

Transpiration

Revision notes · Water loss from leaves, the factors that affect its rate, and how transpiration pull draws water up the xylem.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

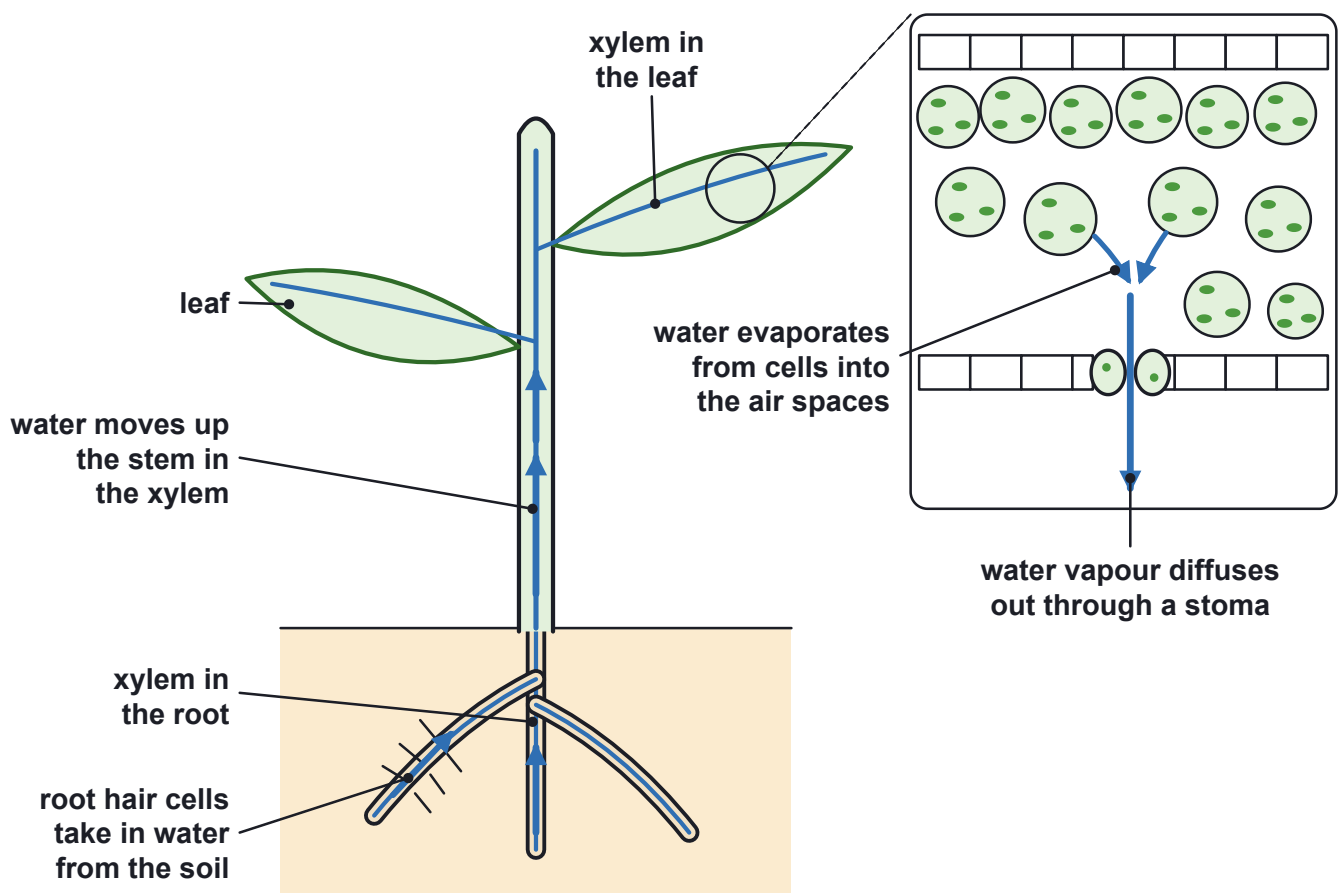
Transpiration Spec 8.3

Transpiration Spec 8.3.1, 8.3.2, 8.3.4

Transpiration is the loss of water vapour from leaves.

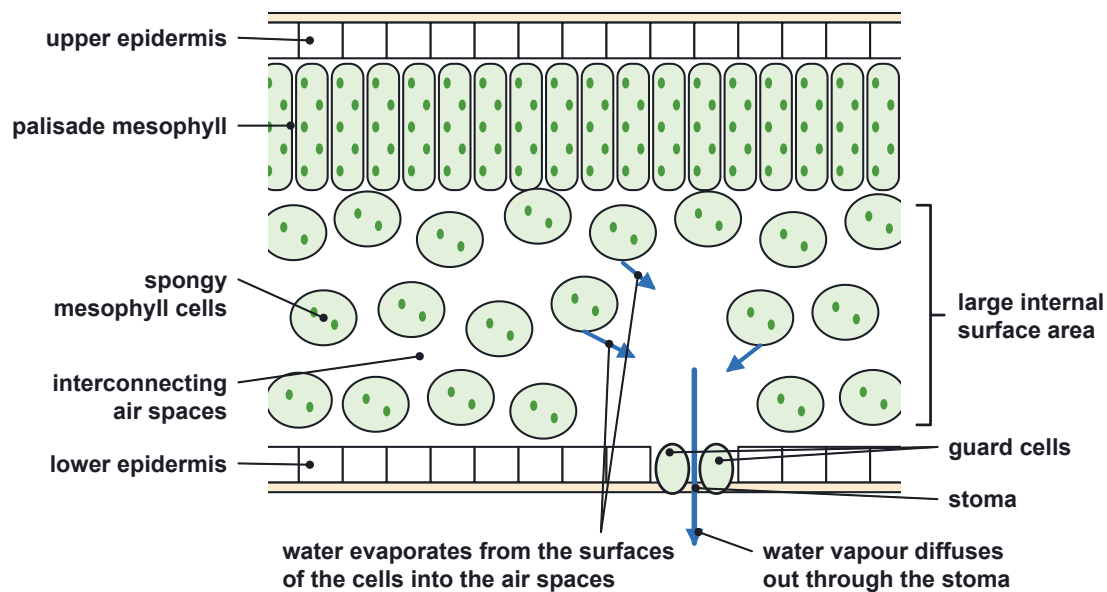
Water evaporates from the surfaces of the mesophyll cells into the air spaces inside the leaf. The water vapour then diffuses out of the leaf through the stomata, down a concentration gradient, into the drier air outside.

1. Water moves from the xylem into the mesophyll cells.
2. Water evaporates from the surfaces of the mesophyll cells into the air spaces.
3. Water vapour diffuses out of the leaf through the stomata.

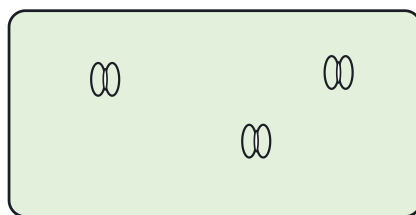


In the leaf, water evaporates from the mesophyll cells and the vapour diffuses out through the stomata.

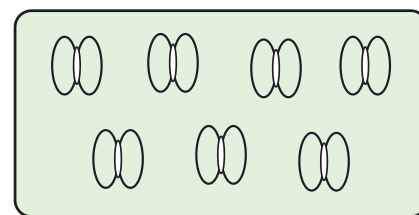
Supplement



leaf surfaces seen from below



few, small stomata
less water vapour lost



many, large stomata
more water vapour lost

The air spaces give a **large internal surface area**. More stomata, or larger stomata, means **more water vapour lost**.

Supplement

Why leaves lose water so quickly

Supplement

Two features of a leaf mean that a lot of water vapour can be lost.

Supplement

- The mesophyll cells are surrounded by interconnecting air spaces. These give a **large internal surface area** from which water can evaporate.
- The **size and number of stomata** affect how much water vapour can diffuse out. More stomata, or larger stomata, means more water vapour is lost.

Exam tip: Use the correct words: water **evaporates** from the mesophyll cells and water vapour **diffuses** out through the stomata. Do not say that water 'escapes' or 'leaks'.

Factors affecting the rate of transpiration Spec 8.3.3, 8.3.6

The rate of transpiration changes with the conditions around the plant. You must be able to describe the effects of **temperature** and **wind speed**.

Effect of environmental factors on the rate of transpiration

Factor	Effect on rate
Temperature	higher temperature gives a faster rate
Wind speed	higher wind speed gives a faster rate

Supplement

Explaining the effects of temperature, wind speed and humidity

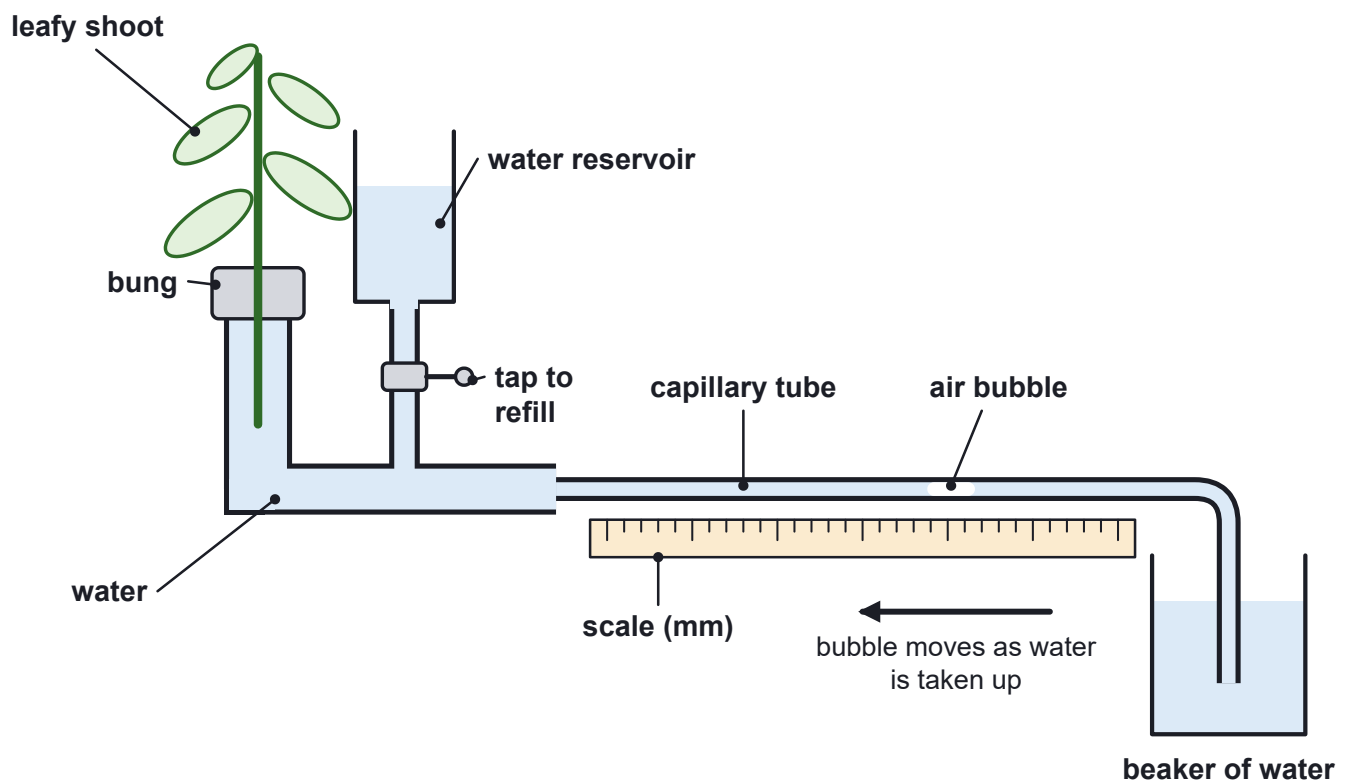
Supplement

- **Temperature:** a higher temperature gives water molecules more energy, so they evaporate from the mesophyll cells faster. Water vapour also diffuses faster.
- **Wind speed:** wind blows water vapour away from around the stomata. This keeps the **concentration gradient** between the air spaces and the outside air steep, so diffusion is faster.
- **Humidity:** higher humidity gives a slower rate. Humid air already contains a lot of water vapour, so the concentration gradient between the air spaces and the air outside is less steep and diffusion out of the leaf is slower. In dry air the gradient is steeper and transpiration is faster.

Measuring the rate: the potometer

A **potometer** measures how much water a cut shoot takes up. Most of the water taken up is lost by transpiration, so water uptake is used as an estimate of the rate of transpiration. As the shoot takes up water, an air bubble in the capillary tube moves along a scale.

1. Cut a leafy shoot under water and fit it into the potometer, keeping the apparatus full of water with no air bubbles.
2. Introduce an air bubble into the capillary tube and note its starting position.
3. Change one factor, for example place a fan at different distances to vary wind speed, or use rooms or water baths at different temperatures.
4. Measure the distance moved by the bubble in a set time.
5. Repeat and calculate a mean. Keep everything else the same.



As the shoot takes up water, the **air bubble** moves along the scale.

rate of water uptake = distance moved by bubble ÷ time

Calculating a rate

In a potometer, the air bubble moved 45 mm in 15 minutes. Calculate the rate of water uptake in mm / min.

1. rate = distance ÷ time
2. rate = $45 \div 15$

Answer: 3 mm / min

Practical skill: Name the independent variable (for example wind speed), the dependent variable (distance moved by the bubble in a set time) and at least two controlled variables (such as the same shoot, temperature and light). Repeat the experiment for reliability.

Transpiration pull and wilting Spec 8.3.5, 8.3.7 Supplement

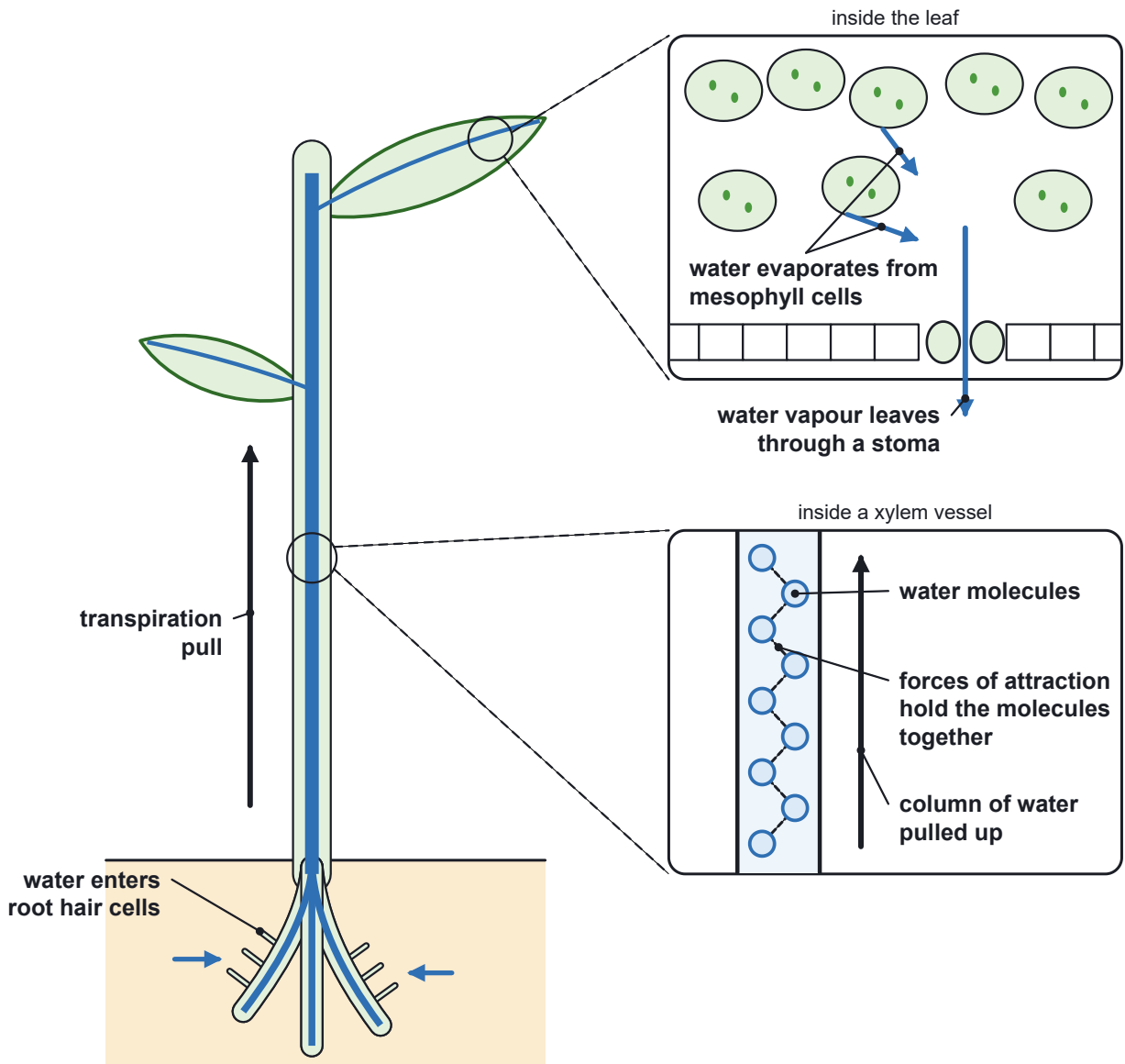
How water moves up the xylem

Water is lost from the mesophyll cells by evaporation. This pulls more water out of the xylem to replace it. This pull is called the **transpiration pull**.

The pull is passed down the xylem because water molecules are **attracted to each other**. These forces of attraction hold the water molecules together as a continuous **column of water**, so the whole column is drawn up the xylem, from the roots to the leaves.

1. Water evaporates from the surface of the mesophyll cells and diffuses out through the stomata.
2. Water is drawn out of the xylem to replace it. This is the transpiration pull.
3. The water molecules are held together by forces of attraction, so the column of water is pulled up the xylem.

4. More water enters the root to replace it.



Evaporation from the leaves causes the **transpiration pull**. Forces of attraction between water molecules hold the column together.

Wilting

Wilting happens when a plant loses water by transpiration faster than it can take water up from the soil. Water leaves the cells by osmosis, so the cells lose their **turgor** (they become flaccid). The cells no longer press against each other, so the leaves and stems are not supported and droop.

- Wilting is more likely in hot, dry or windy conditions, because transpiration is fast.
- Wilting also happens when the soil is dry, because there is little water to take up.
- When water uptake is greater than water loss again, the cells take in water, become turgid and the plant recovers.

Exam tip: Explain wilting in terms of cells: water loss means the cells lose turgor (become flaccid), so the plant loses its support and droops.

Quick check

1. Define transpiration.
2. Name two factors that increase the rate of transpiration when they increase.
3. **Supplement** How does higher humidity affect the rate?
4. **Supplement** What holds the water column together in the xylem?

Quick check answers

Transpiration

1. The loss of water vapour from leaves.
2. Temperature and wind speed.
3. It slows transpiration, because the concentration gradient is less steep.
4. Forces of attraction between water molecules.