Transport of water in the xylem

Water is absorbed through the roots, specifically through root hairs. In flowering plants, most water is transported through hollow, thick-walled tubes called xylem vessels. Transpiration is the main force that pulls water through the xylem vessels in the stem and is the evaporation of water from leaves. The energy for this is supplied by the sun and is therefore passive.

Movement of water out through stomata:

The humidity of the atmosphere is usually less than that of the air spaces next to the stomata. As a result there is a water potential gradient from the air spaces through the stomata to the air. Provided the stomata are open, water vapour molecules diffuse out of the air spaces into the surrounding air. Water lost by diffusion from the air spaces is replaced by water evaporating from the cell walls of the surrounding mesophyll cells. By changing the size of the stomatal pores, plants can control their rate of transpiration.

Movement of water across the cells of a leaf:

Water is lost from mesophyll cells by the evaporation of their cell walls to the air spaces of the leaf. This is replaced by water reaching the mesophyll cells from the xylem ether via cell walls or via the cytoplasm. Water movement occurs because:

1. **mesophyll cells lose water to the air spaces by evaporation due to heat supplied by the sun**
2. **These cells now have a lower water potential and so water enters by osmosis from neighbouring cells**
3. **The loss of water from these lowers their water potential**
4. **They in turn take I water from their neighbours osmosis**

In this way, a water potential gradient is established that pulls water from the xylem, across the leaf mesophyll and finally out into the atmosphere.

Movement of water up the stem in the xylem:

The main factor responsible is **cohesion-tension**. The movement of water follows:

1. **water evaporates from the mesophyll cells due to heat from the sun leading to transpiration**
2. Water molecules form hydrogen bonds between one another and hence tend to stick together = **cohesion**
3. **Water forms a continuous, unbroken column across the mesophyll cells and down the xylem**
4. As water evaporates from the mesophyll cells in the leaf and into the air spaces beneath the stomata, more **molecules of water are drawn up behind it as a result of this cohesion**
5. A column of water is therefore pulled up the xylem as a result of transpiration = **the transpiration pull**
6. **Transpiration pull puts the xylem under tension (there is a negative pressure within the xylem, hence the name cohesion-tension theory)**

Evidence of the cohesion-tension theory:

- **Change in the diameter of tree trunks according to the rate of transpiration. When transpiration is at its greatest (during the day), there is more tension (negative pressure) in the xylem. This pulls the walls of the xylem inwards and causes the trunk to shrink in diameter. At night (at its lowest) there is less tension in the xylem so the diameter of the trunk increases.**
- If a xylem vessel is broken and air enters, the tree can no longer draw up water. This is because the **continuous column of water is broken and so the water molecules can no longer stick together.**
- **When a xylem vessel is broken, water doesn't leak out, as would be the case if it was under pressure. Instead air is drawn in = consistent with it being under tension.**

Transpiration pull is a passive process and therefore doesn't require metabolic energy to take place. Xylem vessels are dead and cannot actively move the water. Xylem vessels have no end walls which means that xylem forms a series of continuous, unbroken tubes from root to leaves.