TOPIC 9.1: XYLEM TRANSPORT

Transpiration

Transpiration is the loss of water vapor from a plant
- Active uptake of ions by roots promotes water uptake
- Water moves up the stem of a plant by mass flow
- Water is evaporated from leaves (via stomatal pores)

The flow of water from root to leaf is the *transpiration stream*

Root Uptake

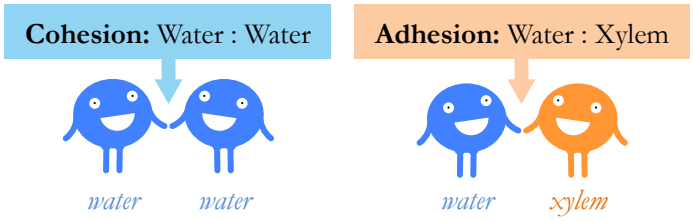
Soil contains anionic clay particles to which minerals attach
- Examples of cationic minerals include K^+, Na^+, Ca^{2+}

Roots pump H^+ ions into the soil to displace the minerals
- Displaced minerals diffuse into root *(indirect active transport)*
- Water follows mineral ions into the root via osmosis

Mass Flow

Water moves up the stem via *mass flow* in vessels called **xylem**
- Pressure is high in root *(water in)* and low in leaf *(water out)*
- The pressure differential results in the mass flow of water

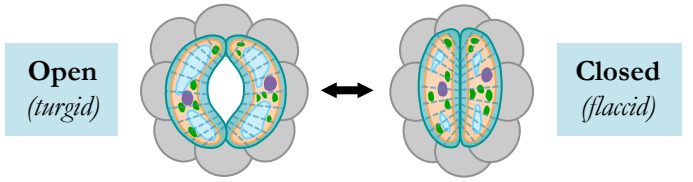
This capillary action is mediated by two forces:
- Cohesion (water molecules stick together by H-bonding)
- Adhesion (water molecules adhere to the xylem wall)



Evaporation

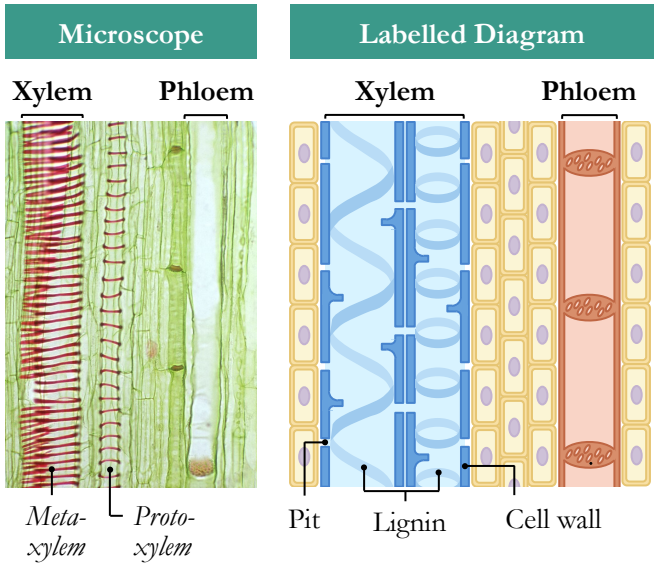
Some of the light absorbed by a leaf is transformed into heat
- This heat converts water into vapor (evaporation)

The vapor diffuses out of stomata, resulting in transpiration (transpiration is a consequence of gas exchange in the leaf)
- Transpiration rate is regulated by the stomatal guard cells
- Guard cells occlude the stomatal opening when flaccid



Xylem Structure

Diagrams of xylems contain the following features:
- The vessel elements form a continuous tube
- The remnants of fused end walls are shown as indents
- The xylem lining contains pits and pores
- It is reinforced with lignin (spiral or annular)



Water Conservation

Plants have adaptations to reduce water loss (transpiration)

Xerophytes (desert plants):
- Reduced leaves (lowers evaporative surface area)
- Thick, waxy cuticles (reduces water loss from leaves)
- Stomata in pits with hairs (traps vapor = ⬇ evaporation)
- CAM physiology (only opens stomata at night)

Halophytes (salt water plants):
- Cellular sequestration (salt is stored within the vacuoles)
- Tissue partitioning (abscission of leaves containing salt)
- Salt excretion (salt is actively removal from the plant)
- Root level exclusion (roots avoid salt uptake)

Measuring Transpiration

Water transport in xylems can be modeled in various ways:
- Capillary tubing *(water moves along tubing via surface tension)*
- Filter paper *(absorbs water due to adhesive properties)*
- Porous pots *(semi-permeable containers can model osmosis)*

Transpiration rates in plants are measured with **potometers**
- Potometers measure movement of air bubble / meniscus
- More movement represents increased transpiration rate