Water and its route into and through plants

At least 20 points

- Water enters through the root hair cells and then moves across into the xylem tissue in the centre of the root.
- Water moves in this direction because the soil water has higher water potential, than the solution inside the root hair cells.
- This is because the cell sap has organic and inorganic molecules dissolved in it.
- The root hairs provide a large surface area over which water can be absorbed.
- Minerals are also absorbed but, as you should be able to work out, their absorption requires energy in the form of ATP because they are absorbed by active transport.
- They have to be pumped against the concentration gradient.
- Water taken up by the root hairs moves across the cortex of the root either via the cytoplasm of the cells in between the root hair cell and the xylem (the symplast pathway) or through the cell walls of these cells (the apoplast pathway).
- The root hair cell will have higher water potential than the cell next to it. As always, water moves by osmosis to where the water potential is lower.
- In this way, as water is always being absorbed by the root hairs, water will always move towards the centre of the root.
- When the water reaches a part of the root called the endodermis, it encounters a thick, waxy band of suberin in the cell walls. This is the Casparian strip and it is impenetrable.
- In order to cross the endodermis, the water that has been moving through the cell walls must now move into the cytoplasm.
- Once it has moved across the endodermis, it continues down the water potential gradient until it reaches a pit in the xylem vessel.
- It enters the vessel and then moves up towards the leaves.

- Water evaporates from the mesophyll cells into air spaces in the leaf. If the air surrounding the leaf has less water vapour than the air in the intercellular spaces, water vapour will leave the leaf through stomata.

- This process is called transpiration and will continue as long as the stomata are open and the air outside is not too humid.

- On dry, windy days when water vapour is continually diffusing out and being removed, transpiration will increase in rate.

- Although this loss of water can cool the plant, it is essential that the plant does not lose too much water.

- Therefore water must be continuously supplied to the leaves.

- The xylem ensures that this happens. Xerophytes are plants, which are well adapted to living where conditions are very dry.

- They may have rolled up leaves - for example, Marram grass, which exposes the waterproof cuticle on the outside and means the stomata open into an inner humid space.

- Other Xerophytes store water in their stems and reduce the surface area of their leaves, which become spines - for example, Cactus.

- Water is removed from the top of xylem vessels into the mesophyll cells down the water potential gradient.

- This removal of water from the xylem reduces the hydrostatic pressure exerted by the liquid so the pressure at the top is less than at the bottom. This pushes the water up the tube.

- The surface tension of the water molecules, the thin lumen of the xylem vessels and the attraction of the water molecules for the xylem vessel wall (adhesion), helps to keep the water flowing all the time and to keep the water column intact.

- Pressure to push water up can also be increased from the bottom. By actively pumping minerals from cells surrounding the xylem into the xylem itself, more water is drawn into the xylem by osmosis.

- This increase in water pressure, called root pressure, certainly helps in the process but is less important than the simple movement of water down the water potential gradient, ultimately from the soil at the bottom, to the air at the top.

- This is because moving water this way does not require energy (it is passive).