

# 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.

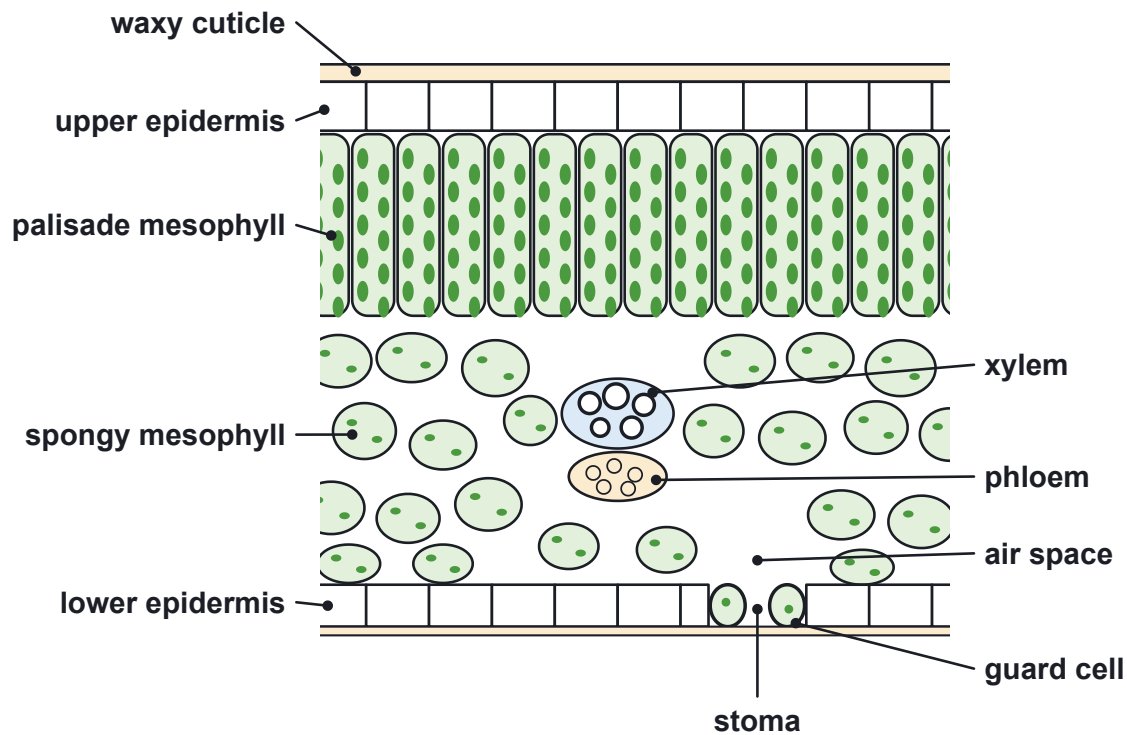
For Edexcel GCSE Biology 1BI0 and Combined Science 1SC0. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

## 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                                                                         |
| <b>Whole leaf</b>                             | Broad, flat and thin                                                        | Large surface area to absorb light, and a short distance for gases to diffuse        |
| <b>Waxy cuticle</b>                           | A waxy, waterproof layer on the surface                                     | Reduces water loss by evaporation                                                    |
| <b>Upper epidermis</b>                        | A thin layer of transparent cells                                           | Lets light through to the cells underneath                                           |
| <b>Palisade mesophyll</b>                     | Tightly packed, tall cells near the top of the leaf, with many chloroplasts | Most photosynthesis takes place here, close to the light                             |
| <b>Spongy mesophyll</b>                       | Loosely arranged cells with air spaces between them                         | Carbon dioxide can diffuse through the leaf to the cells, and oxygen can diffuse out |
| <b>Stomata and guard cells</b>                | Pores, mostly in the lower epidermis, opened and closed by guard cells      | Allow gases to enter and leave, and control water loss                               |
| <b>Xylem and phloem (veins)</b>               | 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.

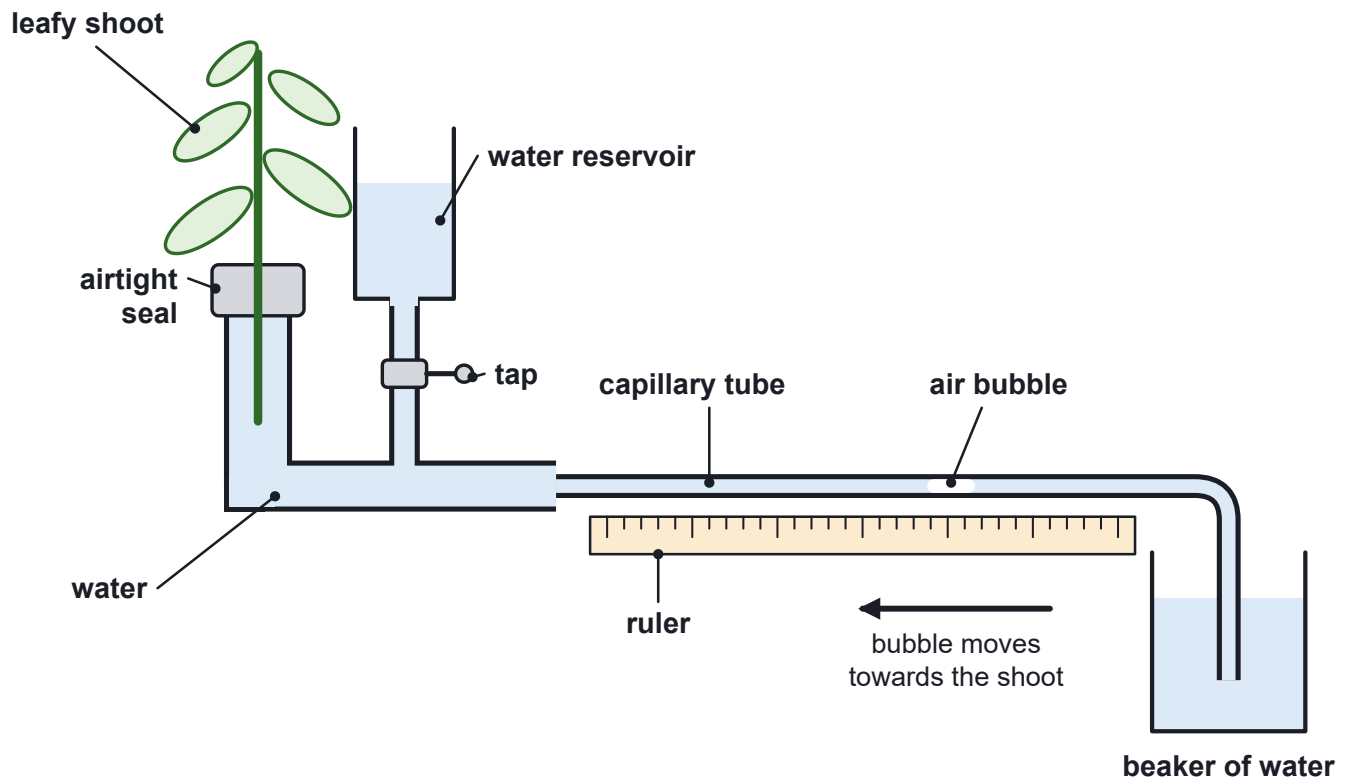
*Exam tip: Always give an adaptation and the reason it helps. For example, 'the air spaces in the spongy mesophyll allow carbon dioxide to diffuse to the photosynthesising cells'.*

## 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                                                                                                                                   |
| <b>Light intensity</b>                          | 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.                   |
| <b>Air movement</b>                             | 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. |
| <b>Temperature</b>                              | 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.

$$\text{rate} = \text{change in quantity} \div \text{time taken}$$

$$\text{percentage change} = (\text{change in mass} \div \text{original mass}) \times 100$$

### 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  $\div$  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%

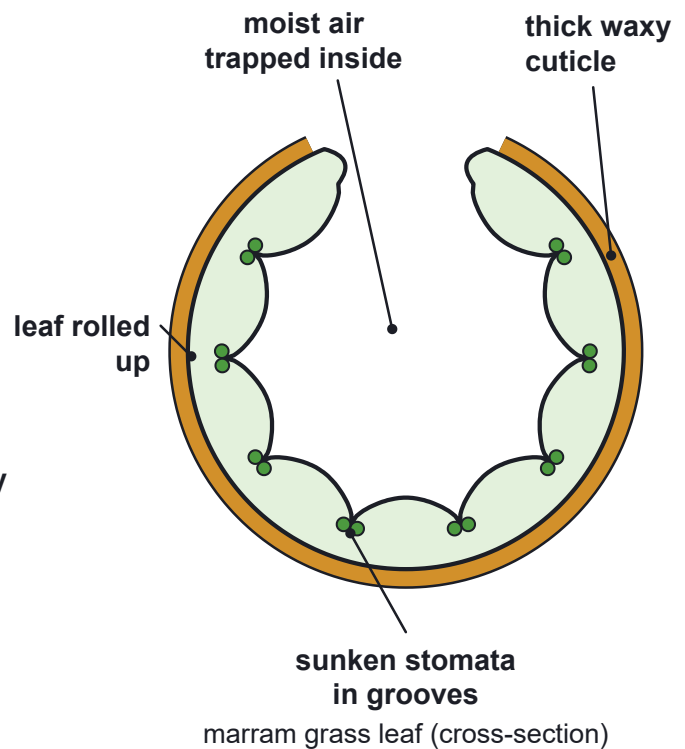
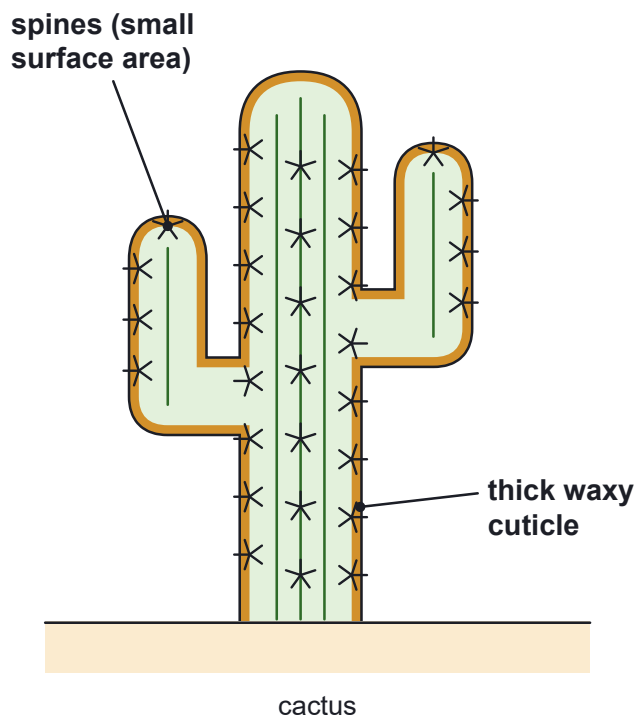
*Maths skill: Always include the unit with a rate, for example mm per minute or cm<sup>3</sup> per hour. Calculate a mean first if you are given repeats.*

### 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                                                                                                                  |
| <b>Leaf size and shape</b>                       | 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.                          |
| <b>Cuticle</b>                                   | A thick, waxy cuticle                                                                                     | Waterproof, so less water evaporates through the leaf surface                                                                 |
| <b>Stomata</b>                                   | 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.