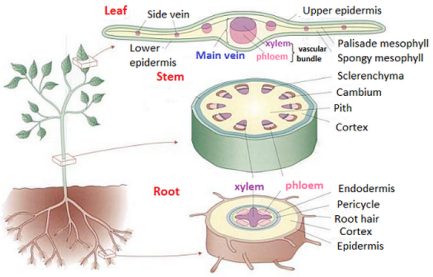
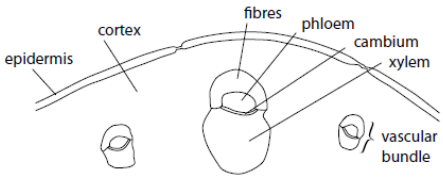
UNIT 7 - TRANSPORT IN PLANTS





Large organisms need transport systems as they have a very small surface area to volume ratio, so there is a greater distance for diffusion to occur. Diffusion would therefore be too slow of a transport method to rely upon, so transport systems are required to move essential nutrients around the organism.

The xylem and phloem are the two main tubes in the plant transport system. They are bunched together to form the vascular bundles.

- The xylem transports water and mineral ions
- The phloem transports assimilates e.g. sucrose

Dicotyledons - flowering plants whose seeds contain 2 cotyledons and adult plants have leaves with a blade and stalk (lamina and petiole).

Parenchyma - typically used as packing tissue between structures e.g. the cortex. Metabolically active. Functions include food storage and support.

Collenchyma - modified parenchyma cells that have extra cellulose thickening and so functions include providing structural support in the midribs of leaves and corners of square stems.

Sclerenchyma - cells have thick walls impregnated with lignin & mature cells are dead, with no visible contents.

The movement of water through the plant is driven by its evaporation from the leaves (transpiration)

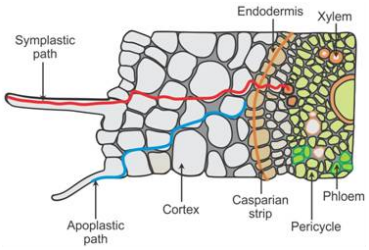
- Transpiration removes water from the leaves, creating a water potential gradient
- As the water potential changes, water is pulled up through the xylem to the leaf
- This is known as the transpiration stream

Movement of water through a plant leaf:

1) Transpiration of water through stomata (this is the film of water coating mesophyll cells)
2) Evaporation of water into air leaf spaces
3) Water moves from the xylem veins to the cells
4) Water is pulled up the xylem
5) Water enters the xylem through the root
6) Water is taken in by the root hairs from the soil
    - Transpiration maintains a steep water potential gradient which keeps the movement of water through the xylem constant
    - Water leaves the xylem vessels through structures called pits

Symplast pathway - the living system of interconnected protoplasts expanding through plants used as a transport pathway for the movement of water and solutes, individual protoplasms are connected via plasmodesmata

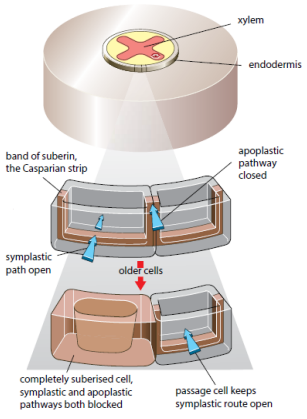
Apoplast pathway - the nonliving system of interconnected cell walls extending throughout a plant used as a transport pathway for the movement of water and mineral ions.



The pericycle consists of a ring of cells that contain a band of waterproof protein called suberin. The cells are adjacent and so these bands line up to form a line of suberin called the Casparian strip.

Since the strip is 100% impermeable to water, the apoplast pathway is blocked, forcing the water to move through the symplast pathway. <u>This is to ensure that only water and essential nutrients are circulated around the plant, as the selectively permeable cell membrane only allows these materials to pass through.</u>

- The Casparian strip also prevents the backflow of water



The pressure in the xylem vessel is lower, and substances travel at relatively low speeds, whereas in the phloem, assimilates travel at higher pressures and speeds.

The Phloem

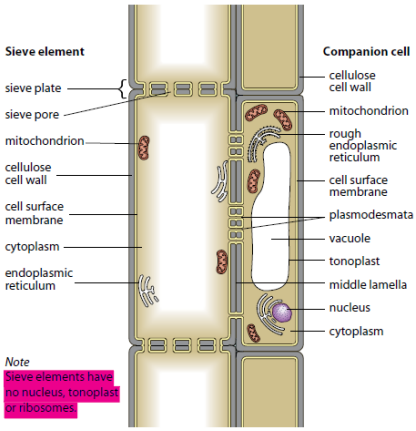
- Assimilation is the conversion of inorganic material into organic material (e.g. photosynthesis converts sunlight into glucose)
- The 2 most important assimilate products in plants are sucrose and amino acids
- Assimilates are transported by the phloem from source to sink

Source - site in a plant which provides from source to sink. Features of sources:

- Sources are not actively growing or reproducing
- Sources LOSE food
- Example: leaves

Sink - a site in a plant that receives food from the source. Features of sinks:

- They are actively growing and reproducing
- They GAIN food. They may be storage organs
- Examples: flowers, buds, fruits, and bulbs



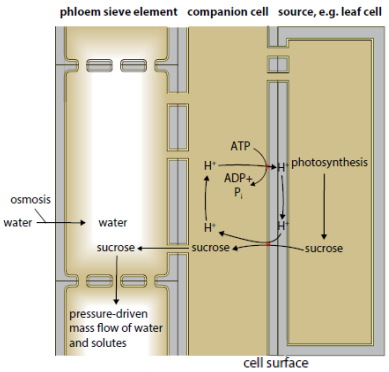
Sieve tube element - a cell found in phloem tissue, with non-thickened cellulose walls, very little cytoplasm, no nucleus, and end walls perforated to form sieve plates through which sap containing sucrose is transported.

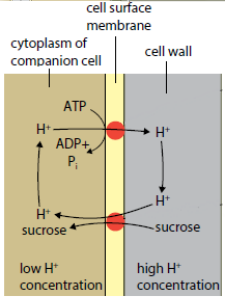
Sieve Tube Elements	Companion Cells
Living cells	Contain many mitochondria
Elongated and tubular	1 companion cell per sieve element
Joined end-to-end, end walls are perforated and form sieve tubes	High metabolic activity. Exchange substances with sieve elements via plasmodesmata
A very thin layer of cytoplasm; the few organelles present are pushed to the periphery	Sucrose is the main transport sugar in plants because it is relatively unreactive and so does not interfere with metabolic activity during transport.
Have a hollow area to transport sucrose	

At the source, sucrose is loaded onto the phloem. Since a water potential gradient must be maintained, water is also loaded with the assimilates

- At the sink, sucrose and water are unloaded and used for respiration, storage, or for the production of cellulose (sucrose can be broken down into glucose and fructose which are used for these purposes)

<u>The bulk movement of substances in the xylem and phloem is called mass flow.</u>





- The active proton pump driven by ATP pumps H^+ ions out of the cell into the cell wall, creating a high concentration of H^+ ions outside the cell. The transport protein responsible for this is known as the <u>H^+ion-sucrose co-transporter carrier protein</u>. It also allows for the movement of sucrose and ions back into the cell.
- Sucrose cannot cross the membrane without an H^+ ion accompanying it
- Since the movement of sucrose takes place secondary to the active transport of H^+ ions, it is called secondary active transport
- The cell membrane is impermeable to H^+ ions and sucrose because of their charged nature (they cannot pass directly through the bilayer which consists of non-polar tails, and require trans-membrane proteins)
- When entering the cell, sucrose is moving AGAINST the concentration gradient (there is more sucrose inside the cell than outside – active transport is required)
- H^+ ions are moving AGAINST the concentration gradient when EXITING the cell, and ALONG the concentration gradient when ENTERING the cell (so H^+ ions use active transport to leave the cell and facilitated diffusion to enter the cell)
    1) H^+ ions are actively pumped out of the cell
    2) The concentration of H^+ ions builds up outside the membrane. The membrane is impermeable to H^+ ions so they cannot diffuse back into the cell.
    3) H^+ ions use facilitated diffusion to move back into the cell, DOWN the electrochemical gradient
    4) The co-transport of sucrose occurs AGAINST the concentration gradient as the sieve tube companion cells are already abundant in sucrose