1. **How water enters a plant**
   - Water enters the root, from the soil
   - Via root hair cells
   - By osmosis
   - Water moves through the cell walls
   - Then it travels across a partially permeable cell membrane, into the cytoplasm

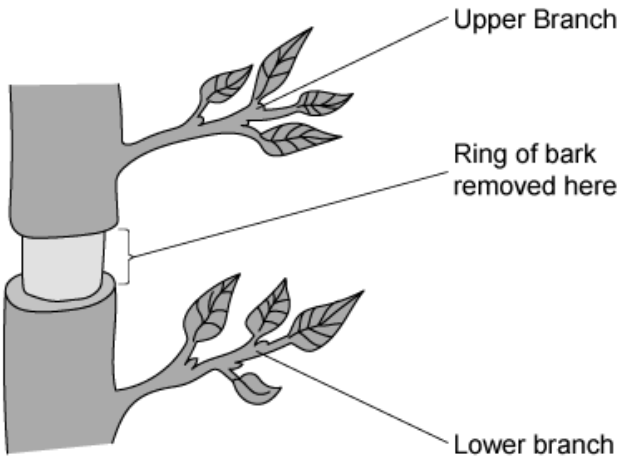
2. **Describe the pathway of water from outside the root to the xylem vessels at the centre of the root**
   - Water enters root hair cells
   - By osmosis
   - Active transport of ions creates a water potential gradient between soil & root cells
   - The soil has a higher water potential than the root cells // the root cells have a lower water potential than the soil
   - Water moves from an area of higher water potential to lower water potential
   - Movement of water occurs across / through partially permeable membranes
   - Water moves across the root cortex to xylem vessels

NOTE: root hairs increase surface area for absorption of water by osmosis, and ions by active transport.

3.

The diagram below shows part of the trunk of a small dicotyledonous tree with a ring of bark removed.

Removing the ring of bark removes one type of transport tissue but leaves the other type intact.



What effect does removing the bark have on the two branches?

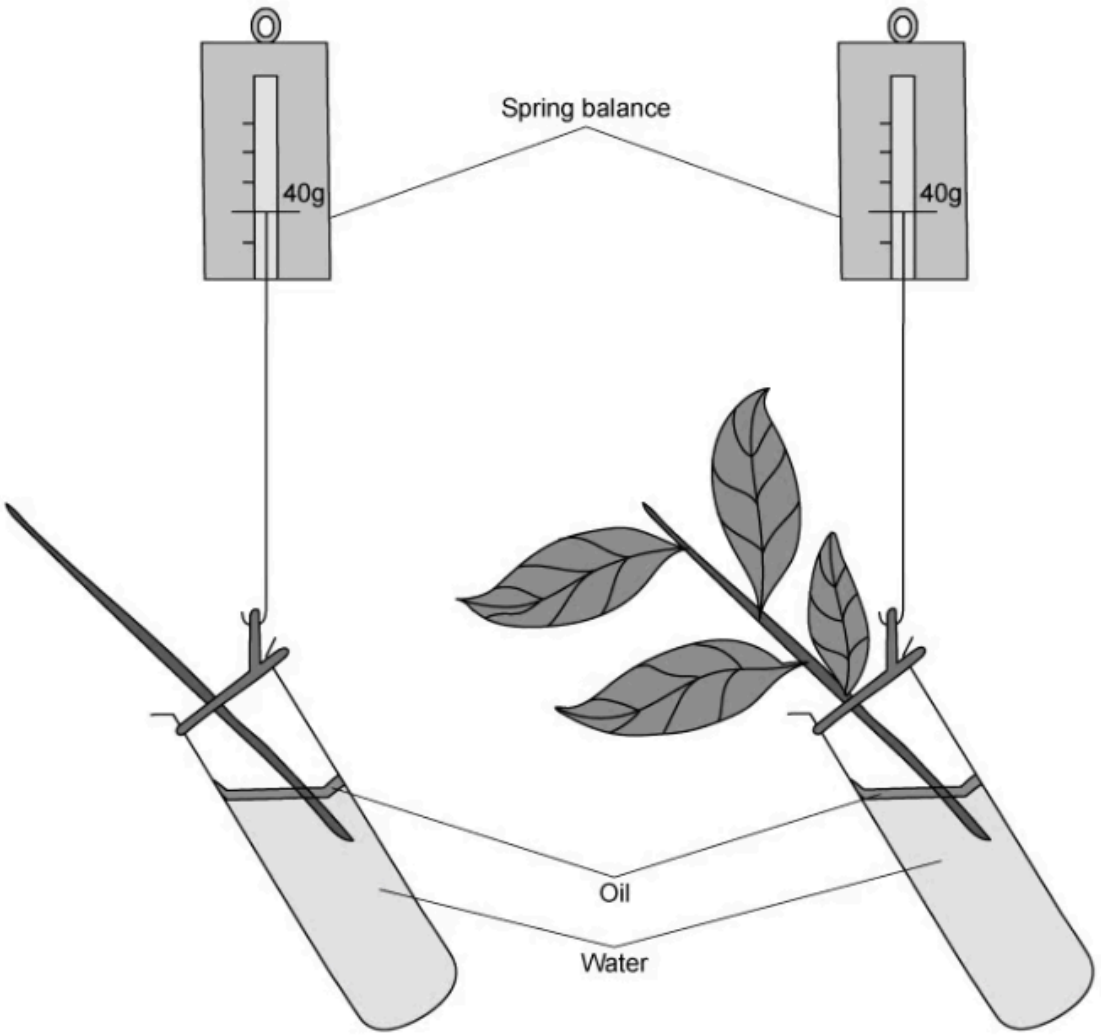
	upper branch		lower branch	
	leaves	**growth**	**leaves**	**growth**
A	normal	normal	normal	reduced
B	wilted	normal	wilted	normal
C	wilted	reduced	normal	normal
D	normal	reduced	wilted	reduced

Answer: A

- The xylem is still intact: in dicotyledonous plants the xylem runs through the middle of the stem. Water transport to all leaves will be unaffected and none of the leaves wilt
- As the phloem is located in rings around the outer edge of the stems of dicotyledonous plants, it has been removed from part of the trunk and consequently the lower branch may get less sucrose and amino acids as it can no longer receive any from further up the plant; this could cause reduced growth. The leaves higher up the plant will probably receive more light (as lower leaves may be shaded) so have a higher rate of photosynthesis and produce more sucrose as a result

4.

The diagram below shows two shoots at the start of an experiment set up by a group of students.



What are the most likely readings on the spring balances after four days?

	Spring balance readings / g	
	shoot A	**shoot B**
A	40	40
B	40	34
C	34	40
D	34	34

Answer: B

- Shoot B has leaves and so transpiration will occur

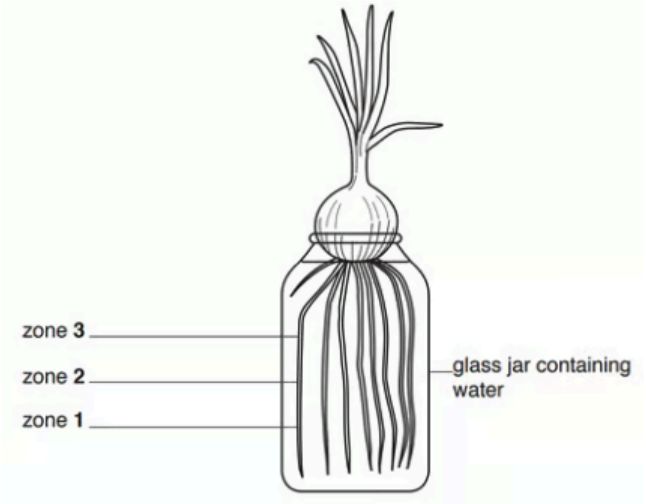
- The water level in the tube will decrease, leading to a loss in mass

NOTE: When using a potometer to measure rate of transpiration, the leaves of the shoot should be dry.

5.

Scientists wanted to determine the flow-rate of water in roots.

They measured the flow-rate in three zones of onion roots as shown in Fig. 2



They measured the flow-rate in healthy roots and roots that had been treated with a toxic solution.

Their results are shown in Table 1.

Table 1

zone in Fig. 2	average flow-rate of water / arbitrary units	
	healthy roots	treated roots
1	150	160
2	230	200
3	280	270

a. Scientists observed that xylem vessels nearer root tip were narrower than xylem vessels higher up the root. Describe how width of the xylem vessels in different zones of a root affects the average flow-rate of water

- The nearer to the tip (zone 1), the lower flow rate // the further from the tip, the higher the flow rate
- Flow rate increases from tip to bulb in both treated and healthy roots
- Flow rate is greater in zone 1 in the treated roots than the healthy roots

- Flow rate is lower in zones 2 and 3 in the treated roots than the healthy roots
- Comparative data quote with units e.g. flow rate in zone 1 of the treated roots was 160 au whereas in zone 3 it was 270 au

b. Suggest why there was little difference in flow-rate in healthy roots & in roots treated with toxic solution

- Xylem vessels are dead, so toxins/treatment have no effect
- osmosis/ water flow into roots does not rely on living cells/ energy / it is passive

6. Environmental conditions affecting the rate of transpiration

- Temperature
- Wind speed
- Light intensity
- Humidity

7. Explain what happens to the cells of a leaf to cause wilting

- Water moves by osmosis
- Water is lost from / moves out of cells / vacuoles
- Movement occurs down water potential gradient
- The pressure of water / cell contents on cell wall decreases
- The cell loses turgor / turgidity // becomes flaccid / plasmolysed
- Water in cells not being replaced as quickly as it is being lost
- Plants / cells rely on water for structural support / to prevent wilting

8. Advantage of wilting

- Wilting causes the stomata to close
- Wilting leads to a decrease surface area exposed to the Sun
- This helps to prevent more water loss
- Therefore water is conserved for other processes

9. Compare transpiration & translocation

<u>Similarities</u>

- Substances flow through vascular bundle
- As aqueous solutions
- Both can travel upwards in a plant

<u>Differences</u>

- Transpiration occurs in the xylem; translocation is in the phloem
- Transpiration carries water / mineral ions; translocation carries sucrose / amino acids
- Transpiration only travels upwards; translocation travels upwards and downwards
- Transpiration involves some dead tissues; translocation needs live tissues to function

- Transpiration is an open loop (soil → air) whereas translocation is more a closed loop to avoid wastage

10. **What is a source**
- A tissue that acts as the site of synthesis/production of a particular nutrient/food compound
- Any photosynthetically-active part of a plant
- The part of a plant where a particular nutrient enters/is taken up

11. **When do seeds act as a source?**
When the seeds are germinating / the plant is growing from seed

12. **Outline the role of a guard cell in the leaf**
- When turgid stomatal opening is large
- Allows gas exchange / carbon dioxide to diffuse in for photosynthesis

13. **Why large number of stomata is not always advantageous**
- Water vapour is lost through the stomata
- Larger number will increase water loss of the plant by transpiration
- A plant will have to absorb more water from the soil to make up for larger transpiration loss

14.

The students then measured the mean widths of the stomata from three different species of plant which had been growing under different light conditions.

Table 1 shows their results.

Table 1

Condition	Time in light or dark / hours	Mean width of stomata as a percentage of their maximum width		
		Species A	Species B	Species C
Light	1	45	67	7
Light	1	89	72	4
Light	1	98	78	2
Light	1	100	64	1
Dark	1	5	14	96
Dark	1	5	16	87
Dark	1	6	11	78
Dark	1	5	13	76
Light	1	49	57	4
Light	1	83	64	1
Light	1	100	79	0
Light	1	99	80	1

Explain why species A is unlikely to be found growing in a hot, dry desert

- For species A, stomata are open in the light and closed in the dark
- For species A, stomata would be open during the day, when it is hottest
- In the desert the heat in the light / day would increase water loss by transpiration
- Desert plants close their stomata in light/day // Species C is more likely a desert plant

15. **Describe & explain how reduced concentration of water vapour in the air would increase the movement of water through crop plants**
    - Increased rate of transpiration

    Because:
    - The concentration of water vapour is greater inside the leaf than outside
    - More water vapour diffuses out of the leaf / the rate of diffusion of water vapour out of the leaf increases
    - Diffusion occurs through the stomata
    - More water moves up the xylem / due to transpiration pull (to replace the water lost at the stomata by transpiration

16. **Explain how the internal structure of leaves results in the loss of large quantities of water in transpiration**
    - Xylem supplies water
    - Air spaces in the leaf
    - Which create a large internal surface area
    - Water evaporates from surface of mesophyll cells
    - Guard cells open / close stomata
    - Water vapour diffuses / moves out through stomata

17. **Explain the role of phloem in plant transport**
    - Transport in phloem is called translocation
    - Phloem allows bidirectional movement / movement in two directions / movement up or down the plant
    - Movement of food/phloem sap occurs from a source to a sink
    - Sucrose/amino acids/food are produced at a source
    - A region of respiration/storage/growth is called a sink
    - example of a source/sink: e.g. roots act as a sink when leaves are photosynthesising
    - Organs can be either a source or a sink at different times

18. **How xylem is adapted for its functions**

    <u>Functions</u>
    - Xylem tissue conducts/transports water and mineral ions
    - To replace water lost through transpiration
    - Water flows with low/little resistance in xylem vessels
    - Xylem provides structural support for plants
    - Spirals allows some flexibility / bending of stems to prevent breaking

    <u>Adaptations</u>
    - It consists of long/elongated cells/vessels/tubes
    - Xylem vessels are hollow / contains no cytoplasm / organelles
    - There are no end/cross walls between cells
    - The walls contain lignin / are lignified
    - Secondary thickening of cell walls / secondary thickening appears as rings / spirals
    - Cell walls) are impermeable to water / waterproof / do not allow water through
    - There are pits in the walls for lateral water movement between vessels

    - **Structure:** Xylem have no cell contents / cells are empty/dead / hollow pipes/tubes
    - **Function:** There is no/little resistance to flow of water / water can flow easily / continuous columns of water can flow / there is no obstruction to water flow

- **Structure:** Xylem cells have no cross/end walls
- **Function:** There is no/little resistance to flow of water / water can flow easily / continuous columns of water can flow / there is no obstruction to water flow

- **Structure:** Xylem cells have a thick/strong cell wall
- **Function:** Xylem can withstand / will not be negatively affected by tension/collapse/ hydrostatic pressure

- **Structure:** Cells have lignin in walls / walls are impermeable
- **Function:** Lignin prevents collapse // provides waterproofing of xylem / prevents water from escaping

- **Structure:** Xylem cells have bordered pits
- **Function:** This allows lateral transport / movement of water out of the sides of the xylem into neighbouring vessels

- **Structure:** Xylem lumen is wide / has a large diameter
- **Function:** Xylem can transport large volumes of water

- hollow / no cell contents, to reduce resistance / allow efficient flow ;
- no end walls, to reduce resistance / allow efficient flow ;
- large cross-sectional area / wide, to allow transport of large volume of water ;
- lignin to, prevent collapse / provide support / provide strength ;
- waterproof to prevent water loss ;

19. How increase in temperature affects the rate of transpiration

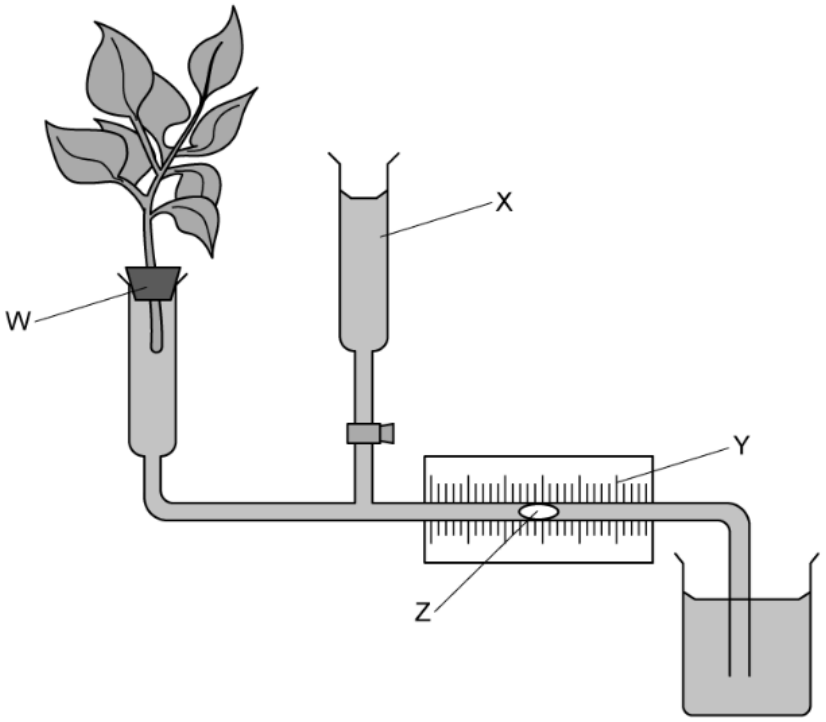
- Increase in temperature increases the rate of transpiration
- Because there will be more / increased rate of evaporation from the surface of the mesophyll cells
- This leads to increase in rate of diffusion of water vapour out of the stomata
- Increasing temperature increases kinetic energy of water molecules
- Stomatal pores become wider at higher temperatures
- Pores widen because guard cells become turgid

20. Mechanism responsible for movement of water in xylem // how transpiration occurs

- Water is lost by evaporation from cell walls in mesophyll in the leaf
- This evaporated water is then lost by diffusion of water vapour through stomata
- This leads to decrease in (hydrostatic) pressure at the top xylem, resulting in water moving upwards/ down the pressure gradient

- Water moves in a continuous column in the xylem // there are no breaks/gaps/air bubbles in the column of water
- This is because of cohesion of water molecules
- Cohesion is the attraction between water molecules
- Adhesion between water molecules and the cellulose in xylem helps to move water
- This force pulling the water up through the xylem is known as transpiration pull
- Water enters/leaves xylem by osmosis / down water potential gradient

21. Label the parts of the potometer



W: bung
X: water reservoir
Y: cm/mm scale
Z: air bubble

In the experiment shown in Fig. 1, the bubble moved a distance of 23 mm in 47 minutes of experiment time.

The bore (internal diameter) of the capillary tube that the bubble is in is 1 mm.

a. Calculate volume of water take up by plant in the given time

$\pi \times 0.5^2 \times 23 = 18 mm^3$

b. Calculate rate of transpiration of the piece of plant (in mm^3/hr)

(18) / (47/60) = 23 mm^3/hr

22.

A different piece of the plant (from a species of tree) was measured and its transpiration rate was found to be 350 mm^3hr^{-1}.

The piece of the tree being studied contained 8 leaves whereas a mature tree of the same species would consist of an average of 65 000 leaves.

(i) Estimate the rate of transpiration of a mature tree of this species.

Express your answer in litres per day (dm^3day^{-1})

$1dm^3 = 1\,000\,000\ mm^3$

$\frac{350}{8} \times 65000 = 2843750\ mm^3/hr$

$\frac{2843750}{1000000} = 2.84375\ dm^3/hr$

$2.84375 \times 24 = 68.25\ dm^3/day$

Give reasons to suggest why this estimate is likely to be inaccurate

- The whole tree is standing outside / not in controlled conditions
- Unlikely that the whole tree is under the same conditions throughout eg. varying temperature / wind patterns
- 24 hours will include the night when the tree is not photosynthesising / low transpiration rate
- Not all leaves transpire at the same rate / no account of leaf age/size is taken here
- The piece of the cut tree may be dying / dead / not as metabolically active as the whole tree because it's been cut off the tree
- Water may be in short supply to the whole tree in its habitat SO the tree cannot transpire as much water

23. Advantage of the root hair cells

- They give the roots a large surface area
- Root hairs can grow between the soil particles
- This increases osmosis of water / active transport of minerals into the root cell

24. State the predominant process by which water is lost from the leaf

diffusion/ evaporation

25. Functions of water in a plant

- Photosynthesis
- A solvent to dissolve mineral ions/sugars/soluble substances
- Transport of mineral ions around the plant
- Support of cells/stems/tissues (turgor pressure)

- A coolant // maintain optimum temperatures for plant growth

26. **Functions of transpiration**
    - Transport of water for photosynthesis OR to maintain cell turgidity
    - Transport of dissolved minerals/mineral ions/named mineral ion for growth / chlorophyll / protein synthesis
    - Helps keep the leaves cool (as heat energy is lost as the water evaporates)

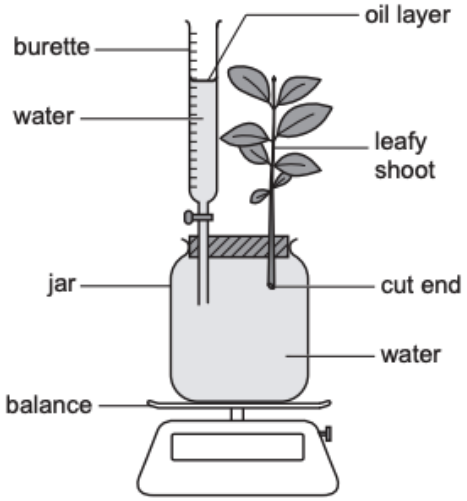
27. **Xylem & phloem vessels running side-by-side make up a recognisable structure within a plant's stem and roots. State the name of this structure:** Vascular bundle

28. **Advantage of xylem containing dead tissue**
    - No need to supply the cells with food/nutrients/minerals // no cell waste products to excrete
    - Cells can be hollow / no cell contents TO allow free passage of water / minerals

29. **In a transpiration investigation using a potometer:**
    a. **How can temperature be varied:** by carrying out experiment in different rooms/ heated/cold rooms
    b. **How can wind speed be varied:** by using a fan

30. **Condition of a plant whose water levels have fallen so low, that it can no longer support itself:** wilted

31. **Apparatus to investigate water loss from leafy shoot**



Before the shoot is inserted into the jar, it must be recut under water. Suggest why.
Ensure continuous column of water / prevents air bubbles / prevents airlock

Purpose of the oil layer on top of the water in the burette

To prevent evaporation / condensation (from top of the burette, affecting the volume of water in the burette)

Method to determine how much water is lost from the leafy shoot.

Measure decrease in volume of water in burette over a period of time / record decrease in mass (over time)

32. Why the mass of water in the apparatus does not change when the leafy shoot is kept at 100% relative humidity

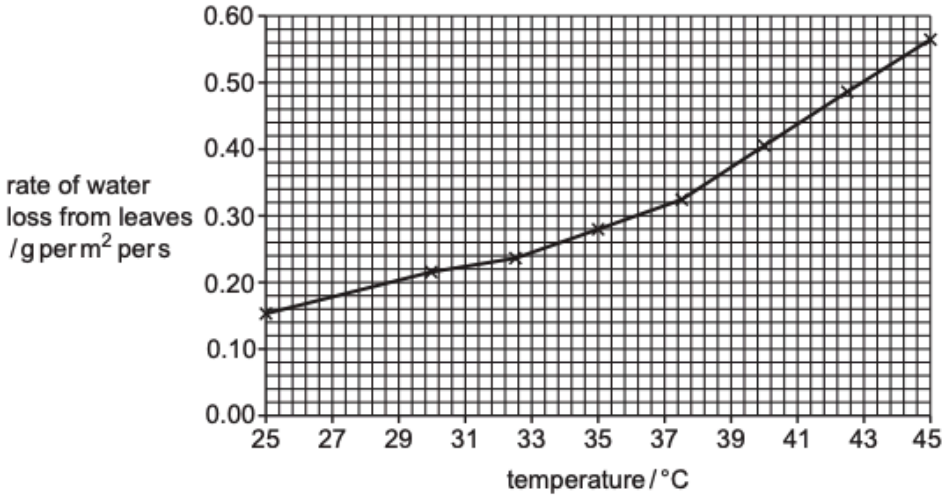
- no diffusion (of water vapour)
- (because) no water potential gradient

33. Even at extremely low relative humidities the leafy shoot did not wilt. Explain why

(it has a) continuous supply of water

34.

The apparatus shown in Fig. 3.1 was used to investigate the effect of temperature on the rate of water loss in a species of plant. The results are shown in Fig. 3.2.



35. Describe & explain effect of increasing temperature on rate of water loss in this plant.

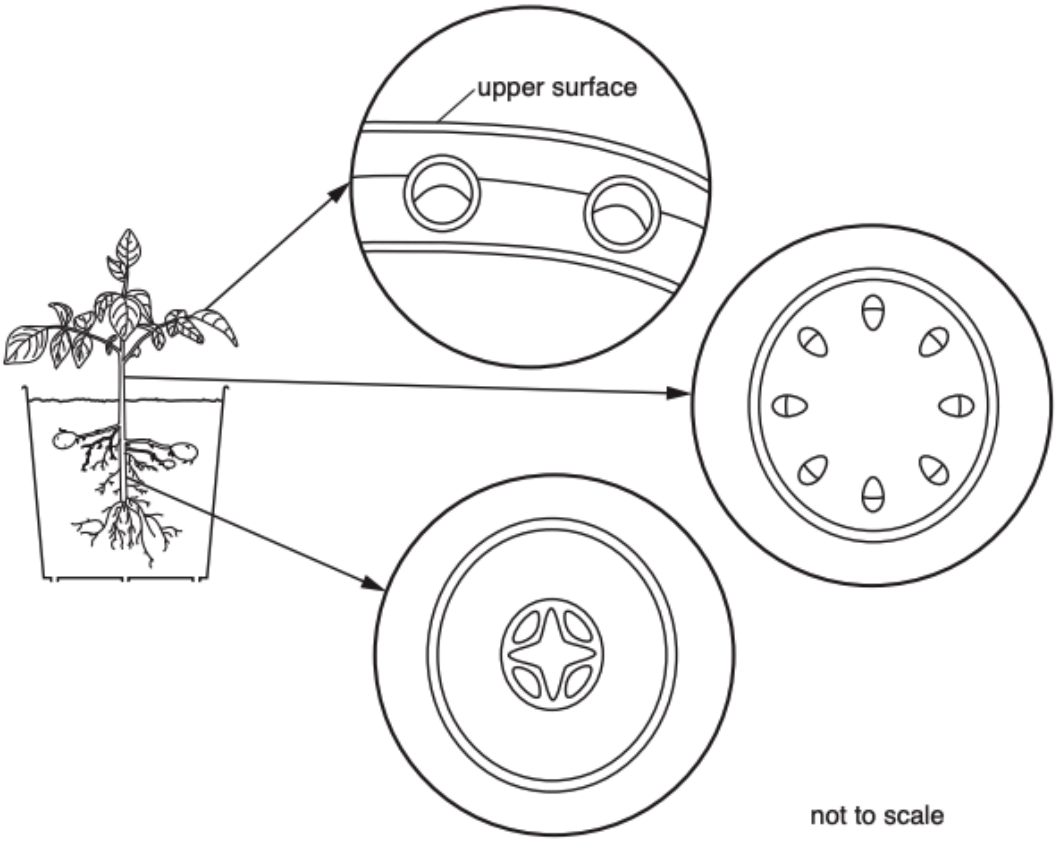
- as temperature increases, rate of water loss increases
- steeper rate / greater loss of water, after 37 / 38°C ;
- comparative data quote (with units)
- diffusion down a water potential gradient
- evaporation from mesophyll into air spaces
- water vapour lost through stomata / between guard cells
- increasing temperature increases kinetic energy (of water molecule)
- faster rate of/ more diffusion

- stomata open wider / more stomata open in high(er) temperatures

36. An insect is feeding on phloem tissue in a leaf. State the names of tissues in the leaf that the mouthparts of the insect pass through to reach the phloem.

- Upper epidermis
- Palisade mesophyll
- Spongy mesophyll
- Xylem

37.



Label xylem and phloem in each of these sections

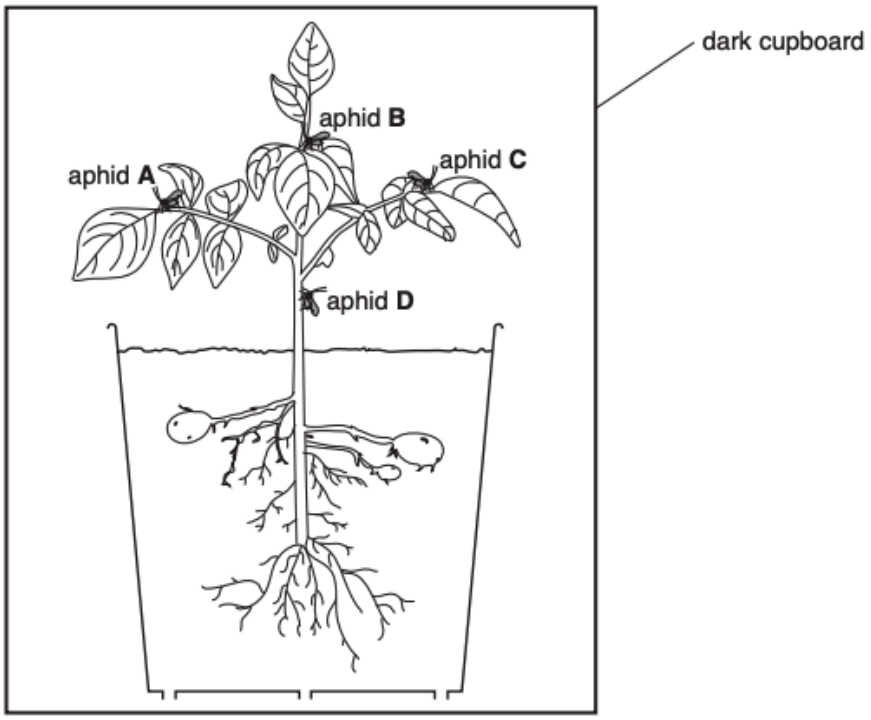
In leaf: xylem is closer to the upper surface

In stem: phloem is outside & xylem is inside

In root: phloem is outside & xylem is inside (star shaped)

38.

A plant was put in a dark cupboard for several days.
Four aphids, **A**, **B**, **C** and **D**, were then placed on the plant in the dark cupboard as shown in Fig. 2.3.



Immediately after the aphids were placed on the plant it was observed that:

- all the aphids ingested the same volume of liquid from the phloem
- aphid **D** ingested the highest concentration of sucrose.

Why aphid D ingested highest concentration of sucrose

- aphid D is nearer the root / is before the branching of the plant
- root / tuber, is a source
- leaves / stems are a sink
- sucrose moves by translocation
- sucrose moves up the plant
- no photosynthesis in the dark
- no / less glucose/sucrose made in the leaves
- plant uses stored starch from root

39.

(b) The movement of sucrose in plants can be modelled using laboratory apparatus.

Fig. 2.1 shows the apparatus used to model the movement of sucrose in a plant:

- Partially permeable bags were attached tightly to the ends of tube **Q**.
- The bag representing a **source** was filled with a coloured sucrose solution.
- The bag representing a **sink** was filled with water.
- The containers and tube **Q** and tube **S** were filled with water.

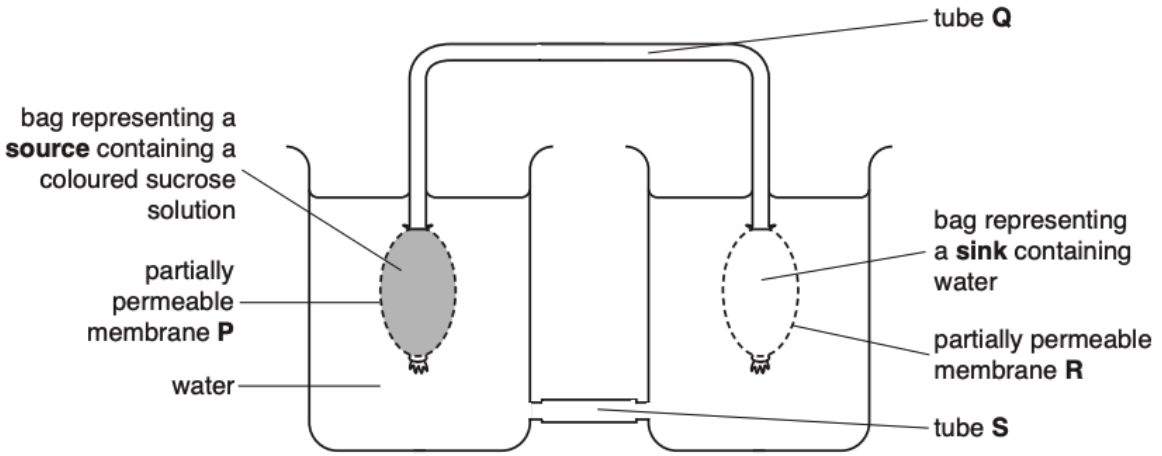


Fig. 2.1

Fig. 2.2 shows the position of the coloured sucrose solution 30 minutes after the apparatus was set up.

The arrows show the direction of the movement of the liquids.

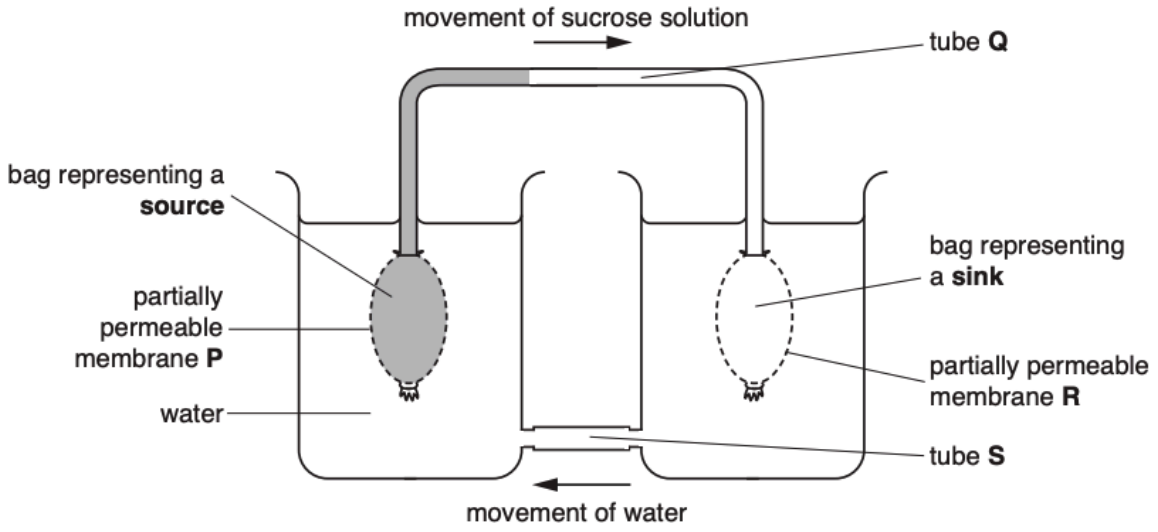


Fig. 2.2

Explain why the sucrose solution moves along tube Q in the model in Fig. 2.2.

- Osmosis of water across the membrane
- Water moves into the source bag
- From high water potential to low water potential

- Sucrose molecules cannot cross the partially permeable membrane
- Sucrose molecules are too large to fit through the partially permeable membrane
- Water moving in increases volume of solution in the source bag
- Increased volume forces/pushes the solution up tube Q
- Water moves out of the sink bag
- Sucrose diffuses along tube Q
- Down a concentration gradient (between source & sink)

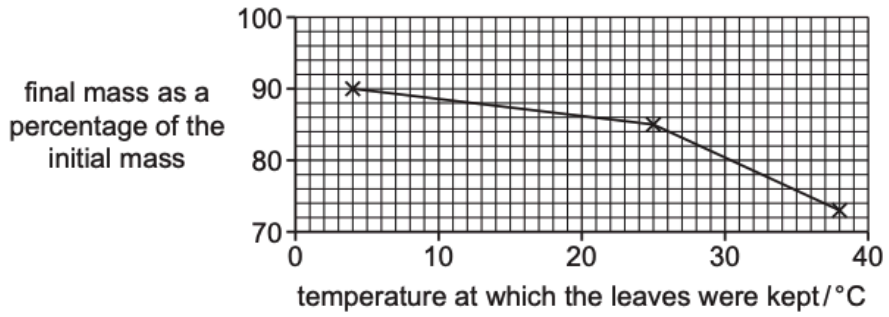
40. mineral ion that is used to make amino acids: nitrate ions

41.

A scientist investigated the effect of temperature on the mass of leaves picked from a tea plant, *Camellia sinensis*.

- Three samples of leaves were picked and the mass of each sample of leaves was recorded.
- Each sample of leaves was kept at a different temperature for four hours.
- After four hours, the mass of each sample of leaves was measured and recorded again.
- The scientist then calculated the final mass as a percentage of the initial mass for each sample.

Fig. 3.1 shows the results.



explain the results shown

- as temperature increases the mass (of leaves) decreases
- by (increased) transpiration ;
- evaporation increases ;
- from surface of the mesophyll cells ;
- due to increased (kinetic) energy of water molecules ;
- diffusion of water vapour increases ;
- through stomata ;

42. Explain how water moves upwards in the xylem

- transpiration pull ;

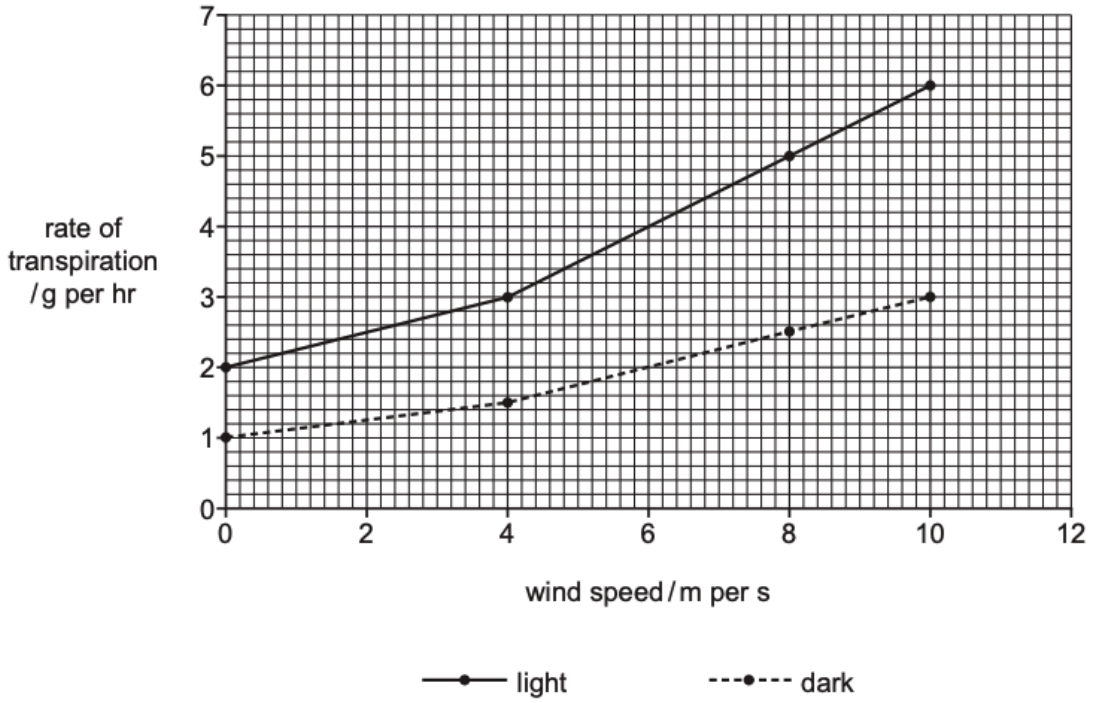
- (draws up) a column of water ;
- held together by forces of attraction between water molecules ;
- (xylem forms) a continuous (empty) tube ;
- loss of water from leaf reduces, water potential / hydrostatic pressure ;

43.

(c) A student investigated the effect of wind speed on the rate of transpiration in a small *Pachira aquatica* tree.

They measured the rate of transpiration when the plant was placed in different wind speeds in both the light and the dark. The tree was given an adequate supply of water.

The results of this investigation are shown in Fig. 2.1.



Describe (max 3)

- as wind speed increases the rate of transpiration increases (in both light and dark)
- (the rate of) transpiration is higher in the light (than the dark) / ora ;
- the rate of increase in transpiration rate is higher in the light than the dark / ora ;
- ref change of gradient at wind speeds above 4 m per s (to 10 m per s) ;
- comparative correct data quote including units ;

Explain:

- (transpiration rate) increases because the water vapour is removed from outside the leaf faster / AW / ora ;
- maintaining the concentration gradient for diffusion ;
- (in the light) (more) stomata are open / stomata are open wider / ora ;

- to allow, gas exchange / carbon dioxide to diffuse in / oxygen to diffuse out, for photosynthesis ;
- energy from light increases the, kinetic energy of the water molecules / rate of evaporation of water ;

The investigation described in 2(c) was repeated (different wind speeds in both the light and the dark). However, the tree was not given an adequate supply of water during the investigation. Predict the result and explain your prediction.

Prediction

- lower rate of / less, transpiration (in the light) ;
- at all wind speeds ;
- little change in the dark ;

Explanation

- less water absorbed by the roots ;
- water moves from the cells ;
- by osmosis ;
- (guard) cells, lose their turgidity / become flaccid ;
- (in the light) stomata close ;
- plant / leaves / tree, wilts ;
- (little change in dark because) stomata already closed ;