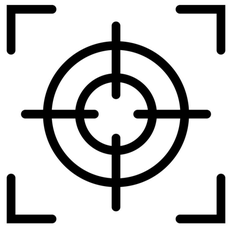
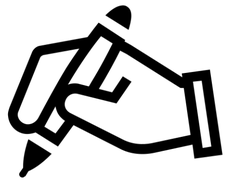
Topic 6: Transport in Plants

Chapter Analysis



FOCUS

- straightforward chapter
- incorporate knowledge from previous chapter



EXAM

- commonly tested in MCQ and structured questions

WEIGHTAGE

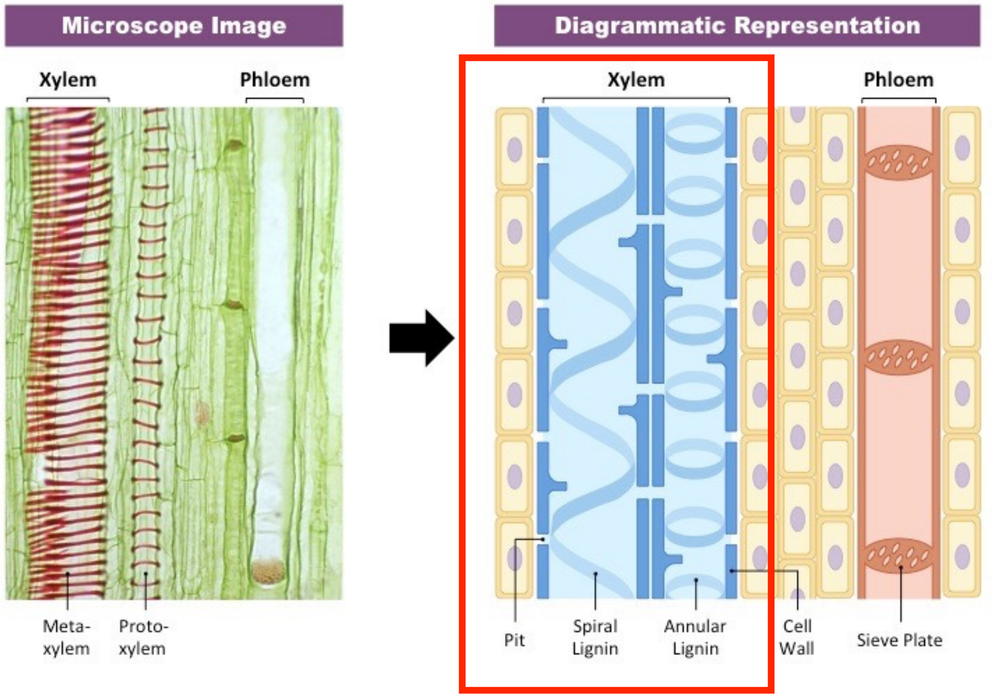
- Constitute to around 5% in Paper 2 in the past 5 years

Key Concept

Xylem
Phloem
Translocation

Vascular Bundle

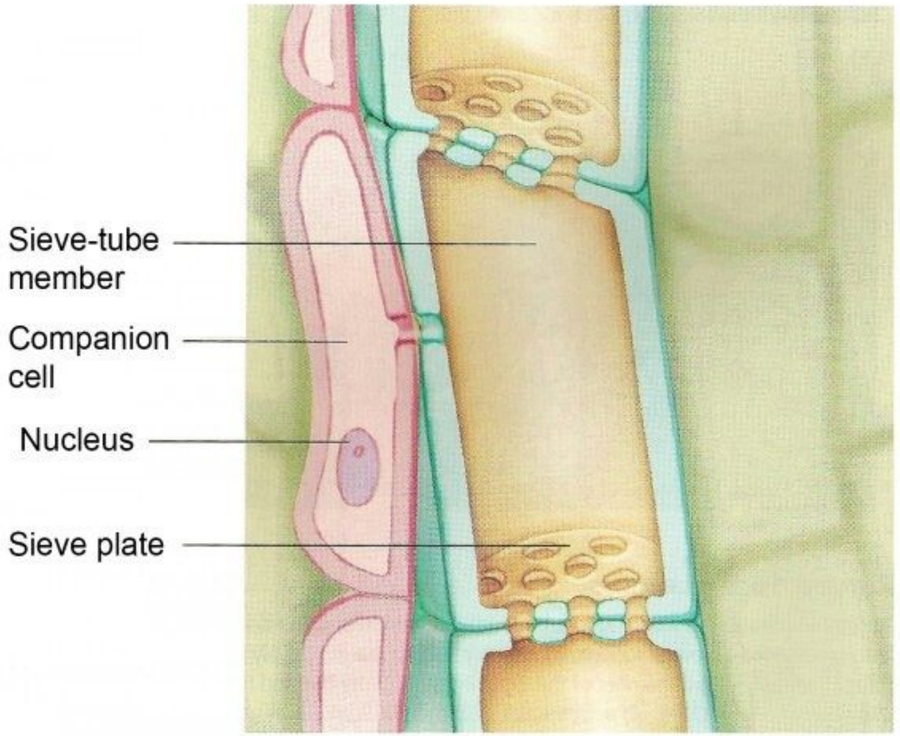
Xylem



Structure	Function	Adaptation
- Xylem cells are **dead** at maturity - Xylem vessels are **long and hollow** tubes that are made of xylem cells	**Transport water** and mineral salts from the roots to the leaves	Absence of protoplasm and cross-walls which could impede water flow through the lumen
- Inner walls of vessels are **deposited with lignin** in different shapes	**Mechanical support** for the plant	Deposition of lignin on the cell walls which strengthens vessel walls, providing support

Vascular Bundle

Phloem



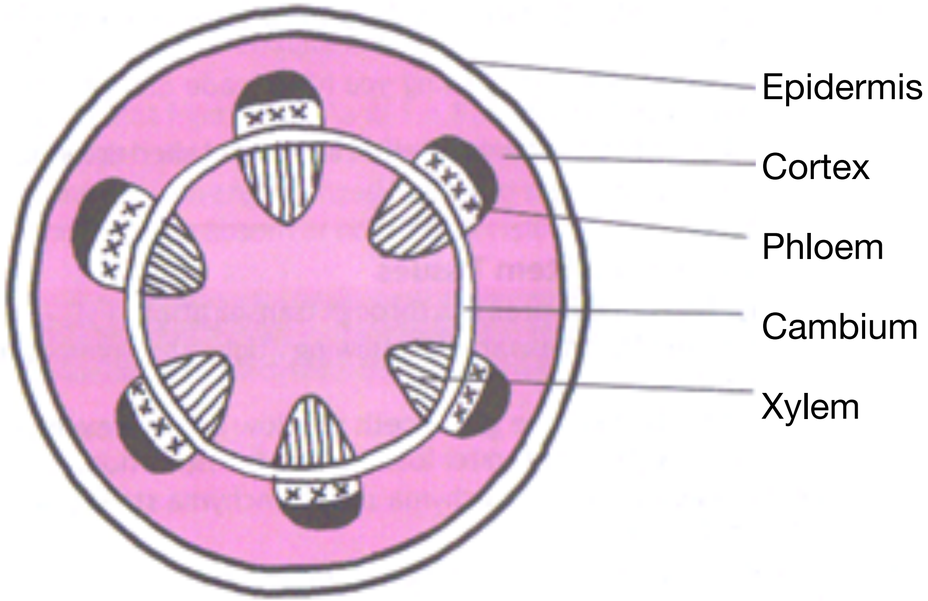
A phloem is made up sieve tube elements and companion cells

Function: **Transport sugars and amino acids** from the leaves to other parts of the plant.

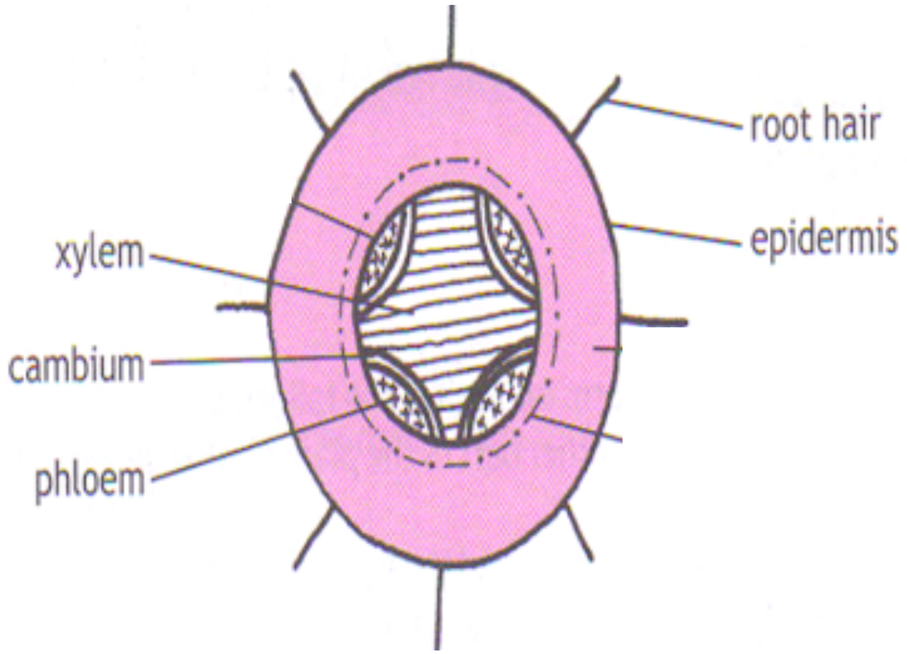
Structure	Adaptation
• **Sieve tube elements** have degenerate protoplasm, they have no organelles such as the nucleus or vacuole • There are porous walls between sieve tube elements called sieve plates	Pores in sieve plates allow uninterrupted flow of food substances through the sieve tubes
• one **companion cell** is closely associated with each sieve tube element, which contains organelles and support the the metabolic functions of the sieve tube elements. • Companion cells have many **mitochondria**	Companion cells contain mitochondria that can carry out respiration and release energy for active transport of manufactured food substances from photosynthesis

Position of vascular bundle

Vascular bundle in dicotyledonous stems

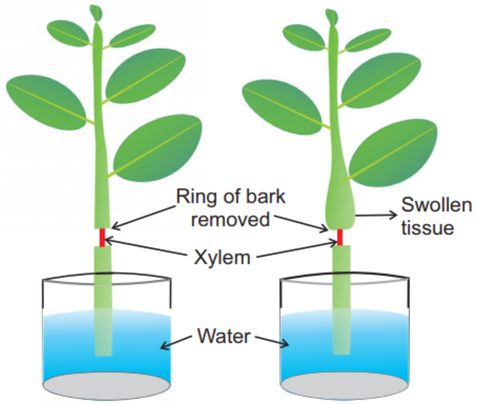


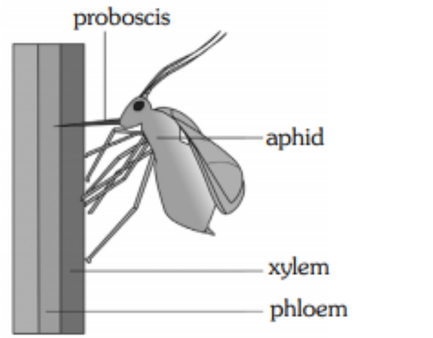
Vascular bundle in dicotyledonous roots



Translocation

- Translocation is the **transport of sugars from the leaves to other parts of the plant** via the **phloem** tissues.
- The source of sugars is the leaves, which is the site of photosynthesis, while other parts of the plant which require sugar are known as the sink.
- **Energy is required** for this process as the mode of uptake of sugars into sieve tube elements in the leaves is active transport.
- At the end of the sieve tube where sugars are being unloaded for use, sugars are also removed from the sieve tube by active transport.





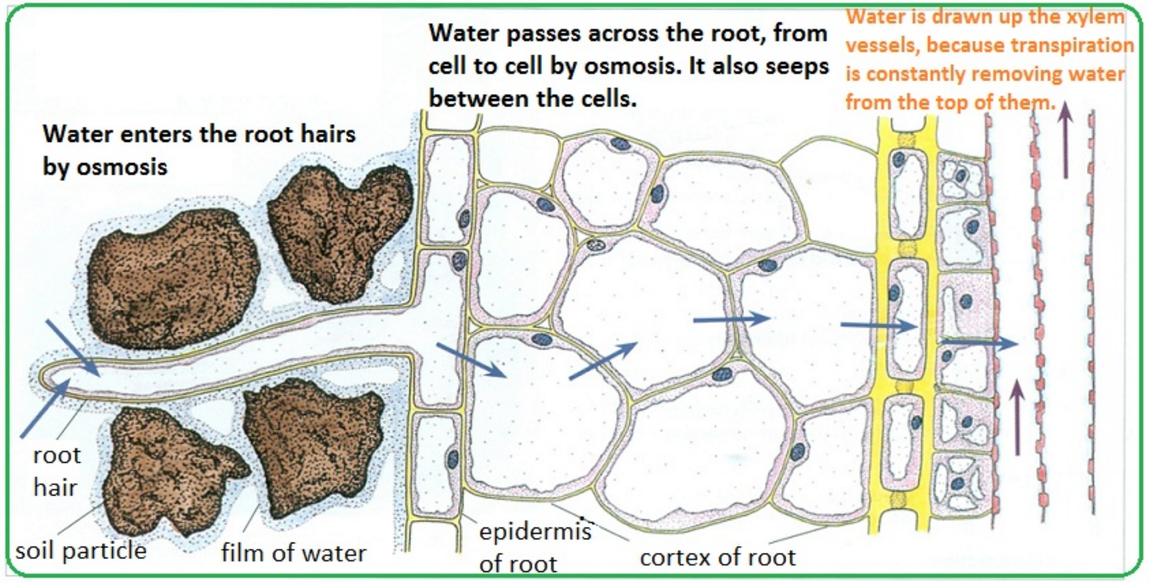
1. In the **ringing experiment**, a ring of bark that contains the **phloem is removed**, exposing the xylem. When sugar is transported from the leaves to the roots, it cannot move beyond the cut, leading to a bulge to form on top of the cut. The bulge is due to accumulation of sugar and retention of water

2. Aphids can be used to collect sap. When an aphid is introduced to a plant, it knows where to **insert its proboscis into the phloem sieve tubes** to feed on the sucrose.

Key Concept

Root Hair Transpiration

Root Hair



Function: Water and ion uptake by root hair

Structure and adaptations

- Root hairs are long and narrow, thus **increasing surface area to volume ratio** for rapid absorption of water and minerals.
- The cell sap contains sugars, amino acids and mineral salts which makes the **water potential of cell sap lower** than that of soil solution

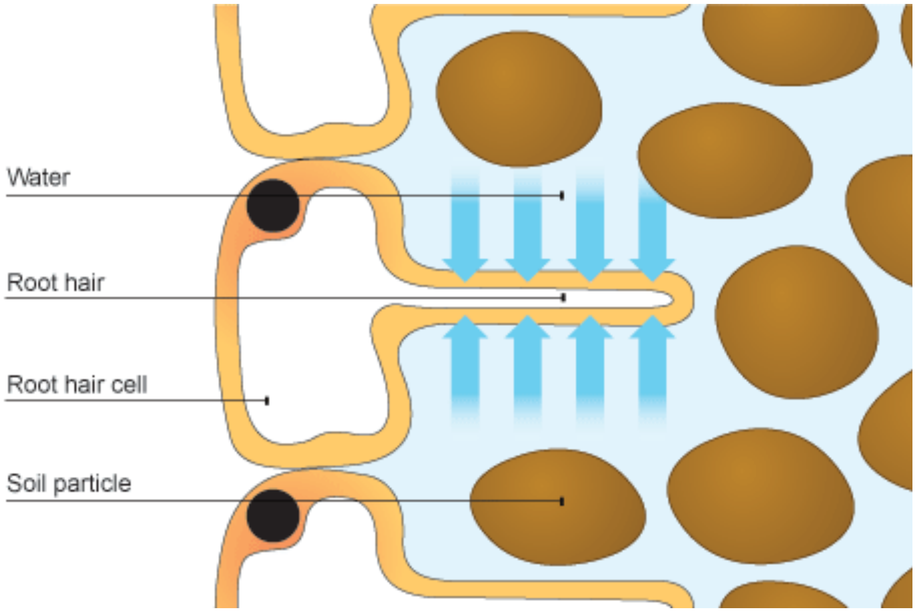
Water uptake

1. Soil particles are usually coated with water and dissolved mineral salts.
2. The cell sap in the root hair cells contains sugars and ions thus it has a lower water potential than soil solution
3. Water enter root hair cells from the soil by osmosis.
4. The cell sap of the root hair cell now has a higher water potential than the cell sap in the adjacent cells, thus water moves across to the adjacent cell by osmosis
5. This process continues until the water enters the xylem vessels and moves up the plant.

Ions and mineral salts uptake

- When the concentration of ions and mineral salts in the soil solution is lower than that in the root hair cell sap, they are absorbed by active transport
- when the concentration of certain ions in the soil solution is higher than that in the root hair cell, they move into the root hair cells by diffusion

Root Pressure

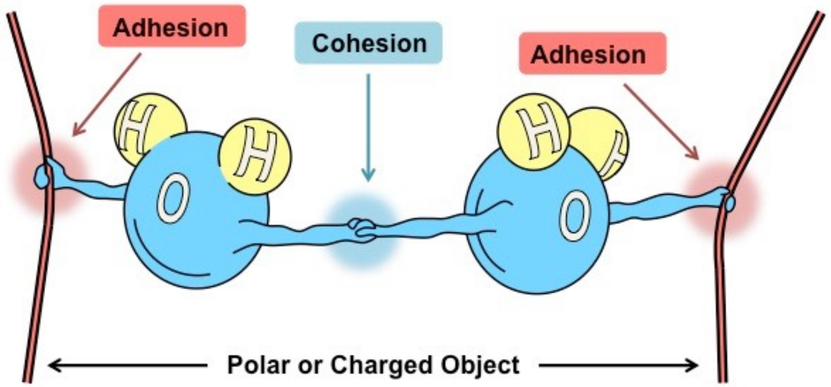


Water travels from the roots to the leaves against gravity through 3 primary mechanisms:

1. **Root pressure**

- Root hair cells pump mineral salts into the xylem vessels using active transport. This lowers the water potential of the xylem vessels, thus water moves from the surrounding cells into the xylem vessels by osmosis, creating a pressure that forces water to move upwards
- Not the main mechanism for movement of water in most plants as it can only force water to travel a short distance.

Capillary action

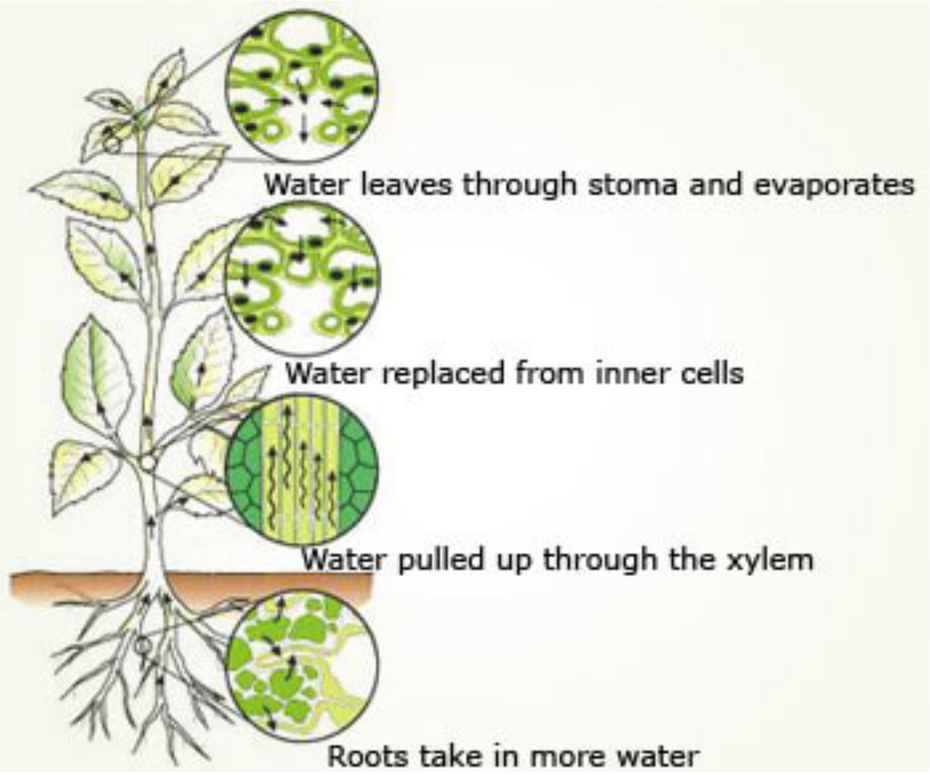


2. Capillary action

- Capillary action is the tendency of water to move up the **narrow xylem tubes** due to the interactions between water molecules and the xylem walls due to forces of cohesion and adhesion
  - **cohesion**: forces of attraction among water molecules
  - **adhesion**: forces of attraction between water molecules and the inner walls of xylem
- Usually observed in young plants with **narrow veins** and is not significant in larger plants.

Transpiration

transpiration pull



3. Transpiration Pull

- Transpiration is the **loss of water vapour** from the **stomata** of the leaves **through diffusion**
- Transpiration is a consequence of gaseous exchange in plants for photosynthesis to occur
  1) For photosynthesis to occur, the **stomata are open** for **carbon dioxide intake**.
  2) Water continuously moves out of the mesophyll cells to form a **thin film of moisture**
  3) **Water evaporates** from this thin film of moisture and **moves into the intercellular air spaces**
  4) This leads to the **loss of water vapour** from the intercellular air spaces in the leaves as the air **diffuse outside** that has a lower water vapour concentration via the stomata
  5) As water evaporates from the mesophyll cells, the **water potential of the cell sap decreases**, thus they **absorb water by osmosis from the xylem vessels**.
  6) This results in **transpiration pull**, which is the main force that causes water to travel upwards in plants.

Transpiration pull is important as

- It **draws water and mineral salts from the root**s to the stems and leaves, which is needed for photosynthesis and to keep plants turgid
- **Cooling of the plants** as evaporation of water from the cells in the leaves removes latent heat of vaporisation.

Transpiration

effect on transpiration

1. Effects of **variation of air movement**: if wind is present, it removes the water vapour that accumulates outside the stomata due to transpiration. This leads to **steep concentration gradient** between intracellular air spaces and atmospheric air, thus increasing the rate of transpiration.
2. Effect of **temperature**: Higher surrounding temperature increases the **rate of evaporation** of the thin film of moisture and and also increases the **movement of water molecules**, thus increases the rate of transpiration
3. Effect of **humidity**: Humidity refers to the concentration of water vapour present in the air. A lower humidity means a lower water vapour concentration, thus a steeper concentration gradient between the atmospheric air and intracellular air spaces. This increases the rate of water vapour diffusing out of the leaves thus the rate of transpiration
4. Effect of **light intensity**: Higher light intensity leads to increased **rate of photosynthesis in guard cells** thus causes stomatal opening. When stomata is open, the rate of transpiration will increase

Effect of transpiration

wilting

- Water lost via transpiration has to be replaced by absorption from the roots to the leaves by xylems
- When the rate of water absorption exceeds the rate of transpiration, plant cells become turgid and plant becomes firm and upright.
- When the rate of transpiration exceeds the rate of water absorption, plant cells become flaccid and plant wilts.

Advantages: When the leaves fold up, the leaves droop and less leaf surface is exposed to the sun thus reducing water loss. Guard cells are flaccid, closing the stoma, further reducing water loss.

Disadvantages: When the plant wilts, the leaves droop and less leaf surface is exposed to the sun and thus rate of photosynthesis decreases.

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