

Plant organ system

4.2.3.2 · Organisation · revision notes

How the roots, stem and leaves work together as an organ system to transport water, mineral ions and sugars: root hair cells, xylem, phloem, transpiration, translocation, and the role of stomata and guard cells. Expect 'explain' questions on the factors that affect transpiration and calculations of transpiration rate from potometer data.

Key facts

- Roots + stem + leaves = the plant transport organ system
- Xylem: water and mineral ions, roots → leaves; hollow tubes strengthened by lignin
- Transpiration = loss of water vapour from the leaves
- Guard cells: turgid → stoma opens; flaccid → stoma closes
- Root hair cells: water by osmosis; mineral ions by active transport
- Phloem: dissolved sugars, leaves → rest of plant (translocation); pores in the end walls
- Faster transpiration: higher temperature, lower humidity, more air movement, higher light intensity
- Rate of transpiration = $\frac{\text{volume of water lost}}{\text{time}}$

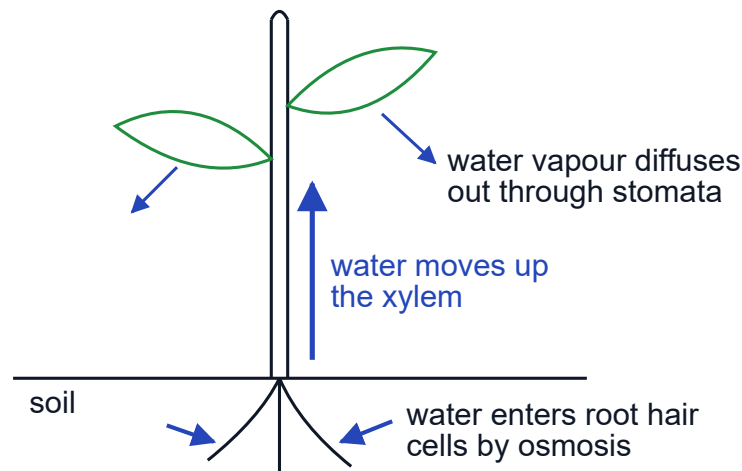
Notes

Roots, xylem and phloem

- The roots, stem and leaves form a plant **organ system** for transporting substances around the plant.
- **Root hair cells** have a long, thin extension that gives a large surface area. They absorb **water by osmosis** and **mineral ions by active transport**, which needs energy from respiration, so they have many mitochondria.
- **Xylem** transports water and mineral ions from the roots to the stems and leaves. It is made of hollow tubes strengthened by **lignin**, suited to carrying water in the transpiration stream.
- **Phloem** transports dissolved sugars from the leaves to the rest of the plant, for immediate use or for storage. This is **translocation**. Phloem is made of tubes of elongated cells, and cell sap moves from one cell to the next through pores in the end walls.

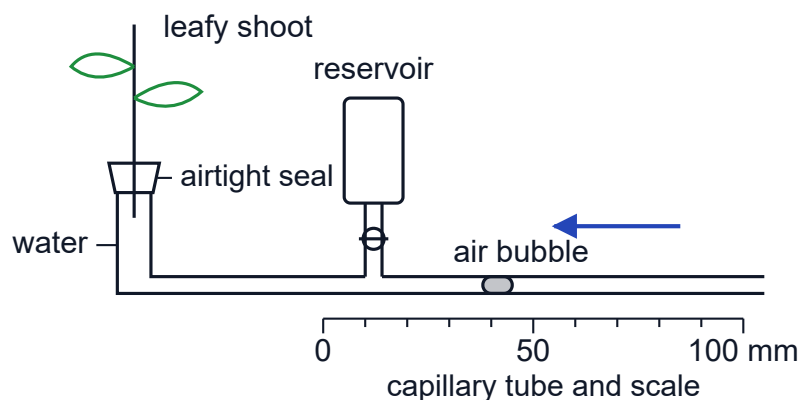
Transpiration

- **Transpiration** is the loss of water vapour from the leaves.
- Water evaporates from the surfaces of cells inside the leaf, and the water vapour diffuses out through the stomata. Water is drawn up the xylem to replace it. This flow is the **transpiration stream**.



The transpiration stream. The arrows show the movement of water.

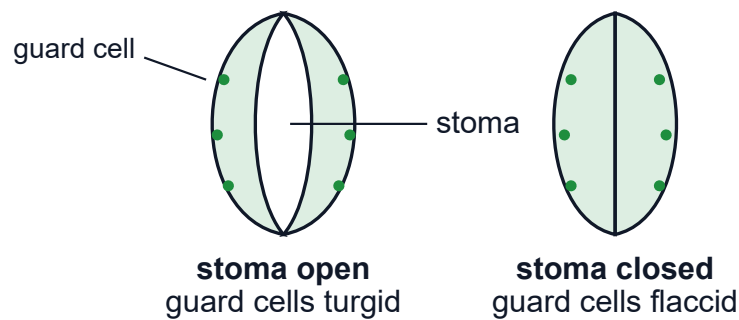
- **Temperature** up → faster: water molecules have more energy, so they evaporate and diffuse faster.
- **Humidity** up → slower: there is more water vapour in the air, so the concentration gradient is smaller.
- **Air movement** up → faster: water vapour is blown away from the leaf, keeping the concentration gradient steep.
- **Light intensity** up → faster: more stomata open to let in carbon dioxide for photosynthesis, so more water vapour escapes.
- Rate of transpiration = volume of water lost ÷ time. A **potometer** measures water *uptake*, which is close to, but not exactly, the water lost.



A potometer. The distance the bubble moves in a set time shows the rate of water uptake.

Stomata and guard cells

- Stomata and guard cells control **gas exchange** and **water loss**.



Guard cells control the size of the stoma.

- Stomata usually close in the dark, when no carbon dioxide is needed for photosynthesis, which saves water.

How to answer each type of question

Explain how root hair cells, xylem or phloem are adapted

2 to 4 marks

Grade 5

- Give a feature of the cell or tissue.
- Link it to its job: absorbing, transporting water or transporting sugars.

Example. Explain how root hair cells are adapted to absorb water and mineral ions from the soil.

Model answer. Root hair cells have a long, thin extension that gives a large surface area (1), so more water can be absorbed by osmosis (1). They have many mitochondria (1), which release energy from respiration for the active transport of mineral ions (1).

Compare xylem and phloem

2 marks

Grade 5

- Compare what each carries, and then how each is built.
- Use 'whereas' so each point covers both tissues.

Example. Give **two** differences between xylem and phloem.

Model answer. Xylem transports water and mineral ions, whereas phloem transports dissolved sugars (1). Xylem is made of hollow tubes strengthened by lignin, whereas phloem is made of elongated cells with pores in the end walls (1).

Don't lose marks

-  Saying water enters root hair cells by diffusion or active transport. Water moves in by osmosis; mineral ions move in by active transport.
-  Saying phloem carries water, or xylem carries sugars.

- ✗ Saying transpiration is the loss of 'water' from the plant in general. It is the loss of water vapour from the leaves.
- ✗ Saying higher humidity increases transpiration. It decreases it, because the concentration gradient is smaller.
- ✗ Saying a potometer measures water loss. It measures water uptake, and some water taken up is used by the plant.
- ✗ Using the diameter instead of the radius, or forgetting to square it, in potometer volume calculations.

More tips

Memory tricks

- Transpiration is fastest in the conditions that dry washing on a line fastest: warm, dry, windy and sunny.
- Humidity is the odd one out: more humidity means slower transpiration.
- Turgid guard cells swell and bow apart, like two bent sausages, opening the stoma.
- Root hair cells: Water by Osmosis, Minerals by Active transport.
- Potometer check: as the shoot takes up water, the bubble moves towards the plant.

Exam technique

- For factor questions, state the effect (increase or decrease), then explain it using the concentration gradient or the stomata.
- In calculations, check the units (mm, mm³, minutes, hours) and give the unit with your answer.
- Keep transpiration (water vapour, xylem) and translocation (sugars, phloem) separate: examiners do not accept them swapped.
- When describing a transpiration graph, quote values from it and say where the rate changes or levels off.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Name the parts of the plant transport system

The roots, stem and leaves form an organ system; xylem carries water and phloem carries sugars.

Grade 4

Define transpiration and translocation

Transpiration is the loss of water vapour from the leaves; translocation is the movement of dissolved sugars through the phloem.

Grade 5

Describe how root hair cells absorb substances

They take up water by osmosis and mineral ions by active transport, helped by their large surface area.

Grade 5

Compare the structure of xylem and phloem

Xylem is hollow tubes strengthened by lignin; phloem is tubes of elongated cells with pores in the end walls.

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