7. Transport in Plants

7.2 Transport Mechanisms

Paper 2

Question Paper

1 The pressure of water vapour inside and outside leaves can be measured. The difference between these pressures is known as the leaf vapour pressure deficit (LVPD).

LVPD is one of the factors that influences the rate of transpiration.

Scientists measured the effect of changing the LVPD on the rate of transpiration in several species of flowering plant that live in a variety of different habitats. Two of these species were:

- *Nerium oleander*, a species that is adapted to grow in hot, dry conditions
- *Helianthus annuus*, a species that is not adapted for survival in hot, dry conditions.

Fig. 5.1 shows the effect of increasing the LVPD on the transpiration rates of the two species.

All other factors were kept constant.

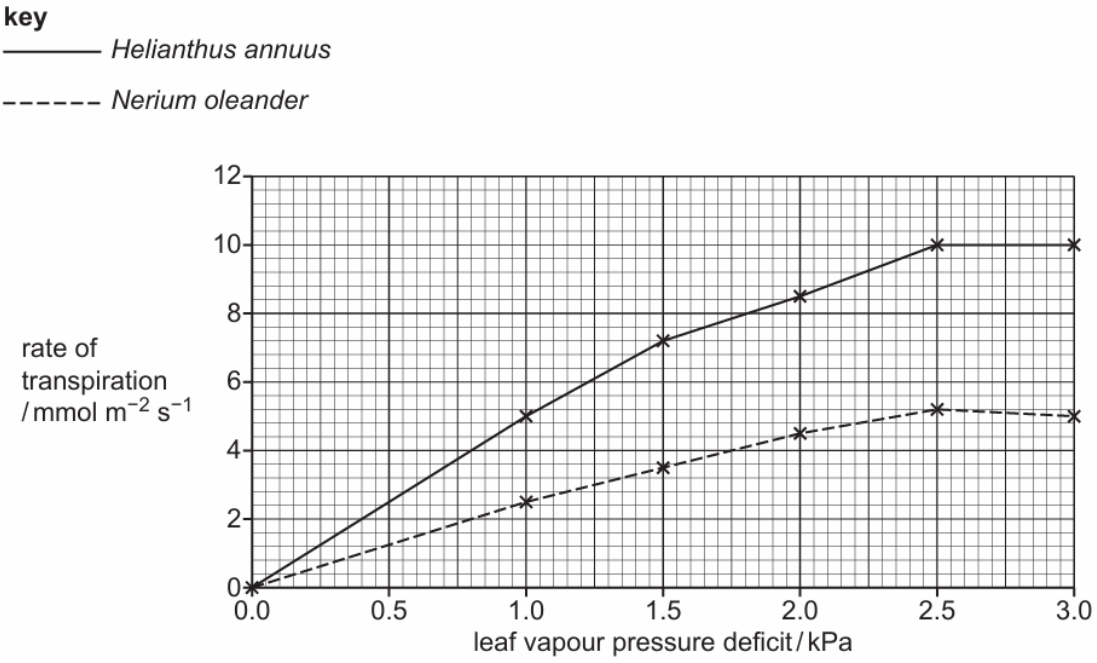


Fig. 5.1

(a) Compare the results of the two species shown in Fig. 5.1.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(b) Fig. 5.2 shows part of a plant of *N. oleander*.



Fig. 5.2

Fig. 5.3 shows a cross-section of part of an oleander leaf.

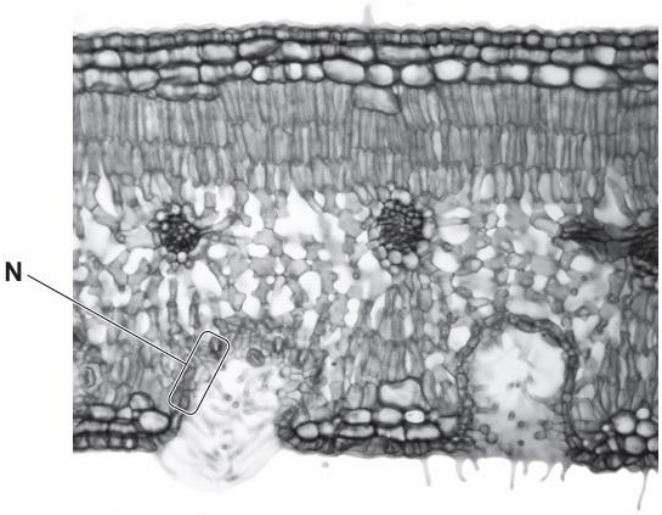


Fig. 5.3

Fig. 5.4 is a drawing of a high-power view of region **N** on Fig. 5.3.

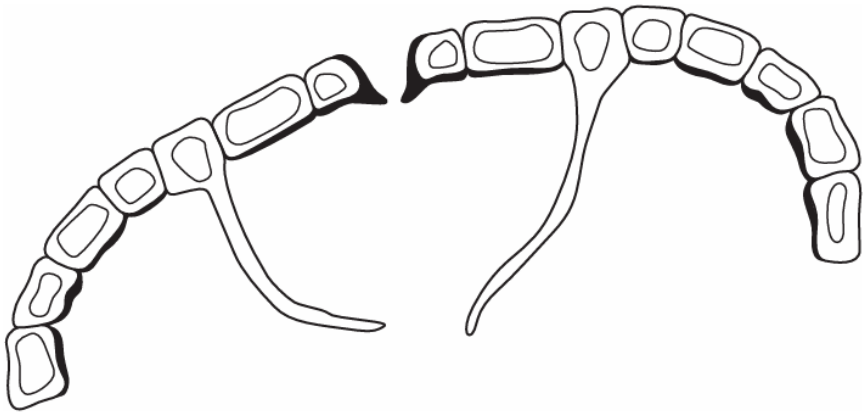


Fig. 5.4

State **and** explain **two** adaptations shown by the leaves of *N. oleander* that are visible in Fig. 5.3 and Fig. 5.4.

one adaptation visible in Fig. 5.3 .....

.....

explanation .....

.....

.....

.....

one adaptation visible in Fig. 5.4 .....

.....

explanation .....

.....

.....

.....

[4]

2 In the mesophyll tissue of leaves, products of photosynthesis can be used to synthesise organic compounds, such as the polysaccharide cellulose and some amino acids.

A source of nitrogen for amino acid synthesis can be provided by nitrate ions that have been taken up in the roots and transported to the leaves.

(c) In the leaf, transport of amino acids from mesophyll cells to companion cells involves using a number of different membrane transport proteins called amino acid transporters.

There is evidence that amino acids can move from the apoplast into the cytoplasm of a companion cell using the same transport mechanism that is used for sucrose transport.

(i) Outline **and** explain the sequence of events that occurs, which allows amino acids to be transported from the apoplast into the cytoplasm of a companion cell.

.....

.....

.....

.....

.....

.....

.....

..... [4]

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

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

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

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

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

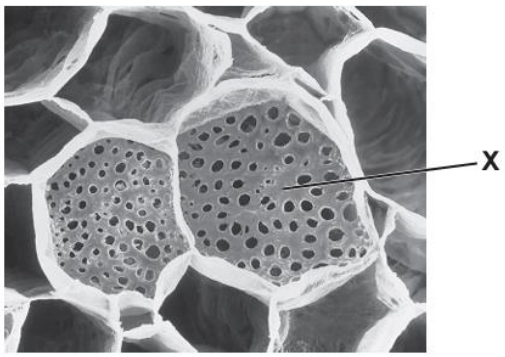


Fig. 4.2

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

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

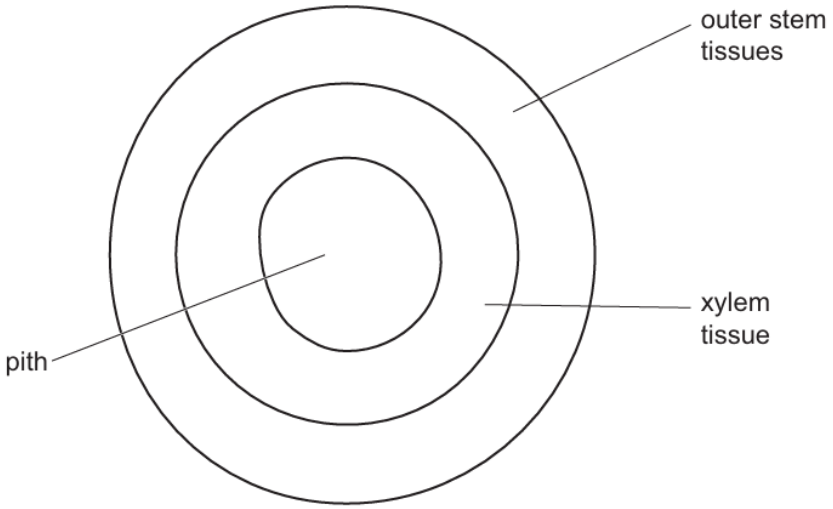


Fig. 4.3

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

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

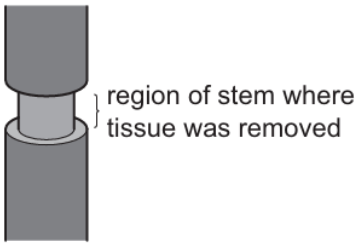


Fig. 4.4

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

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

All other variables remained constant.

Table 4.1 shows the results of this investigation.

Table 4.1

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

Explain the results shown in Table 4.1.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

5 Fig. 6.1 is a diagram showing the passage of water through the tissues of a flowering plant from the soil to the atmosphere. The arrows show the direction of water movement.

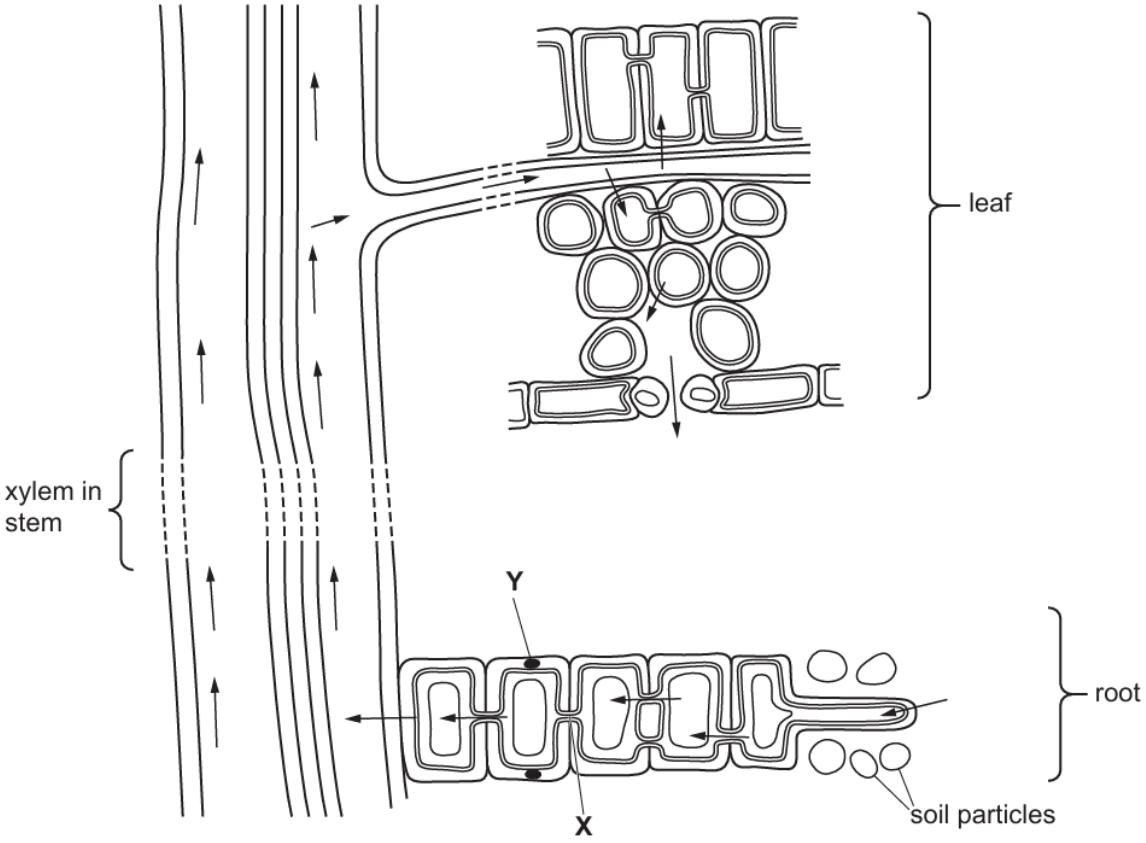


Fig. 6.1

(a) The structure labelled **X** is part of the symplast pathway. State the name of structure **X**.

..... [1]

(b) The structure labelled **Y** in the cell wall is a barrier to the apoplast pathway. State the name of structure **Y**.

..... [1]

(c) With reference to Fig. 6.1, complete the statements about the movement of water in the flowering plant.

Water moves from the soil solution to the cytoplasm of root hair cells by .....

Water moves from the xylem in the root to the leaf by .....

Water moves from mesophyll cell walls to intercellular air spaces by .....

Water vapour moves from intercellular air spaces to the atmosphere outside the leaf by .....

[4]

6 Water that is absorbed from the soil solution by the roots of a plant enters xylem vessels and is transported to the leaves and buds.

Fig. 6.1 shows four important requirements for the efficient transport of water from the roots to the leaves of a plant.

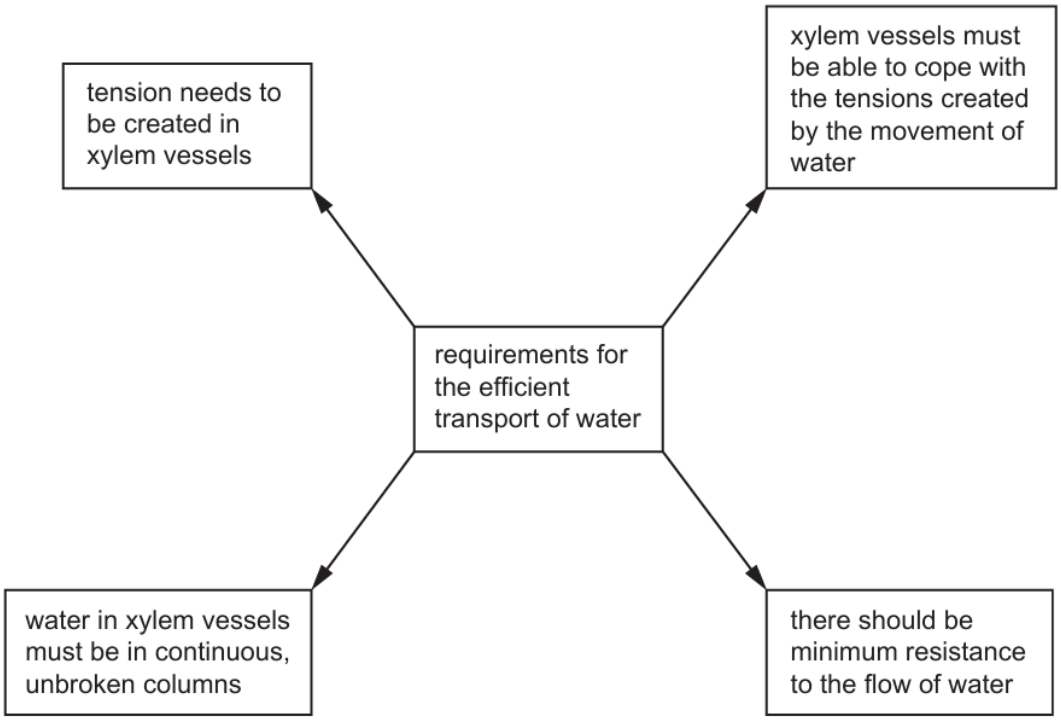


Fig. 6.1

(b) Explain how tension is created in the xylem vessels.

.....

.....

.....

.....

.....

..... [2]

7 Plants have specialised cells for the efficient transport of assimilates.

(c) Hydrogen bonding is important for movement of water through xylem vessels in a plant.

Describe the roles of hydrogen bonding in the movement of water through xylem vessels.

.....

.....

.....

.....

.....

.....

..... [3]

8 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]

9 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.

(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.

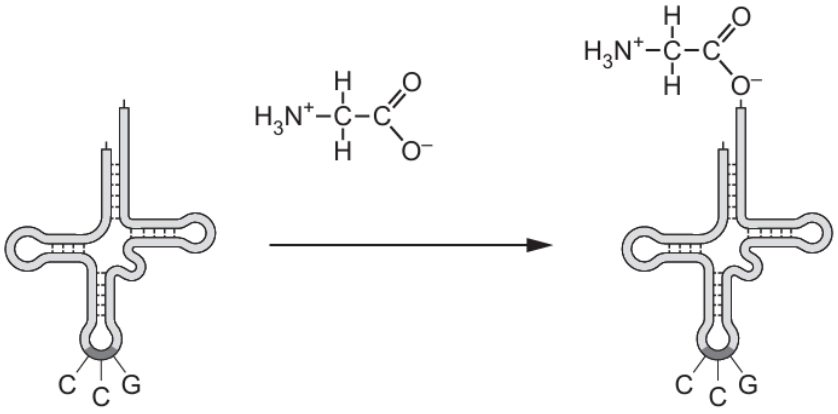


Fig. 6.2

(ii) Outline the role of cotransporter proteins in companion cells.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

10 Xylem and phloem are the transport tissues of plants. Both tissues have more than one cell type.

The conducting cells of xylem contain xylem sap and those of phloem contain phloem sap.
The composition of xylem sap differs from the composition of phloem sap.

(b) Three types of cell associated with the translocation of sucrose are:

- companion cell
- mesophyll cell
- phloem sieve tube element.

A, **B** and **C** are three events that occur at the source. Each event refers to '**the cell**' but does not name the type of cell concerned.

A Sucrose moves through plasmodesmata into **the cell**.
B Hydrogen ions are transported out of **the cell**.
C Sucrose moves into **the cell** through cotransporter proteins.

Complete Table 6.1 by matching the event with a correct cell type.

Each cell type may be identified once, more than once, or not at all.

Table 6.1

event	cell type
A	
B	
C	

[3]

11 **(a)** When water molecules enter a plant through the roots, the molecules cross the cortex and enter the xylem tissue to be transported to other parts of the plant.

There are two pathways that water can take when crossing the root to the xylem tissue.

Complete Table 5.1 with information about the two pathways.

Table 5.1

name of pathway	outline of pathway
	movement of water from cell to cell through plasmodesmata

[2]

12 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]

13 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.

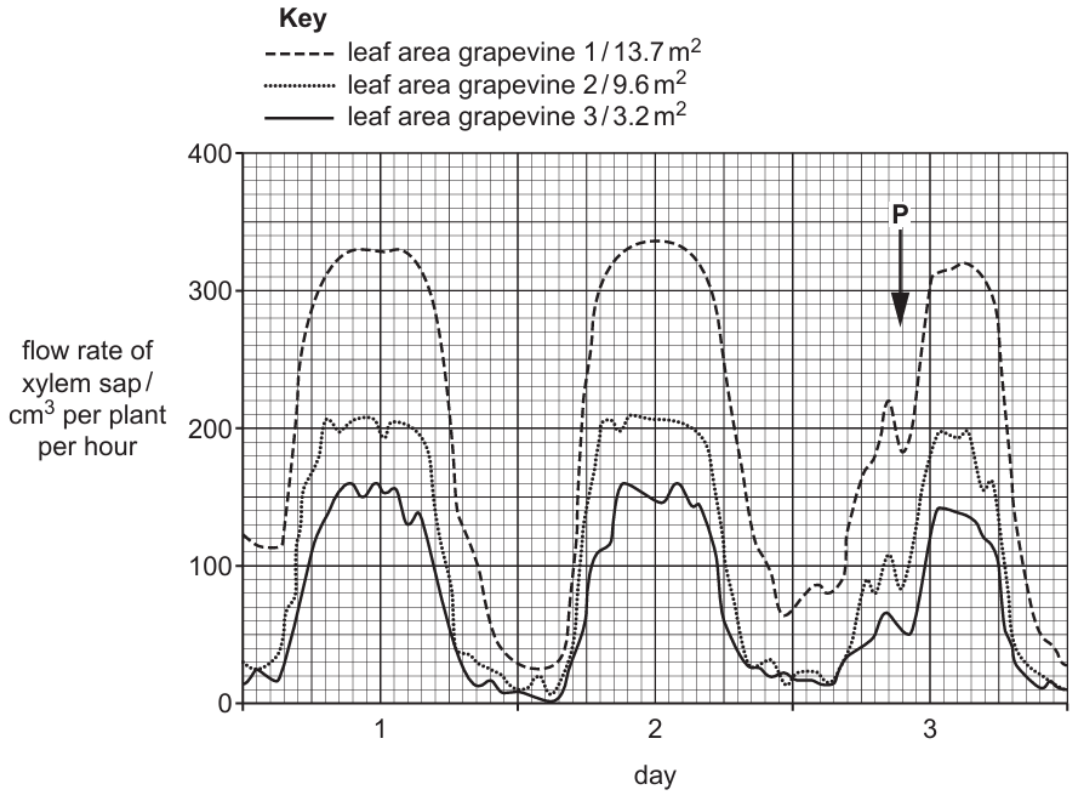


Fig. 4.1

(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]

14 **(c)** Nicotine is one of the components of tobacco smoke. Nicotine can cross cell surface membranes and enter the bloodstream.

(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.

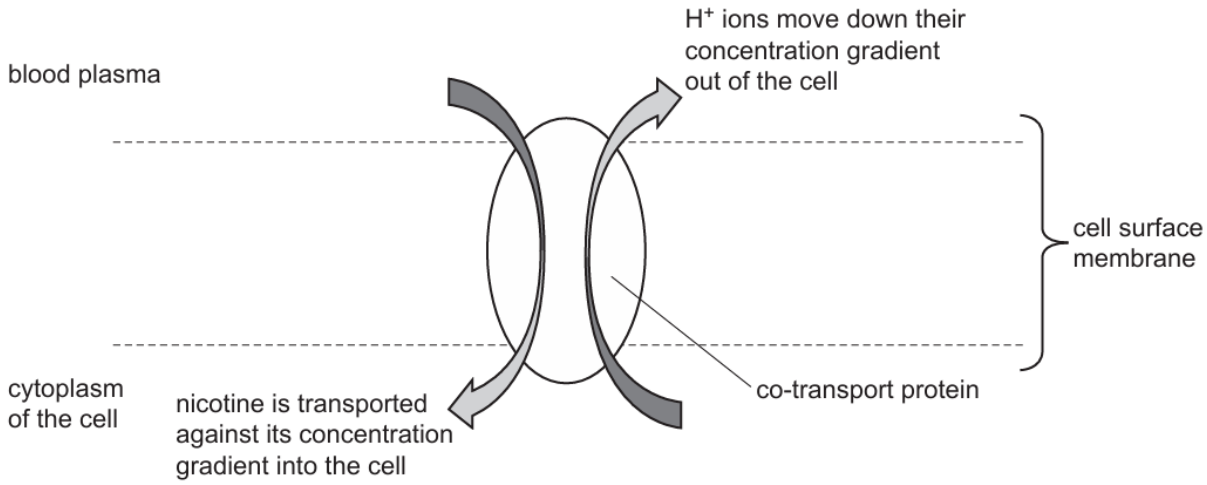


Fig. 2.2

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]

15 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.

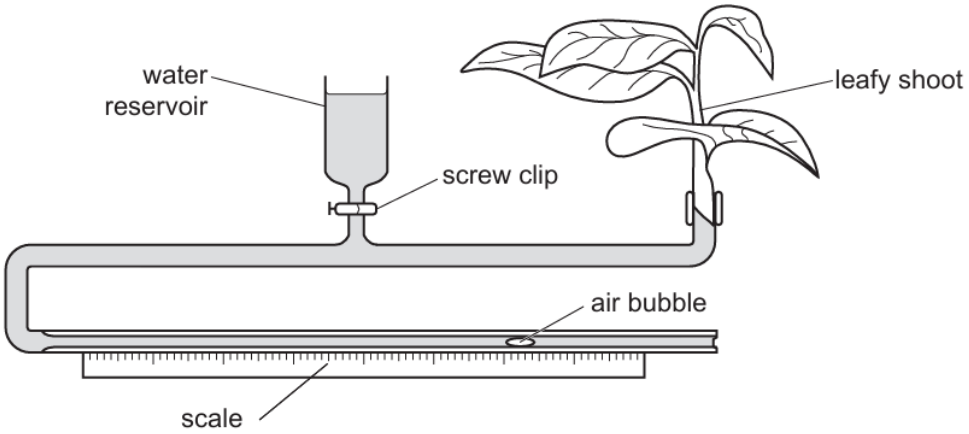


Fig. 5.1

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 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]

16 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]

17 **(b)** Viruses can infect plant cells.

(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]

18 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.

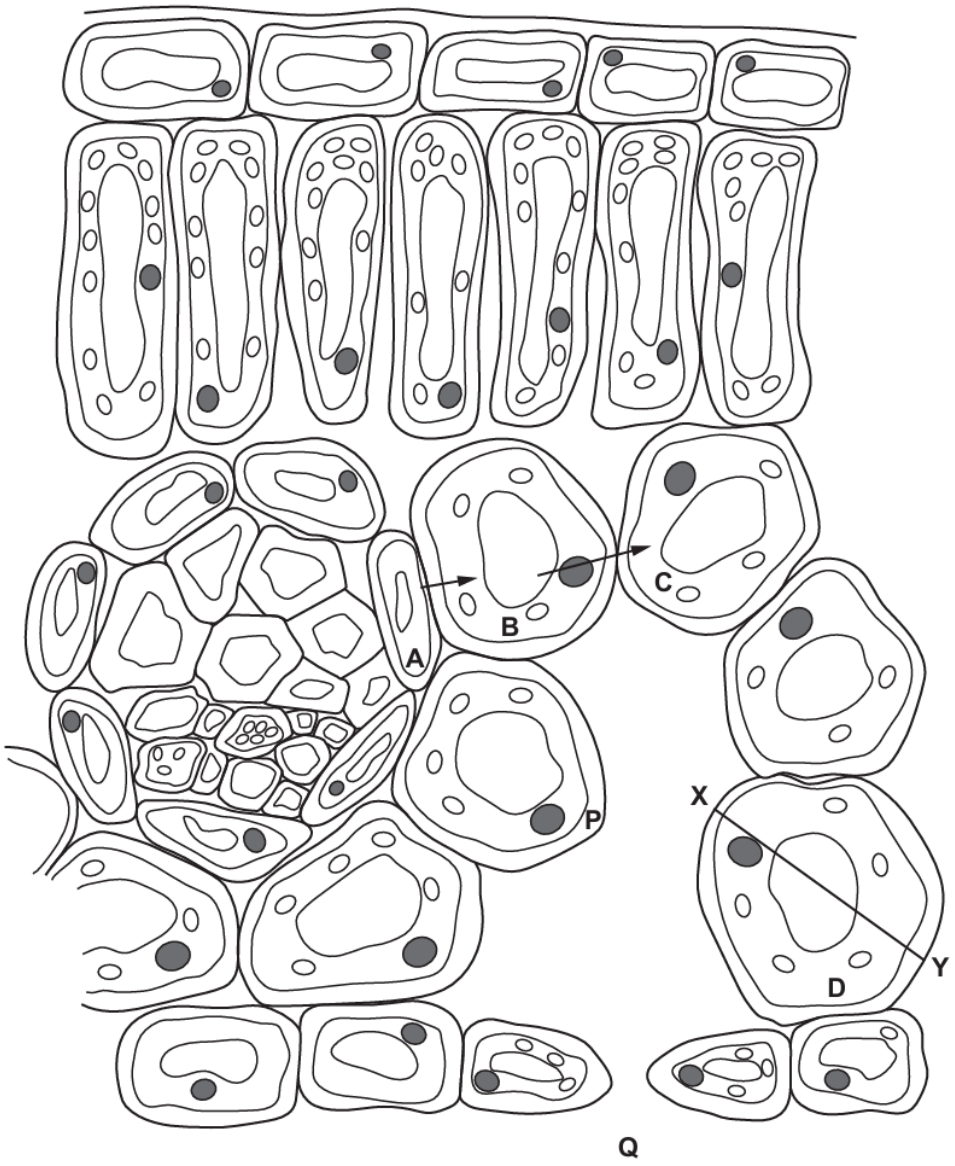


Fig. 1.1

(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]

(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]

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

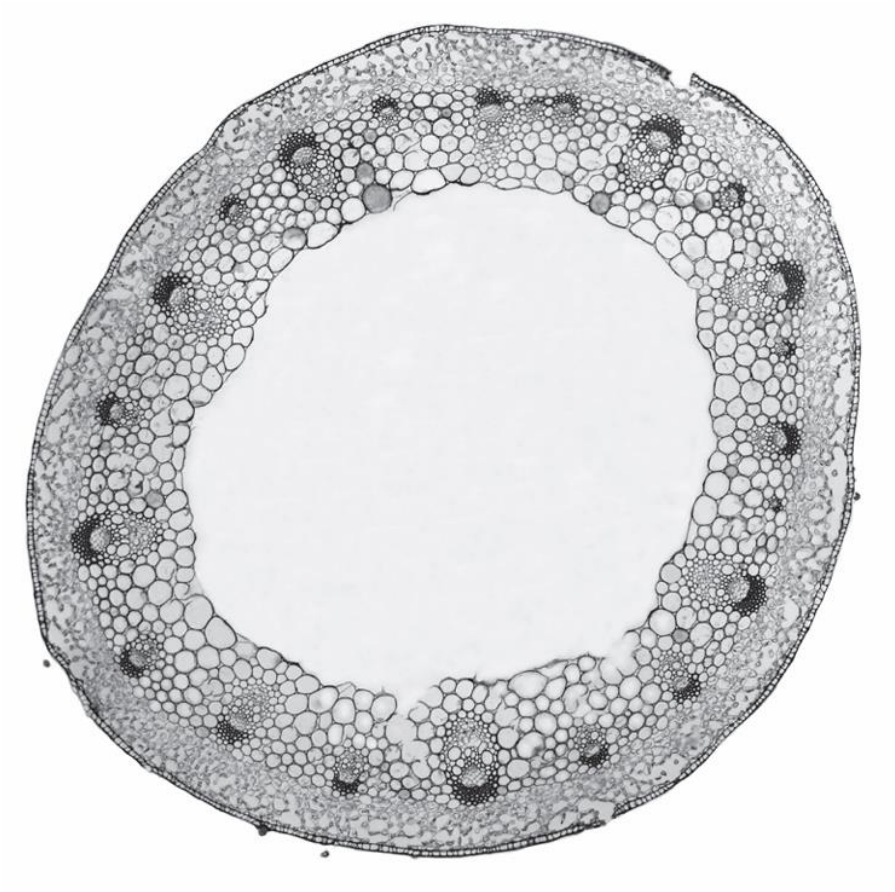


Fig. 1.1

(b) State the role of phloem sieve tubes.

.....

.....

.....

.....

..... [2]

20 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.

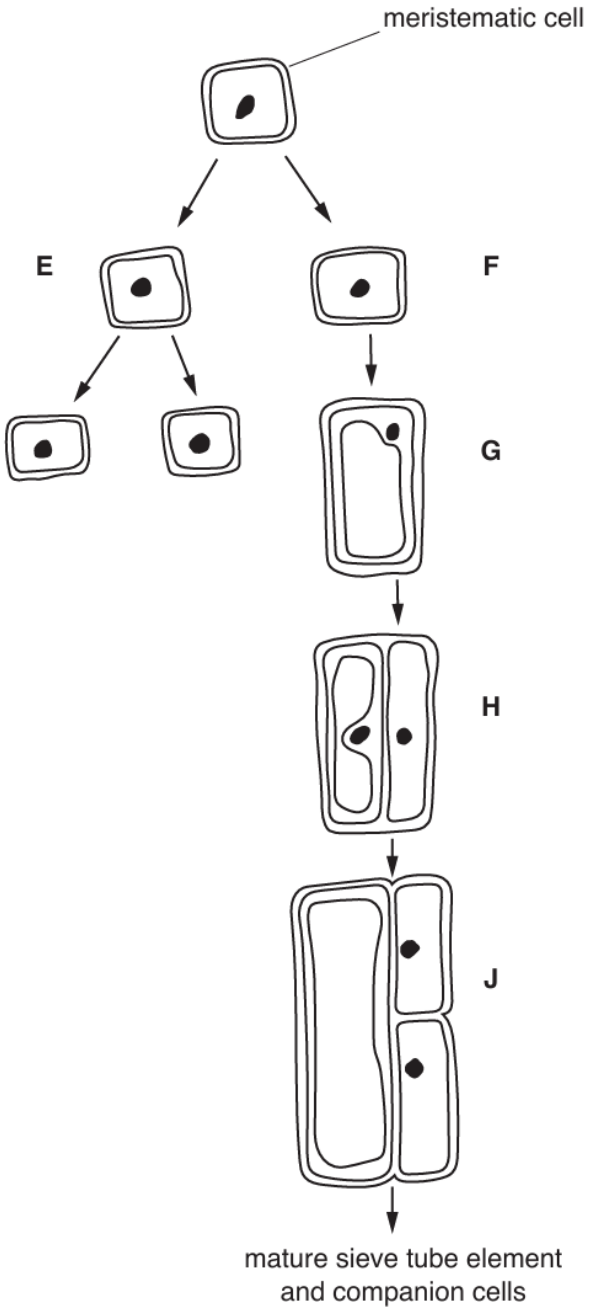


Fig. 4.1

(d) Describe the functions of companion cells in transport in the phloem.

.....

.....

.....

.....

..... [2]

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

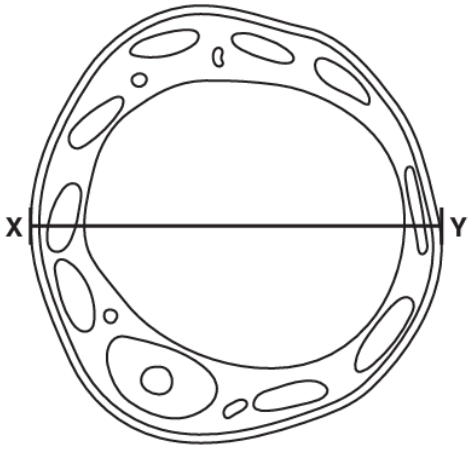


Fig. 1.1

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

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

.....

.....

.....

.....

.....[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]

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

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

23 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*.

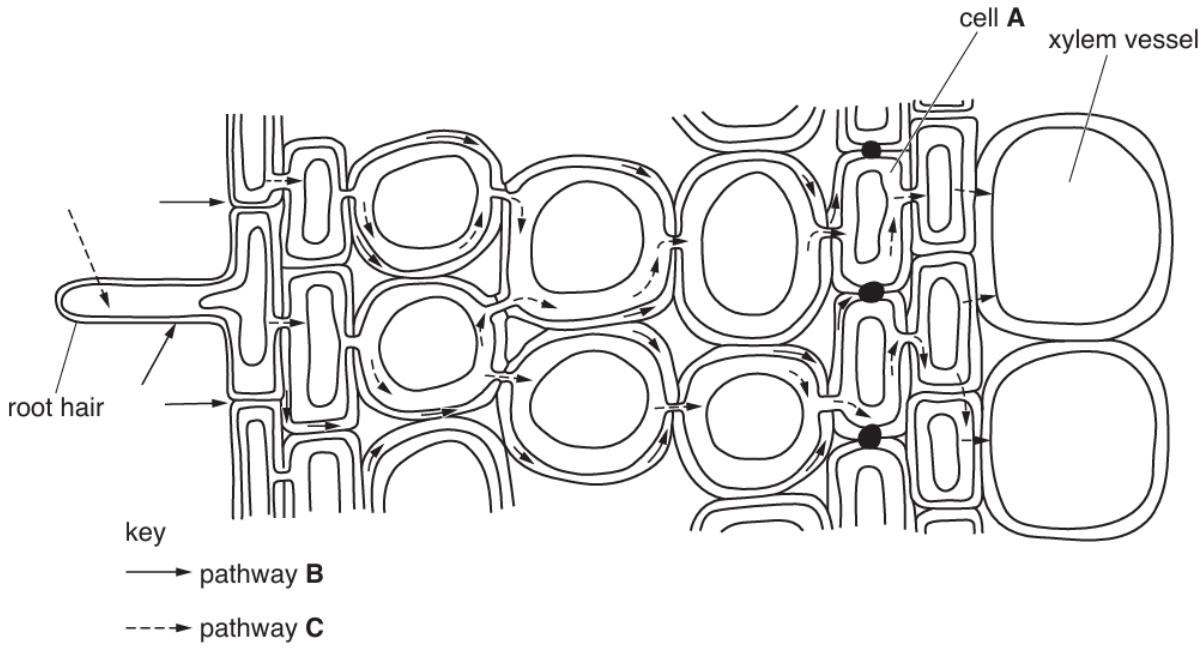


Fig. 6.1

(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]

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

.....

.....

.....

.....

.....

.....[2]

24 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.

(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.

.....

.....

.....

.....

..... [2]

25 **(b)** 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]