TOPIC: PLANT SYSTEMS

Key Knowledge:

- Specialisation and organisation of plant cells into tissues for specific functions in vascular plants, including intake, movement and loss of water
- Regulation of water balance in vascular plants

PLANT TISSUE

Plants are autotrophs and produce their own organic compounds via the process of photosynthesis. These compounds (carbohydrates) are then used in cell respiration to fuel cellular processes needed for survival. The structural organisation of a vascular plant (into tissues and organs) is related to these core functions:

- **Roots:** Responsible for the uptake of inorganic compounds (water and dissolved minerals) from the soil
- **Leaves:** Responsible for photosynthesis (contain chloroplasts) and gas exchange (via stomatal pores)
- **Stems:** Contain vascular bundles (xylem + phloem) for transporting materials between leaves and roots

ROOT STRUCTURE

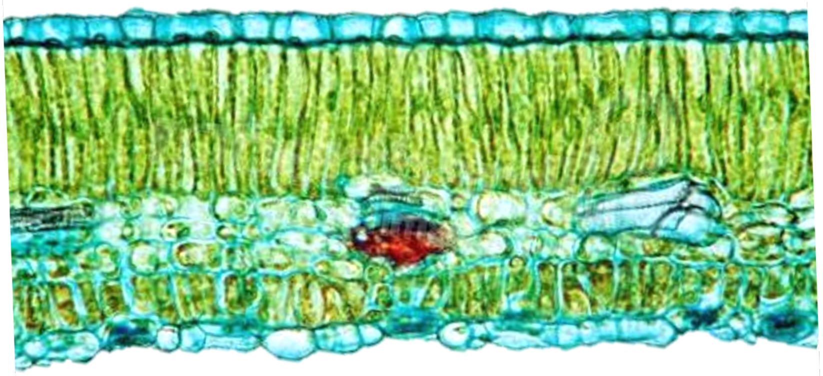
Plants take up inorganic materials (such as water) from the soil and hence need a maximal surface area in order to optimise this material uptake. The type of root system a plant possesses may vary according to its structure:

- Smaller plants have a highly branching (**fibrous**) root system in order to greatly increase the surface area available for water and mineral uptake
- Larger plants may have a deeply penetrating **tap root** (for stability) with many lateral branches to access deeper reservoirs of water in the soil

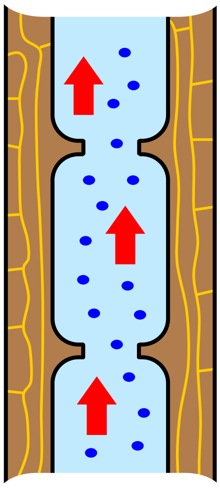
The epidermis of roots may have many cellular extensions called **root hairs** which function to further increase the available surface area for absorption.

LEAF STRUCTURE

Plants undertake photosynthesis within their leaves and so the leaf tissue is organised according to this function. The upper layer of cells (**palisade mesophyll**) all contain many chloroplasts and are tightly packed together in order to optimise light absorption. The lower layer of cells (**spongy mesophyll**) is very loosely packed and contain many air spaces. These cells are responsible for gas exchange via stomatal pores on the underside of the leaf. Vascular bundles are located centrally and facilitate material transport – the xylem transports water to the leaf (for photosynthesis), while the phloem will transport organic nutrients (produced by photosynthesis) from the leaf. A waxy cuticle provides a protective cover for the leaf surface.



TRANSPIRATION



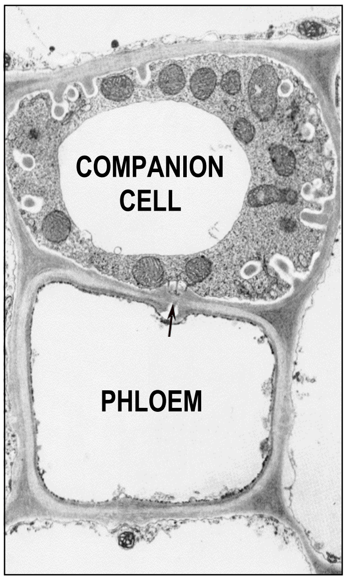
Transpiration is the loss of water vapour from the stems and leaves of plants. Light energy converts the water in the spongy mesophyll into vapour, which **evaporates** from the leaf via the stomata. New water is absorbed from soil by roots, resulting in a difference in pressure between leaves (low pressure) and roots (high pressure). The polarity of water makes it **cohesive** (associate with other water molecules) and **adhesive** (able to associate with the xylem wall via capillary action). Consequently, water will flow along the pressure gradient (**mass flow**) to replace the water lost from the leaves. Over 95% of all water absorbed by roots is evaporated to enable transpiration, only a fraction is retained by the plant for use in cell functions. The xylem is lined by dead cells which are fused together to form a continuous tubing under constant hydrostatic pressure (created by the unidirectional flow of water).

WATER CONSERVATION

Plants that inhabit desert environments (**xerophytes**) will experience higher rates of transpiration (due to high temperatures and low humidity) and may possess certain adaptations in order to minimise water loss:

- Low growth and reduced leaves: Limits exposure to wind and minimises the surface area for water loss
- Thick cuticles and stomata in pits: Helps to trap and retain water vapour within the spongy mesophyll
- CAM physiology: Plants with CAM physiology only open their stomata at night, reducing evaporation

TRANSLOCATION



Translocation is the movement of organic compounds from source to sink. The source is where organic compounds are synthesised (leaves), whereas the sink is where the compounds are delivered, either for use or for storage (roots, fruits and seeds). Organic compounds are transported in a viscous fluid (sap) via a tube system called the phloem. The organic compounds are loaded into the phloem at the source by companion cells, which increases the solute concentration of the sap (making it hypertonic). Consequently, water is drawn from the xylem via osmosis, causing the hydrostatic pressure in the phloem to rise. Hence, the sap will consequently move via mass flow towards the sink – where the pressure is lower. When the compounds reach the sink, they are unloaded from the phloem by companion cells, which will ensure that a concentration gradient is maintained between source and sink. Translocation occurs bi-directionally depending on source and sink location.