

Leaves, water uptake and extreme environments

Revision notes · How a leaf is built for photosynthesis and gas exchange, what changes water uptake, transpiration calculations and plants in extreme environments.

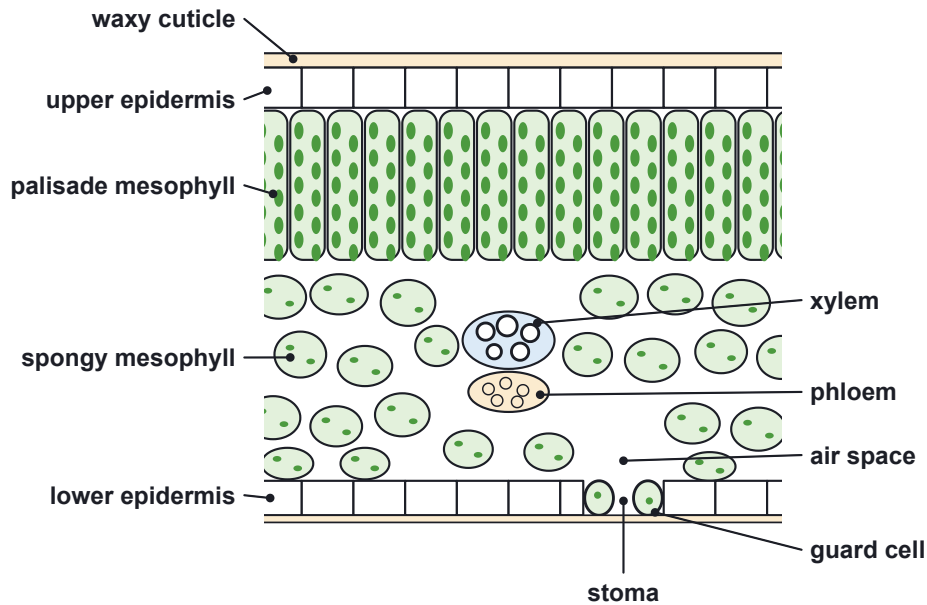
For Edexcel GCSE Biology 1BI0 and Combined Science 1SC0. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Leaves, water uptake and extreme environments **Spec 6.11B-6.14B**

Leaf structure **Spec 6.11B** **Triple only**

A leaf is adapted to absorb light for **photosynthesis** and to allow **gas exchange** of carbon dioxide and oxygen.

Structures in a leaf and how they are adapted		
Structure	Adaptation	How it helps
Whole leaf	Broad, flat and thin	Large surface area to absorb light, and a short distance for gases to diffuse
Waxy cuticle	A waxy, waterproof layer on the surface	Reduces water loss by evaporation
Upper epidermis	A thin layer of transparent cells	Lets light through to the cells underneath
Palisade mesophyll	Tightly packed, tall cells near the top of the leaf, with many chloroplasts	Most photosynthesis takes place here, close to the light
Spongy mesophyll	Loosely arranged cells with air spaces between them	Carbon dioxide can diffuse through the leaf to the cells, and oxygen can diffuse out
Stomata and guard cells	Pores, mostly in the lower epidermis, opened and closed by guard cells	Allow gases to enter and leave, and control water loss
Xylem and phloem (veins)	Vascular bundles running through the leaf	Xylem brings water for photosynthesis. Phloem carries sucrose away.



Leaf cross-section: most photosynthesis happens in the **palisade mesophyll**; gases diffuse through the air spaces and stomata.

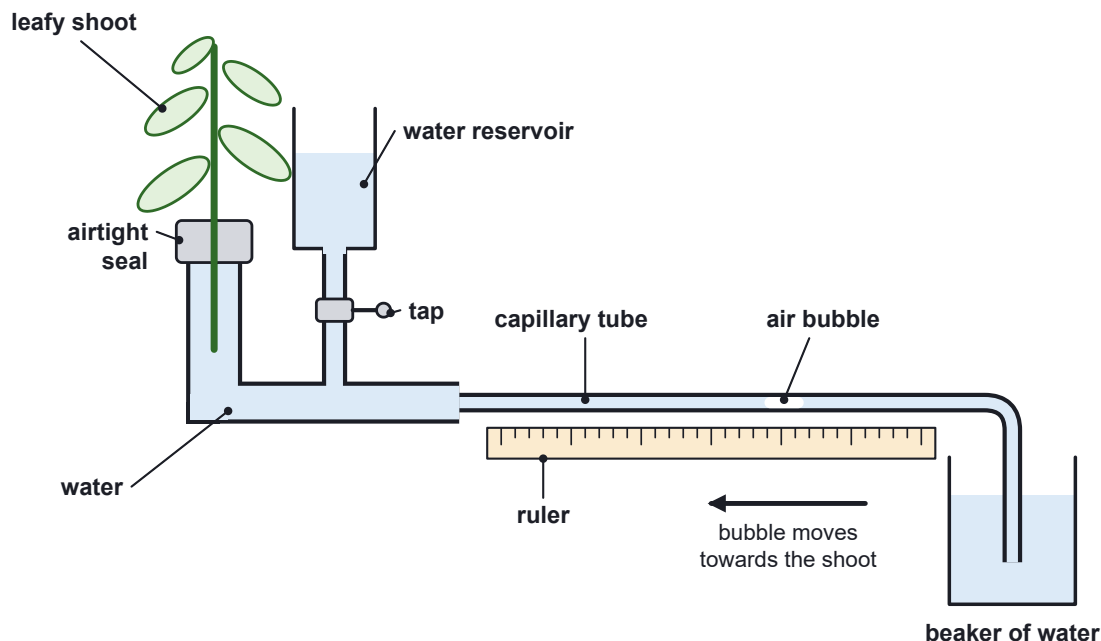
Exam tip: Always give an adaptation and the reason it helps. For example, 'the air spaces in the spongy mesophyll allow carbon dioxide to diffuse to the photosynthesising cells'.

Factors affecting water uptake Spec 6.12

The rate at which a plant takes up water depends on the rate of transpiration. When more water is lost from the leaves, more is pulled up through the xylem. Three environmental factors affect it.

Effect of environmental factors on water uptake		
Factor	Effect on water uptake	Explanation
Light intensity	Higher light intensity increases the rate	Stomata open in the light, so more water vapour can diffuse out of the leaf. Low light or darkness makes the stomata close.
Air movement	More air movement increases the rate	Moving air carries away water vapour from around the stomata. This keeps a steep concentration gradient, so water vapour diffuses out faster.
Temperature	Higher temperature increases the rate	Water evaporates from the cells faster, and water vapour particles move faster, so diffusion out of the leaf is faster.

A **potometer** is used to measure the rate of water uptake of a leafy shoot. As the shoot takes up water, an air bubble moves along a capillary tube. The distance moved in a set time is a measure of the rate. You can compare the rate in different conditions, for example with and without a fan, or in the light and in the shade.



A potometer: the **distance the bubble moves** in a set time measures the rate of water uptake.

Common mistake: Say what happens and why. 'The rate goes up' is not enough. Add 'because the stomata are open' or 'because the water vapour is carried away, keeping a steep concentration gradient'.

Rate calculations for transpiration Spec 6.13

A rate tells you how much something changes in a unit of time. For water uptake or transpiration you can use the distance moved by a bubble in a potometer, the volume of water lost, or the change in mass of a plant.

rate = change in quantity ÷ time taken

percentage change = (change in mass ÷ original mass) × 100

Rate of water uptake

In a potometer, an air bubble moved 31 mm, 28 mm and 34 mm in three repeats of 10 minutes each. Calculate the mean rate of water uptake in mm per minute.

1. Mean distance = $(31 + 28 + 34) \div 3 = 93 \div 3 = 31$ mm.
2. Rate = distance ÷ time = $31 \div 10 = 3.1$ mm per minute.

Answer: 3.1 mm per minute

Percentage loss of mass

A leafy shoot had a mass of 25.0 g at the start of an investigation and 23.0 g at the end. Calculate the percentage loss of mass.

1. Loss of mass = $25.0 - 23.0 = 2.0$ g.
2. Percentage loss = $2.0 \div 25.0 \times 100 = 8\%$.

Answer: 8%

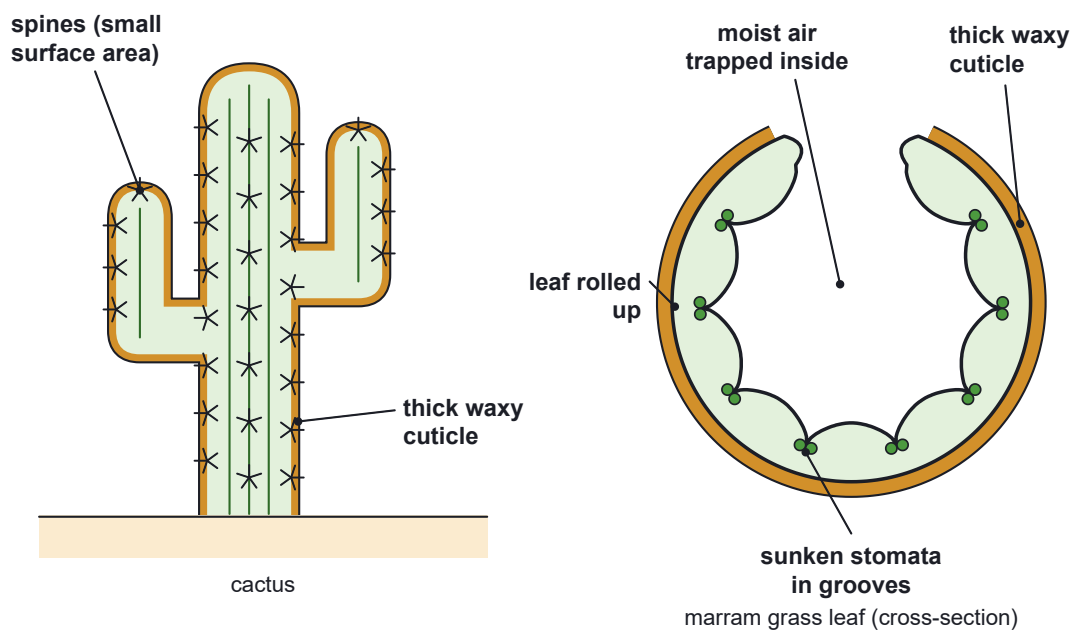
Maths skill: Always include the unit with a rate, for example mm per minute or cm³ per hour. Calculate a mean first if you are given repeats.

Plants in extreme environments Spec 6.14B Triple only

Plants that live in hot, dry or windy places lose water very easily. They have adaptations that reduce water loss by transpiration. These adaptations affect **leaf size and shape**, the **cuticle** and the **stomata**.

Adaptations for survival in extreme environments		
Feature	Adaptation	How it helps
Leaf size and shape	Small, narrow or needle-like leaves, spines (as in a cactus), or leaves that roll up (as in marram grass)	A smaller surface area means less water evaporates. Rolled leaves trap moist air around the stomata.
Cuticle	A thick, waxy cuticle	Waterproof, so less water evaporates through the leaf surface
Stomata	Fewer stomata, or stomata sunk in pits, or stomata that are closed during the day	Less water vapour diffuses out. In sunken stomata, moist air is trapped in the pit, which reduces the concentration gradient.

These adaptations come at a cost. With less leaf area and fewer or closed stomata, less carbon dioxide can enter the plant, so these plants often photosynthesise and grow slowly.



Cactus and marram grass: adaptations that **reduce water loss** by transpiration.

Exam tip: Link each adaptation to water loss. For example, 'spines instead of leaves give a small surface area, so less water is lost by evaporation'.

Quick check

1. What does a potometer measure?
2. Why does moving air increase the rate of transpiration?
3. A bubble in a potometer moves 24 mm in 8 minutes. What is the rate?
4. Why does a higher temperature increase the rate of water uptake?

Quick check answers

Leaves, water uptake and extreme environments

- 1 . The rate of water uptake of a leafy shoot.
- 2 . It carries away water vapour, keeping a steep concentration gradient so water vapour diffuses out faster.
- 3 . $24 \div 8 = 3$ mm per minute.
- 4 . Water evaporates from the leaf cells faster and water vapour diffuses out faster, so more water is pulled up the xylem.