus so more people willing to have vaccine

thermostable vaccine

8 longer shelf-life / doesn't degrade easily / other advantage ;
e.g. no refrigeration needed
could be easily, stored / transported
no wastage

easy to administer

9 (using non-medical staff) increased number of people vaccinated / percentage cover / herd immunity ; *allow idea of faster delivery of vaccination programme*
A *idea that* (makes vaccine) more accessible to people in developing countries

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(ii) *one mark for correct completion of table* ;

type of immunity	gained (✓) not gained (x)
active immunity	✓
artificial immunity	✓
natural immunity	x
passive immunity	x

[5]

7. O/N 20/P22/Q4/c,d

(a) *any **three** from:*

large numbers of B-lymphocytes / plasma cells (in primary immune response)

1 large quantity of (specific) antibody, produced / released
or
(large quantity of) antibody to form antibody-antigen complexes / to bind antigen (for phagocytosis) / AW ;

large numbers of memory B-lymphocytes so

2 provide long term immunity / memory cells long-lived / provides immunological memory ;
A remain in, circulation (for a long time) AW

3 able to produce fast(er), secondary (immune) response ;
A second response will be fast(er)
A immune response faster on second encounter (with antigen / pathogen) / AW

4 higher concentration / faster production, of antibodies (than primary response) ; **I** 'more' alone

5 person does not have, symptoms / become ill (of / from, same disease) ;
A presence of same, pathogen / antigen, does not cause disease

6 AVP ; memory cells can (divide to) produce plasma cells
more plasma cells present than primary response
able to form more memory cells

(b) *any **two** from:*

immune response / antibodies produced, against, self antigens ;
I immune system attacks self
A autoimmunity / autoimmune disease

idea that faulty B-lymphocytes not destroyed ;
A *ref. to* T-lymphocytes *if in correct context*

(specific) antibody, binds to / acts on / AW, self-antigen / receptor, on the (cell surface membranes of) muscle cells / at neuromuscular junction ;
A antibody binds to acetylcholine receptors

ref. to consequence to muscle cells ; e.g.(nerve) impulse conduction impaired
action of transmitter substance hindered

[5]

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8. O/N 20/P21/Q6/b

(a) (i) *any **three** from:*

vaccination stimulates an immune response ;

antigen presentation, qualified ; e.g. TSA engulfed by, phagocyte / named phagocyte

antigen binds to, specific / complementary, receptor, on, T-lymphocyte / cytotoxic T cell / killer T cell ; clonal expansion ; **A** described e.g. divides by mitosis to form a clone

(receptor on) cytotoxic T cell / killer T cell, binds to TSA on tumour cell ;

release of, perforin / hydrogen peroxide (to kill tumour cell) ; **A** other named e.g. granzymes AVP ; e.g. causes lysis of the cell

(ii) *advantage any **one** relevant e.g.*

tumour cells may have more than one TSA ;

stimulate a specific immune response to each TSA ;

idea that TSA on patient's tumour cells has the appropriate antigen

idea that personalised treatment so more effective

*disadvantage any **one** relevant e.g.*

high cost of personalised treatment ;

immune system may not recognise TSA on own body cell as, foreign / non-self , the cells in the tumour may not have the TSA in the vaccine ;

patient's tumour may not be large enough to obtain enough cells for treatment ;

patient needs surgery to obtain (large quantity of) cells ;

AVP ; e.g. *suggestion that* tumour cell may settle in a part of the body and not be destroyed [5]

9. O/N 20/P21/Q4/b

(a) (i) protein coat / capsid ;

DNA or RNA / nucleic acid ; **A** genetic material

ref. to some viruses have envelope ;

(ii) *allow sucrose for assimilates throughout*

*any **five** from:*

viruses / assimilates, enter via plasmodesmata ;

movement / diffusion, of assimilates into (phloem) sieve tubes, lowers water potential/AW;

(so) water enters, by osmosis / down water potential gradient / AW ;

hydrostatic pressure increases (at source) ; **A** turgor pressure *for hydrostatic pressure*

unloading at, sink / named sink, lowers hydrostatic pressure (at sink) ;

detail ; e.g. assimilates move out and water follows osmotically

pressure gradient created / higher pressure in source (than sink) /

lower pressure in sink (than source) ; (so) mass flow ; *term to be used in context*

from source to sink ; *allow mp if terms source and sink used in correct context within complete response* AVP ; (viruses and assimilates travel) through sieve pores [7]

10. O/N 20/P23/Q4/b

(a) *any **three** from:*

*to award the MP1 to MP5 you **must be able to see a difference** between the two stated clearly*

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	vaccines		*antibiotics*
1	(generally) are preventative / are not a treatment /are not a cure **or** use before a person, has an infection / is ill	**v**	are (generally) not preventative/ are a treatment / are a cure **or** used when a person, has an infection / is ill ;
2	effective against bacteria and viruses (in context of different vaccines)	**v**	not effective against viruses/ only effect against bacteria ;
3	*idea of* indirect effect on pathogens	**v**	*idea of* direct effect on pathogens ; **A** example of effect
4	not given as a course / give once or a few times (or with boosters)	**v**	given as a course / over many days / AW ;
5	specific for particular, pathogen	**v**	(most) antibiotics act on a range of pathogens;
6	stimulate an immune response	**or**	do not stimulate an immune response ;
7	detail e.g. stimulate, (B- / T-) lymphocytes / production of antibodies **A** stimulates production of memory cells	**or**	do not stimulate, (B- / T-) lymphocytes / production of antibodies ; **A** no stimulation of memory cells
8	provide long-term, protection / immunity	**or**	do not provide long-term, protection / immunity ;
9	does not lead to resistance	**or**	may lead to resistance ;
10	time delay before being effective / AW	**or**	have effect, faster / sooner / AW ;

[3]

11. M/J 20/P22/Q3

(a) *Mycobacterium tuberculosis* ; **A** *Mycobacterium bovis*

(b) *any one from*
live in an area that has cases of TB ;
recently returned from countries with TB ;
born in a country with TB ;
parents / grandparents whose origin country has TB ;
contact with a person who has TB ;
AVP ; e.g. *ref. to* compromised immune system mother who is HIV-positive

(c) *any three from*
decrease in incidence over time for all groups
or
decrease in incidence over time for low, lower middle, upper middle and plateau for high income group;
one example of, large / AW, differences in incidence ;
e.g. between, upper middle income and, low / lower middle
between high income and, low / lower middle / low and lower middle ;
between upper middle and high ;
decrease in incidence with income group increase (for each year), generally / overall / except for 2015 / 2016 low to lower middle ;
low and lower middle similar incidence ;
data / manipulated data, to support any of above points ;

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(d) *any two from*
max 1 if no ref. to antigens
leprosy bacterium has similar (shaped) antigens ;
memory cells, recognise / bind, antigens on leprosy bacterium ;
anti-TB antibodies also bind to leprosy antigens ;
AVP ; e.g. similar / same, genes so synthesise similar proteins

(e) *any three from*

artificial active	natural passive
deliberate / AW **A** from medical staff	**or** not deliberate / from mother / in breast milk / across placenta ;
vaccine / (foreign) antigens in injection	**or** antibodies passed on ;
immune response	**or** no immune response ;
antibodies / memory cells produced	**o**no, antibodies / memory cells produced ;
longer lasting	**or** short-lived ;
protection not immediate	**or** immediate protection ;

[10]

12. M/J 20/P22/Q6/c

(a) *any three from*
blood smear differences
large / larger, numbers of lymphocytes ;
more lymphocytes than normal blood smear ;
as blood smear or lymphocyte difference
immature / not fully developed ;
ref. to no large nuclei / nuclei not pronounced small nuclei
; **A** nuclei not visible
lymphocyte difference
non-functional / AW ;
detail of lack of function for either B-lymphocytes or T-lymphocytes ;
AVP ; e.g. *ref. to* difficult to distinguish between lymphocytes and
monocytes ; **A** no monocytes visible

[3]

13. M/J 20/P21/Q5/b,c,d

(a) *max 4 if no ref. to, (mature) B-lymphocytes / plasma cells, producing / secreting, antibodies*
any five from:
ref. to fusion of lysosomes releasing hydrolytic enzymes ;
intracellular digestion / described ; e.g. hydrolysis of, (named) cell wall components /
proteins / nucleic acids / lipids
ref. to processing antigens to present on, cell surface membrane / cell surface ;
A macrophage becomes an, antigen presenting cell / APC ;
antigen, recognition / binding, by, B-lymphocytes / T-lymphocytes ;
detail ; e.g. clonal selection / have receptors complementary to antigen / specificity
of, B-lymphocytes /T- lymphocytes to
(non-self) antigen ;
A immunoglobulin / antibody as receptor for B-lymphocytes

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clonal, expansion / proliferation ;
A described e.g. divides by mitosis to form a clone of cells
B-lymphocytes, mature to / form, plasma cells that secrete antibodies ;
T-helper cells release cytokines ;
Cytokine action ; e.g. stimulates, humoral / B-lymphocyte, response

(b) *any three from:* **3**
long-term immunity ;
B and T memory cells remain in the body for, a long time / a lifetime ;
memory cells for secondary (immune) response ;
secondary response is faster / more effective (than primary immune response) ;
(so) higher concentration antibodies / quicker production antibodies ;
Idea of more (specific) memory cells in the body than (specific) lymphocytes before primary response ;
increase chance that pathogen encountered more rapidly (to mount a response) ;
AVP ; e.g. pathogen destroyed before symptoms of illness are caused

(c) *any three from:*
Mycobacterium / TB bacterium, is an intracellular parasite / lives inside host cells ;
antibodies have no effect on bacteria inside cells ;
only when bacteria are in the, plasma / tissue fluid ;
idea that vaccination is not a global occurrence ;
e.g. not part of vaccination programme in many countries
only some countries have as part of their vaccination programme
BCG is not very effective (for adults) / some people do not respond to BCG ;
BCG does not have the same effectiveness across the world ;
many countries, have no herd immunity / do have enough people that are immune, to prevent spread;
ref. *to* civil disturbance / AW, collapse of health services ;
AVP ; *idea that* travellers / tourists / immigrants / displaced people, may be infected with TB and transmit it to host population (that does not have, a vaccination programme / herd immunity)

[11]

14. M/J 20/P23/Q2/c,d

(a) *any three from*
higher concentration of antibodies ;
faster production of antibodies ;
because of presence of memory, B-lymphocytes / B cells ;
higher numbers of specific B-lymphocytes, so increased chance of faster recognition / because of clonal expansion in first response ;
AVP ; e.g. also more memory T-cells to stimulate B-lymphocyte response
ref. to higher concentration antibodies in circulation remaining after recovery

(b) *any two from*
result of an autoimmune disease / AW ;
antibodies produced against, self-antigens / antigens on body cells *or*
antibodies bind to self-antigens / antigens on (own) body cells ;
detail ; e.g. prevents functioning of muscle cells
binds to receptors on muscle cells

[5]

15. O/N 19/P22/Q5/e

(a) *any four from:*
1 (*Plasmodium*) is a, eukaryote / protoctist, so has many antigens ;
R bacterium / virus, is a eukaryote
or (*Plasmodium*) has many genes coding for (different) antigens ;
I antigenic variation

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2 *idea that* different *Plasmodium* species have different antigens ;
I antigenic variation
I strains *for species*
3 (*Plasmodium*) has different stages of life cycle (within human) with different antigens / shows antigenic variation ;
4 antigenic concealment / *Plasmodium* spends part of life cycle within host cells / AW ;
A short time in blood plasma
A spends time inside, red blood cells / liver cells
5 need to find the antigens that give the strongest immune response ;
6 need to, develop / use, more than one type of vaccine ;
A cannot use only one type of vaccine
7 AVP ;
e.g. mutations will give changed antigens
need to find antigens present in, all / most, stages of life cycle
difficulties in producing a generic vaccine max 2
8 costly to produce / need to keep costs low / developing countries need to be able to afford vaccine ;
9 needs to have a long shelf life / be stable / be easily stored (e.g. without cold storage) / AW ;
10 (immunity) needs to be long-lasting / aim to avoid boosters / need to develop a single dose vaccine ; AW [4]

16. O/N 19/P21/Q5/a,b(i)
(a) *two from*
ref.to non-self / foreign (antigen) ;
***one** from*
activation / AW, of lymphocytes ;
ref. to specificity ;
ref. to immunological memory ;
(b) (i) *three from*
(B-) lymphocytes respond / immune response, to self antigens (on muscle cell surface) / antibody produced by, B-lymphocytes / plasma cells ; **A** failure to distinguish between self and non-self
antibody binds to receptor ;
antibody has complementary shape to receptor ; **A** idea of specificity
cell signalling molecule / neurotransmitter / AW, unable to bind to receptor ;
reactions / AW, within cells, not triggered / described ; [5]

17. O/N 19/P23/Q5
(a) *two from*
protein coat / capsid / capsomeres ;
nucleic acid / DNA or RNA (core) ; **I** single- or double-stranded
A 'DNA/RNA' **I** genetic material
size given in nanometres / smaller than prokaryotes ;
I small / very small / microscopic
I acellular
(b) *three from*
1 drugs can be inhibitors (of neuraminidase) ;
either
2 (competitive inhibitor) so binds to active site
or

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(non-competitive inhibitor) so binds to allosteric site / AW
or
(drugs may act by) breaking down / hydrolysing / denaturing, all / part of neuraminidase ; **A** changes active site

3 no / less, enzyme-substrate complexes formed ; **A** ESC
A substrate not able to bind to enzyme
A neuraminidase cannot bind to (host cell) receptor

4 receptor is (still) complementary to haemagglutinin ;

5 haemagglutinin becomes attached to, cell receptor / host cell (so newly formed virus does not leave the cells);

(c) *four from*

1 antigen presentation ; *in correct context*

2 clonal selection / activation, of specific, B-lymphocytes / T-lymphocytes ; **A** B cells / T cells

3 (lymphocytes) divide by mitosis / undergo clonal expansion ;

4 B-lymphocytes, differentiate into / mature into / form / AW, plasma cells ;

5 antibodies secreted by plasma cells ;

6 T-helper cells secrete cytokines ;

7 cytokines stimulate / AW, B-lymphocytes / plasma cells / humoral response ;

(d) (i) *max 2 (out of total three marks)*
advantages
allow references to other pathogen types

1 antibodies are provided to people immediately / no delay for plasma cells to secrete antibodies;
A immediate, immunity / protection
R immediate (immune) response

2 antibodies, immediately neutralise toxins / prevent viruses entering cells ;

3 prevents disease (in the individual) / promotes quicker recovery ;

4 prevents spread of the pathogen through the population / prevents people dying ;

5 antibodies can be manufactured quickly in response to mutations that occur in virus / AW ; *max 2 (out of total three marks) disadvantages*

6 short-term / temporary (immunity) ;

7 no memory cells produced ;

8 can have infections of <u>same</u> pathogen again ;

9 allergic reaction / immune response, to the (non-human) antibodies given ;

10 *ref. to* cost qualified ; e.g. needs to be repeated / high cost of production of antibodies

11 AVP – for advantage (A) or disadvantage (D) ;
e.g. (A) passive can be used for people who are malnourished / immunosuppressed
e.g. (A) *ref. to* using a vaccine with a (live) pathogen that might give person the disease

(ii) across the placenta ; **A** via umbilical cord
in breast milk / colostrum / breast feeding / during lactation ; [14]

18. M/J 19/P21/Q1/b

(a) (i) **X** – site of synthesis of, (light and heavy) polypeptides ; **A** protein(s)
A transport / modification, of, polypeptides / proteins
A assembly of polypeptides / translation
R answers that name the Golgi body

Y – production of ATP ;
R 'produce / create / AW, energy'
A release of energy / provide energy

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(ii) cell / membrane, fusion / AW ; **I** 'mix'
(named) fusogen / hybridogen used ; e.g. polyethylene glycol / electrofusion / electric current **A** PEG for polyethylene glycol
(between) plasma cell / (activated) B-lymphocyte / (activated) B-cell / splenocyte, **and**, tumour / cancer / myeloma, cell ; **R** β cells

(iii) *any three from:* **3**
1 some mAbs act **directly** on target cells / some mAbs work **indirectly** to kill cells / mAbs do not damage other (non-target) cells ;
2 by binding to, specific / complementary, antigens/cell surface receptors ;
3 (named), drugs / radioactive isotopes, can be attached to mAbs ;
A 'tagged'
I labelled
4 enzymes can be attached to mAbs ;
5 so drug can be activated at site of action (linked to mp4) ;
6 bispecific mAbs attach two cells together ;
7 *ref. to* interrupting cell signalling ;
8 use of mAbs for passive immunity ; **A** described
in context of therapeutic antibody for treatment of disease
9 stimulating / AW, immune system / phagocytes / macrophages / T-lymphocyes, to kill, cancer cells ;
10 name of a cancer or autoimmune disease that is treated with mAbs ; [8]

19. O/N 18/P21/Q4/b,c,d

(a) (i) *any two from*
DNA , replication / AW ;
A S phase **I** chromosome replication
(early interphase) chromosome becomes two chromatids ;
A described
DNA checked for errors / errors in DNA repaired ;
synthesis of, (growth) protein / enzymes (for growth) ;
cell growth ;
organelle synthesis ;
centrioles replicate ;
AVP ;
e.g. *ref.* to checkpoint(s)
nucleotide synthesis

(ii) *any two from*
ref. target cells are endothelial cells ;
VEGF / cell signalling molecule, binds / AW, to receptor ; **R** receptor cells
ref. specificity (of receptors) / VEGF/cell signalling molecule, complementary to receptors;
suggestion of detail following binding ;
e.g. triggers secondary messenger
activates enzymes / enzyme cascade
signal transduction
phosphorylation events

(b) *any four from*
VEGF protein / antigen, injected into, mouse / small mammal ;
time for immune response to occur ;
A description of event in immune response
plasma cells / B-lymphocytes / splenocytes, extracted from mouse ;
plasma cells / AW, fused with, myeloma / cancer, cells ;
(to produce) hybridoma cells ;

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clone hydridoma cells ;
separate cells and culture in individual wells ;
screen for cells secreting desired antibody ;
hybridoma cells grown in large scale culture / AW ;
AVP ;
e.g. *ref.* to fusogen

(c) *any one from*
monoclonal antibodies identified, as foreign / non-self / act as an antigen ;
(monoclonal antibodies) stimulate an, immune / allergic, response ;
AVP ; e.g. (antibodies destroyed so) not enough antibody (to be effective) [9]

20. M/J 18/P22/Q3/c(ii)

(a) (i) *three from:*

1 specificity / specific (in correct context) ;
2 (B / T, -) lymphocytes have receptors complementary to antigen ;
A immunoglobulins / antibody *as receptors for B-lymphocyte*
A surface molecules *as receptors for T-lymphocytes*
3 (different) antigens, stimulate / activate / AW, (different) B-lymphocytes / T-lymphocytes ;
A antigens stimulate an immune response
4 *idea that* different antibodies, synthesised / produced / AW, for different (O) antigens / O polysaccharides / lipopolysaccharides ;
5 memory cells will, not respond to different antigen / only respond to same antigen / AW;
6 different O-antigens can, be composed of different sugars ;
A can have different shapes [3]

21. M/J 18/P21/Q5

(a) *five from:*
A 'cells' for 'lymphocytes' throughout
1 ref. to antigen presentation ;
A macrophage presents antigen
2 recognition / binding (in context of B-, or T-lymphocytes) ; e.g. cell surface receptor specific to toxoid / clonal selection
A immunoglobulin / antibody on surface of B-lymphocytes
3 T-lymphocytes or B-lymphocytes, divide by mitosis / clonal expansion ;
4 (some) plasma cells, formed / AW ; **R** if in context of T-lymphocytes
5 antibody molecules / antibodies, secreted / produced / released ;
R if in context of T-lymphocytes
6 T helper cells secrete, cytokines / interleukins ;
7 ref. to action of cytokines / interleukins ; e.g. to stimulate, humoral response / B-lymphocytes / to stimulate macrophages / angry macrophages
8 formation of memory cells ;
only in context of B- / T-lymphocyte activation

(b) (i) *three from:*

1 failure to distinguish between self and non-self / AW ;
2 specific B-,lymphocytes / cells, are not destroyed (during development) ;
3 antibodies are produced against, cell surface / ACh receptors on, muscle cell / neurones / nerve cells ;
4 antibodies, bind to / block, receptors ;
A antibody–antigen, binding / complex *if receptors already given*
5 AVP ; any detail related to the disease
e.g. (chemical) transmitter molecules / acetylcholine, cannot bind (to receptor)
impulses are not transmitted across synapse / neurones cannot send impulses
ref. to causing, muscle weakness / muscle fatigue

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ref. to neuromuscular junction does not function

(ii) *two from:*
so immune response, occurs all the time / recurs ;
(defective) B-lymphocytes still being produced / AW ;
I T (helper) cells
A not destroyed / remain
plasma cells / B-lymphocytes, continue to release antibodies against receptors ;
memory cells / immunological memory, present ;
receptors are always present (on neurones / nerve cells) ;
AVP ; e.g. no cure [10]

22. M/J 17/P21/Q3

(a) (antibody has) more than one polypeptide ; **A** four polypeptides
R two / two or more / two types of / many / AW, polypeptides

(b) (i) *allow epitope for antigen*
1 (two) antigen-binding, site(s) / region(s) ;
A binds to / AW, antigens
R active site
2 (shape / structure is) complementary to antigen ;
3 *idea of* specificity / AW ;
4 *ref. to*, primary structure / sequence of amino acids ;
5 *ref. to* R-groups / (amino acid) side chains, and interactions with antigen / giving specific shape ;

(ii) binds to (receptors on), phagocytes / macrophages / neutrophils ;
A other correct named cell of the immune system
AVP ; e.g. gives class of antibody (e.g. IgM, IgG, IgA, IgE)

(c) (i) 1 antigen, introduced / AW, into, (small) mammal ; **A** named small mammal
2 B-lymphocytes / B cells / plasma cells / splenocytes / antibody-producing lymphocytes, are taken / are isolated (from the spleen / lymph nodes) ;
3 (these) cells are fused / AW, with, myeloma / cancer, cells ;
4 hybridoma cells / hybridomas, formed ; **R** hybridised cells / hybrid cells
5 hybridoma cell, is cloned / AW ;
6 screening / testing, for hybridoma that produces desired antibody ;
7 *ref. to* scaling up / large-scale production / grow in a fermenter ;
8 AVP ; e.g.
fusion using, fusogen / polyethylene glycol / PEG / electric current (electrofusion) / (Sendai) virus HAT medium, for, hybridoma growth / inhibiting myeloma growth
humanisation of monoclonal antibody

(ii) **I** *suggestions for treatment*
1 monoclonal antibodies used all have the same specificity ; **R** 'are specific' unqualified
2 detect only one, antigen / epitope ;
3 can distinguish between different, pathogens / strains of, pathogens ;
A types of cancer cells
4 can be, labelled / tagged / marked / AW ; e.g. with fluorescent label
5 monoclonal antibodies can detect location of, tissues expressing antigen / cancer cells / blood clots ; **A** *idea of* locating areas of infection
6 fast(er) (diagnosis) ;
7 can detect antibody levels (e.g. HIV) ;
8 AVP ; e.g. some pathogens cannot be cultured
I *ref. to* cost [11]

23. M/J 17/P21/Q6/b,c,d,e

(a) 1 ganglioside is the receptor for choleragen ;
2 choleragen is complementary to ganglioside ;
3 any interaction between molecules ; e.g. (hydrogen / ionic) bonding

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(b) endocytosis ; **A** phagocytosis / pinocytosis

(c) 1 loss of water / dehydration ;
2 by osmosis ;
3 (water moves out) down water potential gradient / from high to low water potential / high Ψ to low Ψ ;
4 Loss of cations / positively-charged ions (as well as chloride ions) ;
5 change in potential (difference) / change in charge across membrane ;
6 AVP ; e.g.
disruption of absorption (of products of digestion / vitamins / mineral ions)
disruption of digestion

(d) 1 rehydration therapy, is effective / can treat cholera / reduces death rate ;
2 any detail ; e.g. solution of glucose and salts
3 antibiotic is a selection pressure / described ;
4 *ref. to*, antibiotic / tetracycline, resistance ;
5 *ref. to*, vertical transmission / horizontal transmission, of resistance ;
A described, **A** transfer for transmission
6 antibiotics will become, ineffective / less effective / AW ;
7 keep antibiotics for use 'as last resort' ; AW
8 *ref. to* cost ;
9 antibiotics kill gut bacteria ;
10 *idea that* disrupts functions of digestive system ;
11 AVP ; e.g. antibiotics going into the environment / food chain
antibiotics can cause mutation
decreases need to develop new drugs
prevents development of active immunity
idea of transmission between bacterial species
plasmids with resistance genes [8]

24. O/N 16/P22/Q6/b,c

(a) (i) bone marrow ;
(ii) lobed / irregular ;
(iii) lysosomes / vesicles ;

(b) (i) *two from*
ref. to loss of control over entry and exit substances ;
A membrane no longer partially / selectively, permeable
A becomes more permeable
lose, ions / nutrients ; **A** gains, ions / nutrients
lose water ; **R** gains water *(as cell wall still intact)*
metabolic reactions, prevented / impaired ; AW
enzymes no longer function ; AW
water potential affected ;
increase or decrease depends on rest of answer
e.g. gains ions so decreases water potential
cytoplasm shrinks ; AW **R** lysis / bursting
contents leak out ;

(ii) breakdown / weaken / digests / AW, cell wall ; **A** destroyed / damaged
I breaks cross-links / cross-links cannot form
(water enters so) lysis occurs / bursts / AW ; [7]

25. O/N 16/P21/Q5

(a) (i) antigen binding site / variable region / V_H and V_L ; **A** F_V

(ii) *four from*
1 *ref. to* monoclonal antibody, is recognised as, non-self / foreign ;
or

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diseased cell (now) recognised as non-self/foreign ;
2 stimulates an immune response ;
max three suggestions from
3 recognition and binding by / activation of / AW, T-lymphocytes/ B-lymphocytes / AW ; **A** clonal selection
A T- / B-, cell
4 *ref. to* specificity so healthy cells not destroyed ;
5 clonal expansion/mitosis ;
6 plasma cells (formed that) secrete antibody ; **A** B-lymphocyte
7 consequence ; e.g. antibody binds monoclonal antibody to lead to cell destruction
8 T-helper lymphocyte secretes cytokine, to activate macrophages / B-lymphocyte response / T-killer response ; AW
e.g. stimulates humoral response
9 T-killer/T-cytotoxic, releases, perforin to, punch holes in (cell) membrane/ cause death of cell ; AW
10 detail of involvement of phagocytes/macrophages ;
e.g. receptor recognition of (monoclonal) antibody
engulf the diseased cells with monoclonal antibody attached/AW
A diseased cell (with monoclonal antibody) destroyed by phagocytosis

(b) *one of*
failure to distinguish self and non-self (antigens) ; **A** foreign *for non-self*
immune response/antibodies produced, against self antigens ;
in context of lack of good health **R** does no harm [6]

26. M/J 16/P22/Q3/b,c,d,e

(a) *can give values of percentage vaccinated to describe 'increasing/decreasing' percentage vaccination*
support
1 Gambia high percentage vaccinated (throughout) and low number of cases ;
A Eritrea
2 data to support ; *e.g. a percentage vaccination for a year and number of cases (same, or following, year after vaccination) or a range given for percentage vaccinations over the whole, or stated, number of years or a compilation of the two*
partial/weak, support
3 Central African Republic decreasing vaccination and number of cases in 2011, higher/ 15.31 ;
4 Chad (from 2008) increasing percentage vaccination and, low/stated, number of cases,
2009/2010/2012 ;
1.45 1.66 0.96
do not support
5 Niger/Ethiopia/Chad, (generally) increasing percentage vaccinated and number of cases, fluctuates/increase and decrease (ora)/AW ;
A stated correct data *to show increase and decrease*
A for Chad if mp 4 given and ref. to increase/71.6 in 2011
6 (generally) increasing percentage vaccinated and number of cases, increases/goes from 2.34–4.67, in 2011 in Niger **or**
increases/goes from 1.39–4.86, in 2010 in Ethiopia **or**
increases/goes from 1.66–71.6, in 2011 in Chad **A** 1.45–1.66 in 2010 ;
7 Central African Republic decreasing vaccination and low number of cases in, 2009/2010/2012 ;
8/9 AVP ;; e.g.

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- *idea that* most values for number of cases are low irrespective of vaccination percentage
- *ref.to* needs, high/90%, vaccination to be effective
  A < 80%/low, vaccination ineffective
- *idea that* generally Gambia/Eritrea, have higher percentage vaccinated and have lower number of cases than, (three of) Ethiopia, Chad, Central African Republic, Niger/the other countries
- *ref. to* Chad/Central African Republic, in 2011 and, epidemics/inability to keep number of cases down/ineffectiveness of vaccination programme **I** *ref. to* 71.6 (Chad) or 15.31 (Central African Republic)
- Eritrea 2012 high vaccination but, increase in/3.16, cases
- *ref. to* increasing percentage of vaccination in Niger and decrease in cases, 2009–2010 from 5.23 to 2.34/2011–2012 from 4.67–1.59
  A 2009–2012 from 5.23 to1.59

(b) *points refer to smallpox, look for points written as ora*
any two from

1 high, percentage/proportion, immunised/vaccinated ; AW
A mass vaccination

2 no boosters required/one dose enough/immunity very long-lived ;
A *idea of* long-lasting effect of vaccine

3 same, vaccine/antigens, used (throughout) ;
treat as neutral ref. to, low mutation rate/stability, of smallpox virus

4 heat stable/thermostable/freeze-dried/lyophilised, vaccine ; **I** frozen
A no need to refrigerate/AW
A *idea of* longer shelf-life

5 ease of, administering vaccine/training people to give vaccine ;

6 ring vaccination/described, e.g. contact tracing ;

7 easy to identify infected people/AW, (to begin ring vaccination) ;

8 lower percentage cover required for smallpox than measles/lower herd immunity required ;

9 AVP ; smallpox less infectious (so lower percentage cover required)
idea of less, civil unrest/war/movement of populations (so easier to implement)
suggestion that smallpox live vaccine (and measles not live)

(c) active artificial/artificial active ; *treat as neutral* acquired

(d) *can be from point of view of country programme or WHO programme cost*

1 preparing/manufacturing/purchasing, vaccine ; **A** cost to provide vaccine free to developing countries

2 disposables/equipment to administer (vaccine) ;
e.g. syringes/needles/(protective) gloves

3 storage ; e.g. space, security

4 refrigeration/maintaining cold chain ;

5 transport (of, vaccine/health care workers) ;

6 wages/training, of staff involved ; e.g. wages for, health care workers administering vaccine/staff involved in training health care workers

7 record keeping/contact tracing ;

8 advertising/informing/marketing/education ;

9 research/development ;

10 setting up vaccination/immunisation, camps (for remote/epidemic, areas) ;
I building, hospitals/clinics

[9]

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27. M/J 16/P21/Q2/b,c

(a) **I** *fusion of lysosomes with phagosome and diffusion of products of digestion*

1 bacteria are, killed / destroyed / broken down / digested ; **A** hydrolysed
A cell wall broken down
R bacteria are cut up

2 (by hydrolytic) enzymes ;

3 any example, e.g. carbohydrase / lysozyme / protease / nuclease ;

4 killed by, hydrogen peroxide / H_2O_2 / free radicals / AW ;

5 AVP ; e.g. correctly named substrate for enzyme
murein / peptidoglycan, polysaccharide(s), polypeptides, nucleic acids, lipids
e.g. correctly named bonds broken
glycosidic, peptide, ester, phosphodiester

(b) 1 *idea that* only, a few / some / small number / AW, with correct specificity ;

2 (different) T-lymphocytes are specific to different antigens ;

3 (T cell) receptor is, complementary (in shape to antigen) ;

4 AVP ;
e.g. this may be during a primary immune response so no memory cells
e.g. disease state (HIV / AIDS and leukaemia) or treatment where few T-lymphocytes in the body [5]

28. M/J 16/P23/Q3

(a) *non-self*
foreign / AW ; **A** not from the person's own body
triggers / AW, an immune response / production of antibodies ;
A other events in immune response described

antigen
protein / glycoprotein ; **A** polysaccharide
ref.to, binding of specific antibody / formation of antigen-antibody complex ;

(b) (i) **P** antigen-binding site / site for antigen attachment ; **A** variable region
Q hinge region ;
R constant region / site of attachment to receptors on phagocytes / AW ;

(ii) disulfide (bonds) ; **R** *if more than one type of bond stated*

(c) (i) 1 TNF-α / antigen, introduced into, mice / small mammals / named ;

2 (antibody-producing), B-cells / B-lymphocytes / plasma cells / splenocytes, isolated (from spleen) ; **A** produced

3 fused with myeloma cells ;

4 using fusogen / PEG ;

5 hybridoma cells formed ;

6 *ref. to* screening / testing, for hybridoma producing desired antibody ;

7 *ref. to* scaling up / large-scale production ;

8 AVP ; e.g. HAT medium for, hybridoma growth / inhibiting myeloma growth

(ii) antibodies bind to TNF-α ;
inactivate / destroy TNF-α ;
inflammation cannot be triggered / AW ; in context of destroying TNF- α [12]

29. M/J 16/P23/Q5/a,b,e

(a) *0 marks if another mode of transmission given (e.g. faecal-oral / contact / sexual)*
I in unpasteurised milk / contaminated meat (*M. bovis*)

1 aerosol / droplet, infection ;
only need to have one of 'infected' / 'uninfected' to gain mp2 and mp3

2 infected / AW, person, coughs / breathes / spits / talks / sneezes ;

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3 uninfected / AW, person, inhales / inspires / breathes in, droplets ;
allow one mark if mp2 and mp3 given with no reference to, infected / uninfected
4 organism / pathogen / bacteria / *M. tuberculosis*, in, airborne droplets / droplets in air ; **A** without 'airborne ' or 'in air' if mp2 gained

(b) 1 incomplete treatment / dose not finished ;
2 not all bacteria killed / some bacteria survive ; **R** TB for bacteria
3 mutation ; **R** mutation to give immunity
4 further detail of mutation ;
5 selection of resistant bacteria / resistant bacteria selected for ;
6 resistant bacteria reproduce / vertical resistance ;
7 death of, susceptible / non-resistant, bacteria ;
8 AVP ; e.g. horizontal resistance / described

(c) *idea that* antibiotics act at a cell structure not possessed by a virus ;
e.g. viruses, do not have, a cell wall / a cell surface membrane / ribosomes
suggestion that viruses, are inside host cells / not within reach(of antibiotics) ;
antibiotics act only on, living / growing, cells (viruses do not grow) ;
A can prevent metabolic processes not occurring in viruses
antibiotics do not act on, protein coat / capsid / capsomeres / viral envelope ; [8]

30. O/N 15/P21/Q5/e

(a) *ref. to* recognition and activation by presence of antigen (on APCs / infected cells) ;
T helper and T killer, lymphocytes / cells ; **A** T cytotoxic
T helper
secrete cytokines ;
(cytokines) stimulate / AW, (specific) B-lymphocytes ; **A** humoral response
stimulate / AW, macrophages / phagocytes / phagocytosis / T killer response ;
T killer
kill infected cells ;
detail of killing ; e.g. perforin / H_2O_2
punching 'holes' in membrane
ref. to T lymphocytes become memory cells (for secondary immune response) ; [5]

31. O/N 15/P23/Q1/b,c,d

(a) a protein combined with, a carbohydrate / sugars / AW ;
A protein with sugar
R protein with, glycogen / polysaccharide

(b) *antibody molecule*
has (2) heavy and (2) light chains / two types of polypeptide / different types of polypeptide ;
idea that each different, polypeptide / chain, is coded for by a gene ;
ref. to gene coding for enzyme for carbohydrate attachment (to make the glycoprotein) ;

(c) *points can be taken from an annotated diagram*
1 variable region / Fab region, has antigen binding sites ;
2 *ref. to* specificity for binding antigen / complementary (shape) to the antigen ;
A *idea of* sequence of amino acids (on light and heavy chain) giving specific shapes
3 (IgG has) two (antigen) binding sites (per antibody molecule) ;
4 heavy chains / Fc / constant, region binds to (receptors on), phagocytes / named phagocyte ;

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5 hinge region gives flexibility when binding to, antigen / pathogen / AW ;
6 disulfide bridges, give stability / hold chains together / AW ;
award on a diagram if bond and chains are labelled
7 AVP ; e.g. R groups bind to antigen
bind to antigen by, hydrogen bonding / ionic bonding
constant region gives antibody class / AW [7]

32. M/J 15/P22/Q5

(a)

A *reverse wording for both*
mark vertically / one mark each correct column

description of event	outcome for the individual	production of memory cells / yes or no	precise type of immunity acquired by individual
individual **P** is injected with a live, weakened disease-causing organism	individual **P** does not become ill from the disease and has long-lasting protection from the disease	yes	artificial active
individual **Q** is exposed to a disease-causing organism and is immediately injected with a specific antibody	individual **Q** does not become ill from the disease but suffers from the disease a year later	no	artificial passive

(b) bone marrow ; **A** stem cells / myelocytes **I** white blood cell

(c) (i) 1 healthy body cells, (recognised as) self / have self-antigens ; **A** non-foreign
2 cancer(ous) / tumour, cells, (recognised as) non-self / have non-self antigens ; **A** foreign
3 idea that changes occur to structure of cell surface membrane of, cancer(ous) / tumour, cells ;
4 phagocytes have receptors for, non-self / foreign, antigens **or**
phagocytes have receptors for antibody complexed to non-self / foreign antigens ;

(ii) 1 uncontrolled / AW, mitosis / (mitotic) cell division / cell replication / cell cycle ;
either
2 one example of a change occurring in a healthy cell
e.g. proto-oncogene to oncogene
mutation of / switching of, tumour suppressor gene
uncontrolled growth
increase in growth proteins
shorter interphase (of cell cycle)
(rapid) DNA replication
cells do not respond to signals (from other cells)
or
further detail of tumour formation ;

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e.g. cells immortal / no apoptosis / no programmed cell death
no contact inhibition / cells continue to grow when they contact other cells
cell cycle checkpoints not controlled
abnormal / AW, mass of cells formed
undifferentiated / unspecialised, cells / tissue / mass
cells do not function (as tissue of origin) [7]

33. M/J 15/P21/Q2/b,c,d

(a) (i) **J** – phagocytosis / endocytosis / described in terms of engulfing *or* forming phagosome ;

(ii) digestion of bacteria / described ;
to destroy bacteria / pathogen ; **A** to prevent spread through the body
antigen, presentation / display on cell surface ;
idea of selection of specific, B cells / T cells ;
A recognition / binding of / activation of, appropriate B / T cells

(b) 1 faster ;
in context of whole secondary response

2 memory cells;
in context of production during the first response

3 *idea that* there are many more cells specific for this pathogen ;

4 (so) increases chances of encountering pathogens more quickly / AW ;

5 fast(er) production of, B lymphocytes / plasma cells / antibodies / helper (T) cells / cytotoxic T cells / cytokines ;

6 greater concentration of antibodies (in, blood / lymph) *or* greater numbers of, B / plasma, cells ;
A more, antibodies / plasma cells / B cells

7 pathogen, removed / killed, faster ;

8 person does not become ill / no symptoms ;
A pathogen does not, spread through the body / infect cells / AW

(c) (i) little / no / slower / weak, immune response ;
stated function of T-lymphocytes, does not occur / occurs slowly ;
e.g. release of cytokines / stimulating macrophages / stimulating B cells / killing infected cells
high susceptibility to infectious diseases ;
R 'fighting disease'

(ii) pathogen **not** recognised, as non-self / foreign ;
pathogen is recognised as self ; **A** non-foreign
ignore antigen concealment

(iii) no, antibodies / plasma cells / memory (B) cells, produced ;
no humoral response ;
no antigen presentation by B cells ; [9]

34. M/J 15/P23/Q3/c,d,e,f

(a) Variola (virus) ;

(b) memory cells produced (along with plasma cells) ;
to max 2
idea of greater number of (specific immune system) cells ;
(memory cells are) long(er) lived / remain in circulation ;
memory T and B cells ;
ref. to / detail of, faster secondary response (to give immunity) ;

(c) *two relevant e.g.*

1 vaccine, thermostable / freeze-dried ; **A** *idea of* longer shelf-life / no wastage

2 virus did not mutate ; **A** pathogen / strain

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3 same vaccine could be used everywhere ;
4 cheap to produce (in large quantities) ;
5 ease of production ;
6 used a live virus / vaccine gave a strong immune response ;
7 no need for boosters ;
8 ease of administration ; e.g. ref. to enthusiastic volunteers
needles could be, sterilised / re-used
9 high percentage cover / AW ;
10 ref. to ring vaccination / described ;
11 global effort / AW ;

(d) artificial active / active artificial ; [7]

35. O/N 14/P22/Q4/b

(a) (i) *look for **AW** throughout*
1 required percentage cover not reached / high percentage cover required / not enough people vaccinated ;
2 some do not respond successfully to vaccine ;
3 poor diet / lack of vitamin A ;
4 poor storage of non-thermostable vaccine ;
5 vaccine not cost-free to population ;
6 inaccessible vaccination stations for some of the population ;
7 *ref.to* difficulty in giving boosters ;
8 *ref.to* reluctance to have children vaccinated ;
9 lack of advertising / campaigns / education to encourage vaccination ;
10 different strain (to the one used in vaccine) / antigens changing ;
R *ref.to* resistance

(ii) 1 *ref. to* secondary (immune) response ;
2 memory (B), lymphocytes / cells ;
3 recognition of / binding to antigens ; **A** clonal selection
A proteins / glycoproteins (on *Morbillivirus*)
4 clonal expansion / described ;
5 plasma cells secrete antibodies ;
6 *idea of* faster production / higher levels of antibody ;
7 *ref. to* T (helper)-lymphocytes, release cytokines / stimulate humoral response ; [5]

36. M/J 14/P22/Q5

(a) (gives) flexibility / described, e.g. *ref. to*, changing orientation / movement to bind antigen / allows binding when two antigens are apart / allows each antigen binding site to move independently ;
A (acts as) hinge region

(b) (i) antigen binding sites / bind to antigen / both bind to same (type of) antigen ;
A *other terms for binding* e.g. attaches to antigen *ignore ref. to receptor*

(ii) binding to phagocyte / monocyte / macrophage / neutrophil / B-lymphocyte / named cell type with Fc receptor ;
A gives class of antibody / determines the class of antibody ;

(c) *secreted*
(antibodies need to be) soluble (to function) ; **AW** e.g. needs to be transported in, aqueous / watery plasma
located on surface
(**X** is region required to) hold / anchor / **AW**, (antibody), in membrane / phospholipid bilayer ;

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ref. hydrophobic core / fatty acid tails of phospholipids hydrophobic ;
interaction provides, stability / anchorage / **AW** ;
ref. hydrophobic region of antibody will have tendency to move back into membrane as repelled by, hydrophilic / watery, exterior solution ;

(d) (i) one / 1 ;

(ii) folding / coiling (to form tertiary structure) ;
ref. interaction of, side chains / R groups (of amino acids) ; **R** react
two of ionic / electrovalent, bond
hydrogen bond
disulfide bonds
hydrophobic interaction
Van der Waal's (forces) ; *one mark only for any two*
hydrophobic, side chains / R-groups / amino acids, in centre / **AW** ;
A hydrophobic region faces, towards centre / **AW**
or
amino acids with hydrophilic R groups face, outwards / watery environment / **AW** ;
A hydrophilic amino acids *for hydrophilic R groups* [8]

37. M/J 14/P21/Q4

(a) (i) *non-self*
foreign / **AW** ; **A** ref. to epitope(s) **I** pathogen / organism
antigen
macromolecule / (glyco)protein / carbohydrate / polysaccharide / oligosaccharide ;
stimulates / **AW**, an immune response / production of antibodies ;
A results in formation of antigen-antibody complexes
A other described events in an immune response

(ii) antibody / immunoglobulin / IgG, on cell surface / on cell membrane ;
(act as) receptors ;
ref. to antigen-binding / **AW** ;
(shape) specific / complementary, to antigen ;

(b) (i) DNA / gene transcribed / mRNA using DNA as template / **AW** ;
A transcription unqualified
idea of mRNA associating with ribosome(s) ;
ref. to tRNA with specific amino acid (carried to ribosome) ;
pairing / **AW** of codons on mRNA with anticodons on tRNA ;
formation of peptide bonds (between adjacent amino acids) ;
antibody / protein / polypeptide(s), enters RER / moves to Golgi body ;
ref. to forming, secondary / tertiary structure ;
antibody / protein / polypeptide(s), modified / processed / glycosylated / formation of quaternary structure / formation of disulphide bond(s) in Golgi (body / apparatus / complex) ; **I** *ref. to* packaging

(ii) vesicles move to cell / surface / plasma, membrane (via cytoskeleton) ;
R secreting vesicles unqualified
vesicles fuse with cell (surface) membrane / exocytosis ; **R** active transport
movement of vesicle / exocytosis requires energy *or* ATP / is active ;

(c) memory cells ; **A** form immunological memory **I** 'gives immunity'
remain / stay in circulation / blood / lymphatic system ;
R 'last a long time / long lived' unqualified
for secondary response ;
fast(er) response when exposed again to same pathogen / same antigen ;
A fast(er) clonal selection / fast(er) clonal expansion
A divide quickly / rapidly

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A long(er) lasting response
to form plasma cells (and more memory cells) ;
more antibodies produced / higher concentration of antibodies ;
R if in context of memory cells
to prevent person feeling ill / to prevent symptoms ;

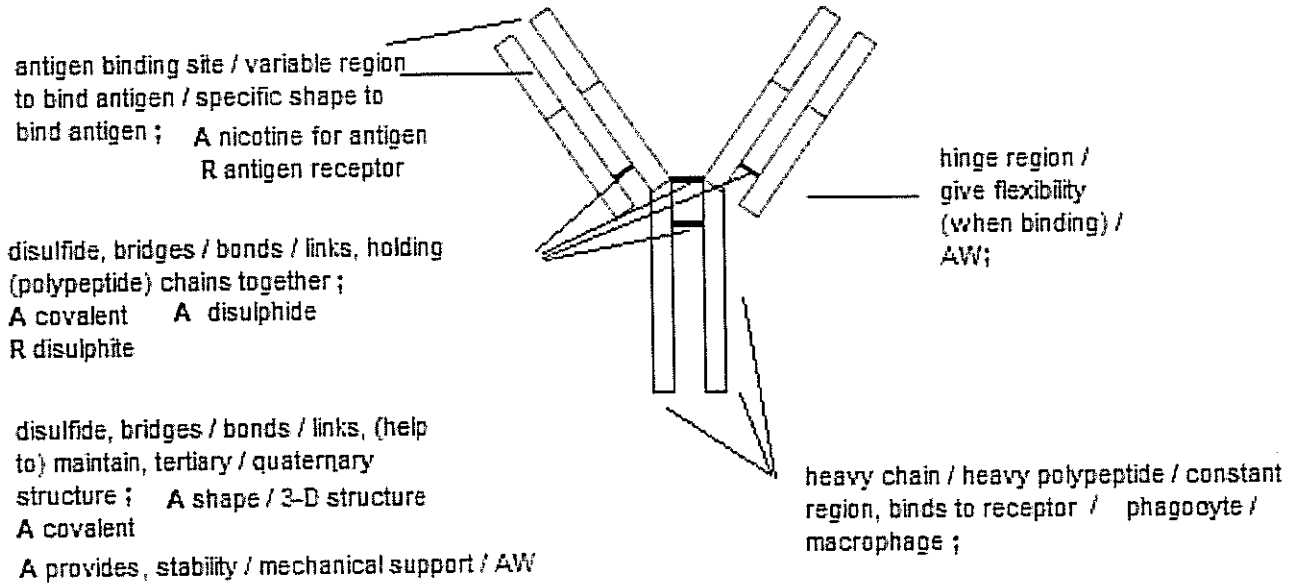
(d) **W** – cytokinesis / cytoplasmic division / cell divides into two ;
I cell division
R mitosis / telophase
Z – (semi-conservative) replication (of DNA) ;
I S phase / interphase of cell cycle
R copying of DNA
R protein synthesis
R if replication is given in any other phase of the cell cycle

(e) 1 breathing in / inhale smoke / 'second hand' smoke / sidestream smoke ;
A passive smoking
I exposed to smoke
2 (tobacco smoke contains) carcinogen(s) ;
3 causes mutation / described ;
e.g. change to / alters / damages, DNA **R** if in wrong type of cell
4 leads to uncontrolled cell division / mitosis / growth ;
5 forming a tumour / mass of cells ;
6 correct ref. to (proto-)oncogenes / tumour suppressor genes ;
e.g. formation of oncogenes / mutation of tumour suppressor genes / 'switching off' tumour suppressing genes
mutation of correct named gene = 2 marks
e.g. mutation of tumour suppressor gene
P53 (gene) mutates = 2 marks

[18]

38. O/N 13/P22/Q6

(a) *labels to correct areas, mark to max 3*



AVP ; e.g.
light and heavy polypeptide chain, ref. forming variable region / different primary structure(s) giving different shapes ;
heavy / polypeptide, chain constant region gives antibody class ; AW

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(b) 1 increases heart rate ;
A heart, pumps / beats faster
2 increased blood pressure / hypertension ;
3 damage to, endothelial / arterial, lining ;
A damage to, tunica intima / lining of veins
4 (so) contributes to plaque / atheroma ;
A atherosclerosis
5 vasoconstriction
or
constricts / reduces diameter of, arterioles / blood vessels ;
A more resistance to blood flow *must be in context*
6 reduced blood flow to extremities / AW ; [6]

39. O/N 13/P23/Q1

(a) **(i)** variable region / antigen binding site ; **A** antigen binding region
A light, polypeptide / chain **R** antigen receptor
(ii) disulfide ; **I** bridge
A disulphide **R** disulfite / covalent
(iii) two or more / more than one , polypeptide(s) / tertiary structure(s) ;
R any specific number of polypeptide on its own
R more than one type of polypeptide / many polypeptides
R more than two / several, polypeptides
I ref to prosthetic group

(b) 1 antigen recognised as / AW, non-self / foreign ;
accept once for macrophage, B-lymphocyte or T-lymphocyte
A non-self / foreign, antigen leads to immune response
2 *idea of* phagocytosis leading to antigen presentation ;
3 antigen (on pathogen or APC) binding to, receptor / membrane, of B-cell(s) / B-lymphocyte(s) ; **A** clonal selection of B-lymphocytes occurs
4 (helper) T-cell / T-lymphocyte, activate B-cells ; **I** killer T-cells
A release cytokines to stimulate B-cells
5 B-cells / B-lymphocytes, divide by mitosis ; **A** replicates / proliferates by mitosis
A clonal expansion of B-cells
6 plasma cells, formed / AW ;
7 plasma cells / B-cells / B-lymphocytes, produce / secrete / AW, antibody / immunoglobulin / Ig ;

(c) *parasite / Plasmodium / pathogen / protoctist / protist / protozoan must be mentioned at least once somewhere in the answer to gain any marks*
e.g. 'malaria / disease has many antigens' = 0
if malaria is caused by a virus / bacterium penalise once only
1 (malarial) parasite / pathogen / *Plasmodium*, (is eukaryotic) has many genes ;
A has greater genetic complexity cf smallpox / AW
2 different (malarial) parasite, species / strains / AW, have different antigens ;
R 'strands'
3 (malarial) parasite has different antigens in different stages of its life cycle ;
4 (malarial) parasite / *Plasmodium*, switches antigens / idea of antigens changing during infection / different genes coding for antigens switching on / AW ;
R 'active sites' of antigens changing
R 'antigens mutate'
5 parasite / antigen / stages of the life cycle, inside (host / liver / red blood) cells ; [9]

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40. M/J 13/P21/Q2

(a) (infected) person, sneezes / coughs / talks / breathes out, (airborne) droplets / aerosol / moist air ;
ignore contact
inhaled / inspire / breathed in, by uninfected, person ;
ignore transplacental transmission

(b) (i) *variable region*
binds / attaches / combines, to antigen ;
R receptor site **R** 'fit'
ref. to specificity ;
ignore complementary shape (to antigen)
R same / similar shape

(ii) *disulphide bond*
ignore ref. to hinge
holds, polypeptides / heavy chains / long chains, together ;
ignore constant as description of chains
maintains, tertiary / quaternary / 3D, structure / shape ;
R shape unqualified

(iii) *constant region*
binds to, receptors / cell (surface) membrane, on, phagocytes / macrophages ;
antigen, marking / tagging, for, phagocytosis / macrophage action ; AW
A ref. to opsonisation
R agglutination [6]

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