


Tree Life Functions

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Review

- Basic plant cell structure
- Meristems and how trees grow
- CODIT
- Leaves
- Stem Structure
- Root structure

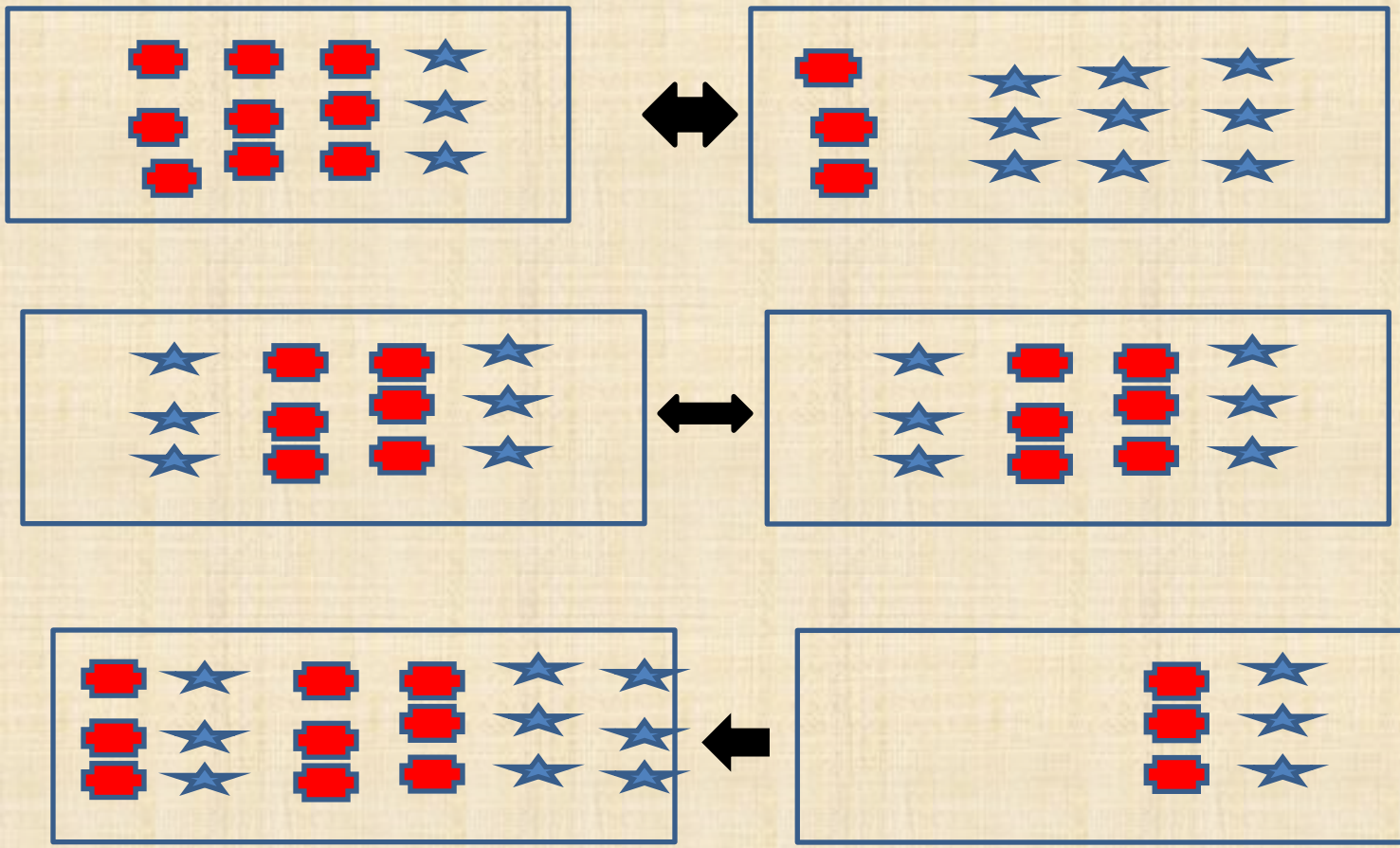



Tonight

- Energy
  - Photosynthesis
  - Respiration
- Vascular Tissue
  - Translocation
  - Transpiration
  - Structure
- Energy Flow and Uses
- Common Urban Stressors
- Hormones




Partial Pressure Differentials






ENERGY




Energy

- Flow of energy is critical to trees and their habitats
- Trees are Autotrophs
  - Auto – Greek, combining form of autós ***self***
  - Troph-Greek trophikós pertaining to ***food***.
- Photosynthesis captures photonic energy as chemical energy in sugar bonds
- Respiration in Krebs cycle releases chemical energy in sugar to power cellular processes




Photosynthesis

$6CO_2+6H_2O \rightarrow C_6H_{12}O_6+6O_2$

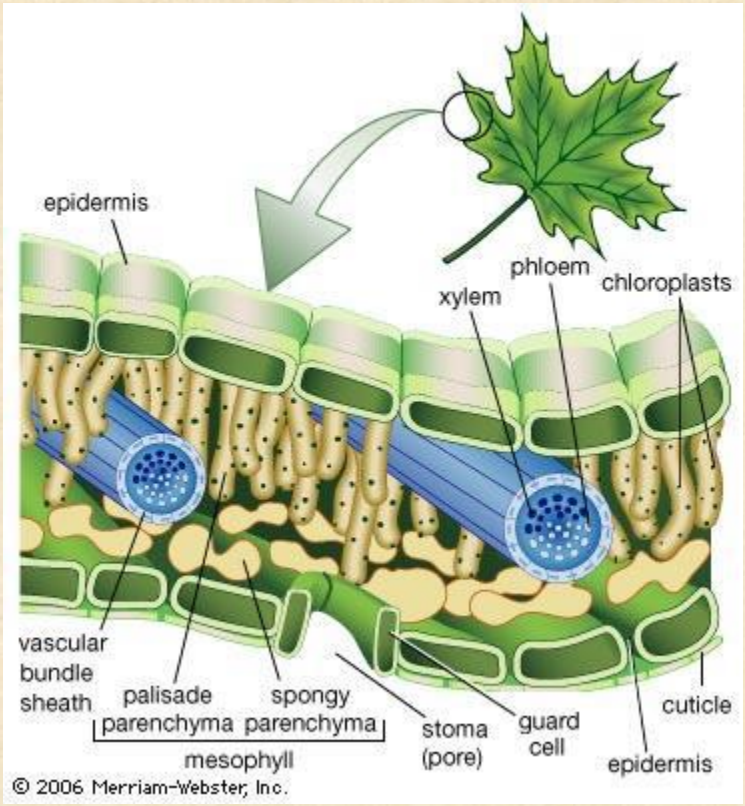
Inputs:

CO_2 from air via stomata

H_2O from roots via xylem

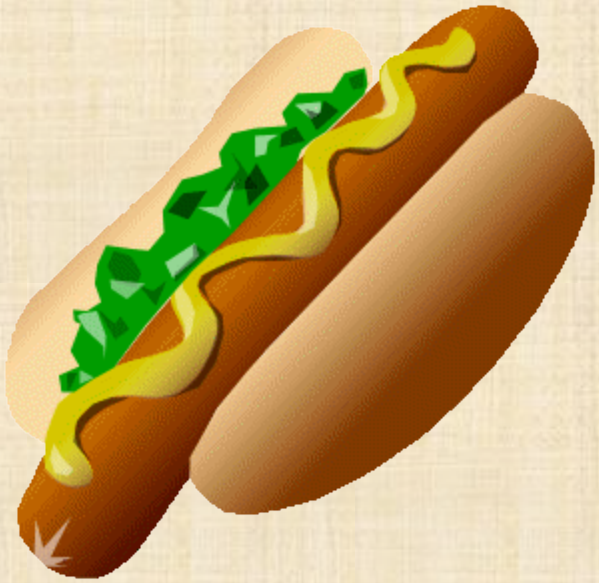
Sunlight

Output: Sugar



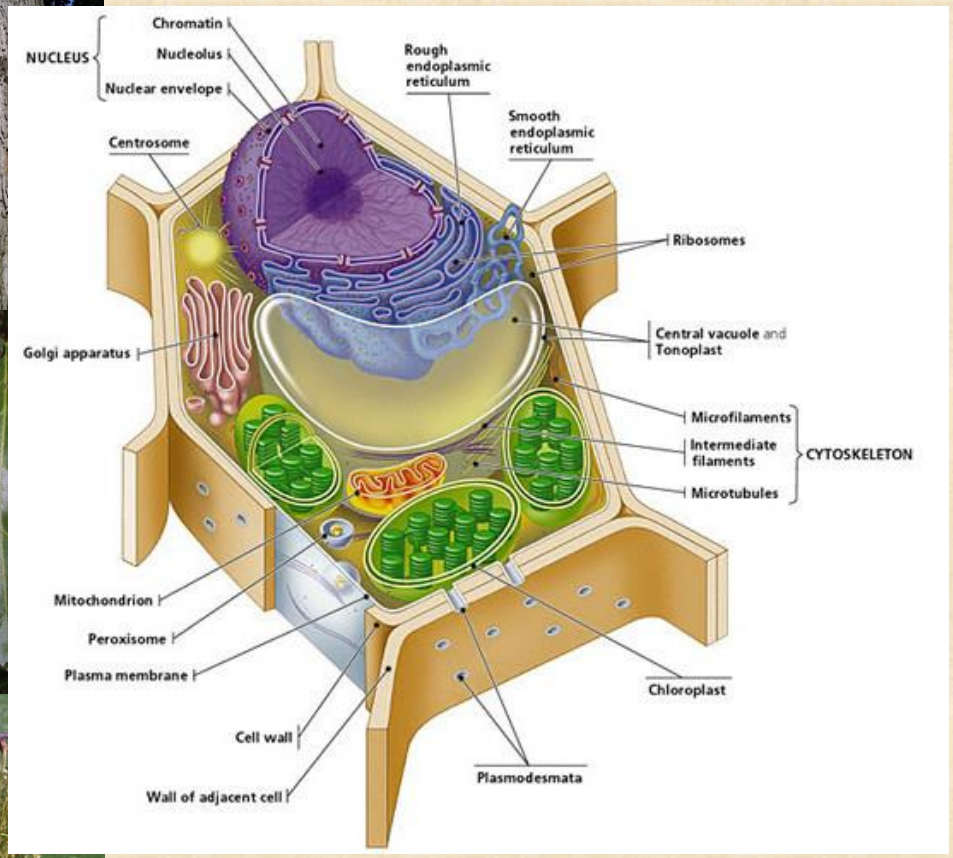
Photosynthesis w/ Extra carbon

$6CO_2+6H_2O \rightarrow C_6H_{12}O_6+6O_2$



- $6CO_2+60H_2O \rightarrow C_6H_{12}O_6+6O_2+54H_2O$
- Climate change → higher CO_2 partial pressure
- So $12CO_2+60H_2O \rightarrow 2C_6H_{12}O_6+12O_2+48H_2O$

Cellular Respiration



$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 3ATP$

Inputs:

Sugar from leaves

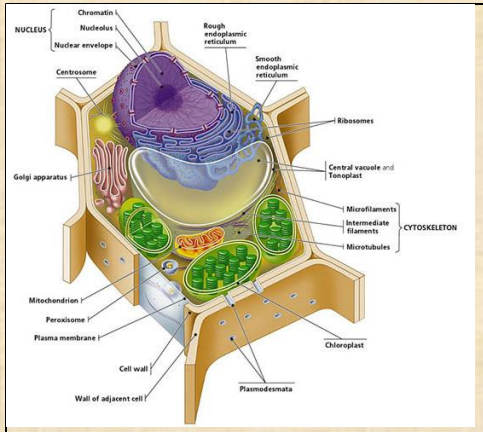
Oxygen from lenticels, mainly in roots

Output:

ATP to ribosomes

In Ribosomes

Macro-nutrients	Micro-nutrients
Carbon	Iron
Oxygen	Zinc
Nitrogen	Manganese
Phosphorous	Magnesium
Potassium	Copper
Sulfur	Boron
Calcium	Molybdenum
Water	



Defense

- Toxins (e.g. nicotine juglone, tannin, salacylic acid)

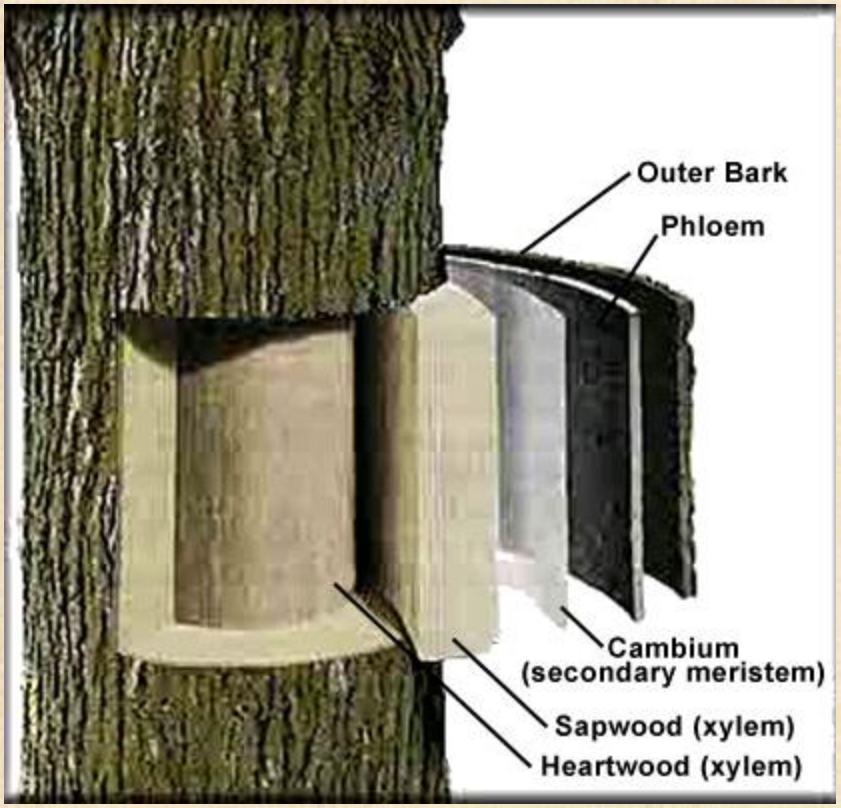
Nutrients in blue come from the air, in brown come from the soil, in green from the leaves(?)




VASCULAR TISSUE




Phloem and Xylem






Translocation

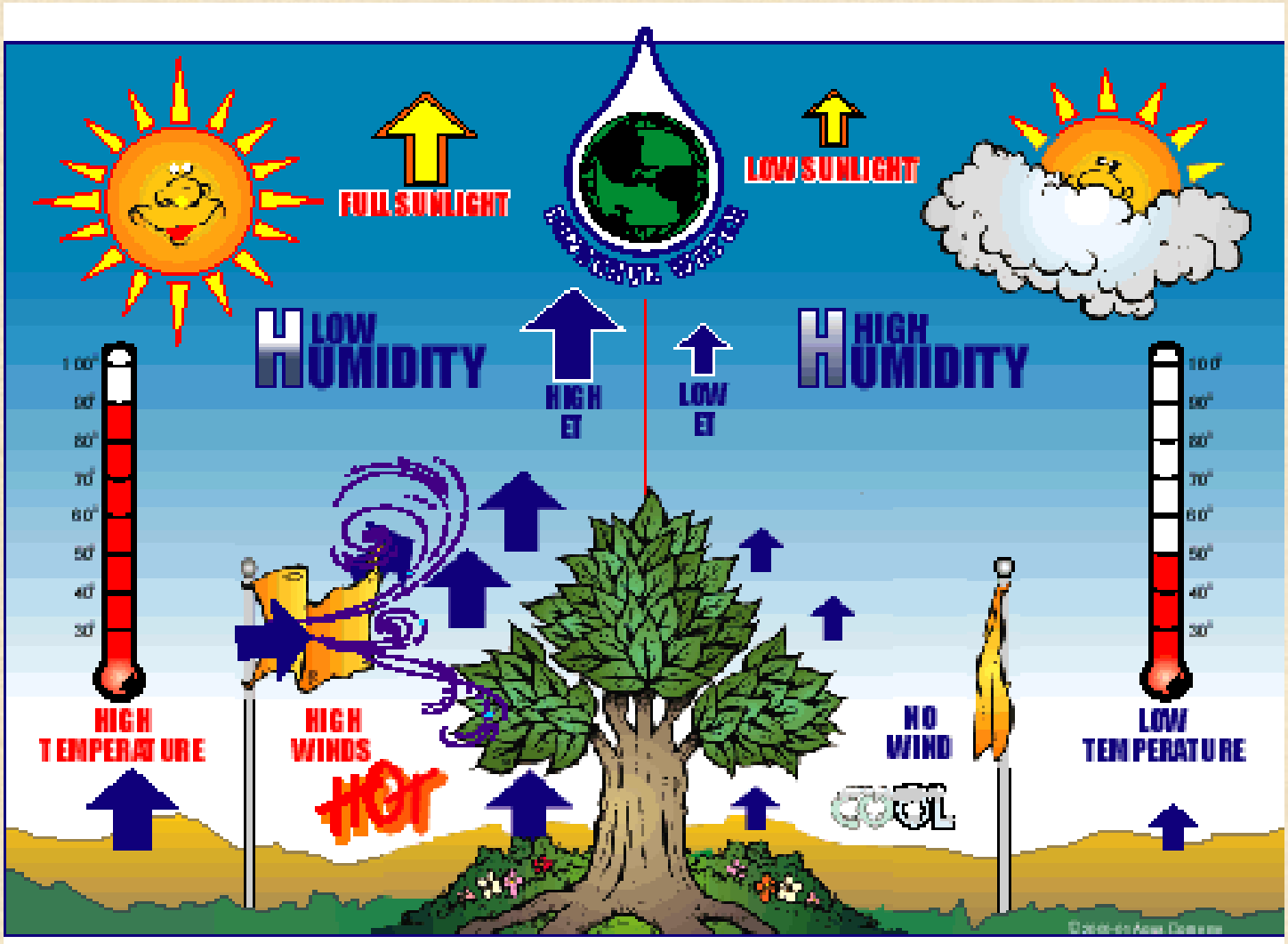
- Movement of sugars from source to sink
- In Spring sugar translocated from roots and rays to twigs to support leaf out, shoot growth and flowering
- In summer sugar translocated from leaves to cells for respiration and to roots and rays for storage.




Water Movement

- Water contains dissolved nutrients
- Water from soil into roots and mychorrhizea via osmosis
- Water and Nutrients are entrained in xylem and ‘pulled’ via transpiration
- Transpiration is the loss of water vapor to the atmosphere from leaves
- Capillary action may also play a role in lifting water
- Trees lift water 350’ without loss of pressure, theoretical maximum for a vacuum pump at sea level is 33.8’.
- Water in at roots = used by tree in photosynthesis+ transpiration

Transpiration

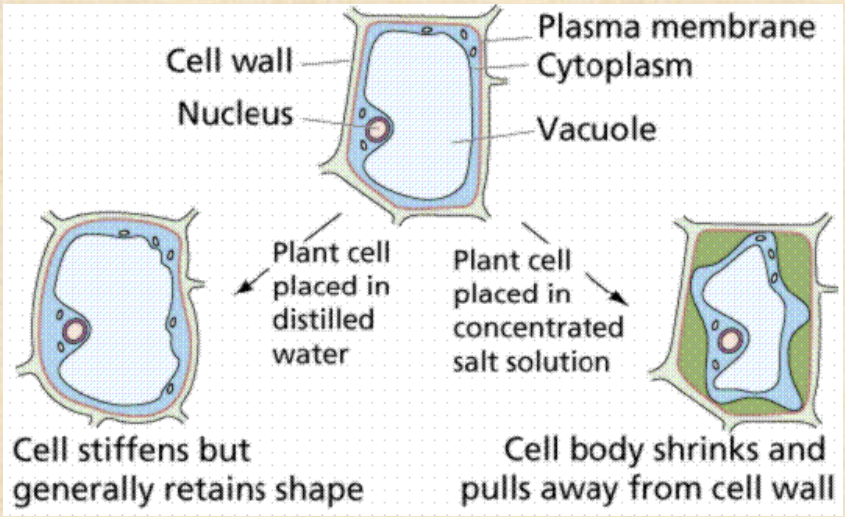




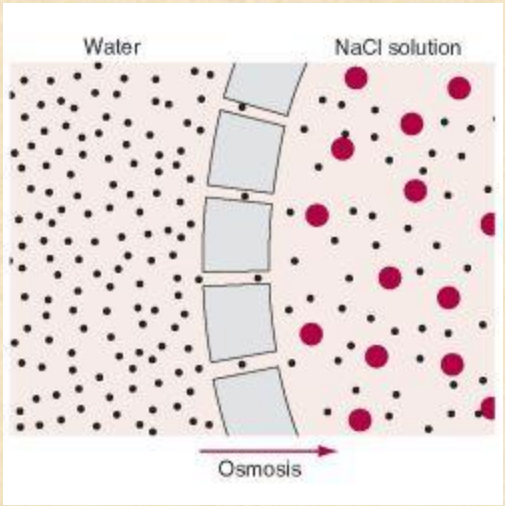

Transpiration

- Helps lift water and nutrients from roots to rest of tree
- Provides water for photosynthesis – part of the tree energy mechanism
- Cools the tree as heat used to accomplish phase change from liquid water to vapor is carried away from tree with vapor – just like human perspiration

Osmosis



Salt and inorganic fertilizer can reduce soil water partial pressure and cause water to move out of root; also kills mychorrhzea.



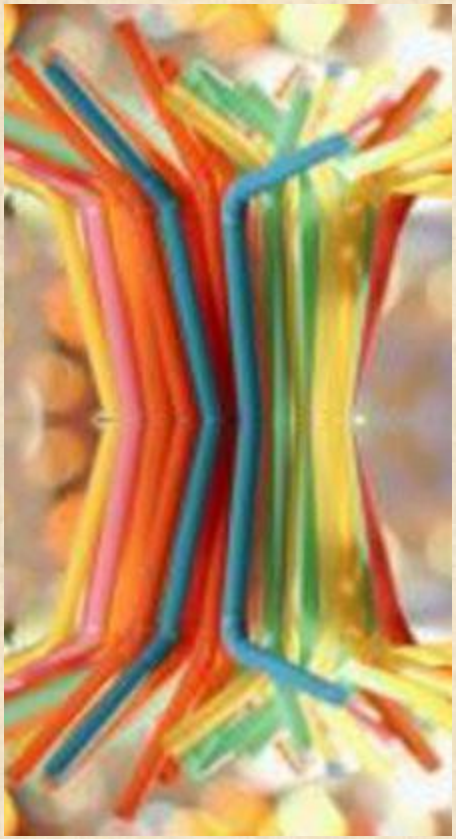
Water moves from high partial pressure of water molecules to low. Adding chemicals reduces water partial pressure.

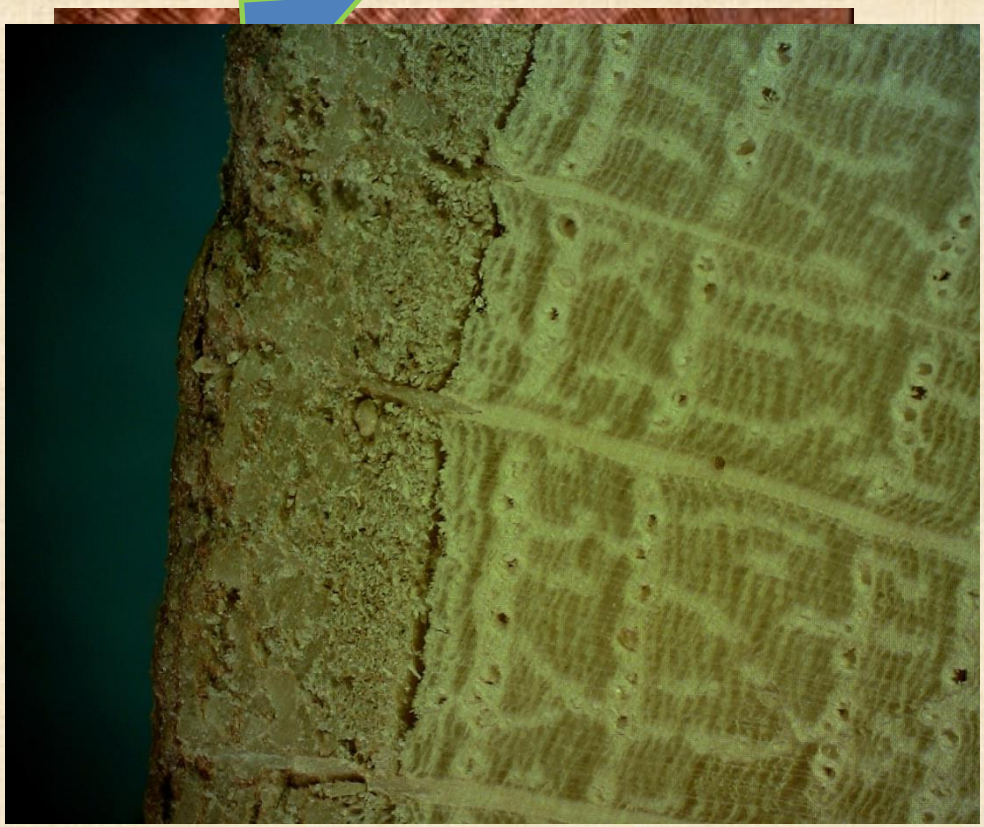



Trees and Ground Water

- Trees need 1mm^3 of water per mm^2 of soil surface per day
- This is 1mm per unit of soil surface per day or about 180 mm per year
- Average rain fall in NOVA is 1079.5 mm (42.5 inches) and fairly evenly distributed
- Loam 1 m deep can hold 130-195 mm of water
- Bottom line trees in NOVA don't need to access ground water, soil moisture is enough
- This why trees don't have tap roots and taking steps (e.g. mulching) to infiltrate storm water and reduce soil moisture evaporation are enough to keep trees hydrated without supplemental watering

Trunk Conductance

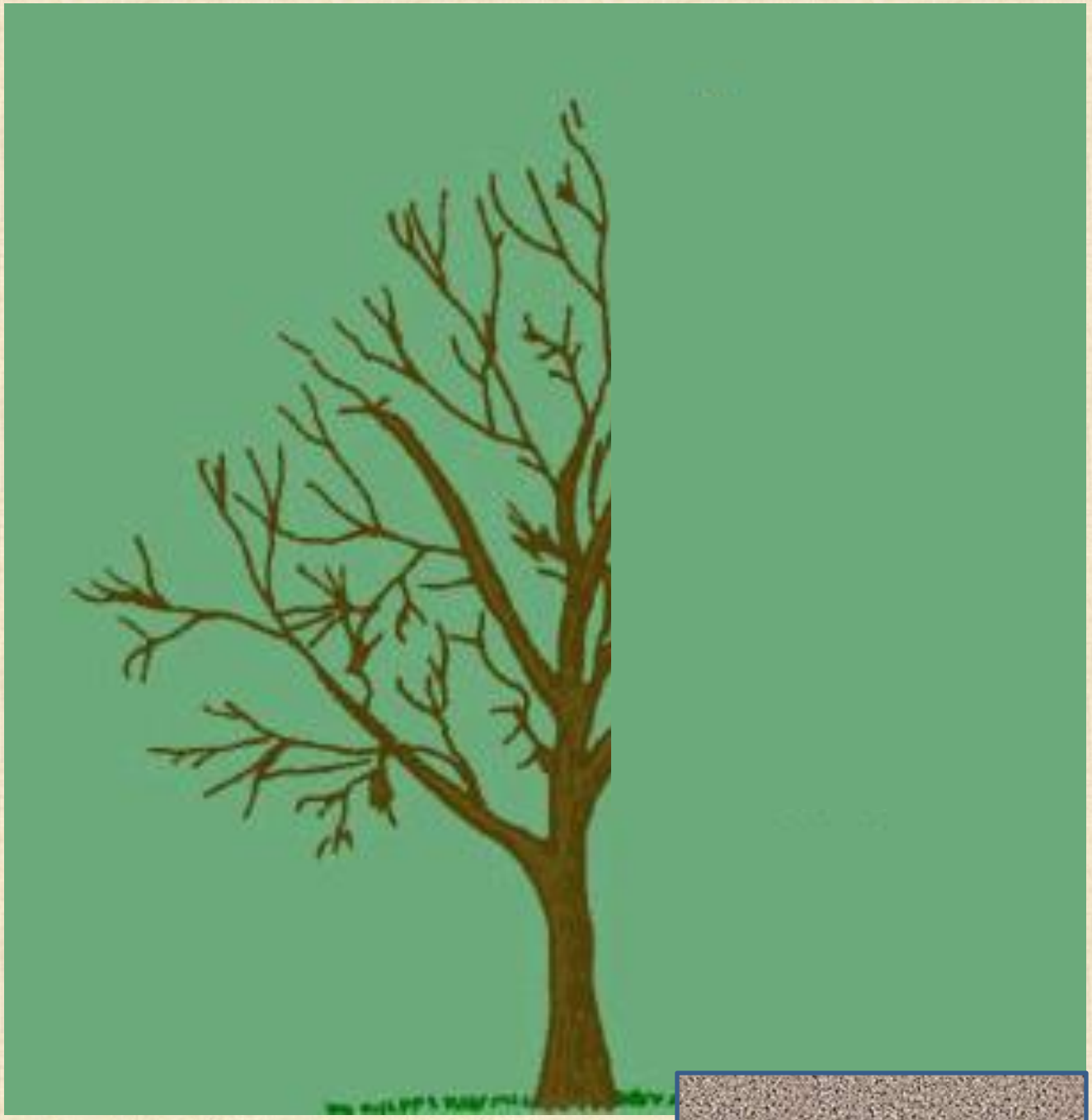







Implication of Anatomical Structure

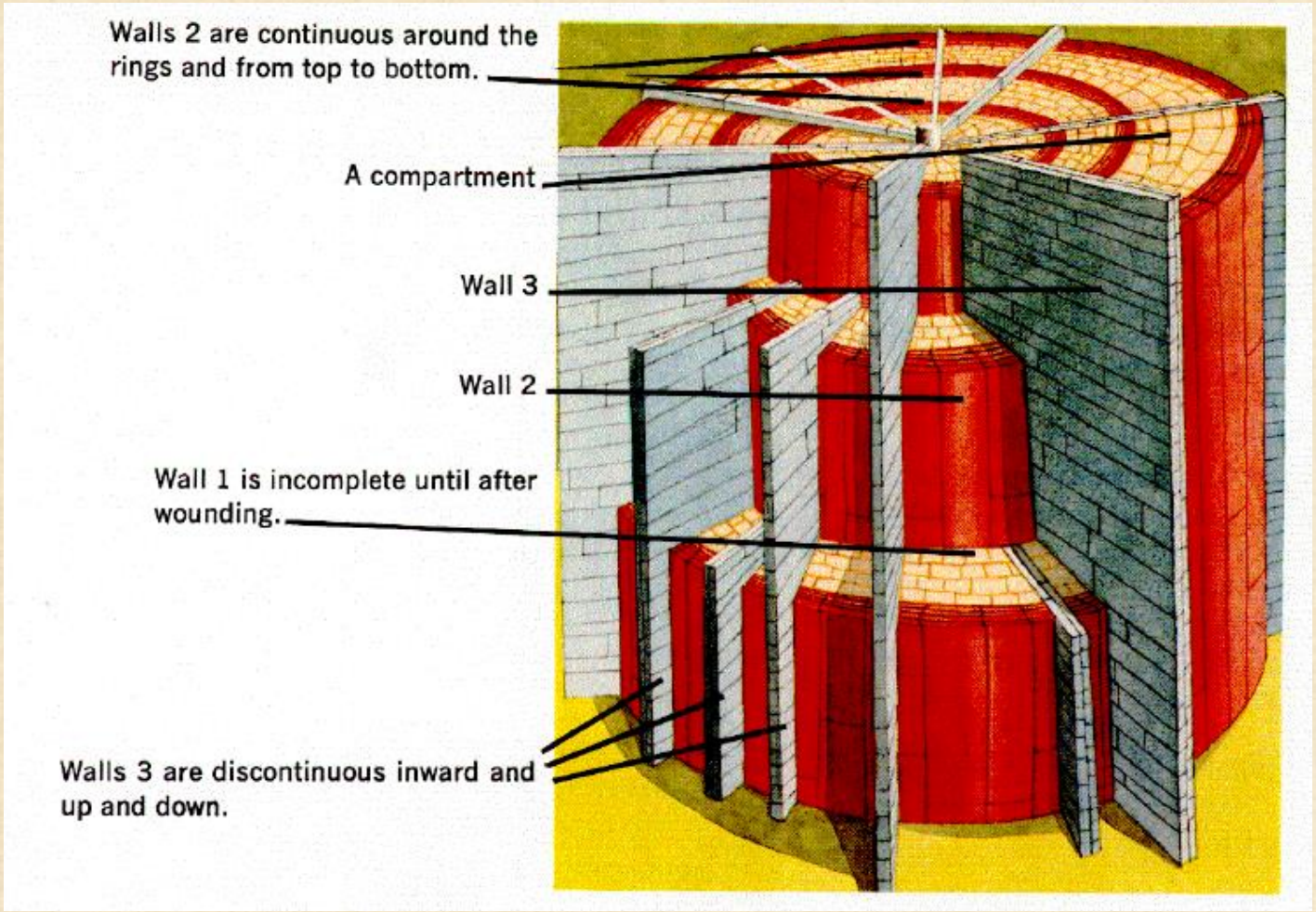
- Roots are well connected to the branches above them, but not connected to the branches on the other side of the tree.
- Damage to the bark and the tissues immediately below can sever the connection between the roots and the branches.
- Damage to the roots (branches) will affect the branches (roots) above (below).



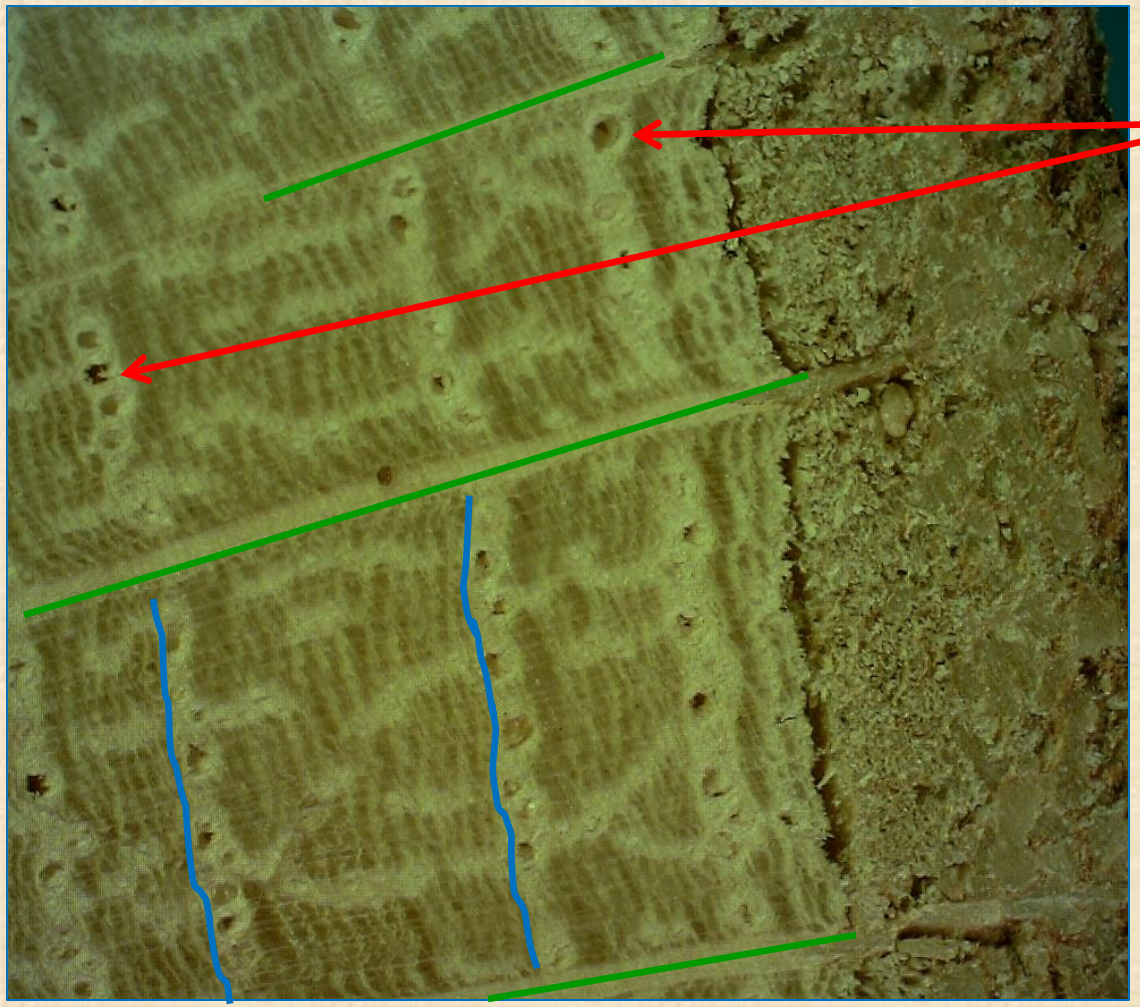



ENERGY FLOWS AND USES

CODIT and Vascular Tissue



CODIT Another View



Wall one: clog these holes

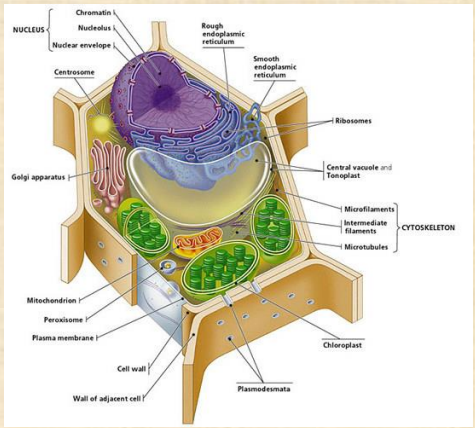
Wall Two: Late Wood

Wall Three: Rays

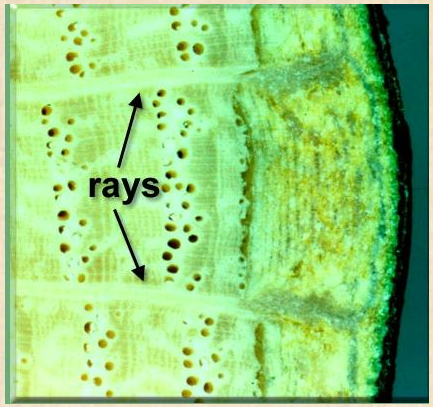



Energy Budget

1. Primary Growth – new shoots and leaves
2. Secondary Growth – new vascular tissue
3. Hormones
4. Cell maintenance
5. Storage – next year's primary growth
6. Defense – toxins and heartwood
7. CODIT










REVIEW




Quick Review

- Energy system needs:
  - Sunlight
  - Carbon Dioxide via Stomata
  - Water via roots (also carries nutrients)
  - Oxygen via roots (and stems)
  - Translocation via phloem (and xylem)
- Reduction in any of these means
  - Less growth
  - Poor cell maintenance
  - Lower defenses
  - Tissue death



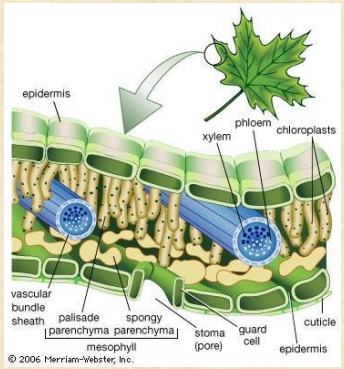

How a Tree Dies

- Animals die when muscle driven circulation stops.
- Trees die when they can no longer produce new tissue
- Damage from injury, pests or disease, compromises the energy system
- Energy demands for growth can also weaken the energy system
- Eventually demands on system are greater than can be supported and tree dies

Tree Energy Model

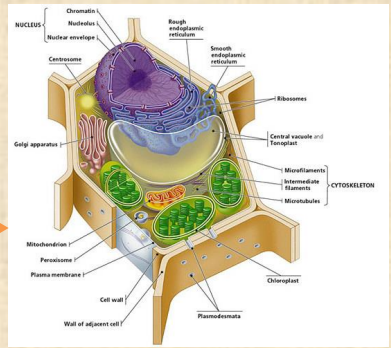
Sunlight

CO_2



Sugar

Tissues
Maintenance
Toxins



Sugar

Water

Nutrients

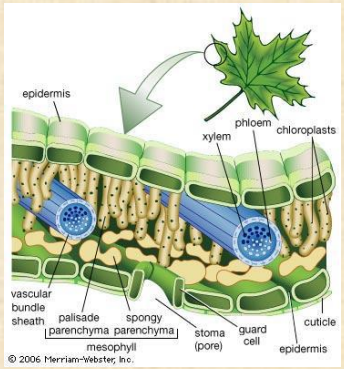
Oxygen




Crowding

Sunlight

CO_2

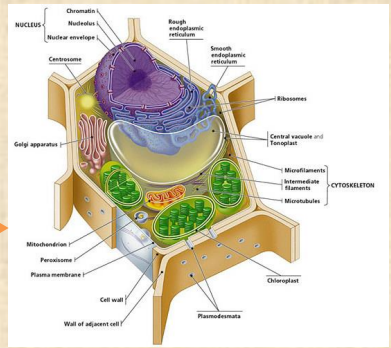


Tissues
Maintenance
Toxins

Sugar

Sugar

Water



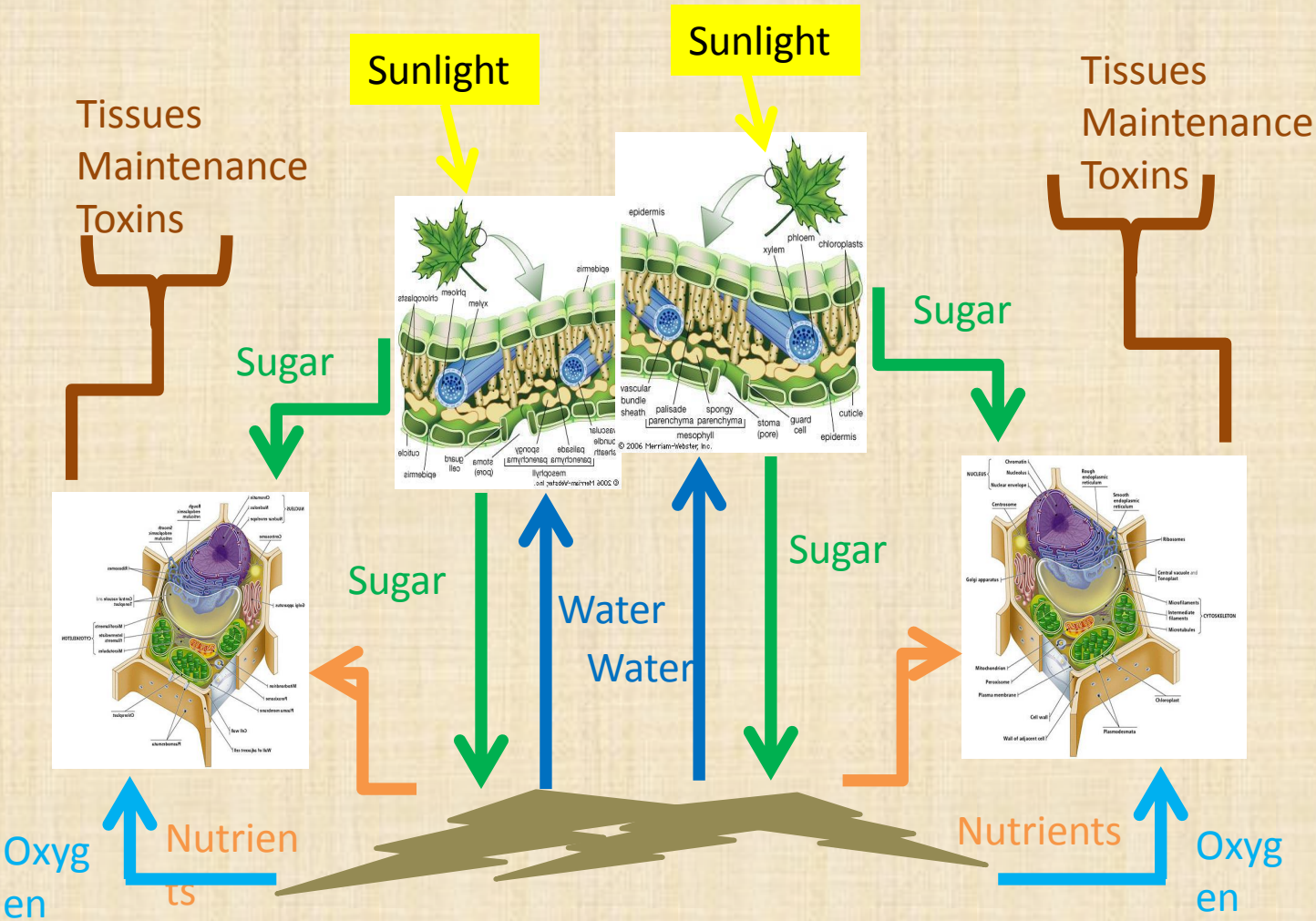
Nutrients

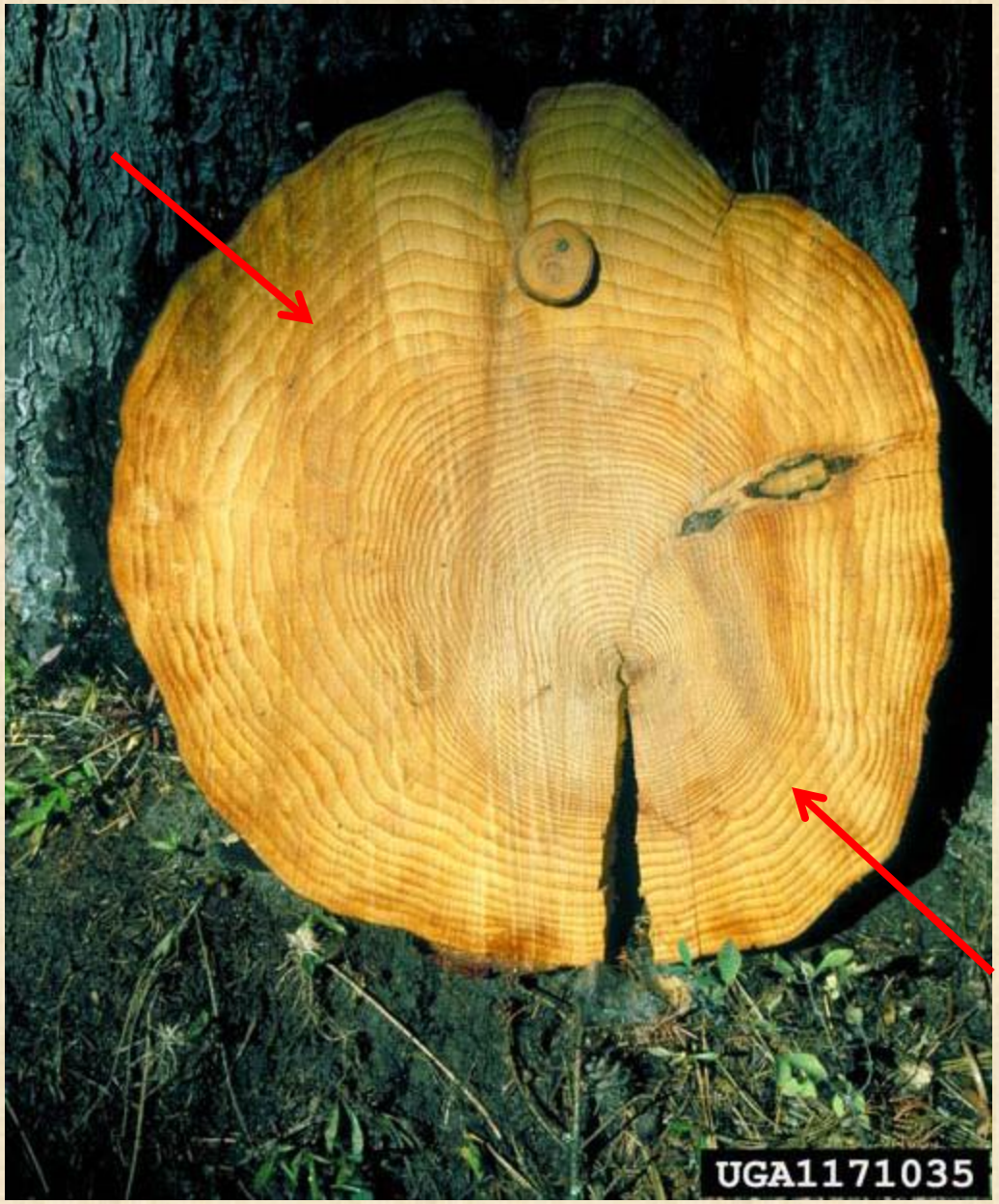
Oxygen





Crowding on one side

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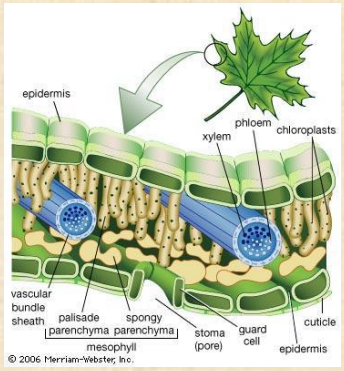
SOME COMMON URBAN PROBLEMS




Air pollution

Sunlight

CO_2



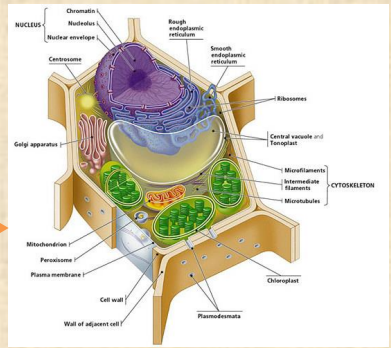
Tissues
Maintenance
Toxins

Causes Stomata to close

Impairs Photosynthesis

Sugar

Water



Nutrients

Oxygen

Air Pollution Damage to Trees

Photo courtesy of R.L. Anderson

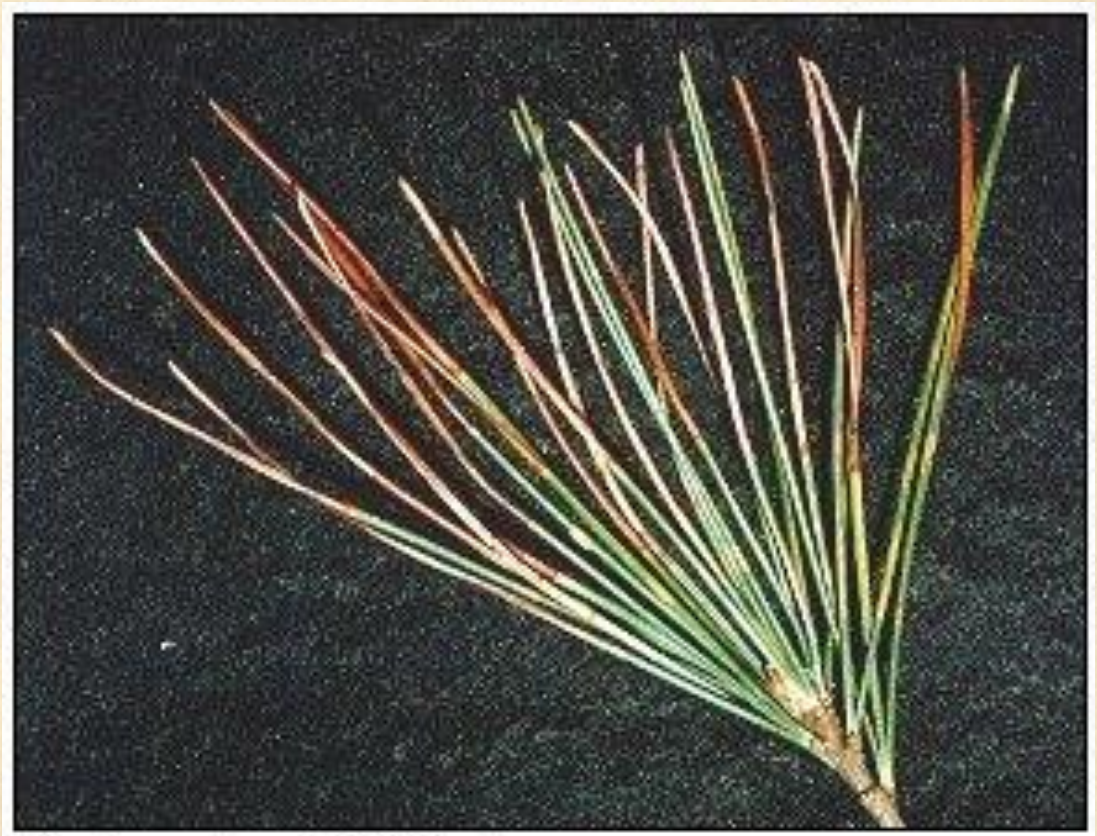


Photo courtesy of R.L. Anderson

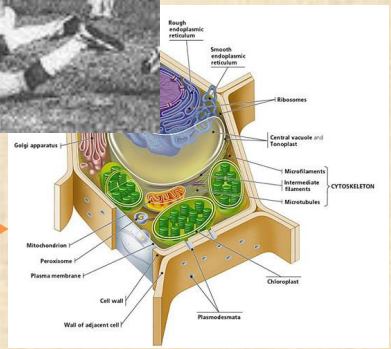
Soil Compaction

Sunlight

Tissues
Maintenance
Toxins

CO_2

Eliminates
macro-pores,
which hold air



Water

Impairs
respiration

Nutrients

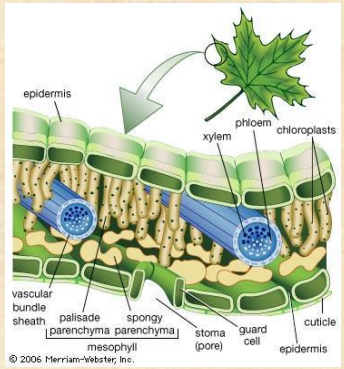
Oxygen




Inadequate Soil

Sunlight

CO_2

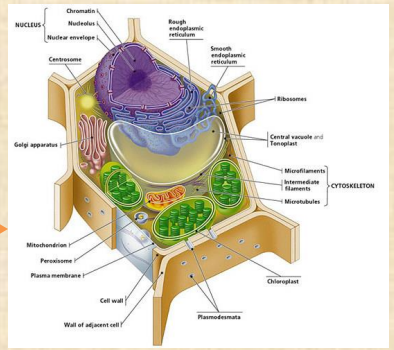


Tissues
Maintenance
Toxins

Sugar

Sugar

Water



Nutrients

Oxygen

Restricted Root Growth

Inadequate water and oxygen

Impairs entire energy system




Soil volume

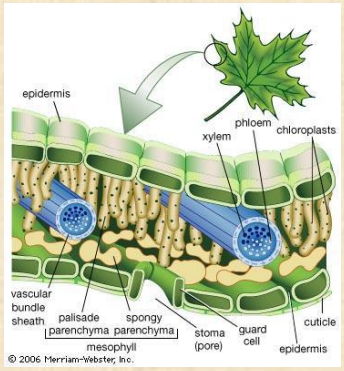
Casey Trees




Drought/low water

Sunlight

CO_2

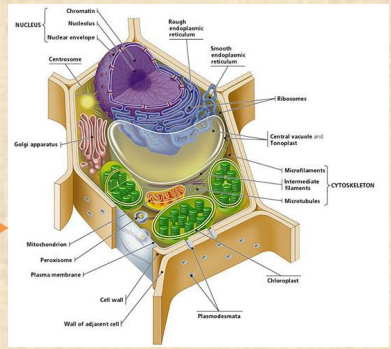


Sugar

Tissues
Maintenance
Toxins

Sugar

Water



Nutrients

Oxygen

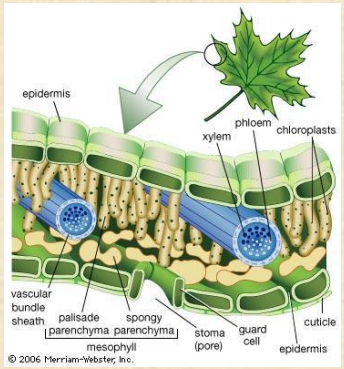
Reduced water to roots
Reduced CO^2 thru stomatal water conservation




Weed whackers/mowers/car doors

Sunlight

CO_2

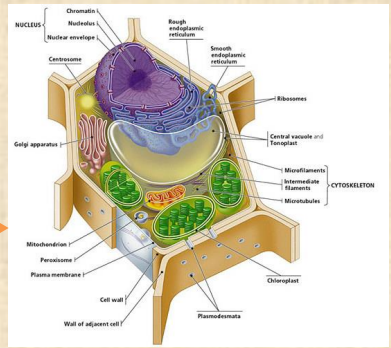


Tissues
Maintenance
Toxins

Sugar

Sugar

Water



Nutrients

Oxygen

Damages Cambium and interferes with translocation of sugar and water

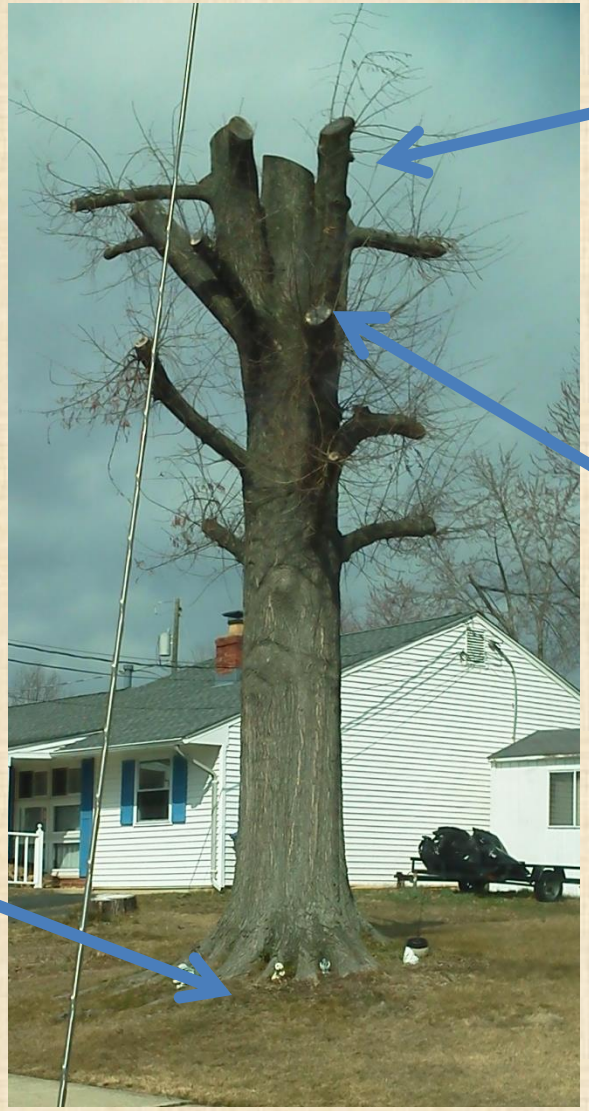
Effects are localized above and below damage and CODIT response




Other issues

- Drowning/poor drainage – low oxygen and impaired respiration
- Road Salt - reduces water, leads to lower respiration and cell death
- Lime/ high ph – nutrient insolubility, usually iron deficiency resulting in chlorosis
- Topping /bad pruning

How Does a Tree Respond to This?



Insufficient energy production to support new sapwood growth

Lowered defenses

Cannot maintain roots



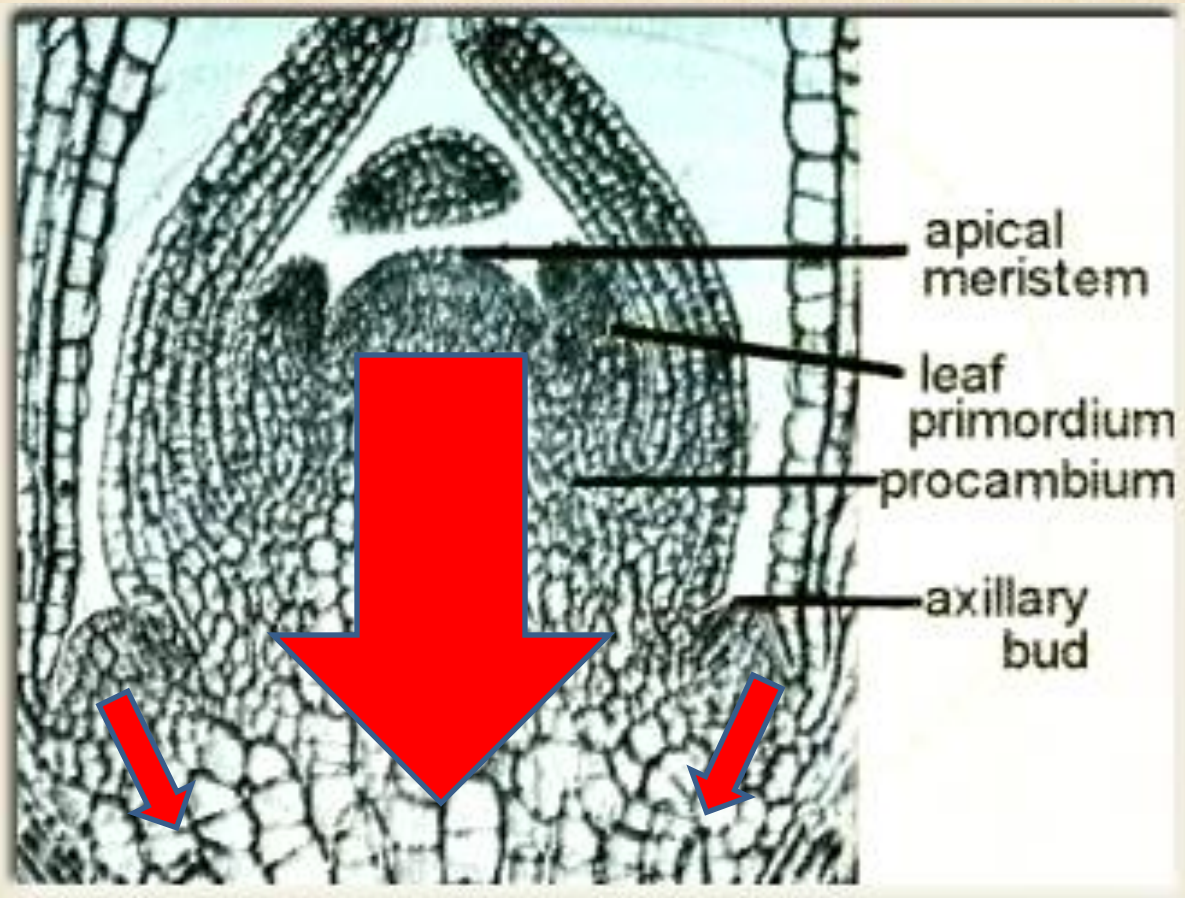

HORMONES AND GROWTH




Auxin

- A primary hormone
- Produced in buds
- ‘Wakes up’ the plant
- Travels from the buds to the roots to stimulate cytokinin production and root growth.
- Plays a role in bud supression

Auxin

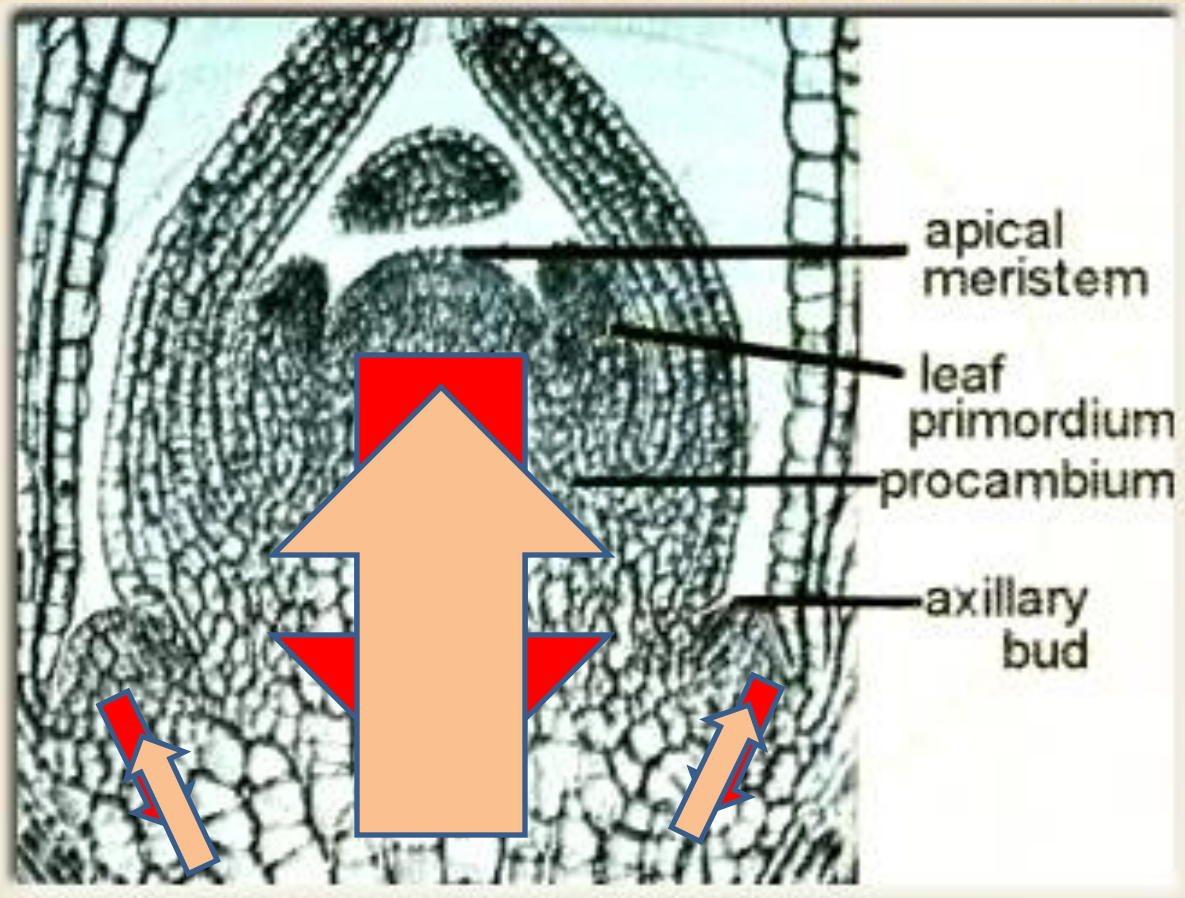





Cytokinin

- Produced in roots
- Stimulates cell division
- Follows Auxin pathways up to shoots
- Signals stomata to open

Cytokinin



Apical Dominance

Excurrent

Decurrent



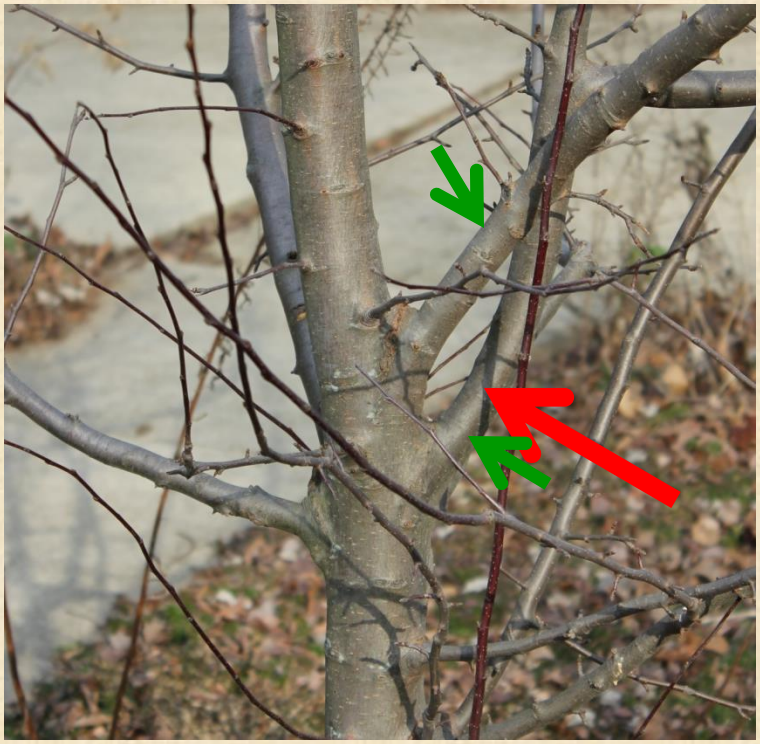

Auxin & Cytokinin

- When top is hurt and buds are lost, tree has a lot of cytokinin and little auxin so cytokinin promotes stem growth

- When roots are hurt, tree has lots of auxin and little cytokinin so auxin promotes root growth

Hormones and Pruning

2008



2012

2016




Other Plant Hormones

- Gibberellin
  - Promotes cell elongation
  - Used to lengthen grape cluster stems
- Abscisic Acid
  - Anti-auxin
  - Promotes dormancy and senescence
  - Causes leaves to change color in Fall
  - Signals stomata to close
  - Produced in abscision zone
- Eythylene
  - Readies abscision zone between leaf petiole and stem
  - Growth inhibitor
  - Ripens fruit