Plant Transport

Water and ion uptake by root hair cells, the path of water through the plant, transpiration and the factors that affect it, the transpiration stream, translocation, and the structure of xylem.

8.1 Uptake and transport of water and ions

Root hair cells

Root hair cells take up water and mineral ions from the soil. Their structure is related to this function:

- a **long, thin extension** (the root hair) gives a very **large surface area** for absorption;
- a **thin cell wall** and membrane, so water can move in easily;
- a **sap vacuole** with dissolved sugars and salts gives the cell a **lower water potential** than the soil water, so water enters by **osmosis**;
- many **mitochondria** release the energy that is needed for the **active transport** of ions.

The pathway of water

Water moves through the plant in this order:

1. **root hair cells**, from the soil, by osmosis;
2. **root cortex cells**, moving from cell to cell down a water potential gradient;
3. **xylem** in the root, then up the stem in the xylem;
4. **xylem in the leaf**, then into the **mesophyll cells**;
5. water **evaporates** from the surface of the mesophyll cells into the air spaces and diffuses out through the stomata (transpiration).

Investigating the pathway of water

Place a cut stem (for example celery or a white flower) in water containing a **dye** such as red ink or eosin. After a few hours, cut the stem across or lengthways and look: the dye shows the **xylem** (stained red) running up the stem and into the leaves, so water travels in the xylem.

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8.3 Transpiration and translocation

Transpiration

> **Transpiration is the loss of water vapour from the leaves of a plant.**

Water **evaporates** from the surfaces of the **mesophyll cells** into the **air spaces**, and then **diffuses out** of the leaves through the **stomata** as water vapour.

Factors that affect the rate of transpiration

Factor	Effect on the rate	Why
temperature	higher temperature, faster	water evaporates faster, and water vapour molecules diffuse faster
humidity	higher humidity, slower	the air already has a lot of water vapour, so the concentration gradient is smaller
wind speed	more wind, faster	the moist air next to the leaf is blown away, keeping a steep concentration gradient
light intensity	more light, faster	the stomata open wider in the light (and the leaf is warmer)

Investigation (a potometer). A cut shoot is fitted to a tube of water with a small air bubble. As the plant takes up water, the bubble moves along a scale, so the distance the bubble moves in a given time shows the rate of water uptake (which is nearly equal to the rate of transpiration). Repeat the measurement with a fan (wind), a lamp (light or heat), or a plastic bag (high humidity).

Wilting

If a plant loses water by transpiration faster than its roots can take it up, the cells lose water and become **flaccid**. The plant loses its support from turgor pressure and **wilts**. Closing the stomata (at night, or when short of water) reduces water loss.

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The transpiration stream

Water moves up the xylem because of a transpiration pull. Evaporation from the leaves pulls up a column of water molecules, which are held together by forces of attraction between water molecules, so the column does not break.

As water leaves the leaf, more water is pulled into the leaf from the xylem. The water column in the xylem is pulled up from the roots all the way up the stem. Water entering the roots replaces it. This stream brings water and mineral ions to the leaves, where water is needed for photosynthesis and for keeping the cells turgid, and it also cools the leaf.

Xylem

The xylem transports water and mineral ions from the roots to the rest of the plant, and it also provides support.

Xylem vessels are adapted to their function:

- **thick walls strengthened with lignin**, which makes them strong enough to withstand the pull of the water column and to support the plant;
- **no cell contents** (no cytoplasm or nucleus), so water can flow through freely;
- cells are joined **end to end with no cross walls**, forming a long, continuous tube.

Phloem and translocation

Translocation is the movement of sucrose and amino acids in the phloem, from parts of the plant that produce or release them (the sources, such as leaves) to parts that use or store them (the sinks, such as roots, fruits, growing shoots and storage organs).

Unlike the xylem, the phloem is made of living cells, and it carries substances in both directions in the plant, depending on where the sources and sinks are.

Positions of the tissues

In a transverse section of a non-woody dicotyledonous plant:

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- **Root:** the xylem is in the **centre** (often in a star or "X" shape), with the phloem between its arms, surrounded by the **cortex**.
- **Stem:** the **vascular bundles** (xylem on the inside, phloem on the outside) are arranged in a **ring** near the edge, with the **cortex** outside them.

> **TRY IT**
>
> Name the tissue that transports sucrose from the leaves to the roots and say what the roots are in terms of sources and sinks.

The **phloem** carries it. The leaves are the **source** and the roots (which store or use the sucrose) are the **sink**.

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