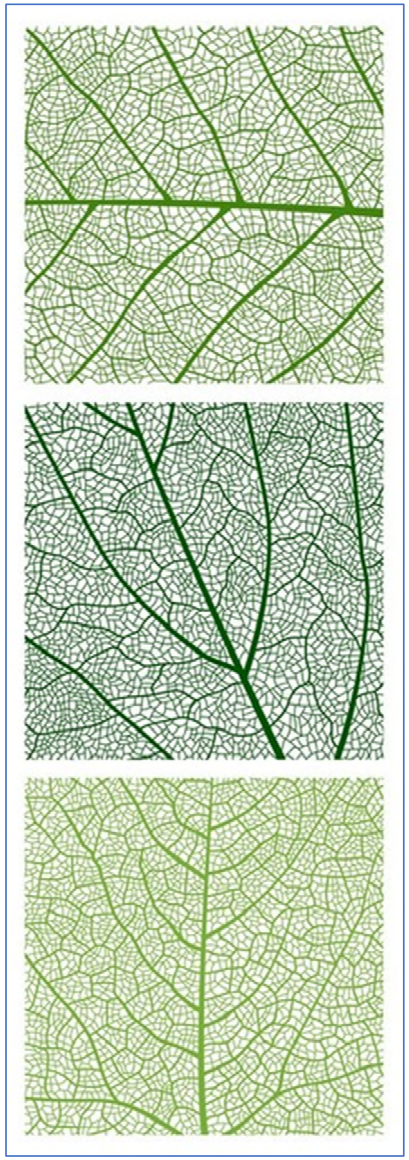
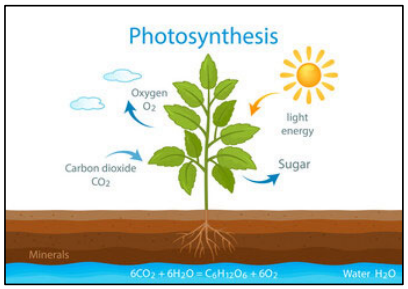


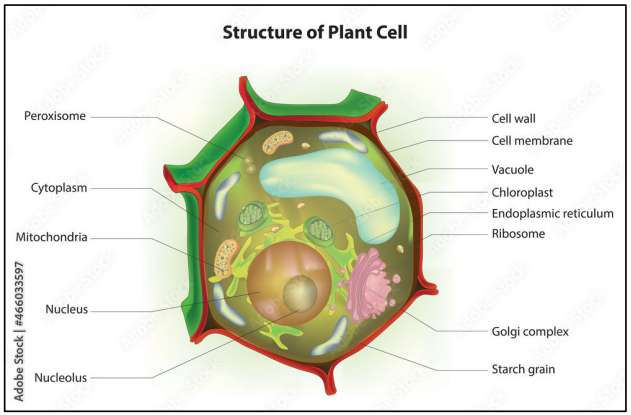
Basic Botany For Master Gardeners

Matt Halldorson
Master Gardener Training
Spring 2024

THE UNIVERSITY OF ARIZONA

What are Plants?





- Living organisms
- Cell wall (primarily cellulose)- “skeleton”
- Non-motile; grow towards resources
- Transpire water
- Usually have Chloroplasts- structures in plant cells that contain chlorophylls and are the site of photosynthesis
  - Chlorophyll- green pigments that absorb light energy from the sun
  - Energy is used to fix carbon from the atmosphere (CO_2) and make sugar (glucose)

Indian pipe

Plant Classification

- Habit (annual, perennial, biennial)
- Structure (woody, herbaceous)
  - Woody (vine, shrub, tree)
- Leaf Retention (evergreen, deciduous)
- Climatic Adaptation (tropical, sub-tropical, temperate)
  - Warm or cool season
- Use (Ornamental, Agricultural)
  - Ag (Food, fiber, fuel)

Kingdom Plantae

Non-Vascular Plants

- Liverworts
- Hornworts
- Mosses

Vascular Plants

Spore-Producing Plants

- Ferns
- Horsetails
- Clubmosses

Seed-Producing Plants

Non-flowering Plants (gymnosperms)

- Cycads
- Ginkos
- Conifers

Flowering Plants (Angiosperms)

- Monocotyledons
- Dicotyledons

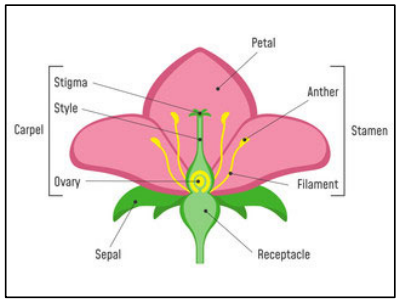
Angiosperms vs Gymnosperms

Angiosperms

- Majority of today's plant species
- Flower reproduction
- Seeds are surrounded by fruit
- Xylem made of vessels
- Leaves usually broad and flat

Gymnosperms

- More ancient
- Cone reproduction
- Seeds are naked
- Xylem made of tracheids
- Many are evergreen
- Many have scales or needles for leaves



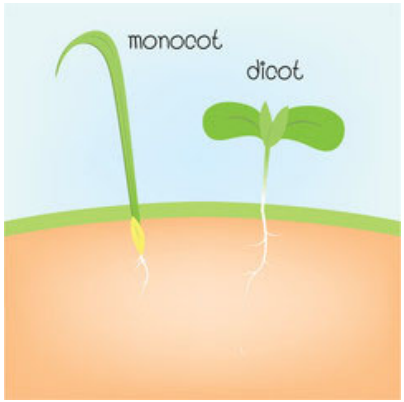
Monocots vs Dicots…

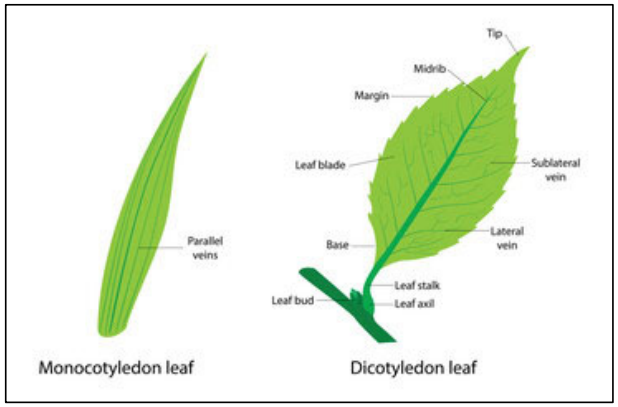
Monocots

- Embryo has a single cotyledon
- Flower parts in multiples of 3s
- Parallel leaf venation

Dicots

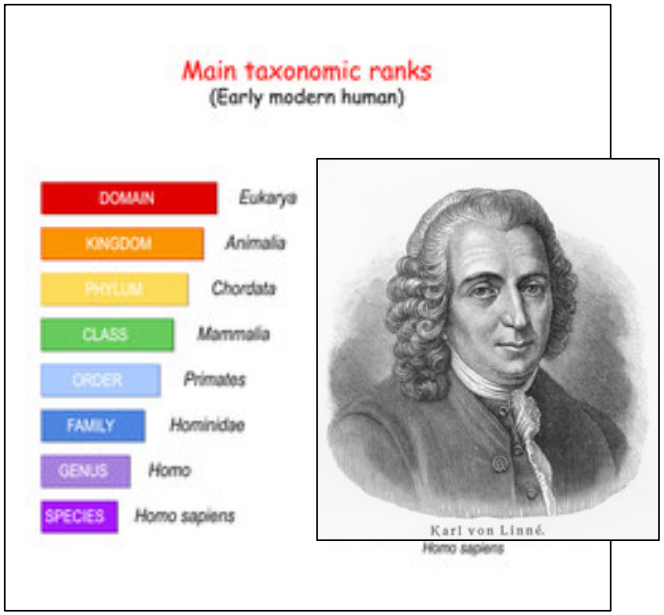
- Embryo has two cotyledons
- Flower parts in multiples of 4s and 5s
- Branching/net leaf venation

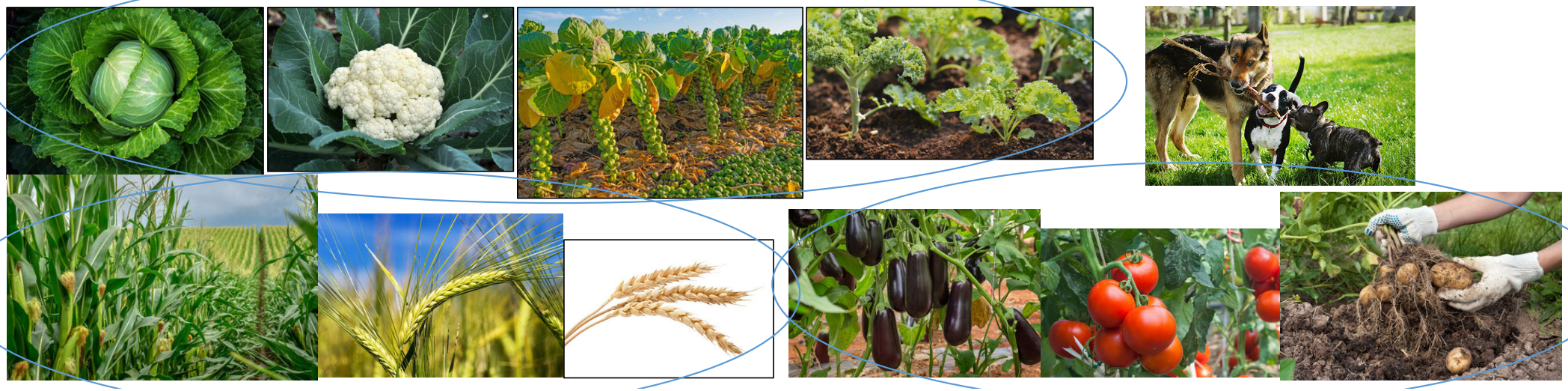




Latin names and Creating Order..

- Taxonomy-the science or practice of classifying organisms
  - Both living and extinct
- Species-basic unit of classification
  - 2 individuals of appropriate sex can mate and create fertile offspring





Some Common Plant Famil

- Apiaceae=Celery, Carrot, Parsley
- Asparagaceae= Agave, Yucca, Asparagus, Spider Plant
- Asteraceae= Sunflower
- Brassicaceae= Mustards, Brassica oleracea
- Ericaceae= Manzanita, Rhododendron, Blueberry, Cranberry
- Fabaceae= Locust, Mesquite, Beans, Peas
- Poaceae= Grasses
- Solanaceae= Tomatoes, Potatoes, Eggplant, Nightshades
- Rosaceae= Apples, Cherry, Photinia, Pyracantha, Almonds, Peaches

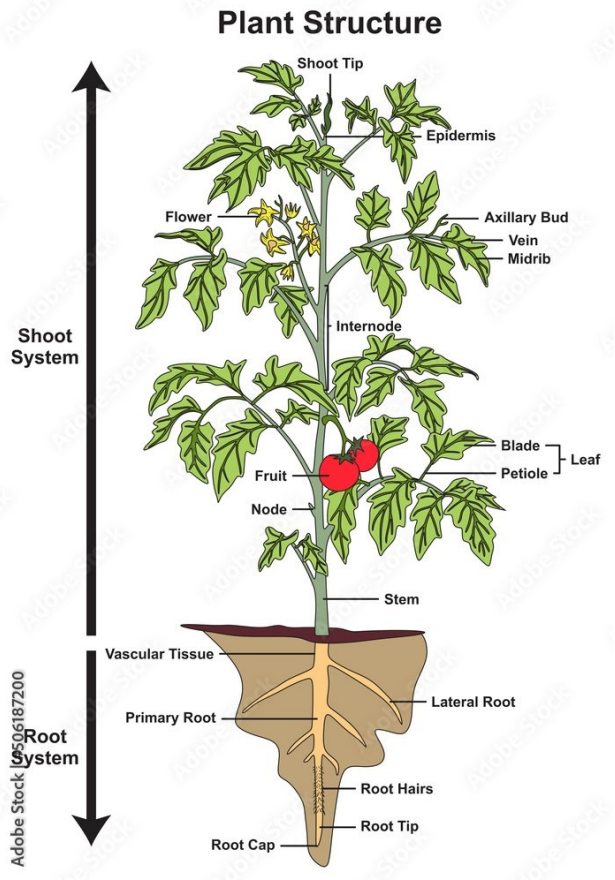
Scientific Classification Example: Wine grapes

- Domain: Eukaryota (“higher” organisms e.g. plants, animals, fungi)
- Kingdom: Plantae (plants, as opposed to animals and fungi)
- Phyllum/Division: Angiospermae (flowering plants)
- Class: Dicotyledoneae (dicots)
- Order: Vitales
- Family: Vitaceae (vines)
- Genus: Vitis (temperate grapes)
- Species: vinifera (wine grapes)
- Variety/Cultivar: Cabernet Sauvignon
- Clone- mutant that has been propagated

Vitis vinifera var. cabernet sauvignon

Plant Structure

- Meristem
- Roots
- Stems and Shoots
- Buds
- Leaves
- Flowers
- Seeds
- Fruits



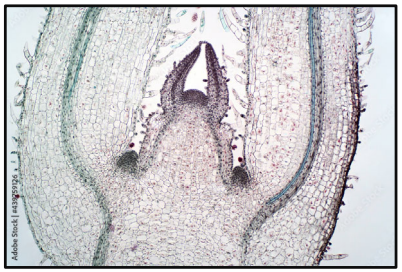
Meristems-regions of growth

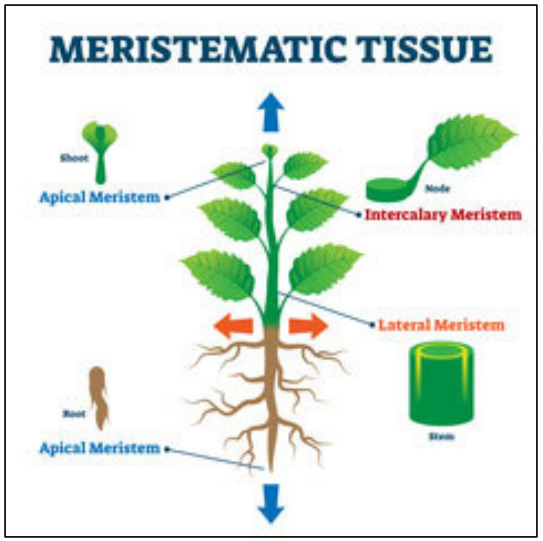
Primary growth Meristems:

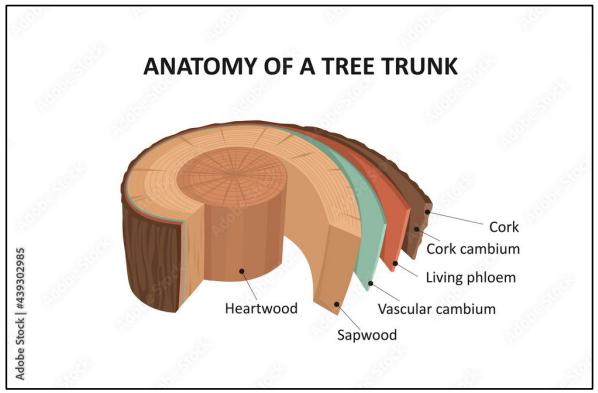
- Apical Meristems- located in the tips of stems and roots
- Lateral Meristems-located in the axillary buds
- Root tip
- Pericycle-internal meristematic tissue of the root that gives rise lateral roots
- Intercalary meristem-grass meristem that initiates at ground level

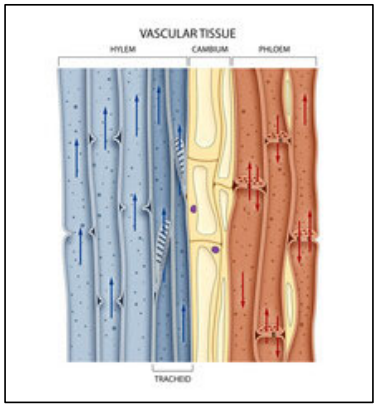
Secondary growth Meristems:

- Vascular cambium-produces new xylem and phloem
- Cork cambium-produces bark/periderm





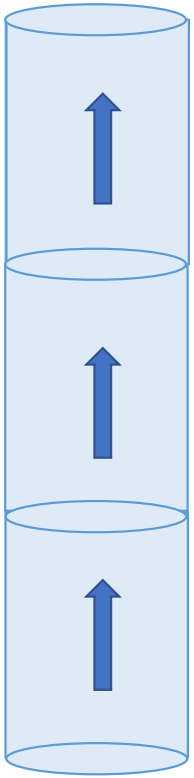




Vascular Tissue

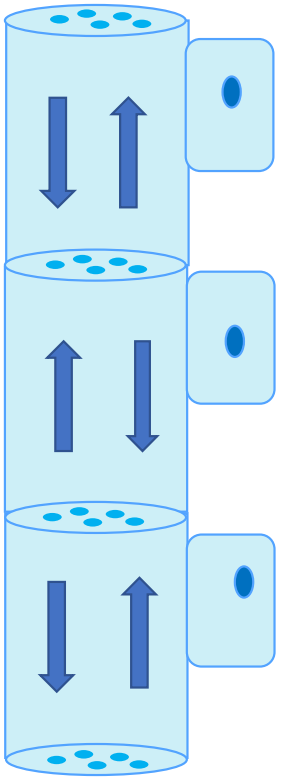
Xylem-responsible for moving water and nutrients up the plant

- Thickened cell walls
- Dead at maturity
- Old xylem becomes wood
- Moves in only one direction



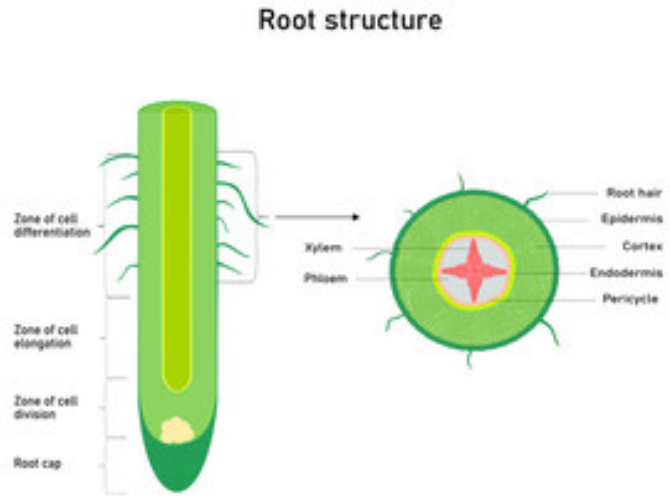
Phloem- moves sugar and other compounds throughout the plant

- Live at maturity
- Controlled by companion cell
- Has perforated sieve plates
- Moves in both directions



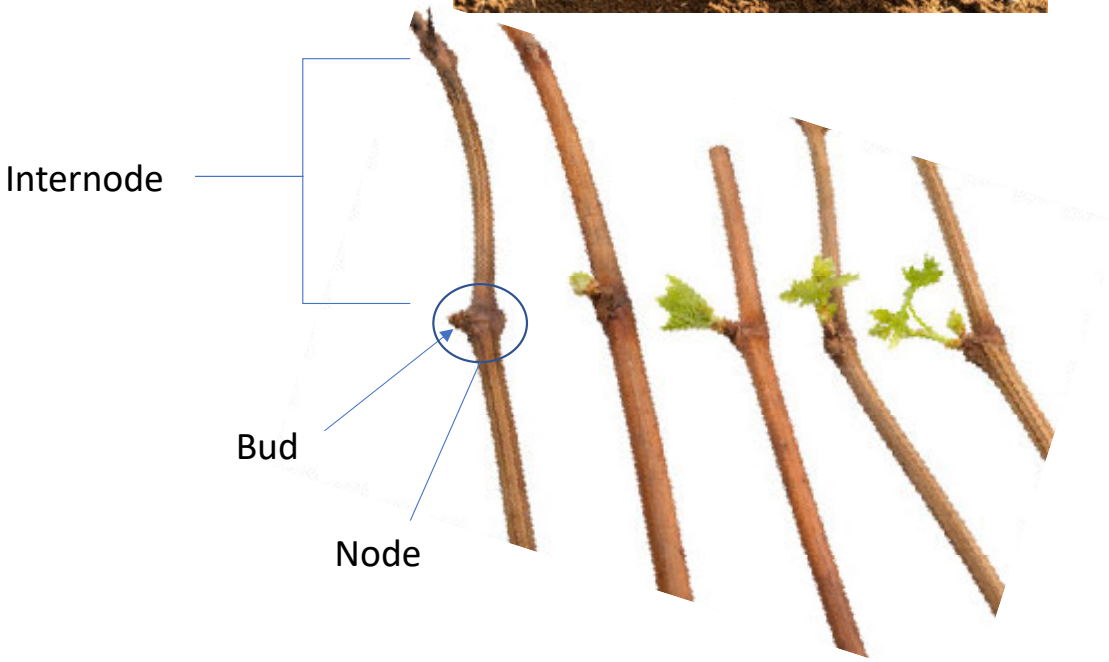
Roots

- Anchor the plant to the soil and hold the soil in place
- Take up water and soluble mineral nutrients (xylem)
- Store energy/carbohydrate reserves (phloem)
- No nodes
- Don’t photosynthesize
- Need water and oxygen

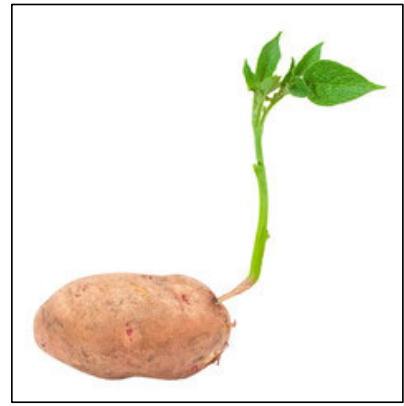


Stems (Shoots, Canes & Trunks)

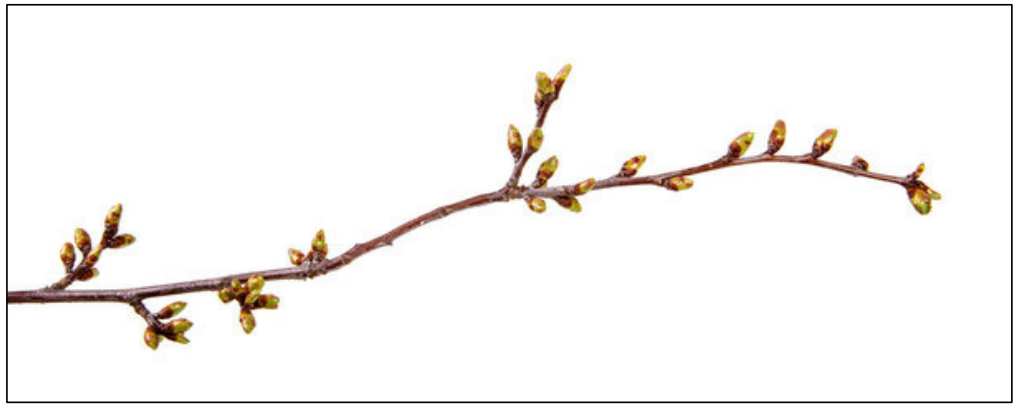
- Above-ground structural portion of plant
- Often arise from buds
- Usually made up of nodes and internodes
- Nodes- regions of shoot where buds and leaves originate
- Internodes-areas of stem between nodes
- Transports sugar, water, and nutrient throughout the plant
- Green shoots become brown canes or branches



Buds



- Meristematic Structures
- Shoots and/or flowers are compressed inside bud (internodes have not elongated
- Often a preformed number of leaves/flowers and a meristem
- Can be terminal/apical or lateral
- Prompt/axillary buds
- Latent buds
- Dormant buds
- Bud pattern creates leaf/stem pattern

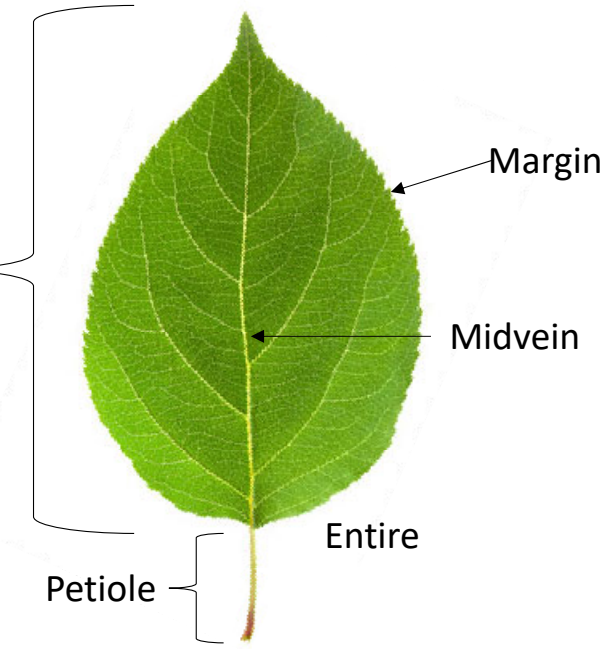


Leaves

- Solar panels of the plant
- Major photosynthetic organs
- Leaf shape

Scale leaf

Needle leaf

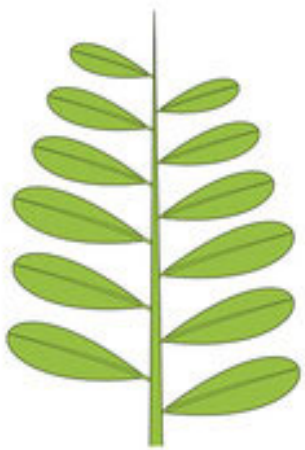


Compound-Palmate

Compound-Pinnate

Compound-Bi-Pinnate

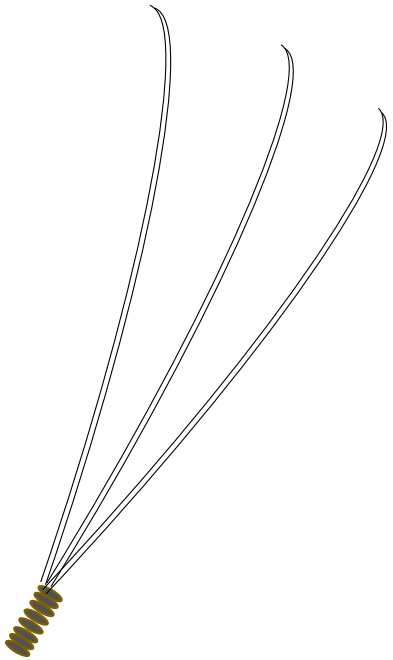
Leaf Arrangement



Alternate

Opposite

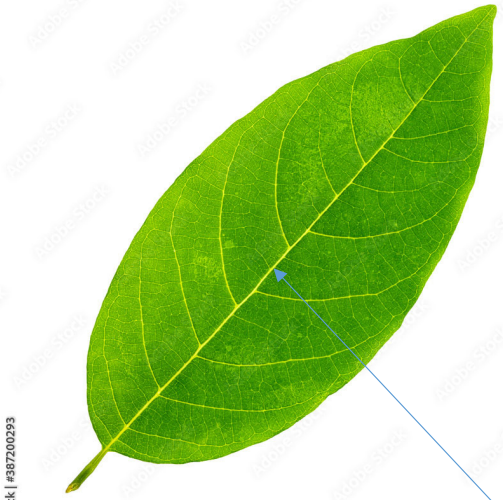
Whorled

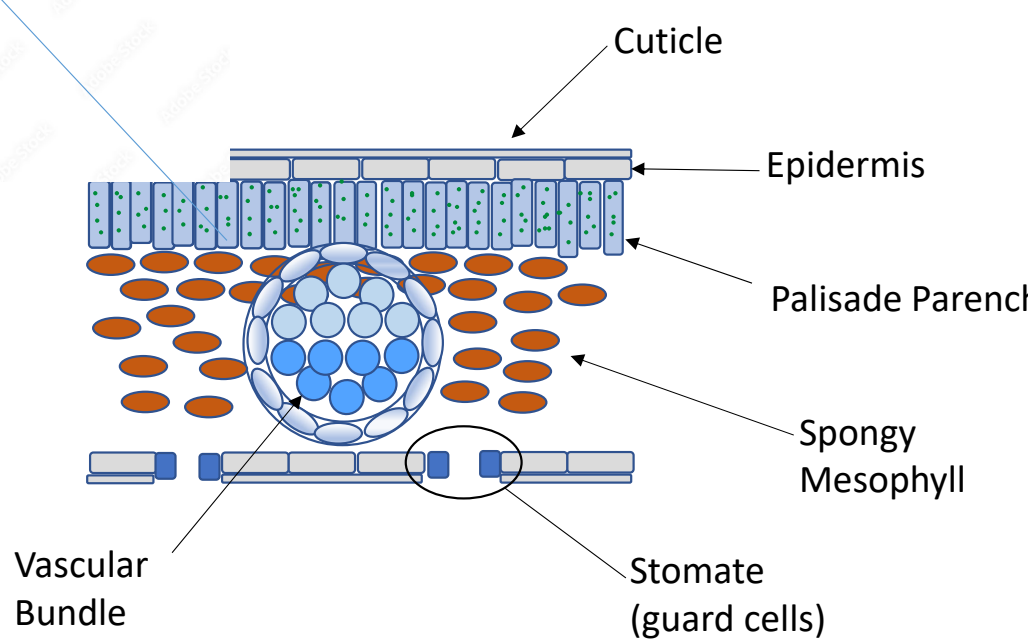


Needles per bundle/fascicle

Leaf Anatomy

- Sight of gas exchange
- CO2 enters
- O2 released to atmosphe





Sun Vs Shade Leaves

Sun Leaves

- Thick, multiple layer of photosynthetic cells
- Thicker cuticle to protect from water loss
- Less surface area to volume ratio
- Lighter in color
- More, smaller stomata

Shade Leaves

- Thin and large with lots of surface area to catch as much light as possible
- Thinner cuticle
- Darker in color-greater concentration of chlorophyll

Flowers (Angiosperms only)

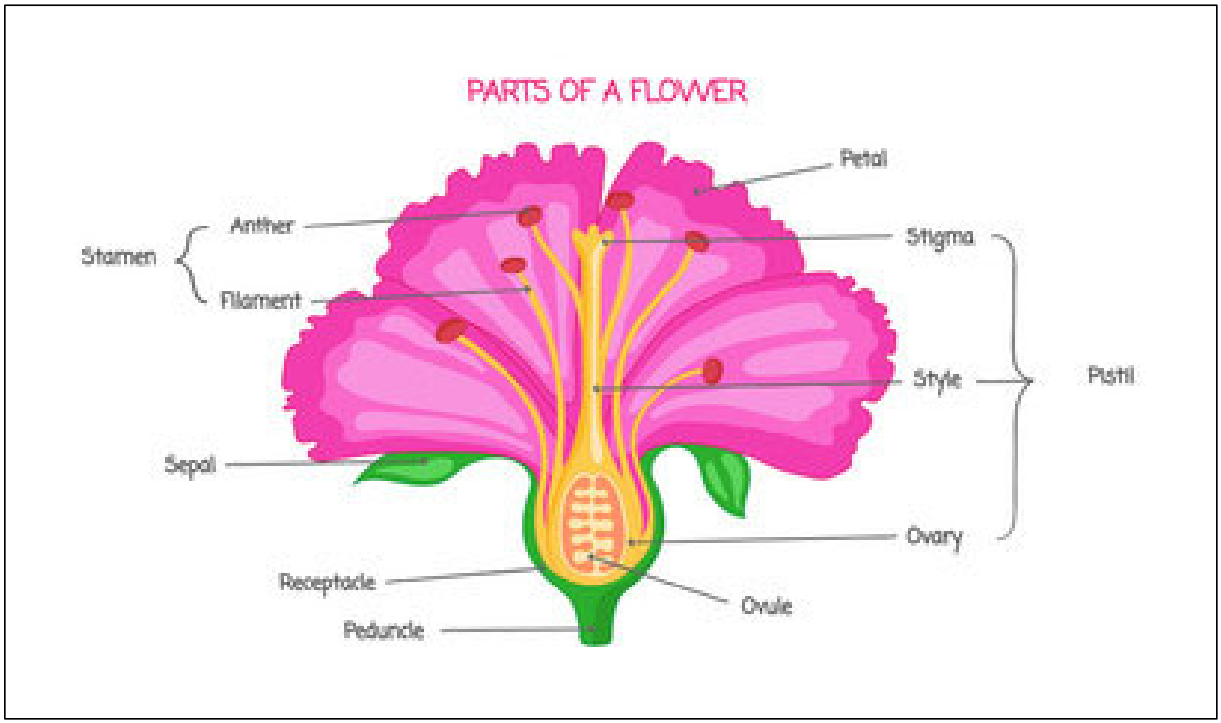
- Contain Male, Female (or both) sexual structures

Stamen=male (Anthers + Filaments)

- Anthers hold pollen that sticks to stigma, which then travels down the style to the ovule inside ovary

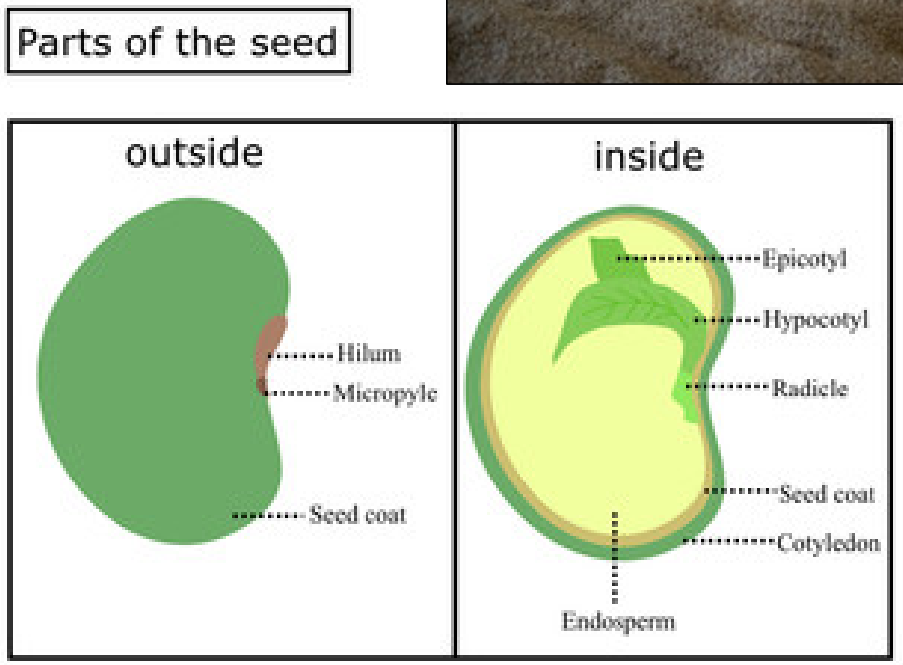
Pistil=female (Stigma + Style + Ovary)

- Ovule becomes seed
- Ovary becomes fruit



Seeds

- Dormant embryonic plant
- Major Parts:
  - Embryo
  - Endosperm
  - Micropyle
  - Aleurone layer



Fruits

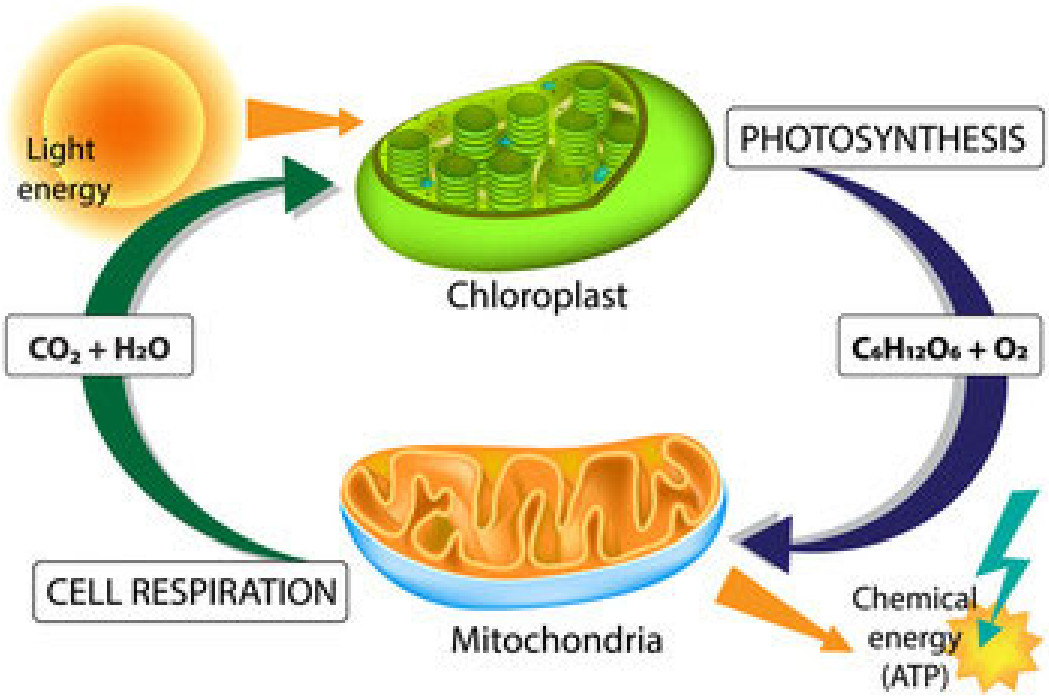
- Swollen Ovary
- Protects the seed
- Method of seed dispersal for plants
  - Appeals to herbivores
    - Color
    - Sugar

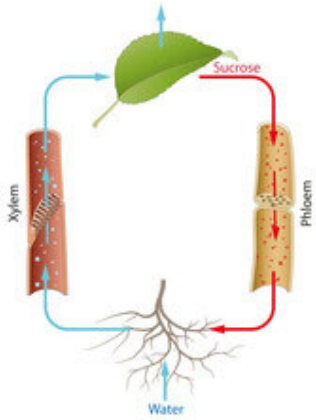
Examples of Types of Fruit

- Legume-Pods that split along two opposite edges. Exan
- Capsule-Poppy
- Berry- Grape, Tomato
- Drupe (stone fruit)- cherry, peach, plum, olive, apricot, p
- Hesperidium- citrus fruits
- Pepo-melons/squash
- Pome- apple

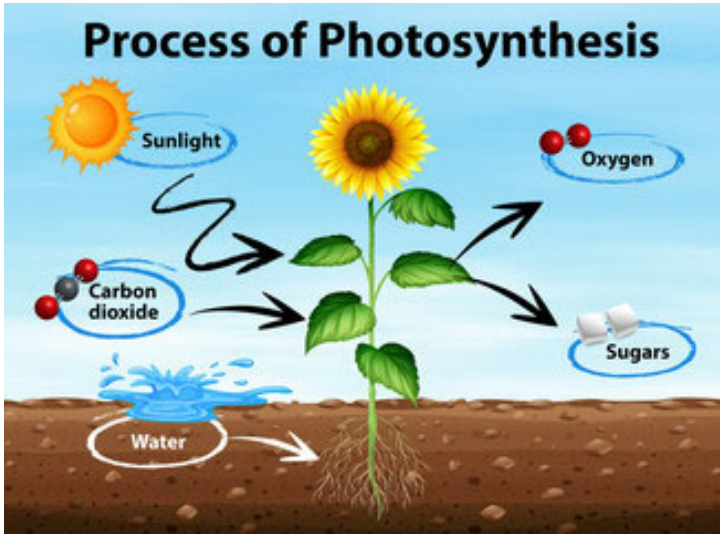
Plant Growth

- Photosynthesis
- Respiration
- Transpiration
- Translocation





Photosynthesis

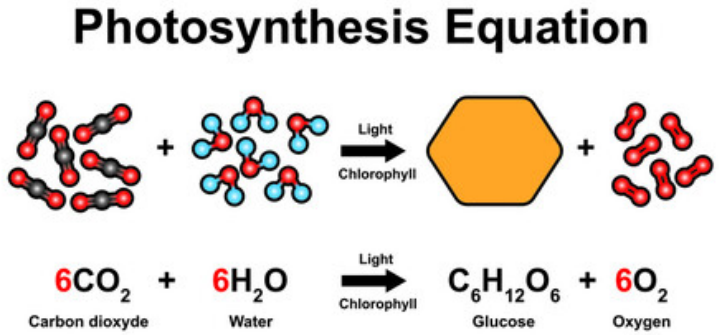


1. Light Reaction (requires light)

- Plants convert sunlight into chemical energy (ATP)
- Water into Oxygen (released)

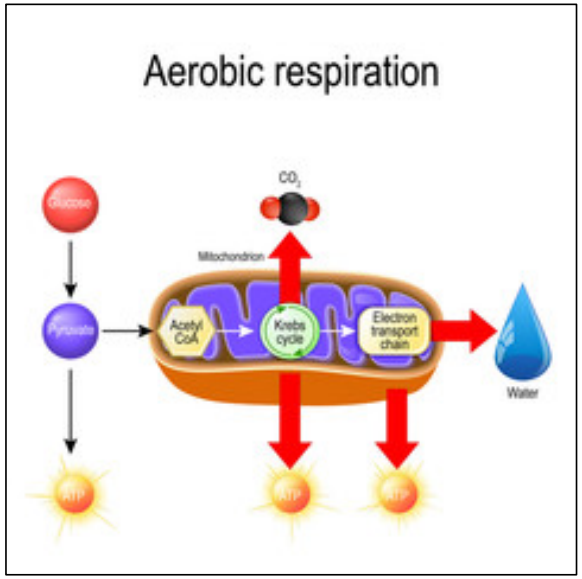
2. Carbon Uptake and Assimilation

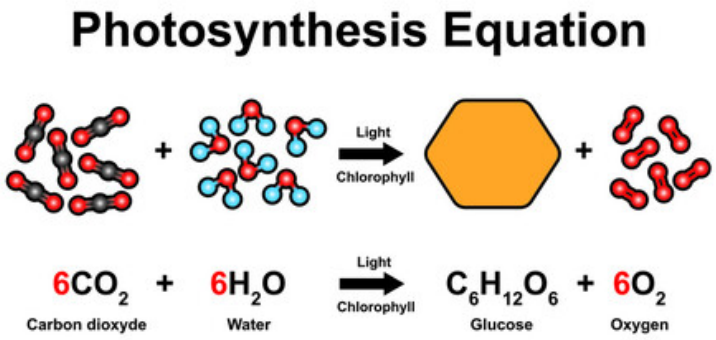
- Carbon dioxide is taken in from atmosphere
- ATP is used to fix CO2 and form sugars



Respiration

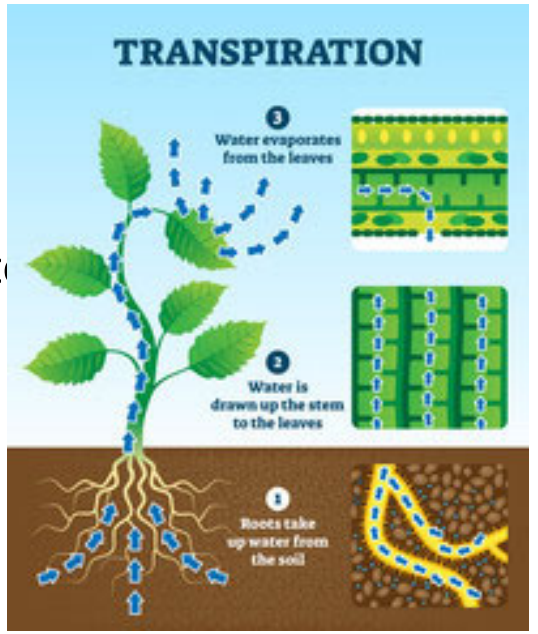
- Common to most living organisms
- Chemical energy from stored energy of carbohydrates (sugars)
- Releases CO2
- Temperature dependent





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

Transpiration



- Evaporation of water from plant surfaces (primarily stomata) t the atmosphere
- Moves along the S.P.A.C. (Soil Plant Atmospheric Continuum)
- Water travels from areas of higher to lower concentration
  - SoilΨ > PlantΨ > AirΨ

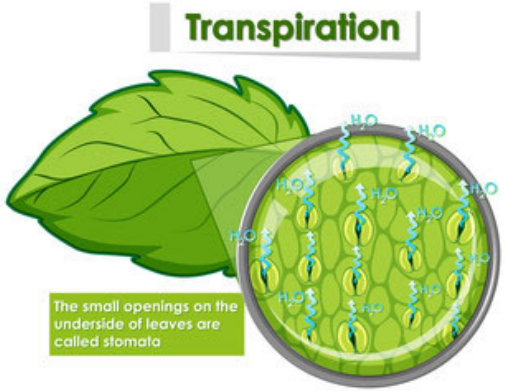
Creates a column of water throughout the plant

Water enters roots and exits the stomata

Helps to cool the plant

Transports minerals from soil to plant

Transpiration (continued)



Rate of transpiration depends on:

- temperature
- Relative Humidity
- Wind
- Availability of water in soil

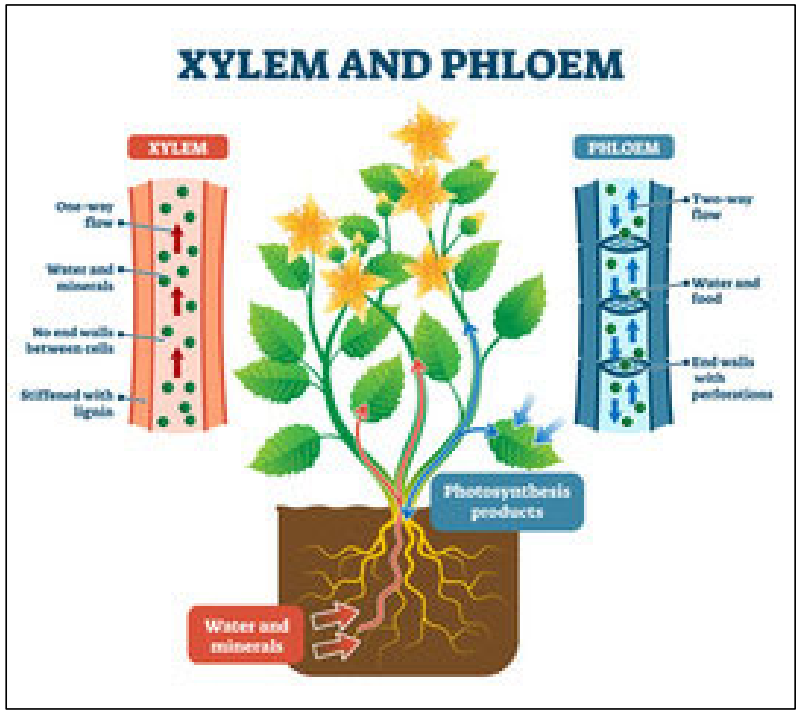
In most plants, stomata are closed at night (no photosynthesis, no need for carbon)

Succulents (cactus, agave, jade, etc.) open stomata at night to avoid water loss during day

Translocation

- The movement of carbohydrates/sucrose, hormones, minerals, and amino acids from one part of the plant to the other

- Source/Sink Relations
  - Leaves=Source
  - Fruit=Sink
  - Roots?



Hormones: internal regulators of growth and development

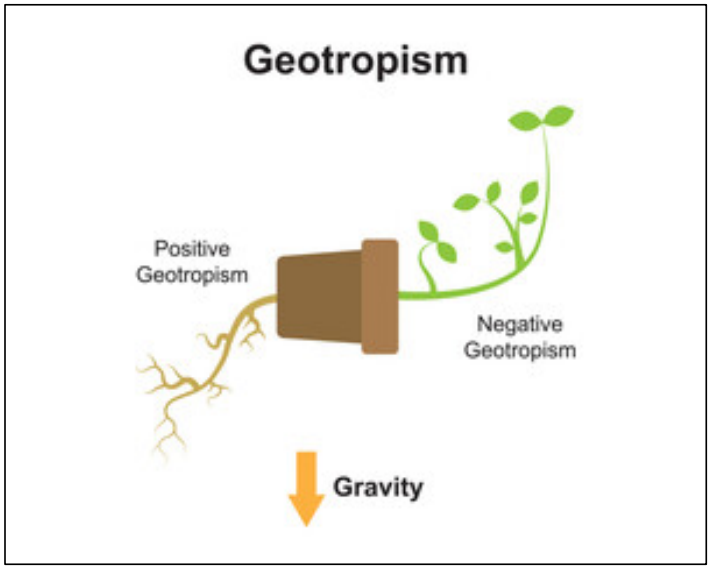
- (Plant) Hormones-compounds that are synthesized in one part of the plant, and are usually translocated to another part
  - Small quantities produce dramatic effects on growth and development

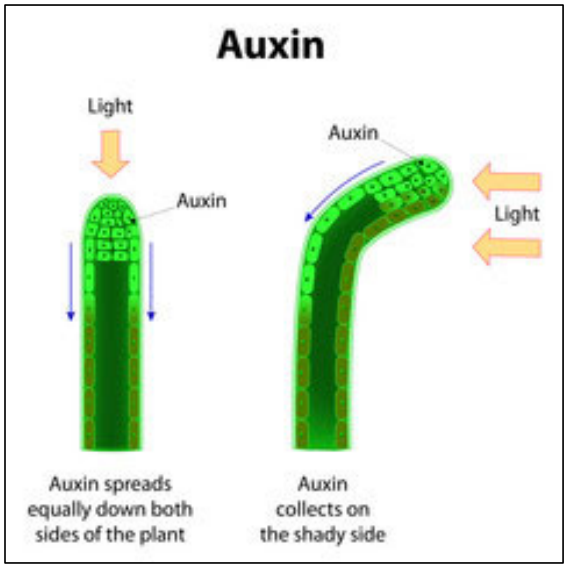
Major Hormone Groups:

- Auxins
- Cytokinins
- Gibberellins
- Ethylene
- Abscisic acid

Hormones: Auxin

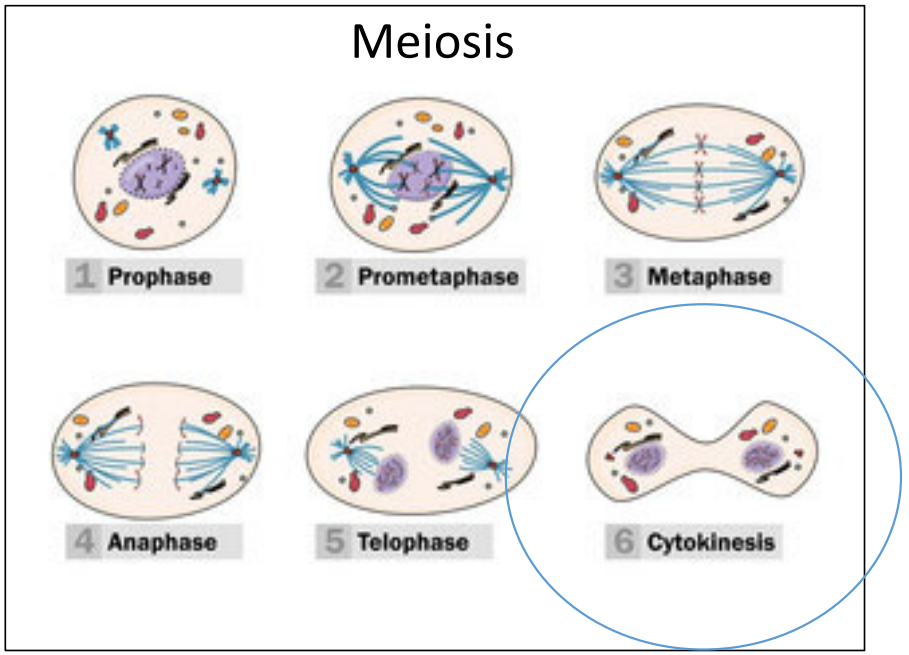
- Regulate cell enlargement
- Suppress lateral bud development/apical dominance
- Direct shoot growth toward light source (phototropism)
- Direct shoots to grow up (geo or gravitropism)
- Promotes the growth of adventitious roots (propagation hormone)





Hormones: Cytokinins

- Stimulates cell division
- Important for dormancy release



Hormones: Gibberellins

- Cell elongation
- Flower induction
- Enzyme activation in germinating seeds

Gibberellins activate the enzymes that break down endosperm starch

Gibberellins used to elongate table grape rachis

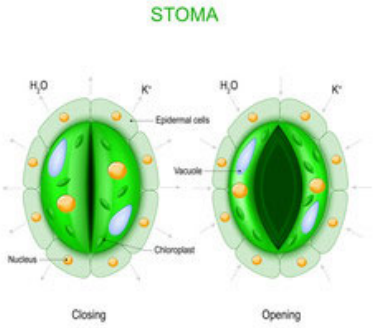
Hormones: Ethylene

- Accelerates fruit ripening
  - Climacteric vs Non-climacteric fruits

- Leaf senescence

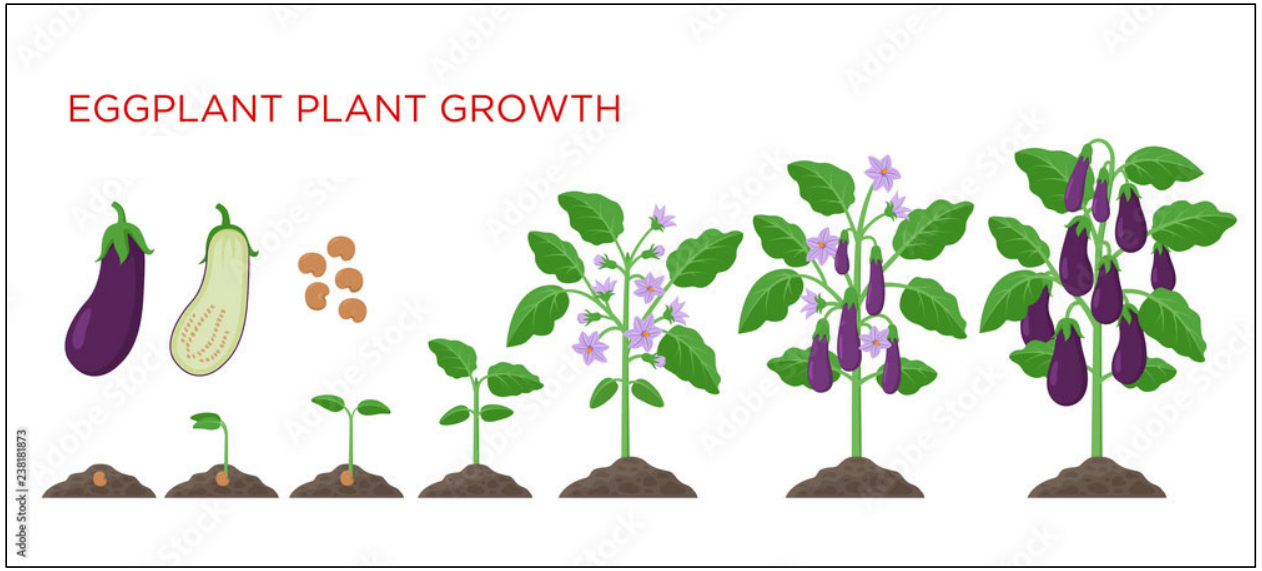
Hormones: Abscisic Acid

- Dormancy regulator
- Stimulates the abscission of leaves on deciduous plan
- Regulates stomatal closure of leaves under drought stress
- Cold-hardiness
- Reduced water content
- Fruit color enhancement



Plant Development

- Vegetative Cycle
  - Dormancy
  - Seed germination
  - Active growth
    - Juvenility
    - Maturity



- Reproductive Cycle
  - Flower induction
  - Flower and fruit development
  - Ripening

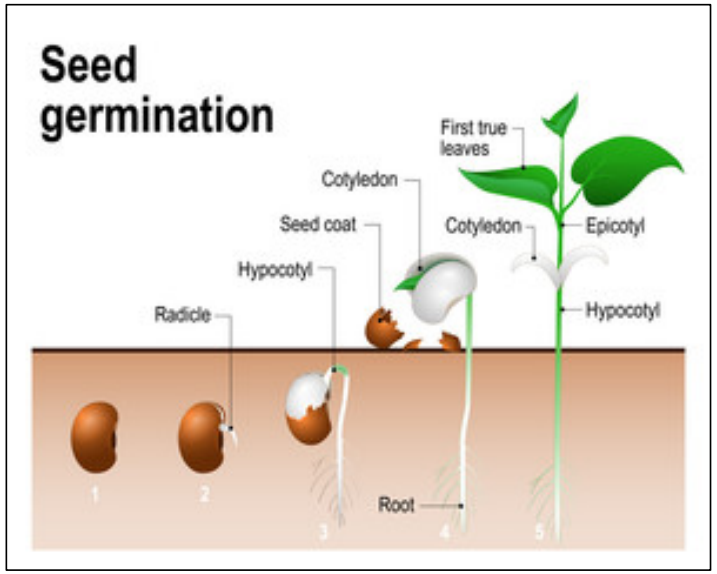
Dormancy

- Alive, but not actively growing
- Mechanism to survive unfavorable conditions

- Can be triggered by:
  - Cold nights
  - Short days
  - Inadequate soil moisture
- Regulated by Abscisic Acid hormone
- Dehydration
- Cold-hardiness increases

Seed Germination

- Germination = Viable/embryo is alive
- Stratification: cold treatment
- Begins when embryo takes in water
- Gibberellins regulate enzymes
- Optimal conditions necessary vs actual conditions determines germination rate:
  - Water
  - Oxygen
  - Species specific temperature range
  - Light (species specific)



Budbreak of Perennials & Biennials

- Chilling hours requirement
  - 35 to 45F for a specific time
- As soils/temperature rise, cold-hardiness is lost
- Tissues are hydrated through root pressure
- Budbreak starts in the uppermost buds first

Vegetative Development: Juvenility to M

- Juvenility: Seedling to flowering (reproductive maturity)
  - Annuals: 1 year
  - Biennials: 2 years
  - Perennials…
    - Tomato: 1 year
    - Apple: 8 years (standard), 2-3 years (d
    - Agave: ~25 years…
- Maturity: fully developed
  - Capable of flowering
  - May still need to wait for proper environment

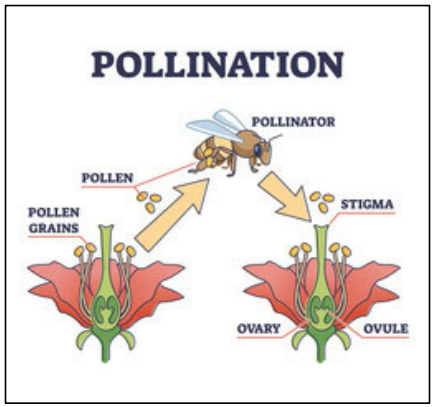
Flower Induction

- Vegetative meristems begin to produce reproductive organs
- Process irreversible
- Set period of time to induce, Set period of time to flower (species dependent)
- Flowering buds of woody perennials are often induced the year before
- Annuals are often weeks after germination
- Environmental factors can also play a role

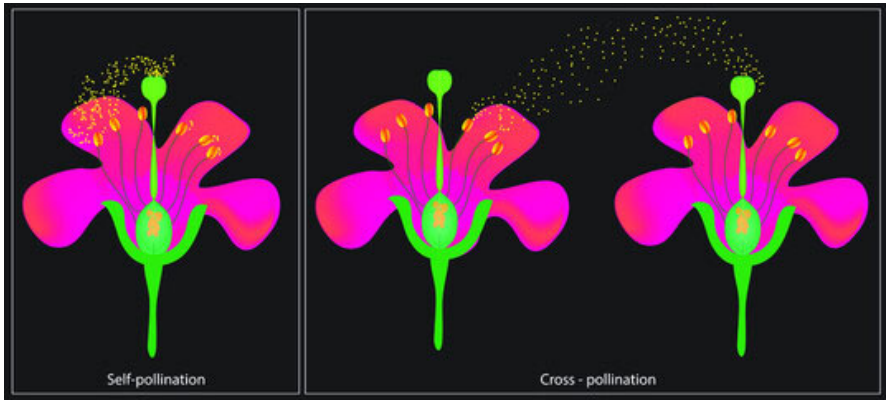
Fruit Development

- Stigma must receive *viable* pollen (must germinate)
- Each ovule must be fertilized by a separate pollen grain
- Fruit set (inhibition of fruit/flower drop) must occur
- Only a fraction of flowers set and develop into mature fruit

Self versus Cross-Pollination



- Self-pollination-pollen from plant pollinates the stigma from the same plant
  - Sometime same flower
- Cross-pollination-pollen from one plant pollinates the stigma from another plant
  - Often by wind or insect (bee, butterfly, moth, etc.)



Fruit Quality and Ripening

- Sugar accumulation
- Aromatic/flavor compounds accumulate
- Fruit may change color and soften
- Acid and tannins breakdown

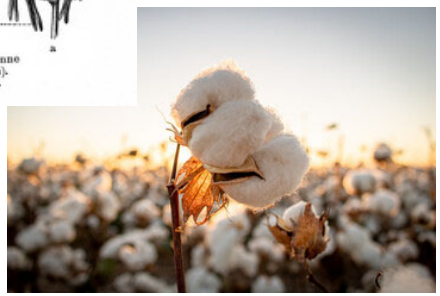
- Climacteric- physiologically mature fruit may continue to ripen off the mother plant
  - Apples tomatoes, bananas, avocados, pears, mango, apricot, peach, plum, nectarine
- Non-climacteric- fruit must stay attached to mother plant to complete maturity/ripening
  - Grapes, citrus, strawberries, cherry, pineapple, pomegranate, grapefruit, lemons

Plant Functionality

- Day Length
- Light Intensity
- Light Quality
- Temperature
- Photoperiod/ Temperature interactions
- Soil Moisture
- CO_2 concentrations
- O_2 Concentrations
- Nitrogen
- Stress

Plant Response to Day Length

Plant initiates flowers, special vegetative organ, or dormancy due to a specific day length (photoperiod)

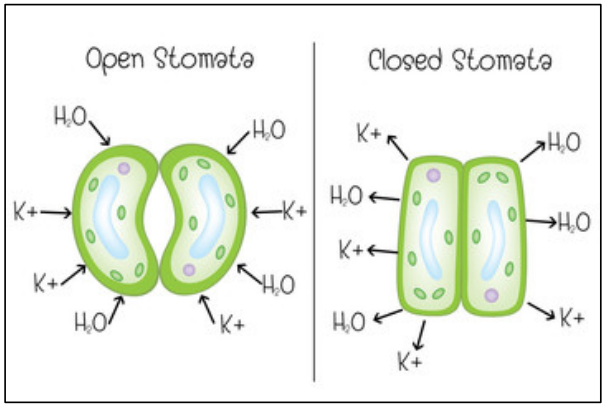


- Short-day (<12 hrs.)-example:
  - Poinsettia, Christmas Cactus, Cotton
- Long-day (>12 to 14 hrs.)- example: perennial ryegrass, California Poppies, Lettuce, Spinach, Potatoes

- Day-neutral (doesn't matter)
  - Corn, tomatoes, cucumbers

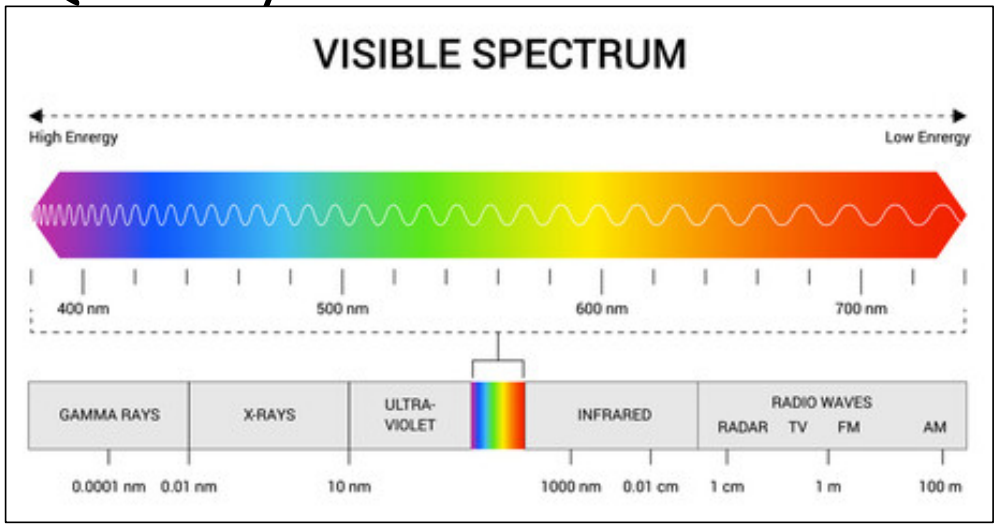
Plant Response to Light Intensity

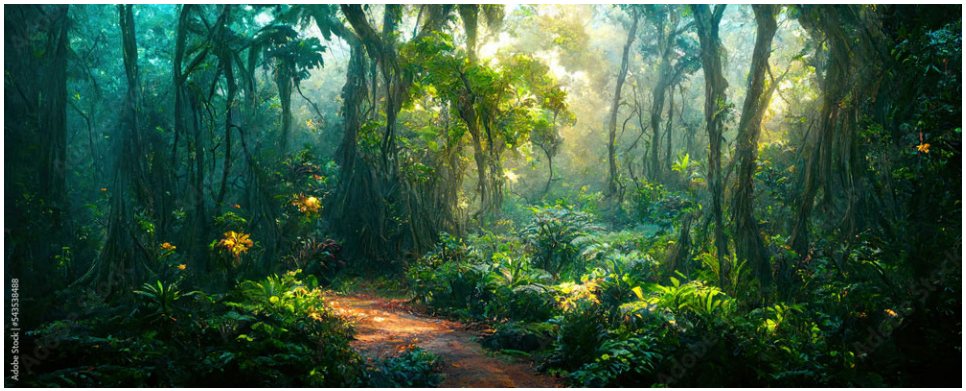
- Intensity = brightness
- Measured by Foot-candle (10,000 fc = full sun)
- Optimal light intensity is species specific
- Effects seed germination
- Often connected to temperature
- Stomata open and close
- High light necessary for color and sugar in fruit
- Leaf architecture
- Phototropism
- Etiolation
- Adaptation; sweater analogy



Plant Response to Light Quality

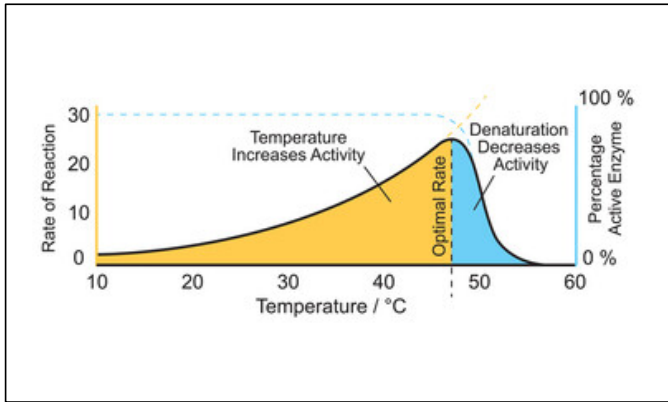
- Relates to the color of the light source
- The light quality is how plants sense competition
- Shade-avoidance: Plants attempt to grow taller, leaf size increases
- Seed germination needs red light
- Stomata need blue light to open





Plant Response to Temperatur

- Growth and development strongly linked to temperatu
- Cellular respiration greatly dependent on temperature
- Implications for transpiration
  - Succulent/CAM plants
- Seed stratification/high temp dormancy
- Bud dormancy-chilling requirements and soil temp
- Vernalization
- Color development



Photoperiod/Temperature Interactions

- Poinsettia example:

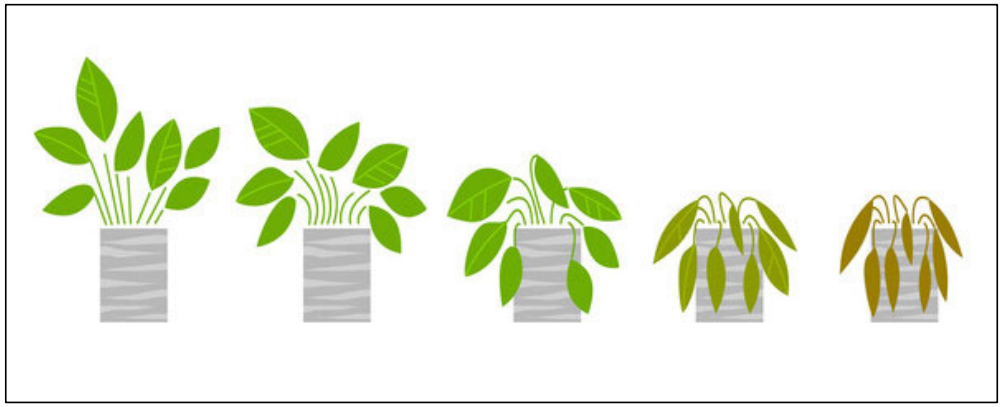
Day Length	Temperature (F)	Time to flower (days)
Short	70	65
Short	60	85

- June-bearing strawberry example:

Day Length	Temperature (F)	Result
Short	>67	Flower
Long	>67	Runner
Short	<67	Flower
Long	<67	Flower

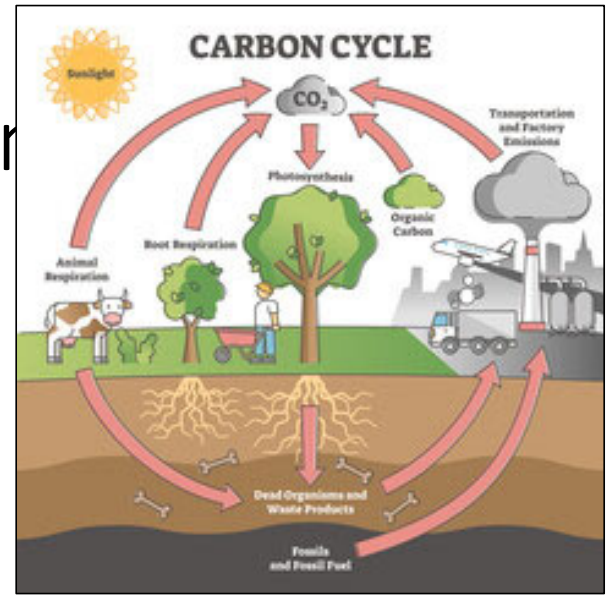
Plant Response to Soil Moisture

- Inadequate:
  - Transpiration, photosynthesis, nutrient uptake diminished
  - Growth rate, flowering, fruit-set, storage organs diminished



- Surplus:
  - Water-logging can cause hypoxia, limiting respiration
  - Some plants form aerenchyma to assist

Plant Response to CO_2 and O_2 Cor

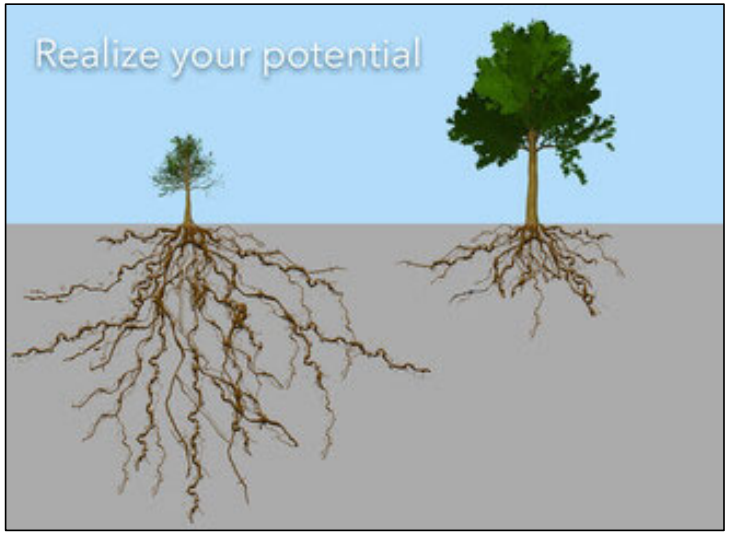


- Higher CO2 levels:
  - More CO2 for photosynthesis
  - Less water loss (less stomatal conductance)
  - Lower nitrogen concentrations (less nutrient uptake)
  - Nutrients become limiting factor in growth

- Less O2
  - Soil compaction, overly-deep planting, water-logging
  - Seed germination
  - Controlled-atmospheric storage for fruit

Nitrogen and Plant Growth and

- **High Nitrogen:**
  - Increased shoot growth
  - Increased root growth at time of N application
  - Lower root: shoot growth ratio
  - Canopy congestion
  - Suppress flower initiation
- **Low Nitrogen:**
  - Increased root growth
  - Restricted photosynthesis (enzyme-limited)
  - Chlorophyll break-down



Stress

- **Non-optimal growing conditions:**
  - Extremes in temperature
  - Insufficient light or water
  - Inadequate nutrition
  - Poor soil aeration

- **Causes:**
  - Premature dormancy, flowering
  - Lots of small flowers and fruits
  - Low viability seeds

- Hardening-withholding water/nutrients to prepare plants for other environments