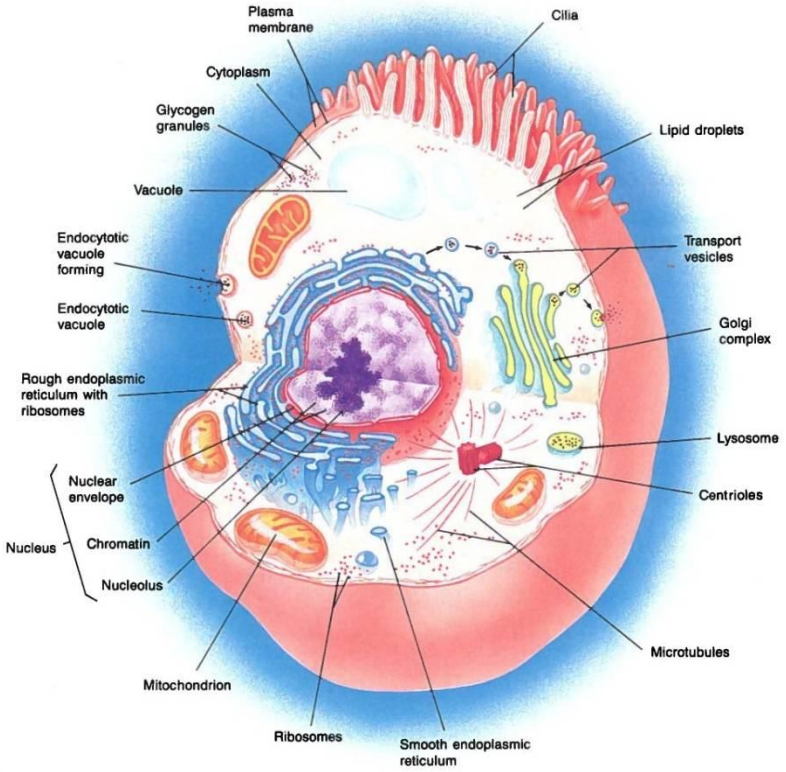
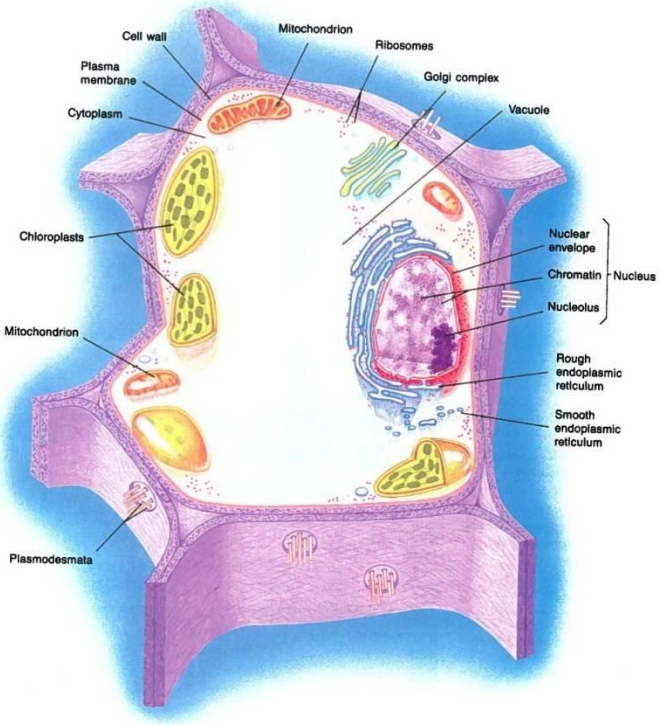
TEXAS FOREST SERVICE

Leaders in Texas Forestry

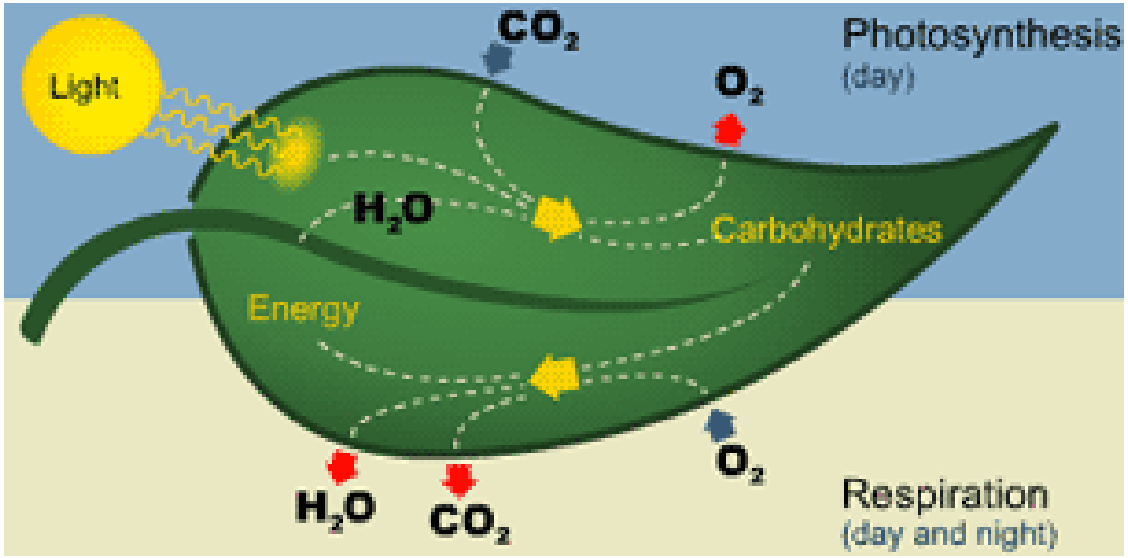
Basic Tree Physiology

Animal and Plant Cells





Conversion of Energy



CO_2 + H_2O + light → (CH_2O) + O_2

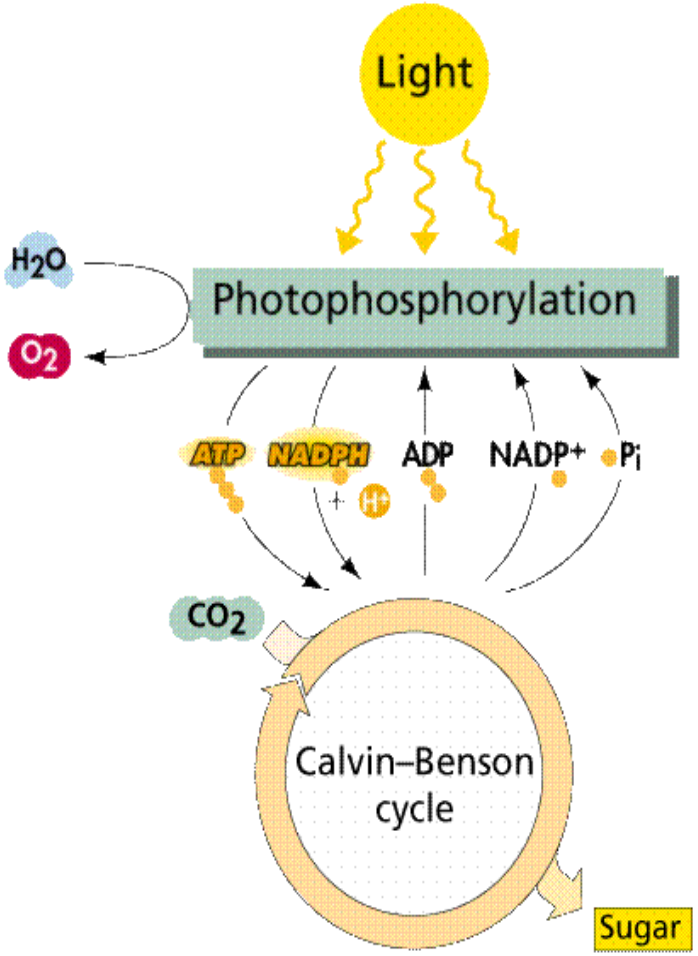
Carbon dioxide from the air	Water taken up by the roots	Energy	Carbohydrates	Oxygen

(CH_2O) + O_2 → CO_2 + H_2O + Energy

Carbohydrates	Oxygen	Carbon dioxide released into the air	Water	

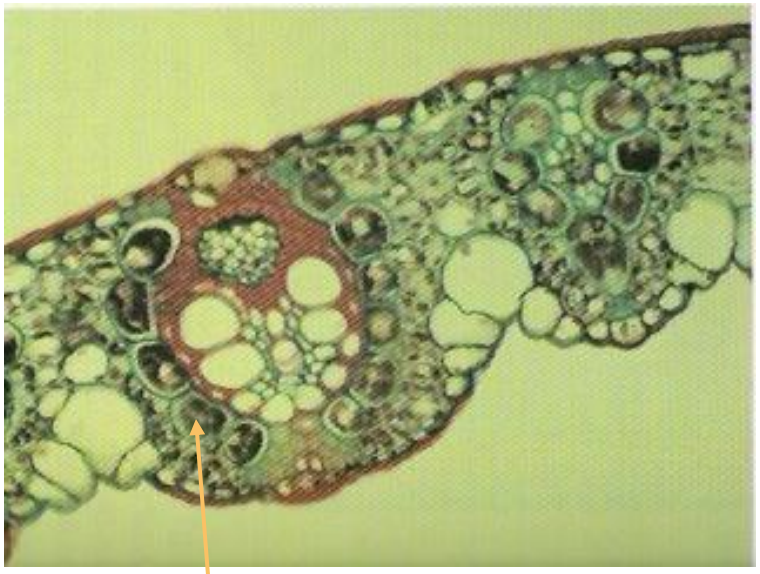
Photosynthesis

- Overall, water, carbon dioxide, and sunlight produce glucose and oxygen.
- 6 CO2 + 6 H2O + energy = C6H1206 + 6 O2
- Sunlight and water create short-term plant energy (ATP and NADH).
- This ATP and NADH energy creates “glucose” from CO2 and RuBP.



The Anatomy of Photosynthesis

Chloroplasts containing Thylakoid Membranes



C4 leaf with Bundle Sheath cells

C3 Photosynthesis

- **Adaptive Value**: more efficient than C4 and CAM plants under cool and moist conditions and under normal light because requires less machinery (fewer enzymes and no specialized anatomy).

C4 Photosynthesis

- **Adaptive Value**:
  - Photosynthesizes faster than C3 plants under high light intensity and high temperatures.
  - Has better Water Use Efficiency because it does not need to keep stomata open as much (less water lost by transpiration).

CAM Photosynthesis

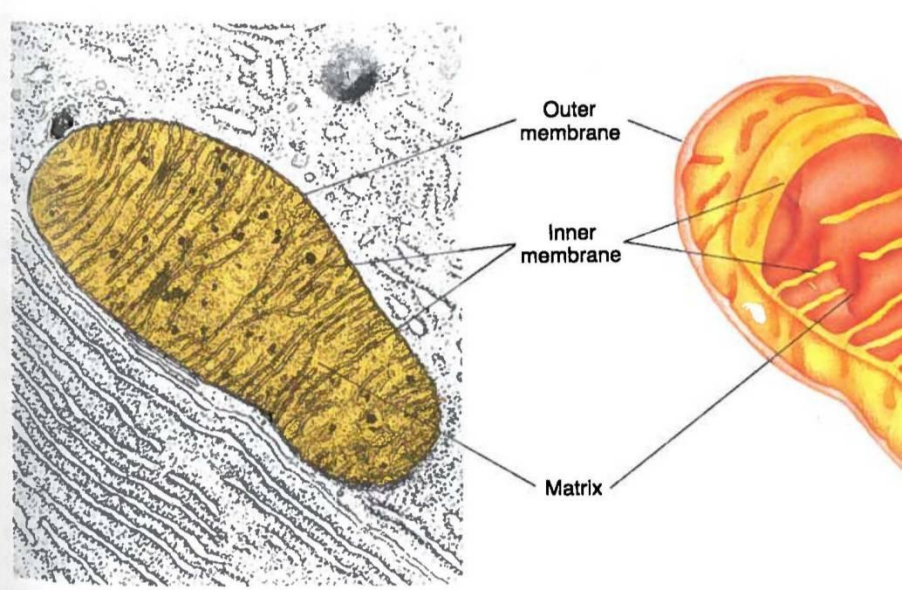
- **Adaptive Value**:
  - Better Water Use Efficiency than C3 plants under arid conditions due to opening stomata at night when transpiration rates are lower (no sunlight, lower temperatures, lower wind speeds, etc.).

Respiration

- Sugar and oxygen produce carbon dioxide, water, and plant energy.
- $C_6H_{12}O_6 + 6\ O_2 = 6\ CO_2 + 6\ H_2O$ + energy
- Oxygen's main job is to bind with extra Hydrogen and let the system cycle.

The Anatomy of Respiration

- "Glucose" is broken down by glycolysis and the citric acid cycle (mitochondria) to produce short-term plant energy (ATP). CO2 and H20 can then be released or used by photosynthesis.
- 1 glucose can produce 26 to 38 ATP.

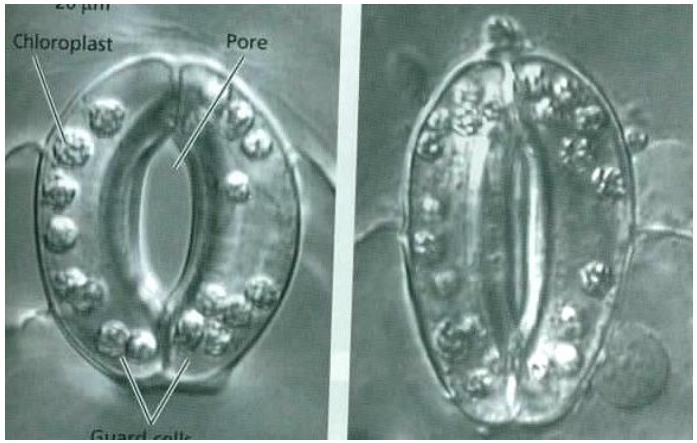


Carbon cycling

- 6 CO_2 + 6 H_2O + light = $C_6H_{12}O_6$ + 6 O_2
- $C_6H_{12}O_6$ + 6 O_2 = 6 CO_2 + 6 H_2O + ATP
- During good growing days, photosynthesis out performs respiration by 40 to 70%. This allows extra sugars to be converted into the growth of wood (fixed carbon). Thus, more O_2 than CO_2 is released into the atmosphere.
- However, respiration occurs year round on all perennial plants. Any time a plant is not actively growing, it releases as much or more CO_2 as O_2.

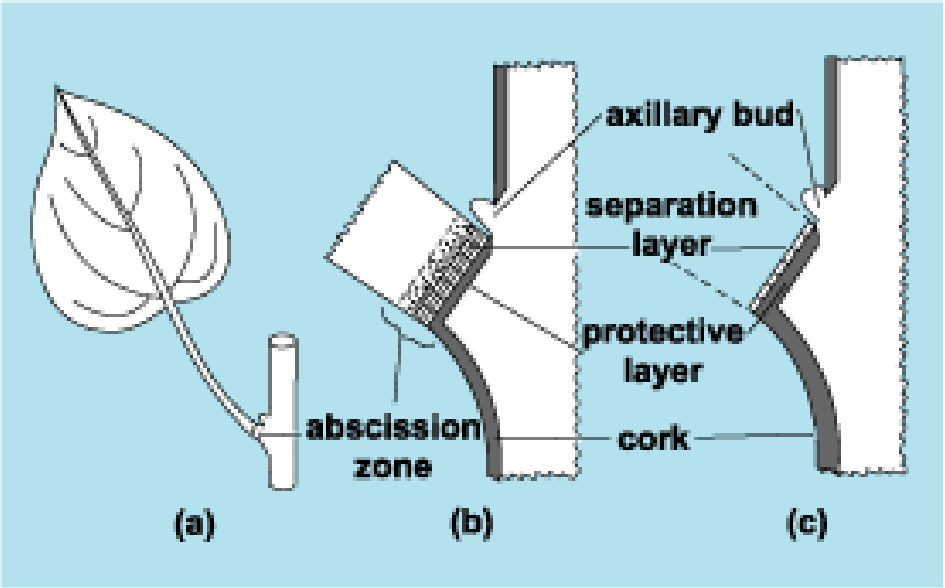
Gas Exchange

- Stomata
- Lenticels
- Collenchyma cells
- Root Absorption



Leaf Fall

Trees that keep their leaves are **evergreens**, trees that lose their leaves are **deciduous**.



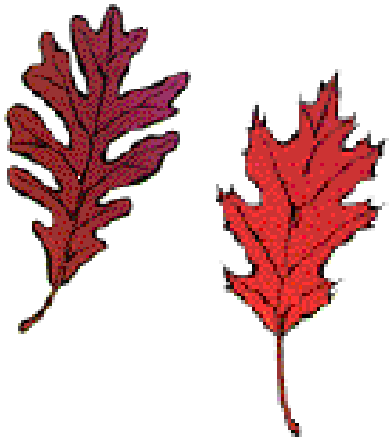
Abscission zone– area at the base of the petiole that breaks down and causes leaf (or fruit) drop

Leaf Fall

Declining intensity of sunlight triggers the processes leading up to leaf fall in autumn.

Chlorophyll reduces, unmasking carotenoids.

Clogged phloem veins trap sugars in the leaf and promote production of anthocyanins.



Tree Growth Hormones

- Plant growth regulators are hormones that work in concert.
  - auxin, cytokinins, gibberelins, ethylene, abscisic acid…etc.
- Environmental triggers
  - Budbreak
  - Leaf fall
  - Seed germination
  - Geotropism
  - Phototropism

Tree Needs

- Soil, water, sunlight
- More in depth: Soil nutrients and stability, H20 runs photosynthesis and expands cells, sunlight provides energy to start photosynthesis and signals plants.

How do trees cope?

Soil Nutrients

- Nitrogen, phosphorous, potassium, calcium, Magnesium, Sulphur, Iron, Manganese, Zinc, Copper, Boron, Molybdenum, and Chlorine are all considered essential to plant growth.

Soil Nitrogen

- Nitrogen makes up proteins and enzymes needed for photosynthesis and cell synthesis.
- Nitrogen deficiency results in chlorosis of older leaves.

Soil Phosphorus

- Phosphorous makes up energy transfer compounds ATP, ADP. It is also essential in the makeup of DNA and RNA.
- Phosphorus deficiency often causes stunting of young trees.

Soil Potassium

- Potassium is essential for the movement of water and minerals within a plant (one of the main ways to manipulate osmosis). It is also essential for protein synthesis.
- Potassium deficiency results in chlorosis followed by marginal scorching of old leaves

How do trees cope?

Soil Gases

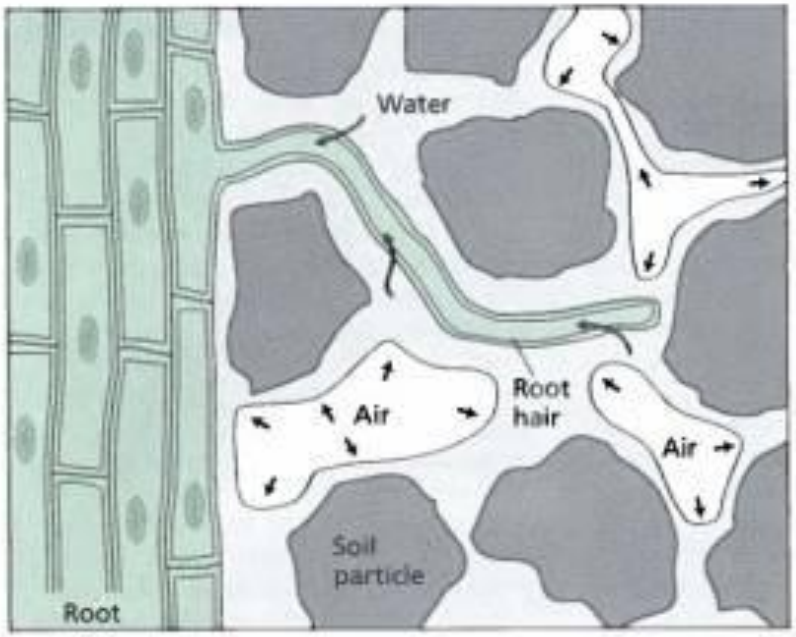
- Tree root cells perform respiration. So they take in O2 and release CO2
- Normal soil contains >18% O2 and <2.5% CO2.
- Compacted soil or clay filled areas can contain 1% O2 and 20% CO2.
- Even just 6 inches of clay fill can decrease O2 from 18% to 8%
- Water runoff is often increase by compaction or excess clay fill.

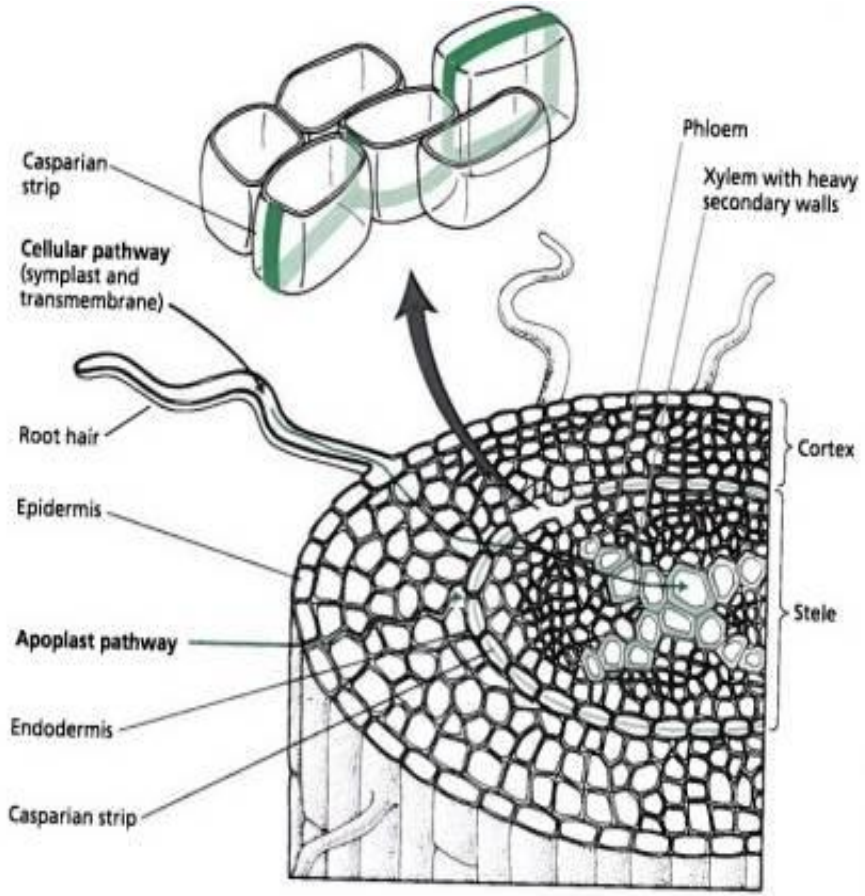
How do trees cope?

Water Needs

- Water absorbed from the soil is needed to drive photosynthesis as well as cell growth.
- Trees have growth characteristics adapted to soil types, water availability, and water needs of the tree species.
- For example, Bur Oak is known to have a tap root which penetrates deep in the soil. Juniper is known to have small roots which can search and exploit cracks in the limestone bedrock.
- Water is also created as a by-product of respiration by all living cells.

Water and Nutrient Uptake

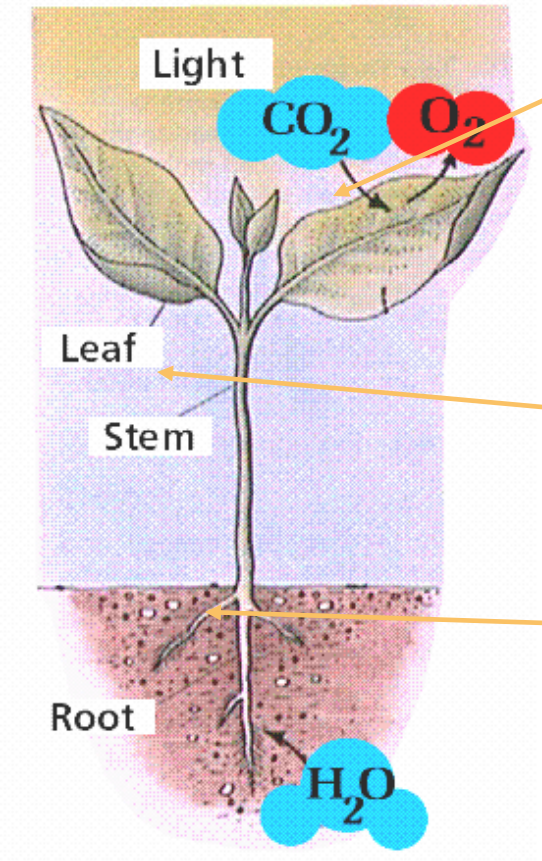




Water Management

- Transpiration is the process by which water in the tree is evaporated out into the air.
- Each tree has it's own unique way of dealing with transpiration. This is an adaptation to not only the trees current or typically climate, but also the water needs of the tree.
- Juniper as juvenile can control their stomata to conserve water until their roots can find water in the bedrock. Later as adults they lose the ability to control their stomata after establishing a root system and a water source.
- Cottonwood trees have a flattened petiole which causes the leaves to "tremble" cooling the leaf. This allows the stomata to remain open (allowing photosynthesis) during hot dry periods.

Tree Summary



- The leaves process water and carbon dioxide (photosynthesis) to form sugars (fuel), which are sent back down (phloem) the tree for storage and use.
- The stem transports water and nutrients up to the crown and leafs via the xylem.
- The roots absorb water and nutrients with help from root hairs.

The End

For More Information

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