

Plant tissues, organs and systems

Revision notes • Plant tissues, the leaf as an organ, and how water, mineral ions and sugars move through the roots, stem and leaves.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Plant tissues, organs and systems **Spec 4.2.3**

Plant tissues **Spec 4.2.3.1**

You need to be able to explain how the structures of plant tissues are related to their functions. Plant tissues include epidermal tissues, palisade mesophyll, spongy mesophyll, xylem and phloem, and meristem tissue.

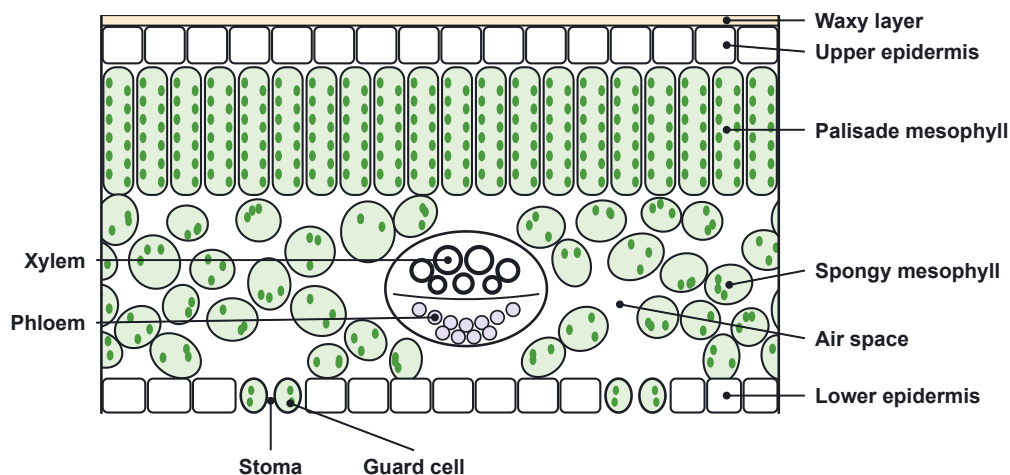
Plant tissues		
Tissue	Structure	Function
Epidermal tissues	A thin layer of cells covering the surface. In the leaf it is covered by a waxy layer	Protects the plant and reduces water loss. The leaf epidermis lets light through
Palisade mesophyll	Tall, tightly packed cells near the top of the leaf, containing many chloroplasts	Photosynthesis: absorbs light
Spongy mesophyll	Rounded cells with air spaces between them	Air spaces let gases such as carbon dioxide diffuse through the leaf. Photosynthesis also occurs here
Xylem	Hollow tubes strengthened by lignin	Transports water and mineral ions
Phloem	Tubes of elongated cells	Transports dissolved sugars
Meristem tissue	Found at the growing tips of shoots and roots. Cells divide and can become different types of cell	Produces new cells for growth

Exam tip: Always give structure and function together: 'many chloroplasts, so absorbs more light for photosynthesis'.

The leaf as an organ **Spec 4.2.3.1**

The leaf is a plant **organ**. It is made up of several tissues that work together. Knowledge is limited to the epidermis, **palisade and spongy mesophyll**, xylem and phloem, and **guard cells** surrounding **stomata**.

- The epidermis covers the leaf. The lower epidermis contains stomata.
- Palisade mesophyll lies below the upper epidermis. It is where most photosynthesis happens.
- Spongy mesophyll lies below the palisade layer. Its air spaces let gases move around.
- Xylem and phloem in the leaf veins bring water to the leaf and take sugars away.
- Guard cells surround each stomatal pore and control its opening.



The tissues of a leaf work together. Most photosynthesis happens in the **palisade mesophyll**.

Exam tip: When you draw a leaf section from a microscope, draw what you see, not what you expect. Use clear lines, draw in pencil, do not shade, and label the tissues.

Roots, xylem and phloem Spec 4.2.3.2

The roots, stem and leaves form a plant **organ system** for transport of substances around the plant.

Root hair cells

Root hair cells are adapted for the efficient uptake of water by **osmosis** and mineral ions by **active transport**.

- The long root hair gives a large surface area for taking in water and mineral ions.
- Mineral ions are usually at a lower concentration in the soil than in the cell, so they move into the cell against the concentration gradient by active transport. This needs energy from respiration, so root hair cells contain many mitochondria.
- Water moves in by osmosis.

Xylem

Xylem tissue transports water and mineral ions from the roots to the stems and leaves. It is composed of hollow tubes strengthened by **lignin**. It is adapted for the transport of water in the transpiration stream.

Phloem

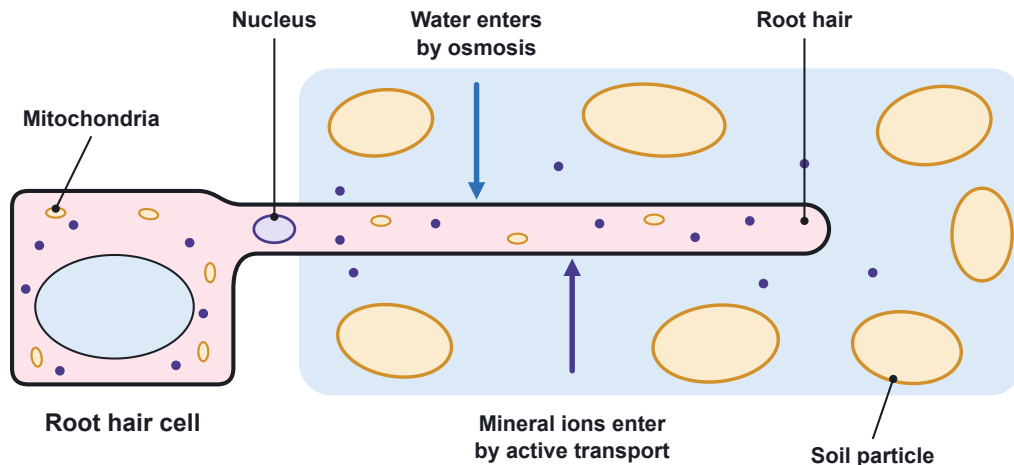
Phloem tissue transports dissolved sugars from the leaves to the rest of the plant for immediate use or storage. The movement of food molecules through phloem tissue is called **translocation**.

Phloem is composed of tubes of elongated cells. Cell sap can move from one phloem cell to the next through pores in the end walls.

Xylem and phloem compared

	Xylem	Phloem
Transports	Water and mineral ions	Dissolved sugars
Direction	From the roots to the stems and leaves	From the leaves to the rest of the plant
Structure	Hollow tubes strengthened by lignin	Tubes of elongated cells with pores in the end walls
Process	Transpiration stream	Translocation

Exam tip: The detailed structure of phloem tissue and the mechanism of transport are not required, so just learn what is written above.



Water enters by **osmosis**. Mineral ions enter by **active transport**, using energy from the mitochondria.

Transpiration and stomata Spec 4.2.3.2

Transpiration is the loss of water vapour from the leaves. Water moves from the roots to the leaves in the xylem in a continuous flow called the **transpiration stream**.

1. Water enters the root hair cells by osmosis.
2. Water moves up through the xylem to the leaves.
3. Water evaporates from the surface of the mesophyll cells into the air spaces in the leaf.
4. Water vapour diffuses out of the leaf through the stomata.

The transpiration stream brings water and mineral ions to the leaves. Leaf cells need water and carbon dioxide for photosynthesis.

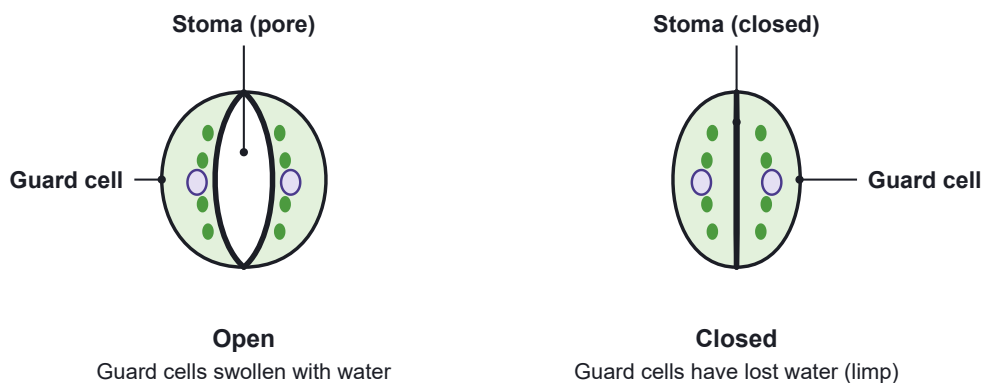
Stomata and guard cells

Stomata are small pores, mainly on the underside of the leaf. Each is surrounded by a pair of **guard cells**. The role of stomata and guard cells is to **control gas exchange and water loss**.

- When the guard cells take in water they swell and the stoma opens. Carbon dioxide can diffuse in for photosynthesis and oxygen can diffuse out. Water vapour is also lost.
- When the guard cells lose water the stoma closes, which reduces water loss.

There is a trade-off. Closing the stomata saves water but stops carbon dioxide getting in, so photosynthesis slows down.

Common mistake: Transpiration is the loss of water vapour from the leaves. Translocation is the movement of sugars in the phloem. Do not mix them up.



Guard cells swell to **open** the stoma and go limp to **close** it.

Factors affecting the rate of transpiration Spec 4.2.3.2

You need to be able to explain the effect of changing **temperature**, **humidity**, **air movement** and **light intensity** on the rate of transpiration.

Factors affecting transpiration			
Factor	Change	Effect on rate	Reason
Temperature	Increase	Increases	Water evaporates faster and diffuses out of the leaf faster
Humidity	Increase	Decreases	The air around the leaf already has a lot of water vapour, so the concentration gradient is smaller and diffusion is slower
Air movement	Increase	Increases	Moving air carries away water vapour from around the stomata, keeping a steep concentration gradient
Light intensity	Increase	Increases	Stomata open wider in the light, so more water vapour can escape

The opposite change has the opposite effect: lower temperature, more humid air, still air and darkness all reduce the rate of transpiration.

Measuring the rate of transpiration

A **potometer** measures the uptake of water by a cut shoot. This is used as a measure of the rate of transpiration.

1. Cut a shoot under water and fit it into the potometer, making sure the apparatus is full of water with no air bubbles.
2. Dry the leaves and seal the joints so no air or water can leak.
3. Introduce an air bubble into the capillary tube and record its starting position.
4. Measure the distance the bubble moves in a set time.
5. Change one factor, such as air movement from a fan, and repeat.

$$\text{rate of transpiration} = \text{distance moved by bubble} \div \text{time}$$

Rate of transpiration

An air bubble in a potometer moves 36 mm in 12 minutes. Calculate the rate of transpiration in mm per minute.

1. Rate = distance $\div$ time.
2. Rate = $36 \div 12$.

Answer: 3 mm/min

Volume of water taken up

The capillary tube has a cross-sectional area of 0.8 mm^2 . The bubble moves 40 mm in 10 minutes. Calculate the volume of water taken up and the rate in mm^3 per minute.

1. Volume = cross-sectional area $\times$ distance = $0.8 \times 40 = 32 \text{ mm}^3$.
2. Rate = volume $\div$ time = $32 \div 10$.

Answer: 32 mm^3 of water; $3.2 \text{ mm}^3/\text{min}$

Other maths skills

Repeat readings and find the arithmetic mean to reduce the effect of random errors. When you plot a graph, put the independent variable on the x-axis, choose scales that use most of the grid, label both axes with units and draw a line of best fit. The same ideas apply when you investigate the distribution of stomata by counting them in several fields of view (a sample) on a leaf.

Mean number of stomata

A student counts the stomata in three fields of view on the lower surface of a leaf: 24, 28 and 20. Calculate the mean.

1. Add the counts: $24 + 28 + 20 = 72$.
2. Divide by the number of fields of view: $72 \div 3$.

Answer: 24 stomata per field of view

Maths skill: *The potometer measures water uptake, which is used as an estimate of the water lost. A fair test keeps all other factors the same each time.*

Quick check

1. Which plant tissue transports water and mineral ions?
2. What is translocation?
3. Why does an increase in humidity decrease the rate of transpiration?
4. What do guard cells control?

Quick check answers

Plant tissues, organs and systems

- 1 . Xylem.
- 2 . The movement of dissolved sugars through phloem tissue from the leaves to the rest of the plant.
- 3 . The concentration gradient of water vapour between the leaf and the air is smaller, so water vapour diffuses out more slowly.
- 4 . The opening and closing of stomata, which controls gas exchange and water loss.