Transpiration

Transpiration is the inevitable consequence of gas exchange in the leaf.

Plants transport water from the roots to the leaves to replace losses from transpiration.

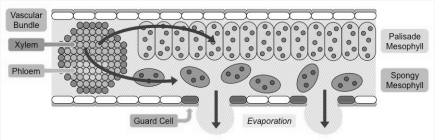
Transpiration is the loss of water vapour from he stems and leaves of plants.

A **transpiration stream** is when water flows (through the xylem) along the pressure gradient as it is absorbed by the roots replace the water lost by the leaves.

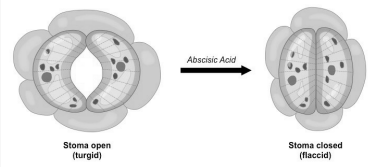
Stomata are pores on the underside of the leaf which facilitate gas exchange required for photosynthesis.

As photosynthetic gas exchange requires stomata to be open, transpiration will be affected by the level of photosynthesis.

Evaporation within leaf tissue



Closing of stomata by Abscisic acid



Transpiration stream

The flow of water through the xylem form the roots to the leaf, again gravity, is called the **transpiration stream**.

Cohesion Force of attraction between two particles of the same substance.
Water molecules are polar and can form a type of intermolecular association called a hydrogen bond.
This cohesive property causes water molecules to be dragged up the xylem towards the leaves in a continuous stream.

Transpiration stream (cont)

Adhesion Adhesion is the force of attraction between two molecules of different substances.
The xylem wall is also polar and can form intermolecular associations with water molecules.
As water molecules moe up the xylem via capillary action, they pull inward the Salem walls to generate further tension.

Structure of the xylem

It is a tube composed of dead cells that are hollow, no protoplasm, to allow fro the free movement of water.

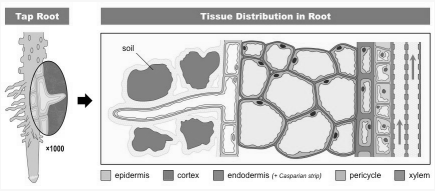
The movement of water is an entirely passive process and occurs in only one direction, as the xylem cells are dead.

The cell wall contains numerous pores (pits), which enable the transfer of water between cells.

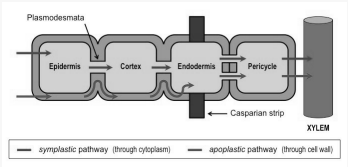
Walls have thickened cellulose and are reinforced by lining to provide strength as water is transported under tension.

Xylems can be made of tracheids (all vascular plants) and vessel elements (only angiospermophytes)	**Tracheids** are tapered cells that exchange water solely by pits, leading o a slower rater of water transfer.
	In vessel elements, the end walls have become fused to form a continuous tube, resulting in a faster rate of water transfer.
All xylem vessels are reinforced by lignin, which may be deposited in different ways:	In **annular vessels**, the lignin forms a pattern of circular rings at equal distances from each other.
	In **spiral vessels**, the lignin is present in the form of a helix or coil.

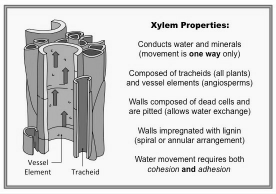
Structure of a root (vascular plant)



Water uptake



Role of the xylem



Water conservation

Xerophytes are plants that can tolerate dry conditions due to the presence of a number of adaptations.

- reduced leaves
- rolled leaves
- thick, waxy cuticle
- stomata in pits
- low growth
- CAM physiology

Halophytes are plants that can tolerate salty conditions due the presence of a number of adaptations.

- cellular sequestration
- tissue plating
- toot level exclusion
- salt excretion
- altered flowering schedule

Evaporation

Evaporation (cont)

Transpiration rates will be higher when stomatal pores are open than when they are closed.

Factors which impact transpiration rate are:

-rate of photosynthesis

- humidity

-temperature

- light intensity

- wind

Root uptake

Active uptake of mineral ions in the roots causes absorption of water by osmosis.

Plants take up water and mineral ions from the soil via their roots and this need a maximal surface area to optimise this uptake.
Some plants have a fibrous, highly branching root system to increase surface area, while others have a main tap root with lateral branches which can penetrate the soil to access deeper pockets of water.

The epidermis of roots may have root har cells, which further increase the surface area available for absorption.

Water uptake

Materials absorbed by the root epidermis diffuse across the cortex towards a central stele, where the xylem is located.

The **stele** is surrounded by an endodermis layer that is impermeable to the passive flow of water and ions (Casparian strip).
Water and minerals are pumped across this barrier by specialised cells, allowing the rate of uptake to be controlled.

Water will follow the mineral ions into the root via osmosis – moving towards the region with a higher solute concentration. The rate of water uptake will be regulated by specialised water channels (**aquaporins**) on the root cell membrane.

The adhesive property of water and evaporation generate tension forces in leaf cell walls.	
Water is lost from he leaves of the plant when it evaporates and diffuses from the stomata.	
The amount of water lost from the leaf is controlled by the opening and closing of the stomata.	Guard cells flank the stomata and can occlude the opening by becoming increasingly flaccid in response to cellular signals.
	When a plant begins to wilt from water stress, dehydrated mesophyll cells release the plant hormone abscisic acid (ABA).
	Abscisic acid triggers the efflux of potassium from guard cells, decreasing water pressure within the cells (lose turgor).
	A loss of turgor makes the stomatal pore close, as the guard cells become flaccid and block the opening.

Root uptake (cont)

	In the **symplastic pathway**, water moves continuously through the cytoplasm of cells (connected via plasmodesmata).
	In the apoplastic pathway, water cannot cross the Casparian strip and is transferred to the cytoplasm of the endodermis

Mineral uptake

Fertile soil typically contains negatively charged clay particles to which positively charged mineral ions (cations) may attach.

Minerals that need to be taken up from the soil include Mg^{2+} (chlorophyll), nitrates (amino acids), Na^{+}, K^{+} and $PO4^{3-}$.

Mineral ions may passively diffuse into the roots, but will more commonly be actively uploaded by indirect active transport.	Root cells contain proton pumps that actively expel H^{+} ions (stored in the vacuole of root cells) into the surrounding soil.
	The H^{+} ions displace the positively charged mineral ions from the clay, allowing them to diffuse into the root along a gradient.
	Negatively charged mineral ions (anions) may bind to the H^{+} ions and be reabsorbed along with the proton.

Xylem structure

Drawing the structure of primary xylem vessels in sections of stems based on microscope images.

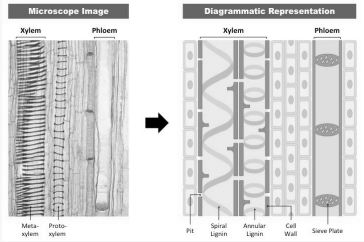
Vessel elements should be drawn as a continuous tube (tracheids will consist of interlinking tapered cells).

The remnants of the fused end wall can be represented as indents (these forms perforated end plates).

The xylem wall should contain gaps (pits), which enable the exchange of water molecules.

Lignin can be represented by either a spiral (coiled) or annular (rings) arrangement.

Xylem diagram



Overview of water conservation adaptations