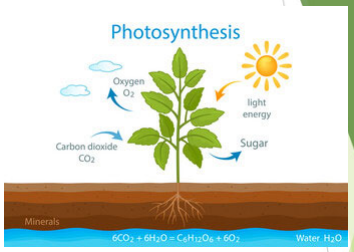
Basic Botany For Master Gardeners

Matt Halldorson Spring 2023

1

What are Plants?

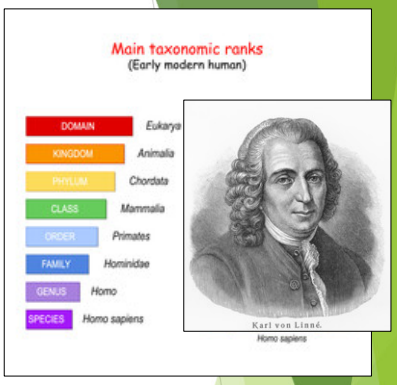


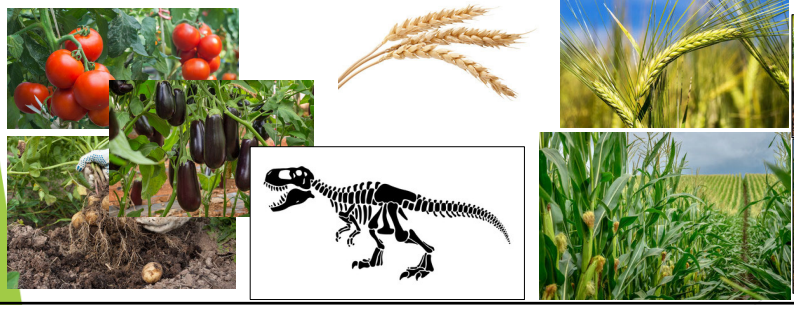
- Living organisms
- Cell wall (primarily cellulose)- "skeleton"
- Non-motile; grow towards resources
- Transpire water
- Usually have Chloroplasts- structures in plant cells that contain chlorophylls and are the site of photosynthesis
  - Chlorophyll- green pigments that absorb light energy from the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

2

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





3

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

4

Kingdom Plantae

Non-Vascular Plants
- Liverworts
- Hornworts
- Mossess

Vascular Plants

Spore-Producing Plants
- Ferns
- Horsetails
- Clubmosses

Seed-Producing Plants

Non-flowering Plants (gymnosperms)
- Cycads
- Ginkos
- Conifers

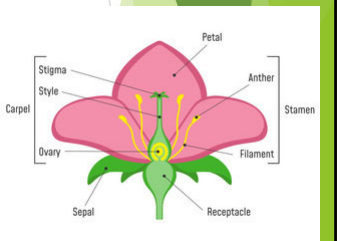
Flowering Plants (Angiosperms)
- Monocotyledons
- Dicotyledons

5

Angiosperms vs Gymnospersms

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



6

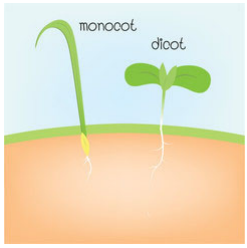
Monocots vs Dicots…

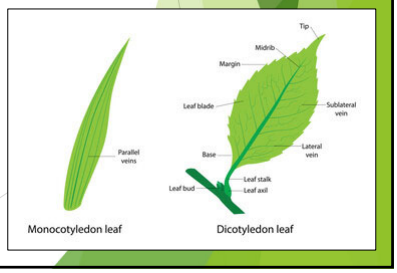
Monocot

- 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





7

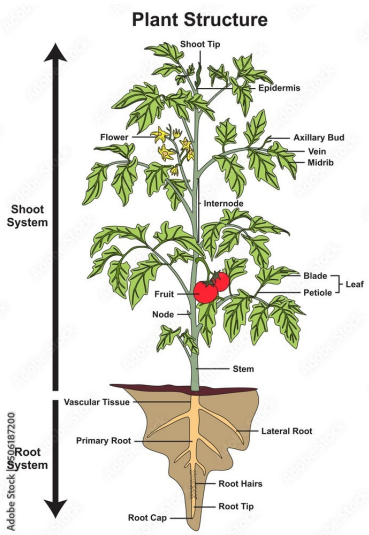
Common Plant Families

- 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, Pears, Quince, Cherry, Photinia, Pyracantha, Almonds, Peaches

8

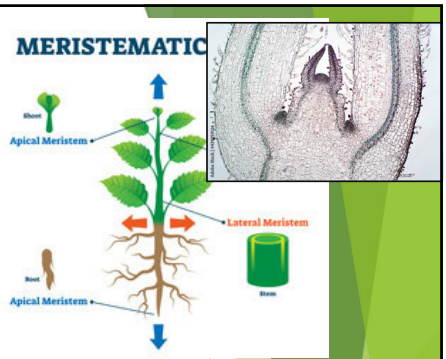
Plant Structure

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



9

Meristems-regions of growth

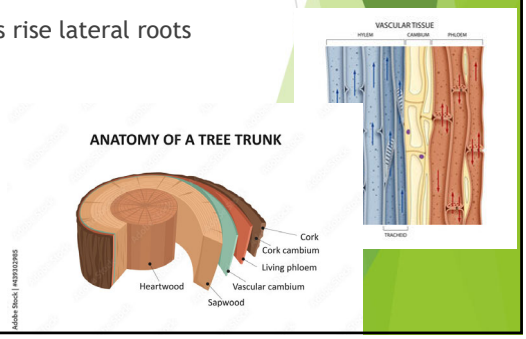


Primary growth Meristems:

- 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

Secondary growth Meristems:

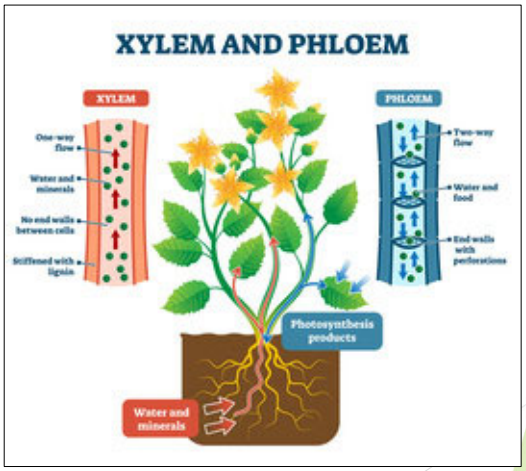
- Vascular cambium-produces new xylem and phloem
- Cork cambium-produces bark/periderm



10

Vascular Tissue

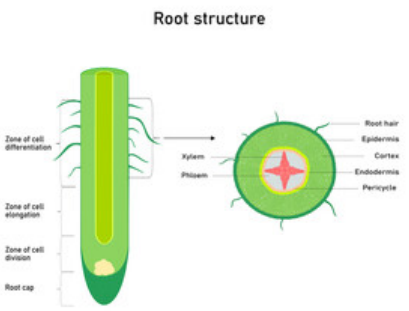
- **Xylem**-responsible for moving water and nutrients up the plant
- **Phloem**- moves sugar and other compounds throughout the plant



11

Roots

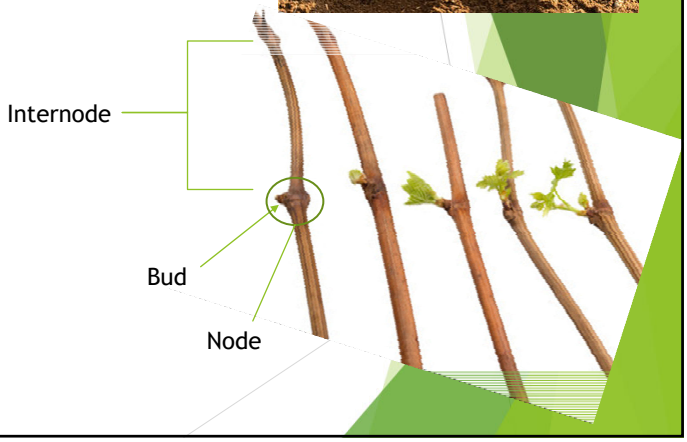
- Anchor the plant to the soil and hold the soil in place
- Take up water and soluble mineral nutrients (xlem)
- Store energy/carbohydrate reserves (phloem)
- No nodes
- Don't photosynthesize
- Need water and oxygen



12

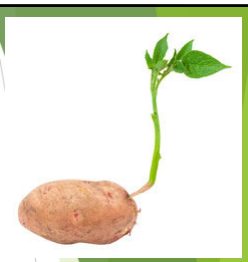
Stems (Shoots, Canes & Trunks)

- 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



13

Buds

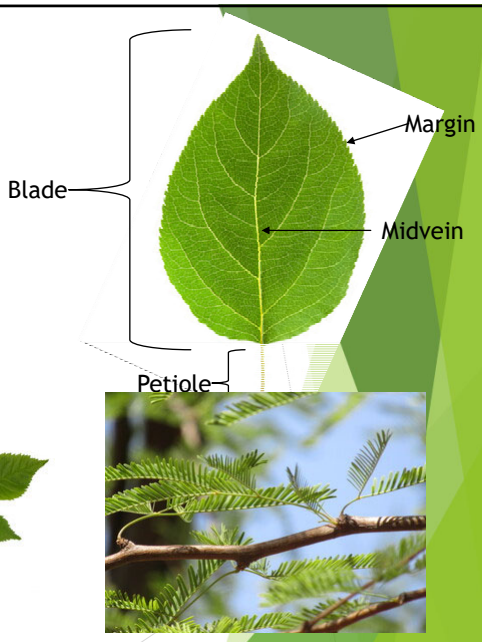


- Meristematic Structures
- Shoots and/or flowers are compressed inside bud (internodes have not elongated
- Often a preformed number of leaves/flowers and a meristem
- Can be terminal/apical or lateral
- Prompt/axillary buds
- Latent buds
- Dormant buds
- Bud pattern creates leaf/stem pattern

14

Leaves

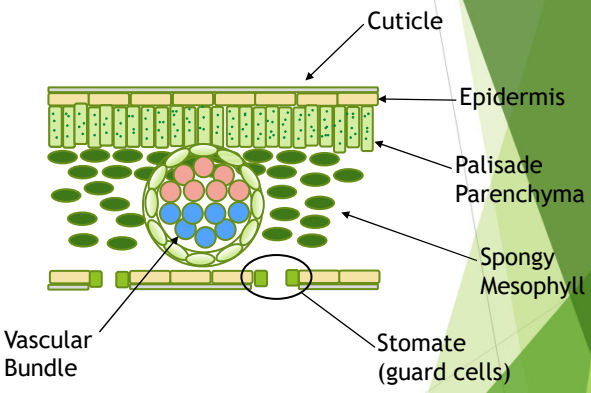
- Solar panels of the plant
- Major photosynthetic organs
- Leaf shape



15

Leaf Anatomy

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



16

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
- Sometimes tinged red
- More, smaller stomata

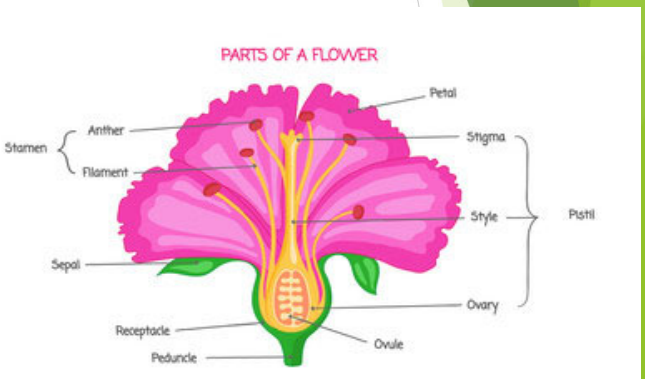
Shade Leaves

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

17

Flowers

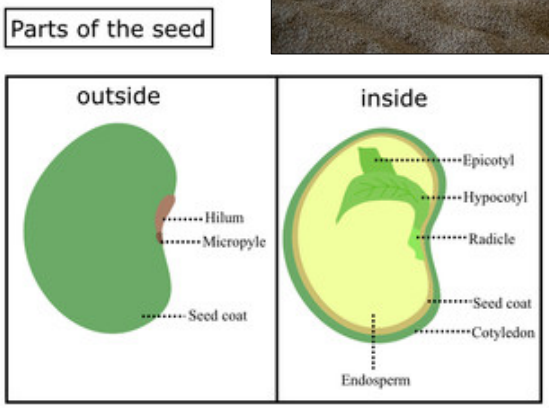
- Contain Male, Female (or both) sexual structures
- Stamen=male
- Pistil=female
- Anthers hold pollen that sticks to stigma, which then travels down the style to the ovule inside ovary
- Ovule becomes seed
- Ovary becomes fruit



18

Seeds

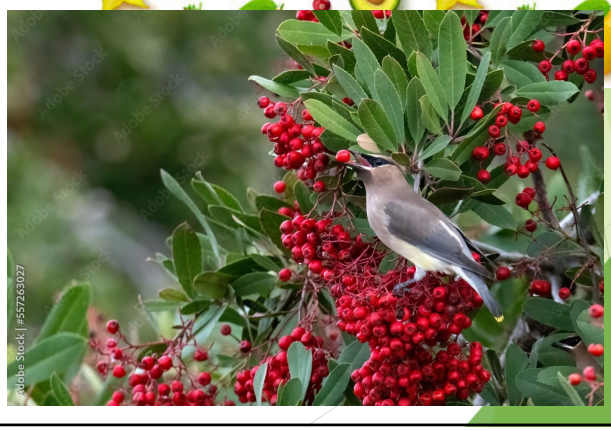
- Dormant embryonic plant
- Major Parts:
  - Embryo
  - Endosperm
  - Micropyle
  - Aleurone layer



19

Fruits

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



20

Types of Fruit

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

21

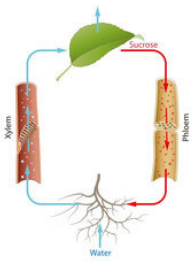
Plant Classification

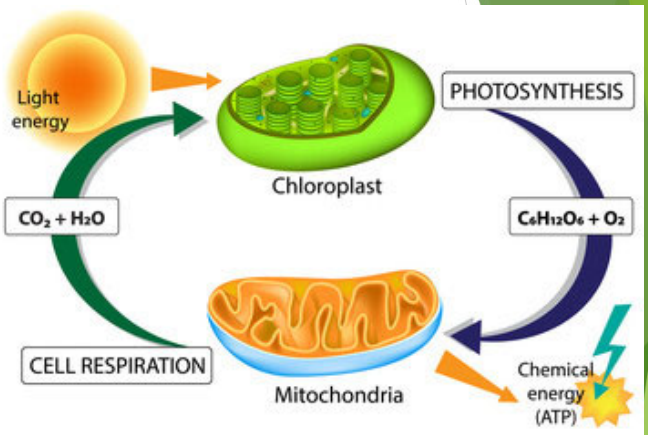
- Habit (annual, perennial, biennial)
- Structure (woody, herbaceous)
  - Woody (vine, shrub, tree)
- Leaf Retention (evergreen, deciduous)
- Climatic Adaptation (tropical, sub-tropical, temperate)
  - Warm or cool season
- Use (Ornamental, Agricultural)
  - Ag (Food, fiber, fuel)

22

Plant Growth

- Photosynthesis
- Respiration
- Transpiration
- Translocation



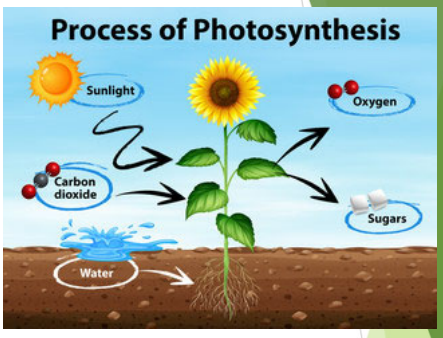


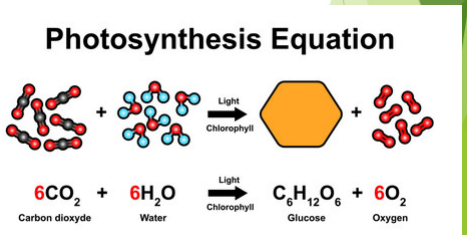
23

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





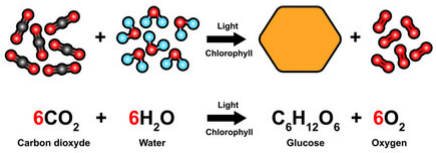
24

Respiration

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

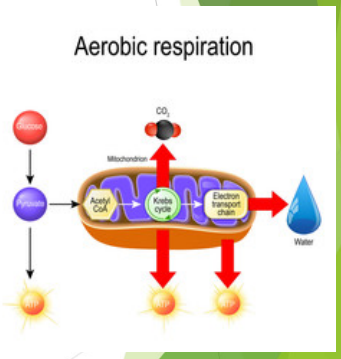
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + Energy$$

Photosynthesis Equation



$6CO_2$ + $6H_2O$ $\xrightarrow[\text{Chlorophyll}]{\text{Light}}$ $C_6H_{12}O_6$ + $6O_2$

Carbon dioxyde · Water · Glucose · Oxygen



25

Transpiration

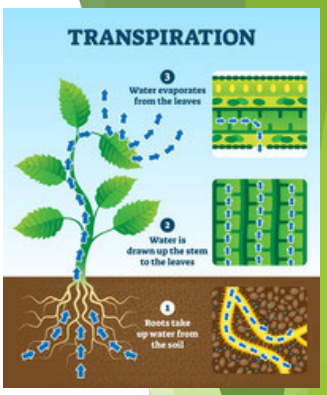
- Evaporation of water from plant surfaces (primarily stomata) to the atmosphere
- Moves along the S.P.A.C. (Soil Plant Atmospheric Continuum)
- Water travels from areas of higher to lower concentration
  - SoilΨ > PlantΨ > AirΨ

Creates a column of water throughout the plant

Water enters roots and exits the stomata

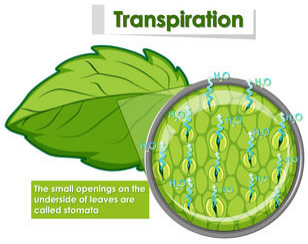
Helps to cool the plant

Transports minerals from soil to plant



26

Transpiration (continued)



Rate of transpiration depends on:

- temperature
- RH
- Wind
- Availability of water in soil

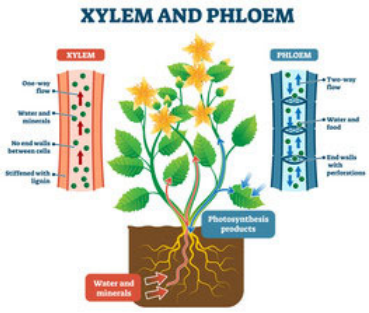
In most plants, stomata are closed at night (no photosynthesis, no need for carbon)

Succulents open stomata at night to avoid water loss during day

27

Translocation

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



28

Hormones: internal regulators of growth and development

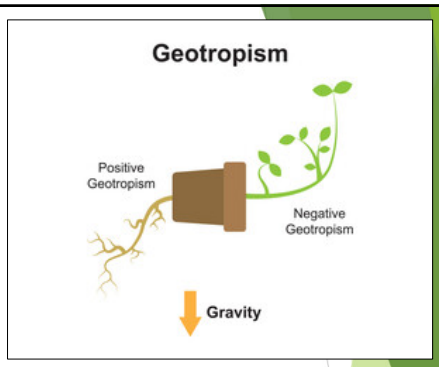
- (Plant) Hormones-compounds that are synthesized in one part of the plant, and are usually translocated to another part
  - Small quantities produce dramatic effects on growth and development

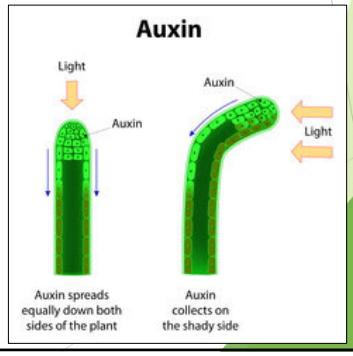
- Auxins
- Cytokinins
- Gibberellins
- Ethylene
- Abscisic acid
- Others… Brassinosteroids, Jasmonates, Salicylic acid, Strigolactones

29

Hormones: Auxin

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

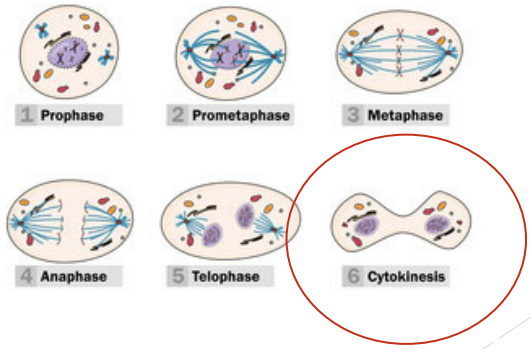




30

Hormones: Cytokinins

- Stimulates cell division



31

Hormones: Gibberellins

- Cell elongation
- Flowering
- Enzyme activation in germinating seeds

32

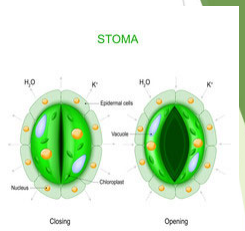
Hormones: Ethylene

- Accelerates fruit ripening
  - Climacteric vs Non-climacteric fruits
- Leaf senescence

33

Hormones: Abscisic Acid

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



34

Plant Development

- Vegetative Cycle
  - Dormancy
  - Seed germination
  - Active growth
    - Juvenility
    - Maturity
- Reproductive Cycle
  - Flower induction
  - Flower and fruit development
  - Ripening

35

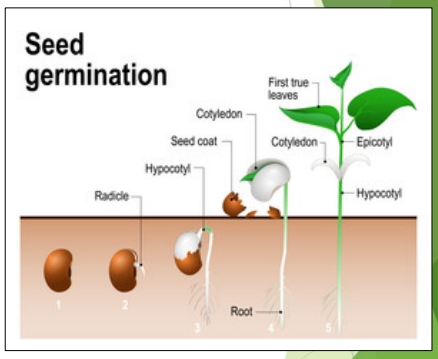
Dormancy

- Alive, but not actively growing
- Mechanism to survive unfavorable conditions
- Can be triggered by:
  - Cold nights
  - Short days
  - Inadequate soil moisture
- Regulated by ABA
- Dehydration
- Cold-hardiness increases

36

Seed Germination

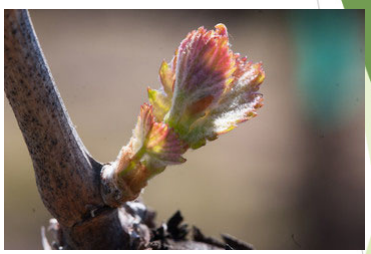
- Germination = Viable/embryo is alive
- Cold requirements/stratification
- Begins when embryo takes in water
- Gibberellins regulate enzymes
- Optimal conditions necessary vs actual conditions determines germination rate:
  - Water
  - Oxygen
  - Species specific temperature range
  - Light (species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



37

Budbreak of Perennials & Biennials

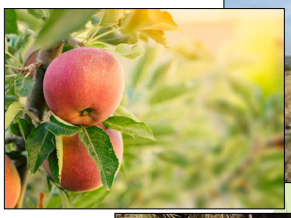
- Chilling hours requirement
  - 35 to 45F for a specific time
- As soils/temperature rise, cold-hardiness is lost
- Tissues are hydrated through root pressure
- Bud starts in the uppermost buds first



38

Vegetative Development: Juvenility to Maturity

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

39

Reproductive Development

- Flower Induction
- Flower and Fruit Development
- Fruit Ripening and quality

40

Flower Induction

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

41

Environmental Factors Controlling Induction

- Day length-number of daylight hours (photoperiod)
- Light intensity
- Temperature
- Soil moisture content
- Nutrient status of the plant

42

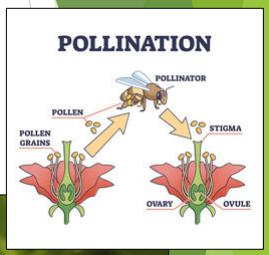
Fruit Development

- 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
- Fruit development is dependent upon:
  - Photosynthetic capacity
  - Plant nutrient status
  - Water availability
- Only a fraction of flowers set and develop into mature fruit

43

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)



44

Fruit Quality and Ripening

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

- Climacteric- physiologically mature fruit may continue to ripen off the mother plant
  - Tomatoes, bananas, avocados, pears
- Non-climacteric- fruit must stay attached to mother plant to complete maturity/ripening
  - Grapes, citrus, strawberries

45

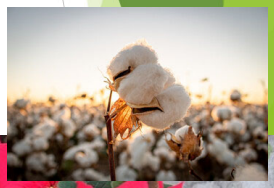
Plant Functionality

- Day Length
- Light Intensity
- Light Quality
- Temperature
- Photoperiod/ Temperature interactions
- Soil Moisture
- CO2 concentrations
- O2 Concentrations
- Nitrogen
- Stress

46

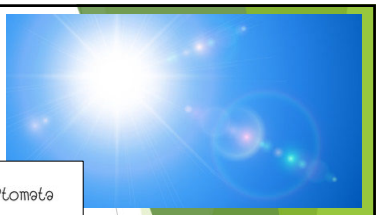
Plant Response to Day Length

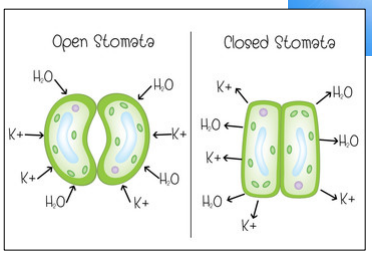
- Plant initiates flowers, special vegetative organ, or dormancy due to a specific day length (photoperiod) for a specific amount of time (60+ days)
- Short-day (<12 hrs)-example: natural fall color change/senescence, cotton flower initiation, poinsettia color change
- Long-day (>12 to 14 hrs)- example: perennial ryegrass
- Day-neutral (doesn't matter)
- Longer days mean more photosynthesis



47

Plant Response to Light Intensity



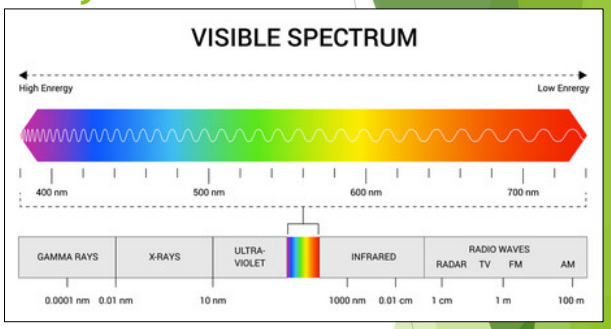


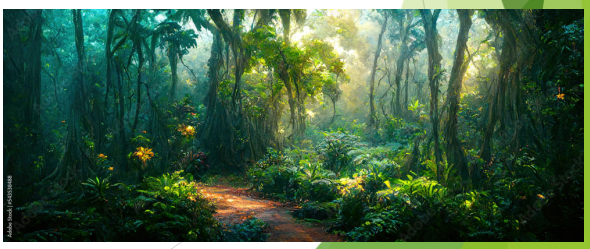
- Intensity = brightness
- Measured by Foot-candle (10,000 fc = full sun)
- Optimal light intensity is species specific
- Effects seed germination
- Often connected to temperature
- Stomata open and close
- High light necessary for color and sugar in fruit
- Leaf architecture
- Phototropism
- Etiolation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

48

Plant Response to Light Quality

- Relates to the color of the light source
- Plants absorb light in the visible spectrum
  - Mostly blue and red light
- Red light is preferentially used, far red not
- 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

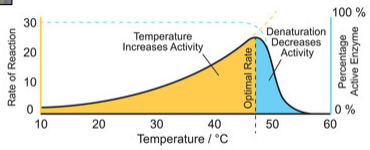




49

Plant Response to Temperature

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



50

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

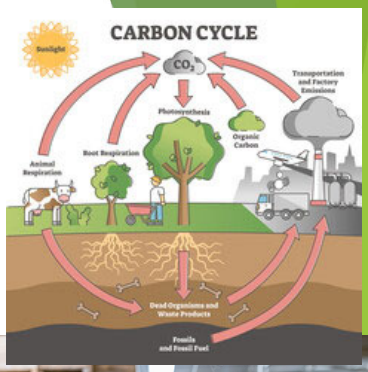
51

Plant Response to Soil Moisture

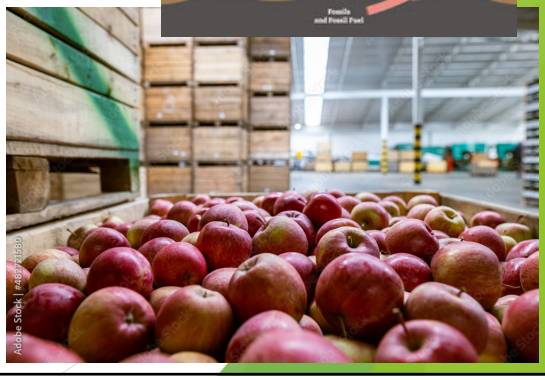
- Inadequate:
  - Transpiration, photosynthesis, nutrient uptake
  - Growth rate, flowering, fruit-set, storage organs
- Surplus:
  - Water-logging can cause hypoxia, limiting respiration
  - Some plants form aerenchyma to assist

52

Plant Response to CO_2 and O_2 Concentrations

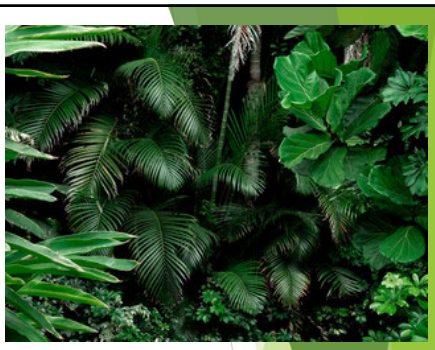


- Higher CO2 levels:
  - More CO2 for photosynthesis
  - Less water loss (less stomatal conductance)
  - Lower nitrogen concentrations (less nutrient uptake)
  - Nutrients become limiting factor in growth
- Less O2
  - Soil compaction, overly-deep planting, water-logging
  - Seed germination
  - Controlled-atmospheric storage for fruit



53

Nitrogen and Plant Growth and Development

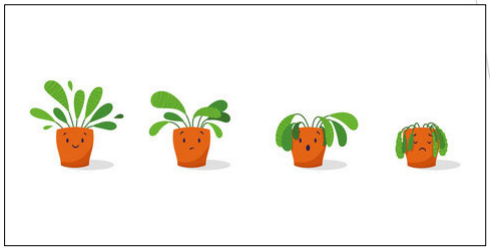


- High Nitrogen:
  - Increased shoot growth
  - Increased root growth at time of N application
  - Lower root:shoot growth ratio
  - Canopy congestion
  - Suppress flower initiation
- Low Nitrogen
  - Increased root growth
  - Restricted photosynthesis (enzyme-limited)
  - Chlorophyll break-down

54

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



55