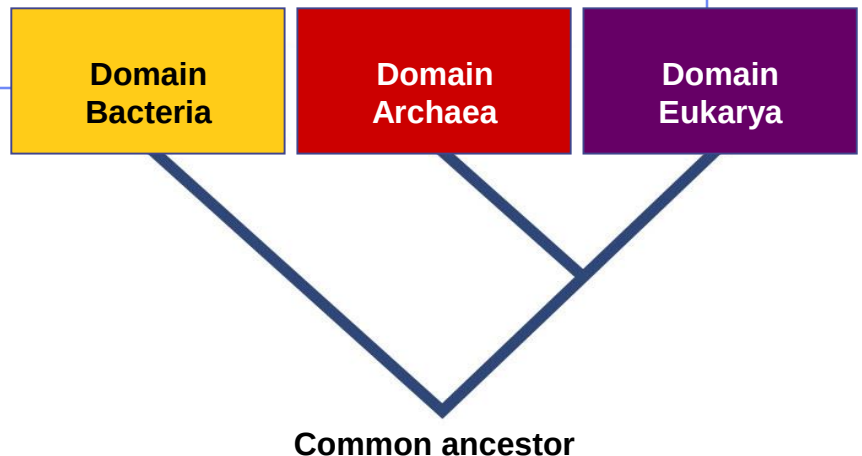
Homeostasis of Plants

Transport, Reproduction, and Responses



Plant Diversity

Bryophytes non-vascular land plants

Pteridophytes seedless vascular plants

Gymnosperm pollen & "naked" seeds

Angiosperm flowers & fruit

flowering plants

conifers

flowers

mosses

ferns

pollen & seeds

vascular system = water conduction

Tracheophytes

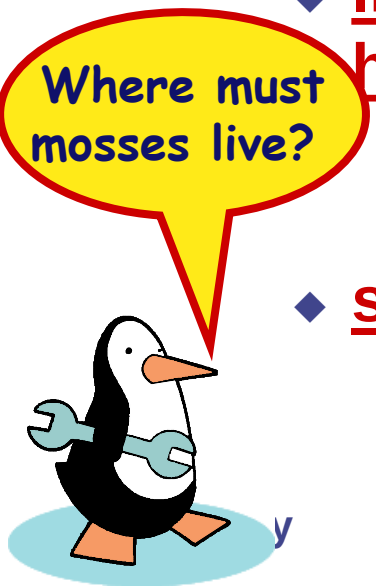
colonization of land

Ancestral Protist

xylem cells = tracheids

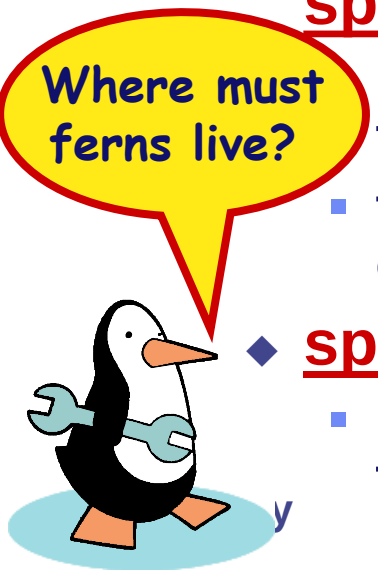
First land plants

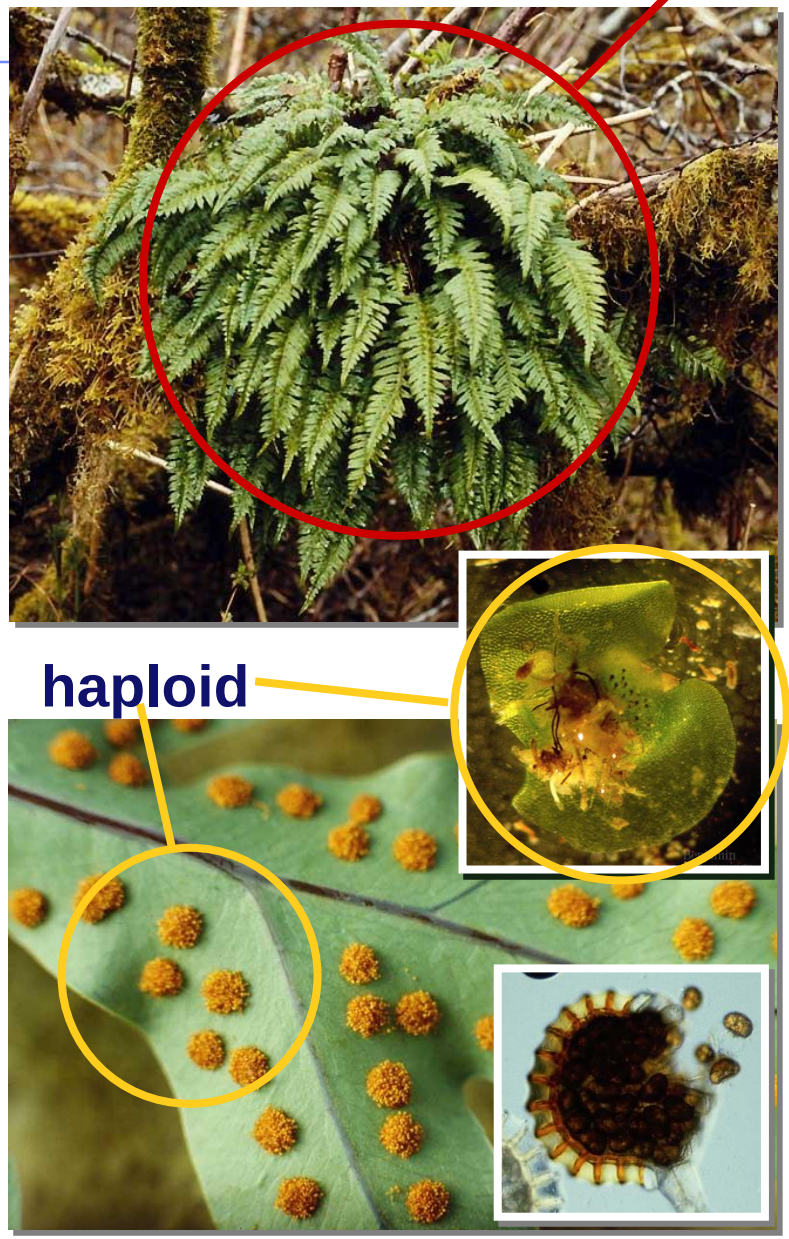
- Bryophytes: mosses & liverworts
  - non-vascular
    - no water transport system
    - no true roots
  - swimming sperm
    - flagellated sperm
  - lifecycle dominated by haploid gametophyte stage
    - fuzzy moss plant you are familiar with is haploid
  - spores for reproduction
    - haploid cells which sprout to form gametophyte



First vascular plants

- Pteridophytes: ferns
  - vascular
    - water transport system
    - xylem, phloem, roots, leaves
  - swimming sperm
    - flagellated sperm
  - life cycle dominated by sporophyte stage
    - leafy fern plant you are familiar with is diploid
    - fragile independent gametophyte (prothallus)
  - spores for reproduction
    - haploid cells which sprout to form gametophyte





First seed plants

- Gymnosperm: conifers
  - vascular
  - heterospory
    - male vs. female gametophytes
  - seeds
    - naked seeds (no fruit)
  - pollen
    - contain male gametophyte
  - life cycle dominated by sporophyte stage
    - coniferous trees you are familiar with are diploid
    - reduced (microscopic) gametophyte
    - reduction of gametophyte protects delicate egg & embryo in protective sporophyte
      - protected from drought & UV radiation

Pollen

- Pollen eliminated the requirement for water for fertilization
  - spread through wind & animal

First flowering plants

- Angiosperm: flowering plants
  - vascular
  - heterospory
    - male vs. female gametophytes
  - flower
    - specialized structure for sexual reproduction
  - seeds within fruit
  - pollen
  - life cycle dominated by sporophyte stage
    - trees & bushes you are familiar with are diploid
    - reduced (microscopic) gametophyte

Animal vs. Plant life cycle

Animal

diploid multicellular individual 2n

mitosis

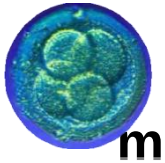
meiosis

zygote 2n

fertilization

haploid unicellular gametes 1n

no multicellular haploid



Plant

diploid multicellular sporophyte 2n

mitosis

zygote 2n

fertilization

meiosis

gametes 1n

spores 1n

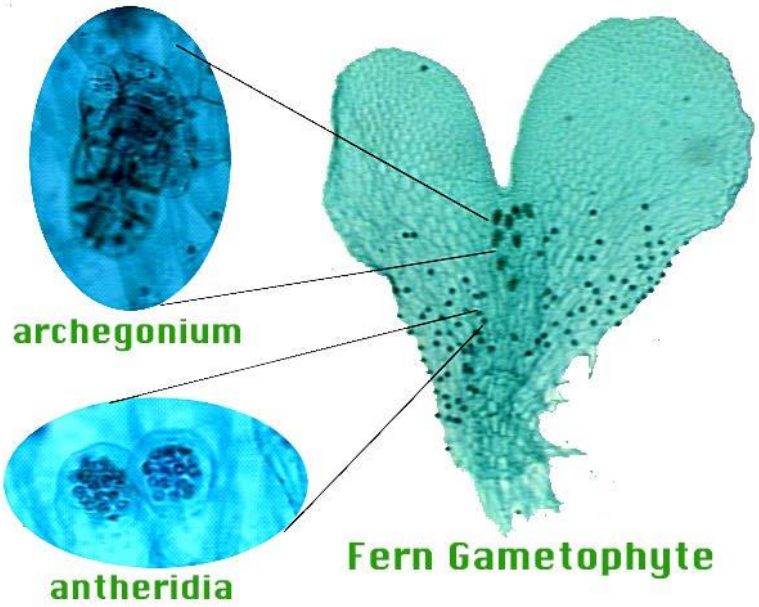
mitosis

mitosis

haploid multicellular gametophyte 1n

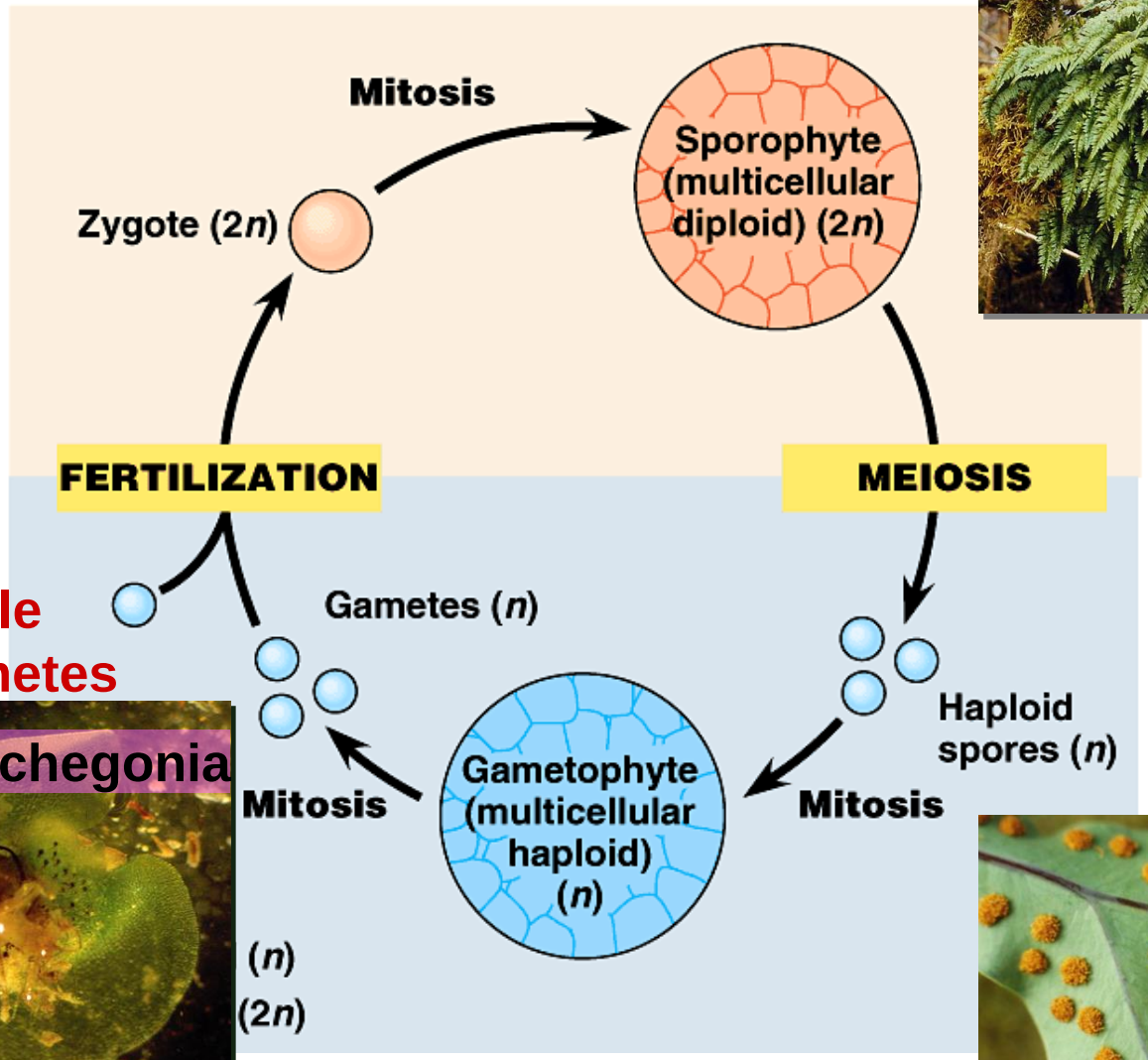
alternation of generations

Antheridia (male)
Archegonia (female)



*Alternation of generations

diploid

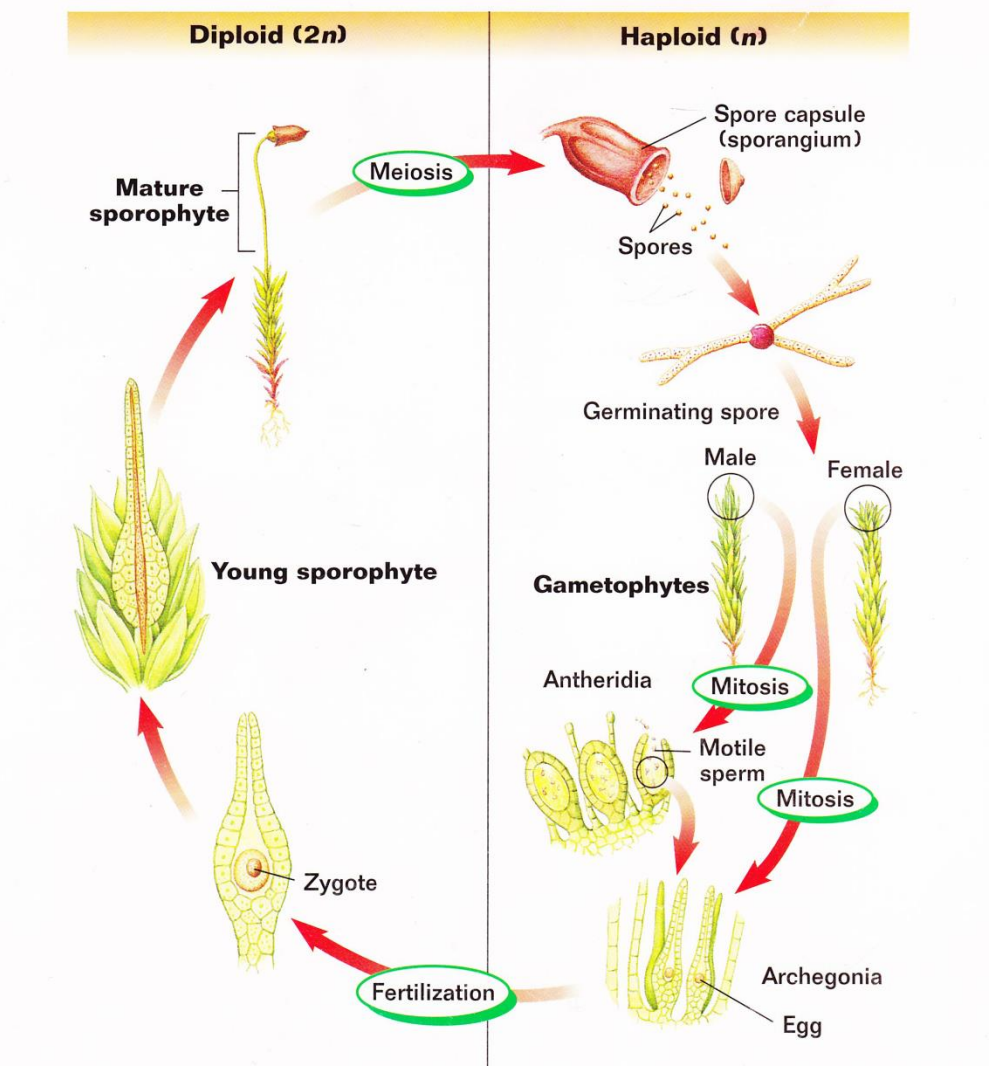


produces male & female gametes

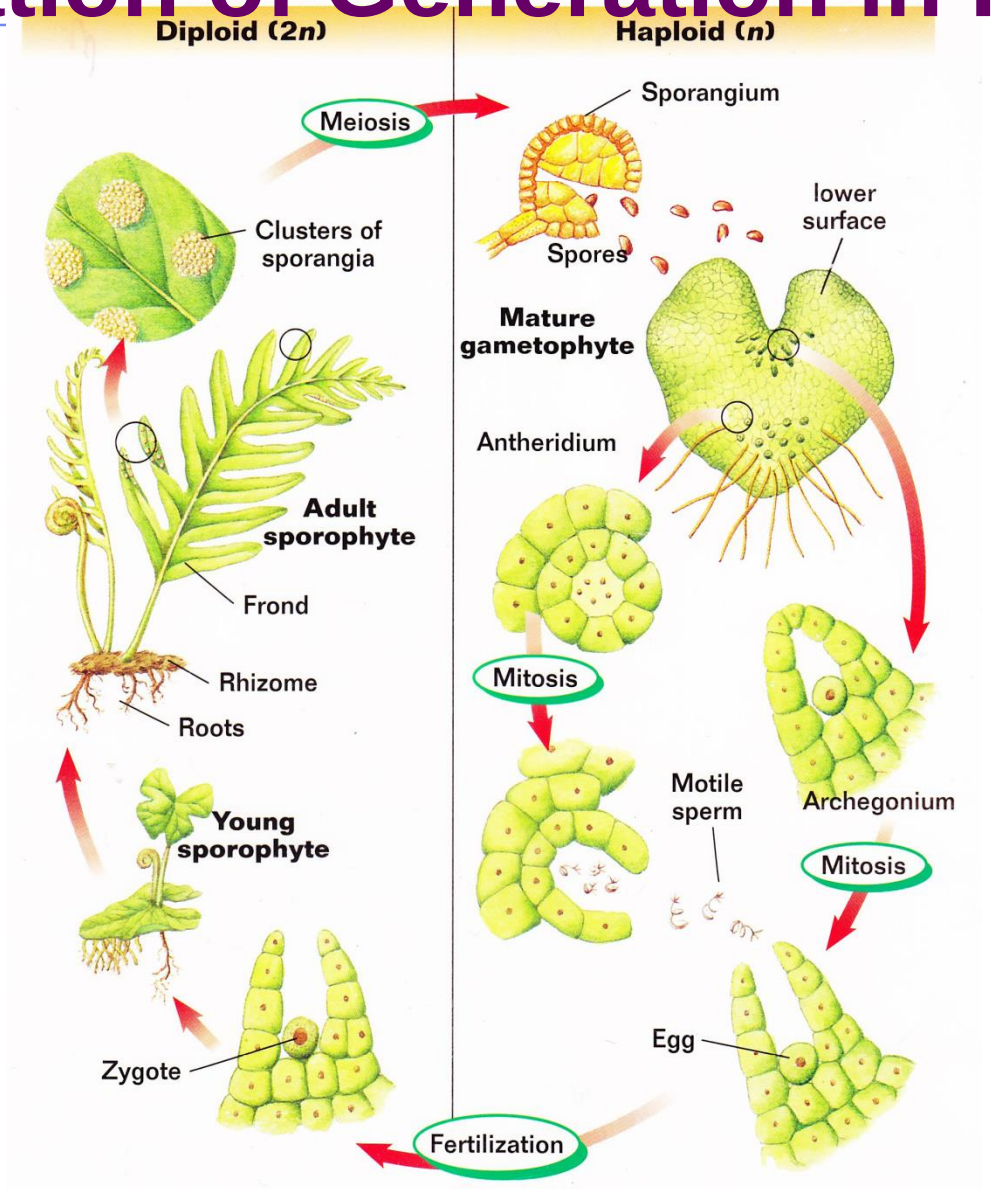
antheridia

haploid

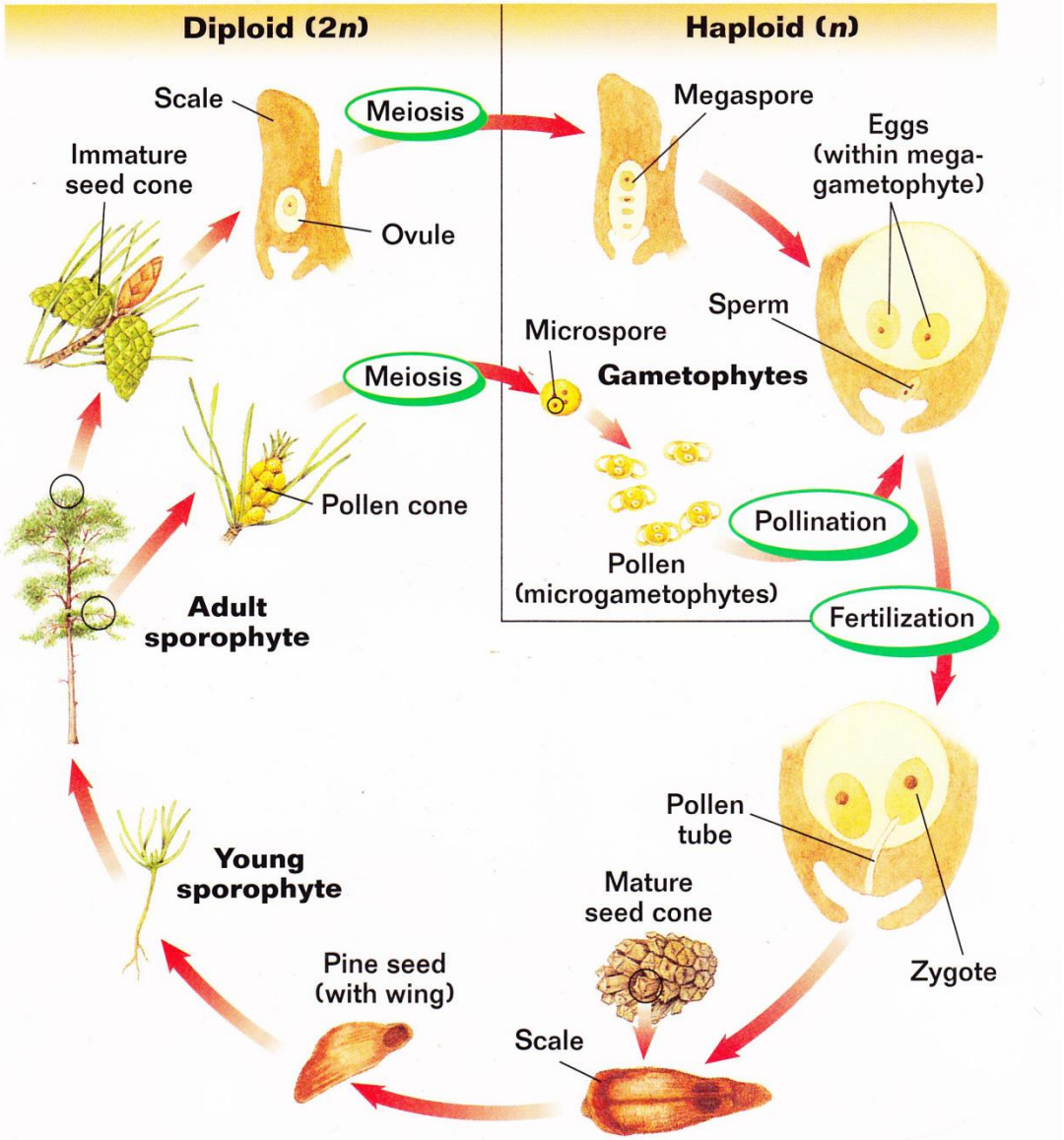
Alternation of Generation in Mosses



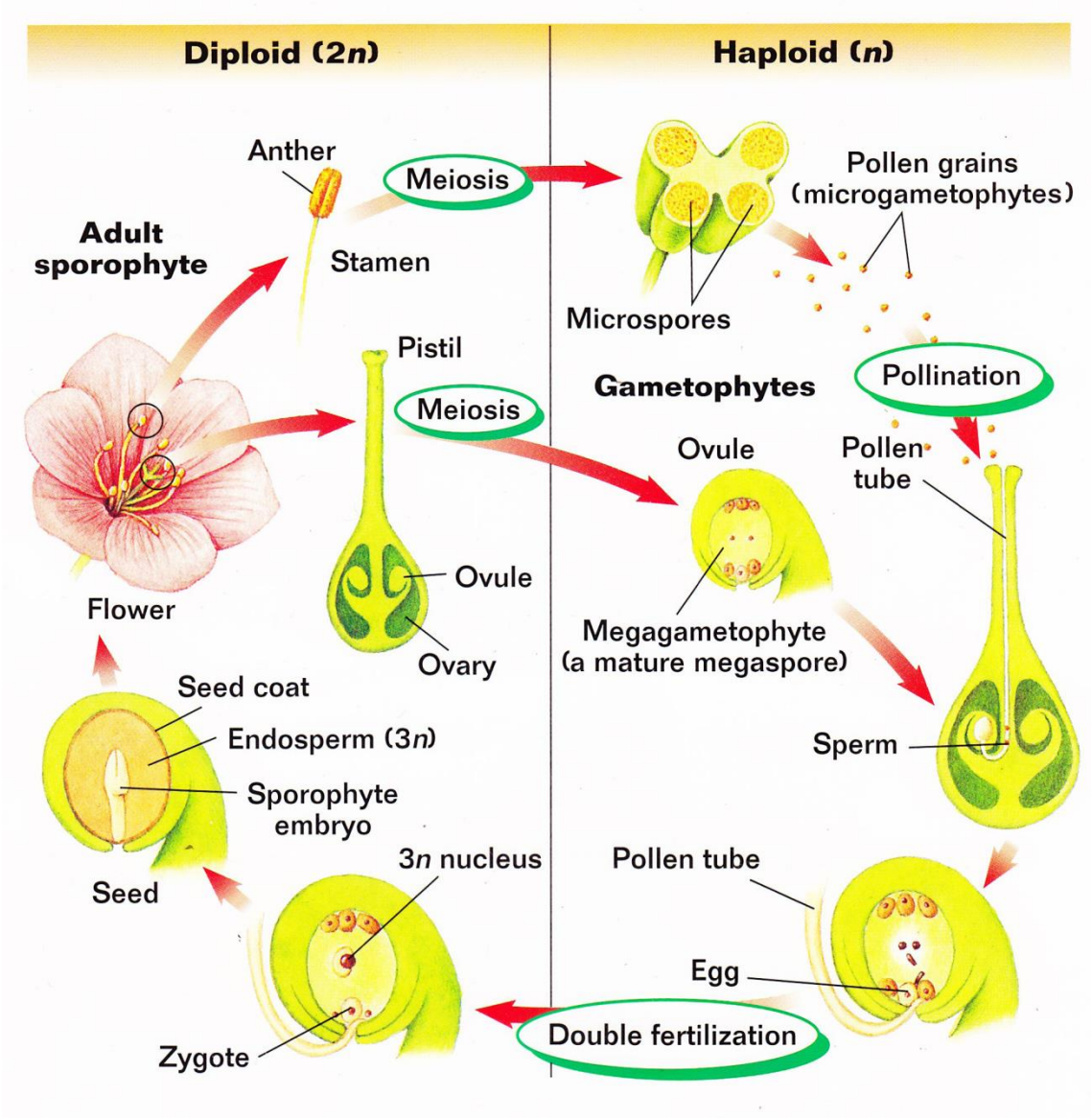
Alternation of Generation in Ferns



Alternation of Generation in Gymnosperms

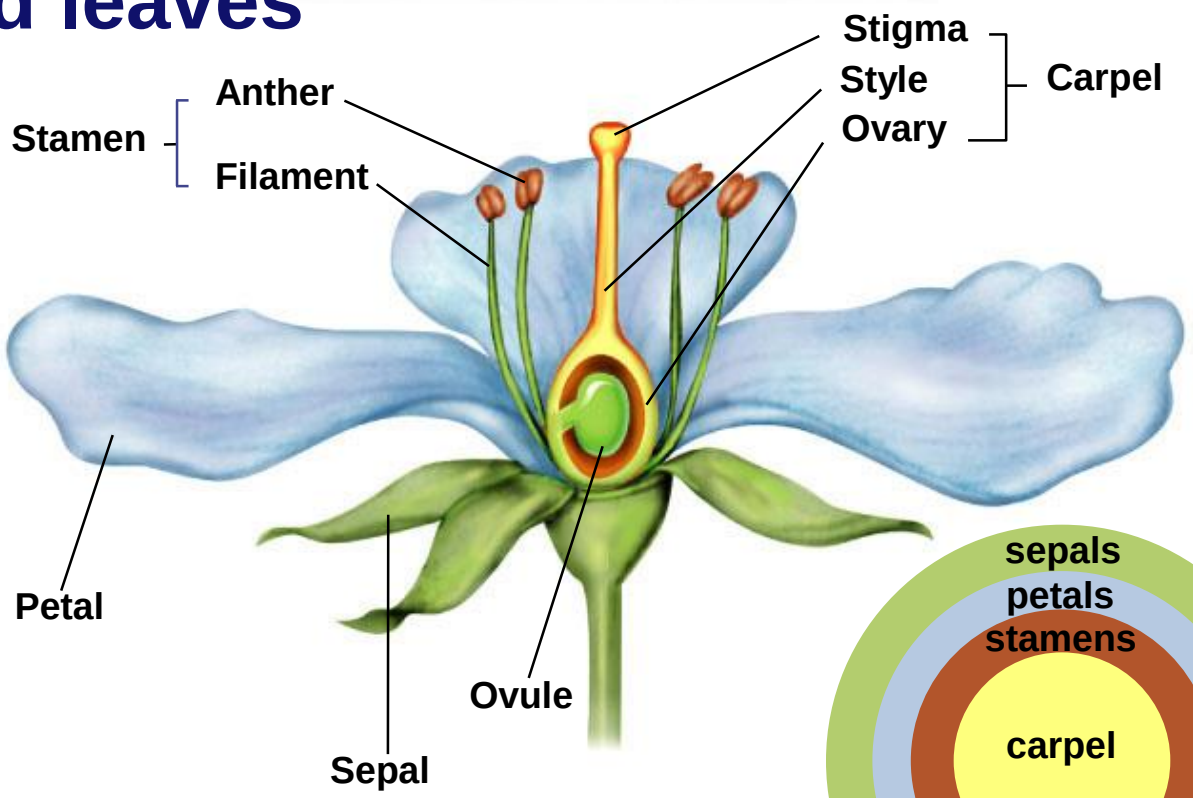


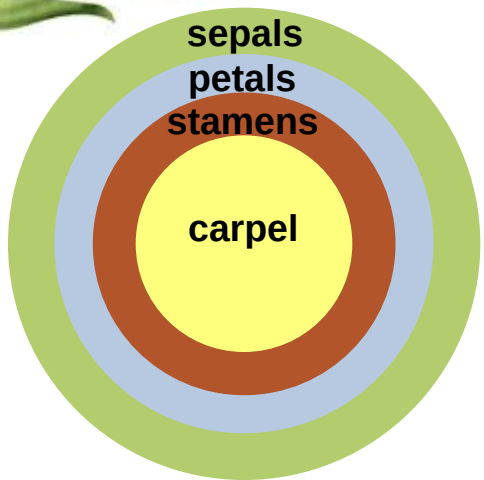
Alternation of Generation in Angiosperms



Flower

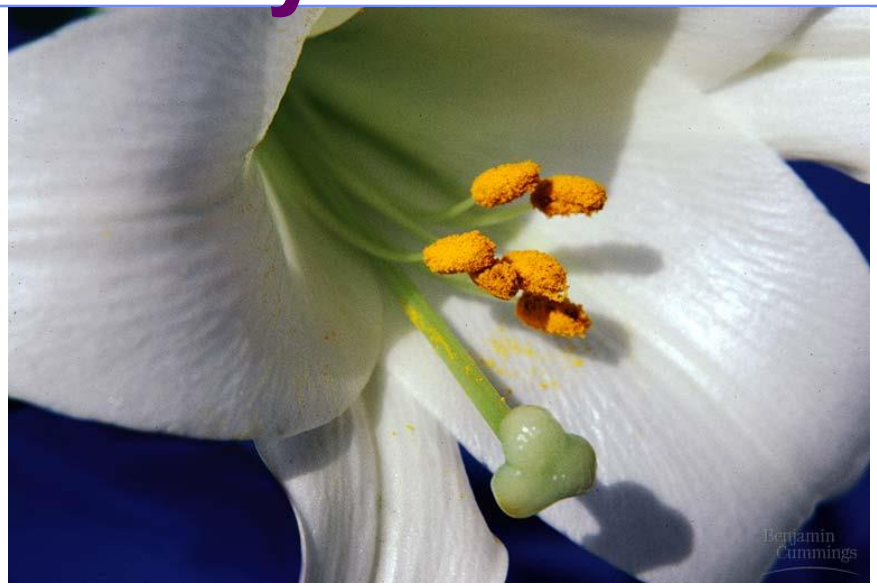
- Modified shoot with 4 rings of modified leaves
  - sepals
  - petals
  - stamens
    - male
  - carpel
    - female

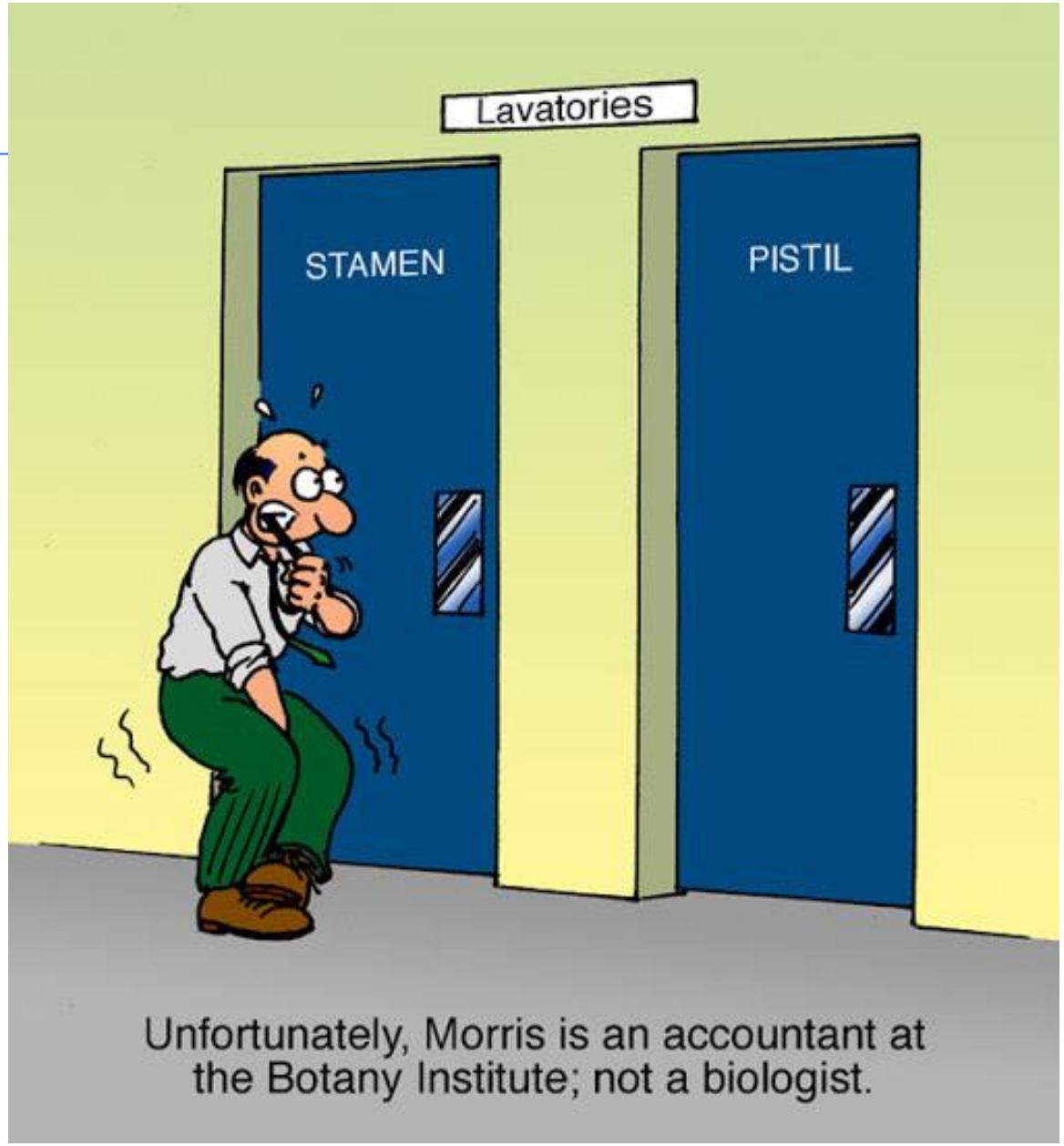




adaptations through mutations

Identify the flower structures…



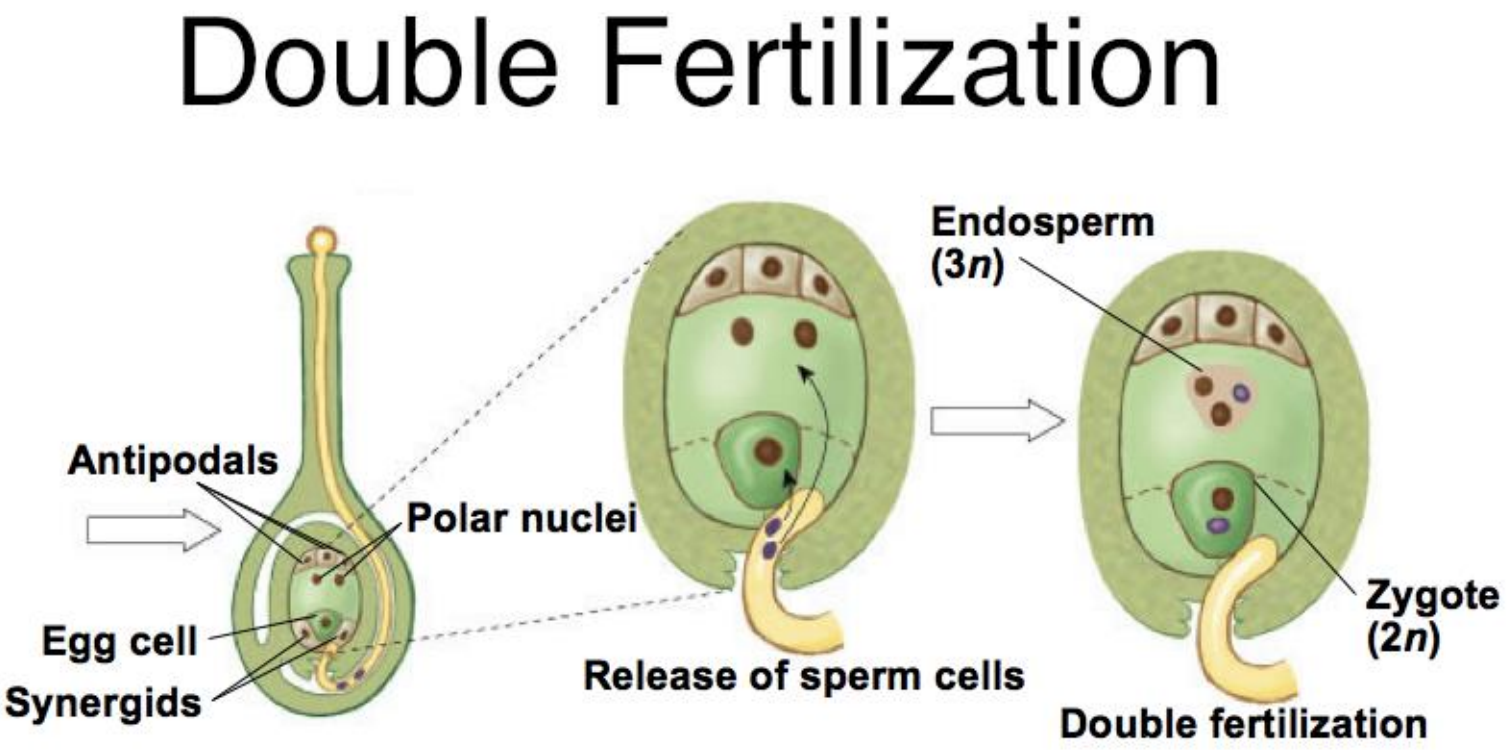

Lavatories
STAMEN
PISTIL
Unfortunately, Morris is an accountant at the Botany Institute; not a biologist.

Double Fertilization

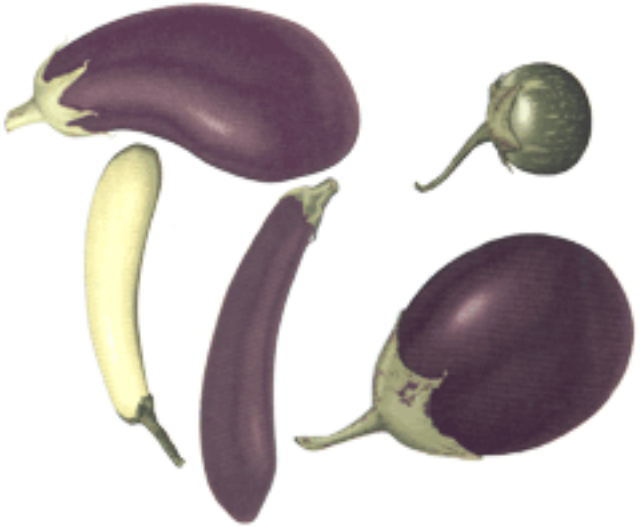
- Each pollen grain contains two male gametes: one combines with egg to form diploid zygote.
- The other combines with two other haploid nuclei of the female gametophyte to form a triploid cell.
- Triploid cell gives rise to the endosperm, which nourishes the embryo during its early development.

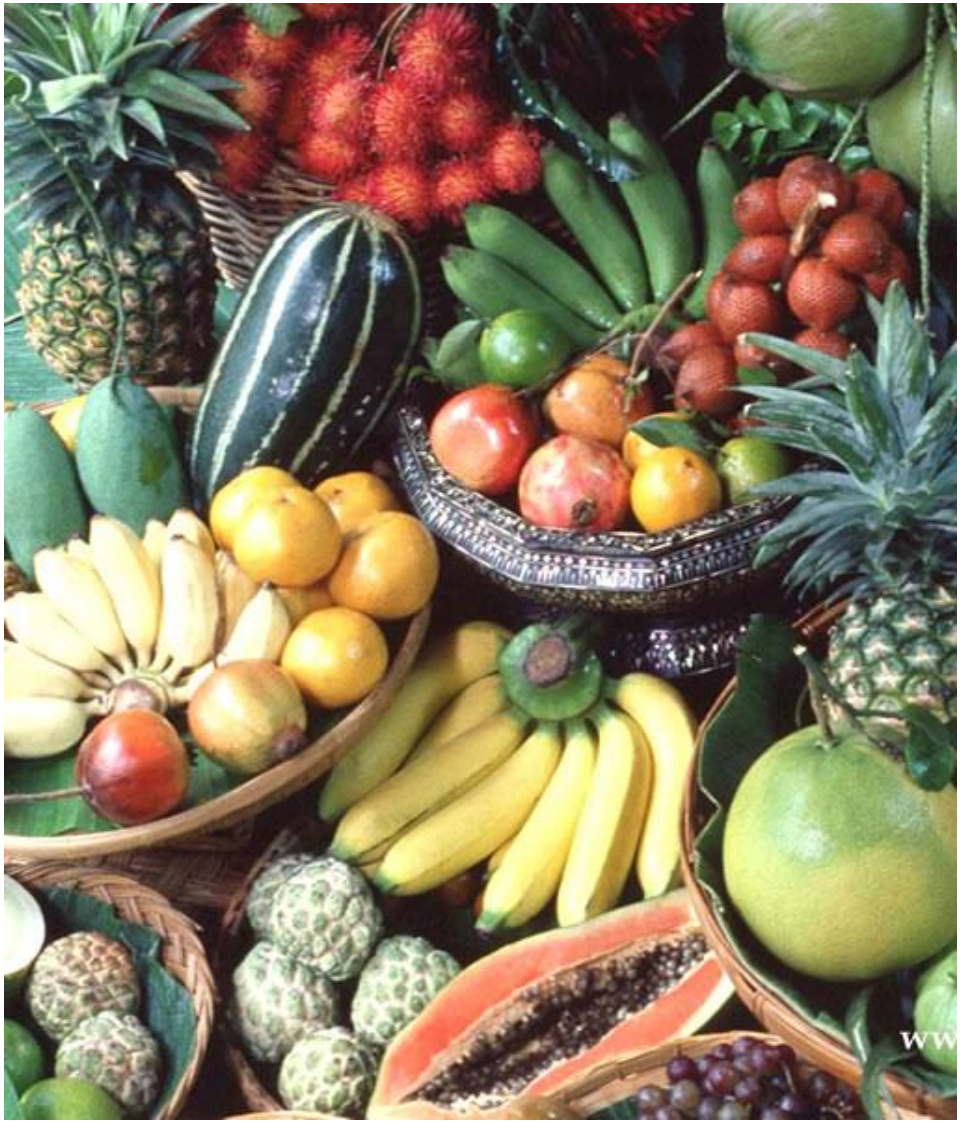
Double Fertilization

- https://www.youtube.com/watch?v=bUjVHUf4d1I&feature=share_email



Angiosperm: fruiting plants

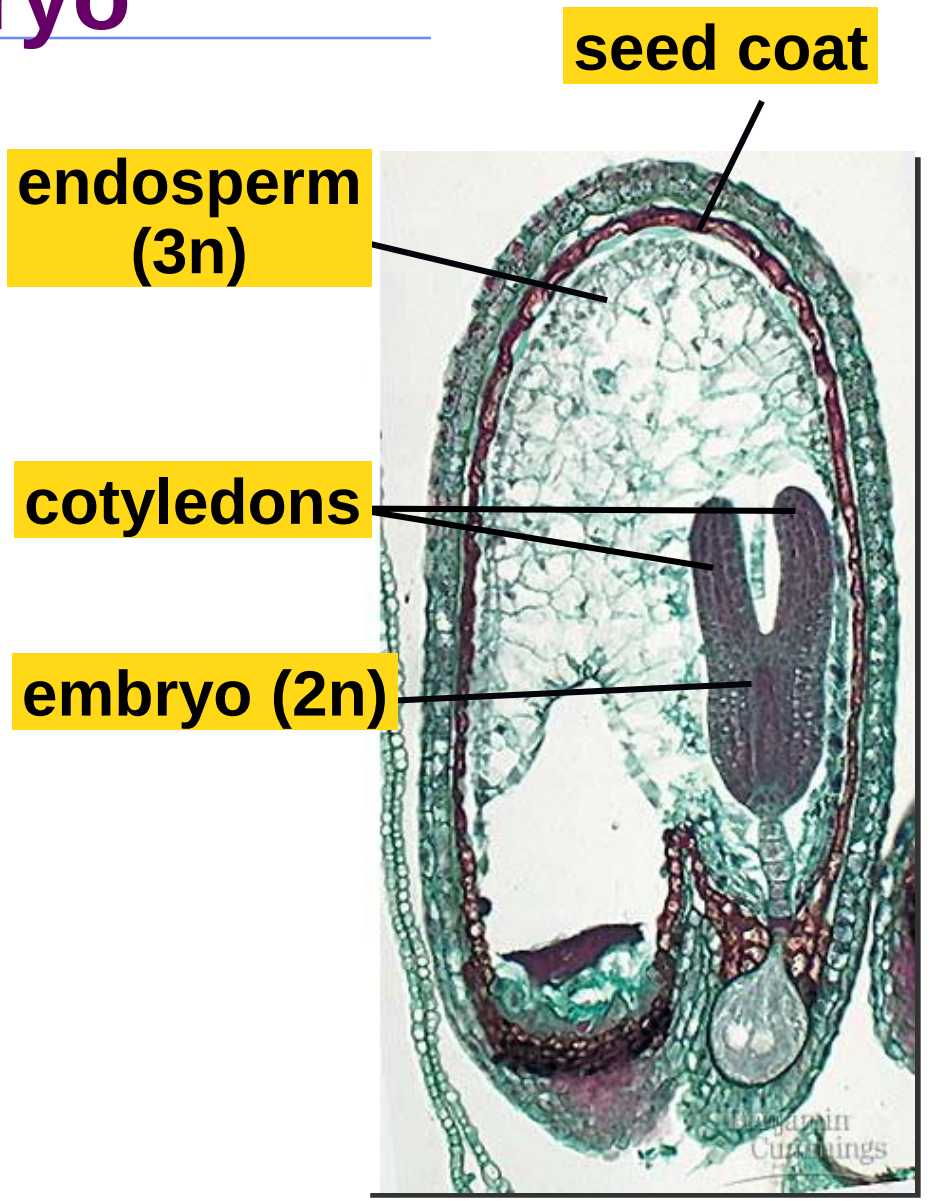




Other fruits…

Seed & Plant embryo

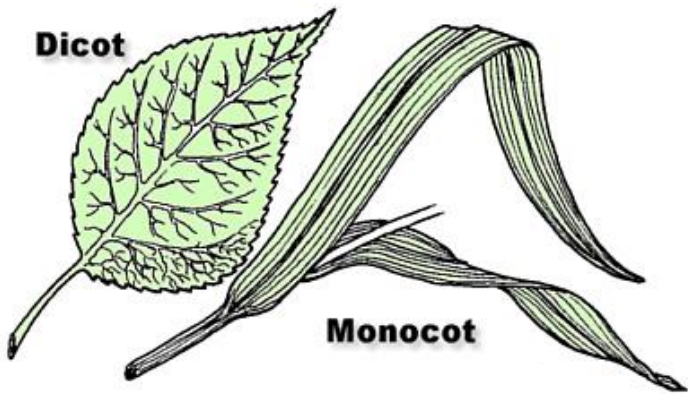
- **Seed offers…**
  - protection for embryo
  - stored nutrients for growth of embryo

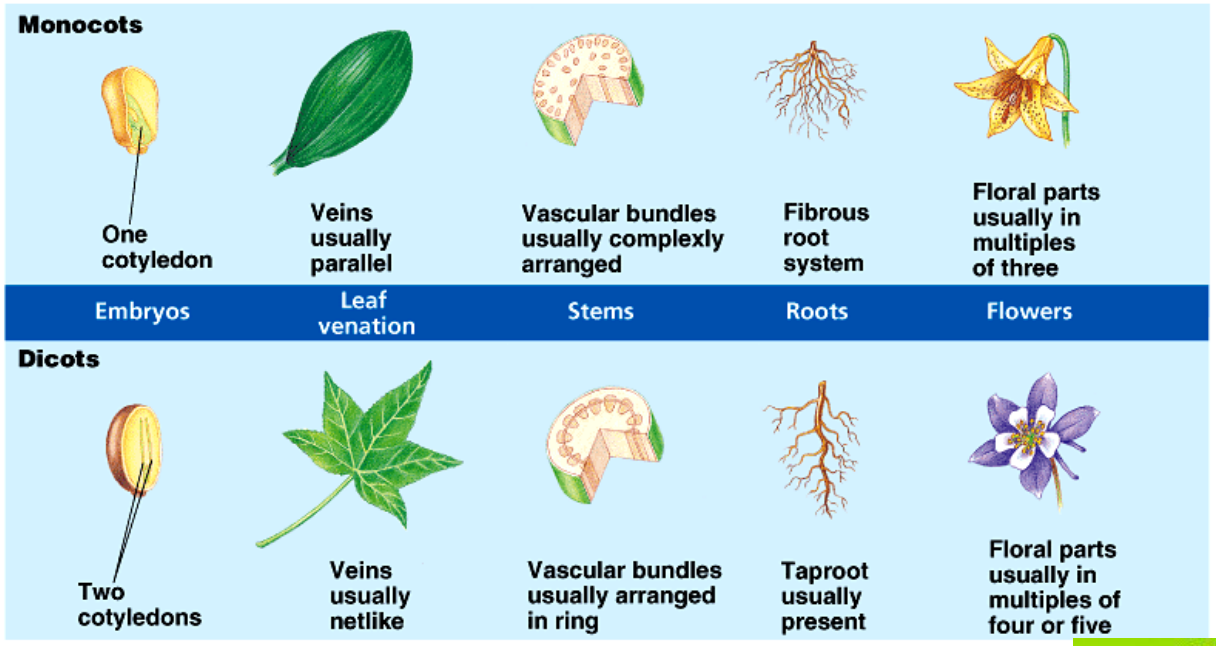


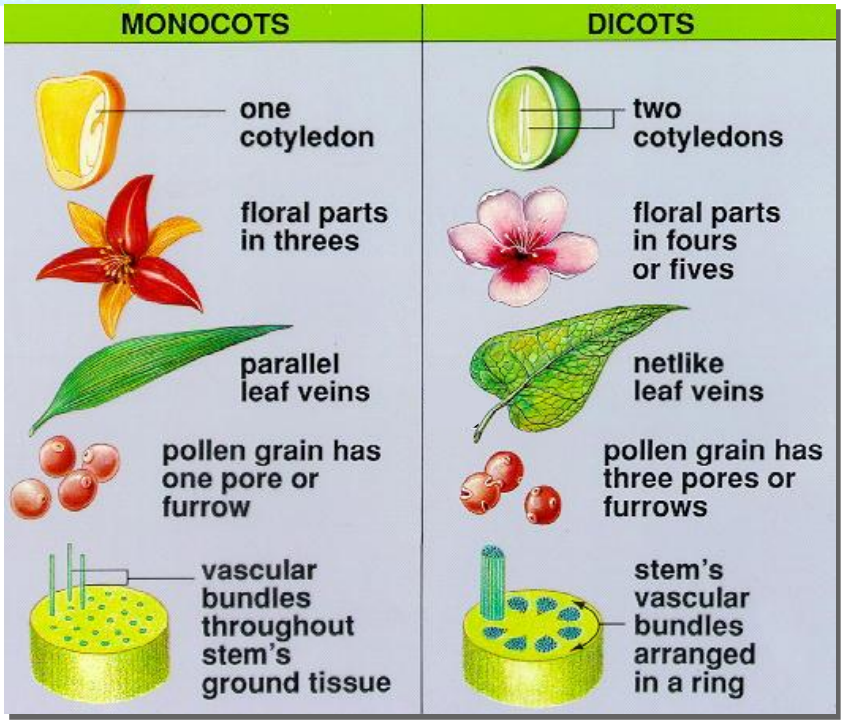
cotyledons = “seed” leaves, first leaves of new plant

Monocots & dicots

- Angiosperm are divide into 2 classes
  - dicots (eudicot)
    - 2 cotyledons (seed leaves)
    - leaves with network of veins
    - woody plants, trees, shrubs, beans
  - monocots
    - 1 cotyledon
    - leaves with parallel veins
    - grasses, palms, lilies

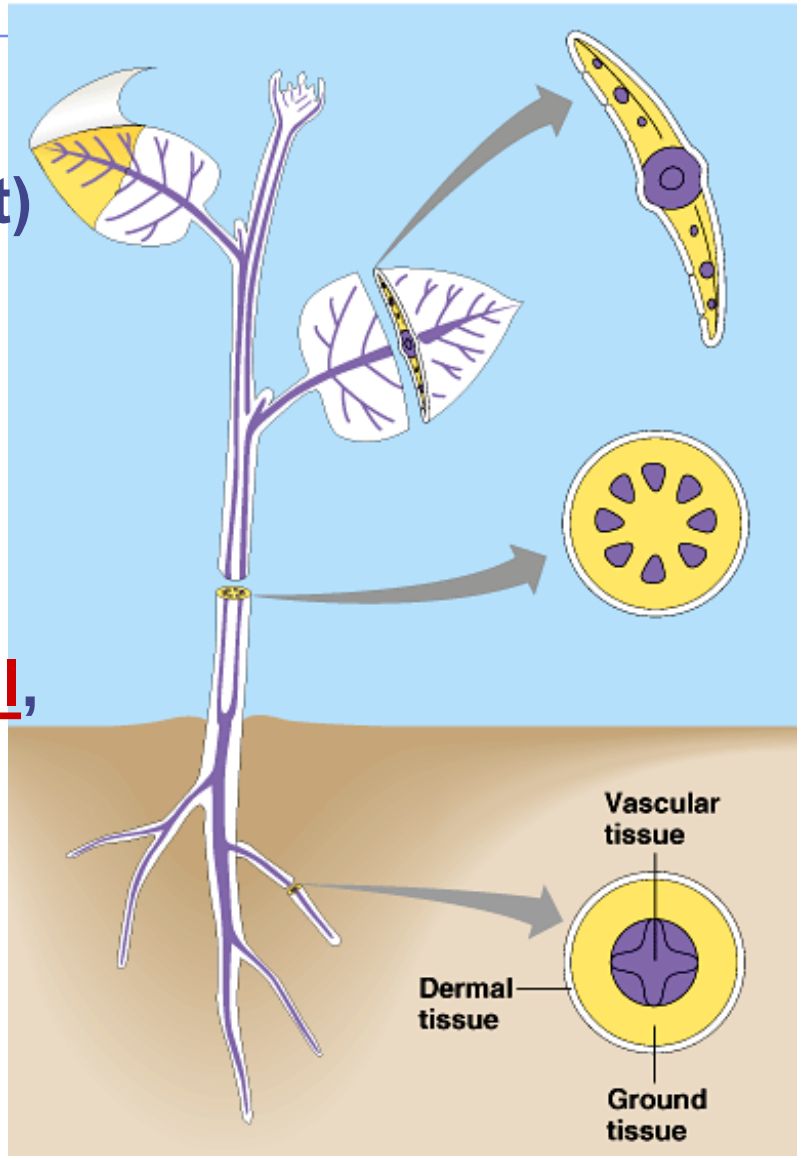






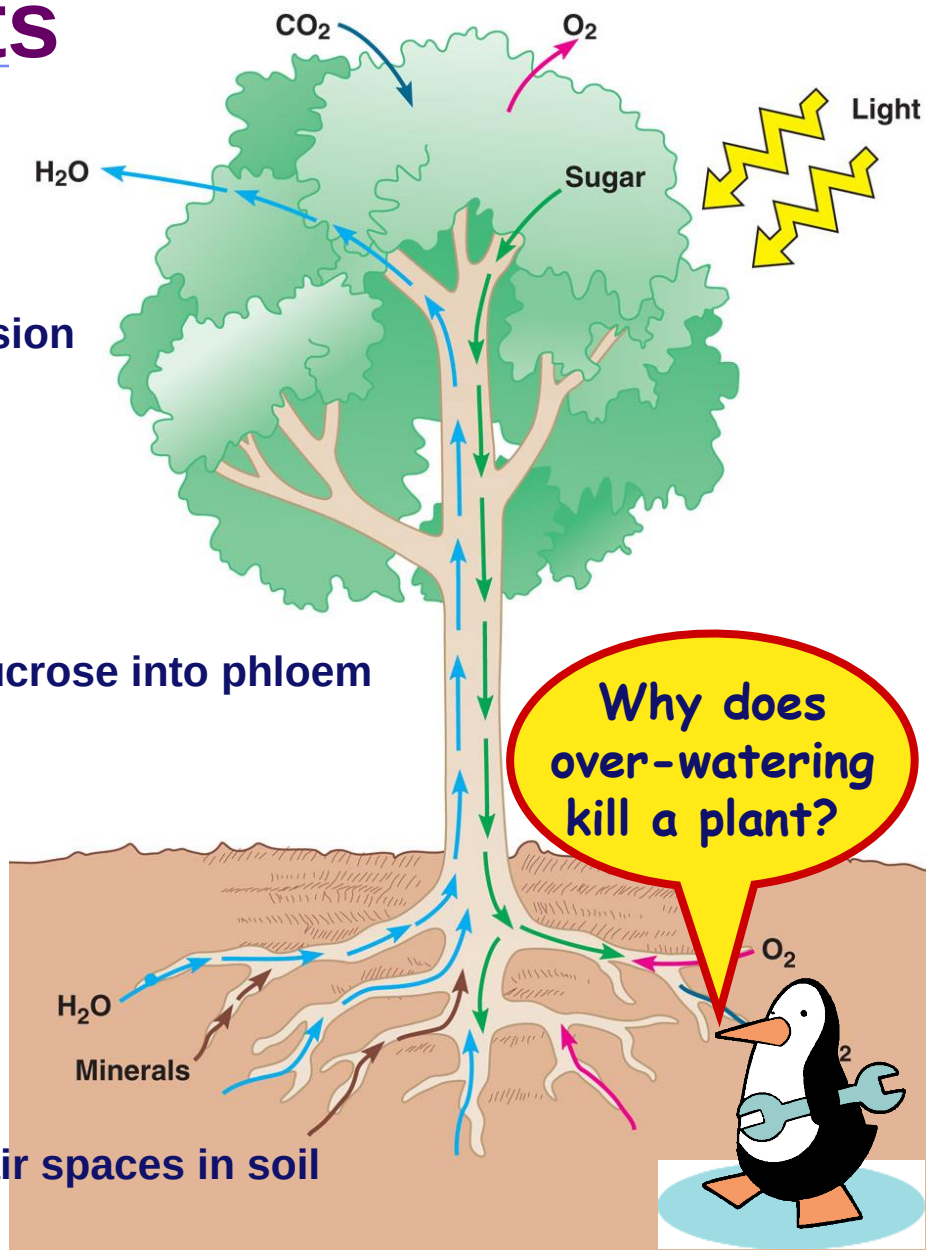
Plant TISSUES

- **Dermal**
  - **epidermis** (“skin” of plant)
  - single layer of tightly packed cells that covers & protects plant
- **Ground**
  - bulk of plant tissue
  - photosynthetic **mesophyll**, storage
- **Vascular**
  - transport system in shoots & roots
  - **xylem** & **phloem**



*Transport in plants

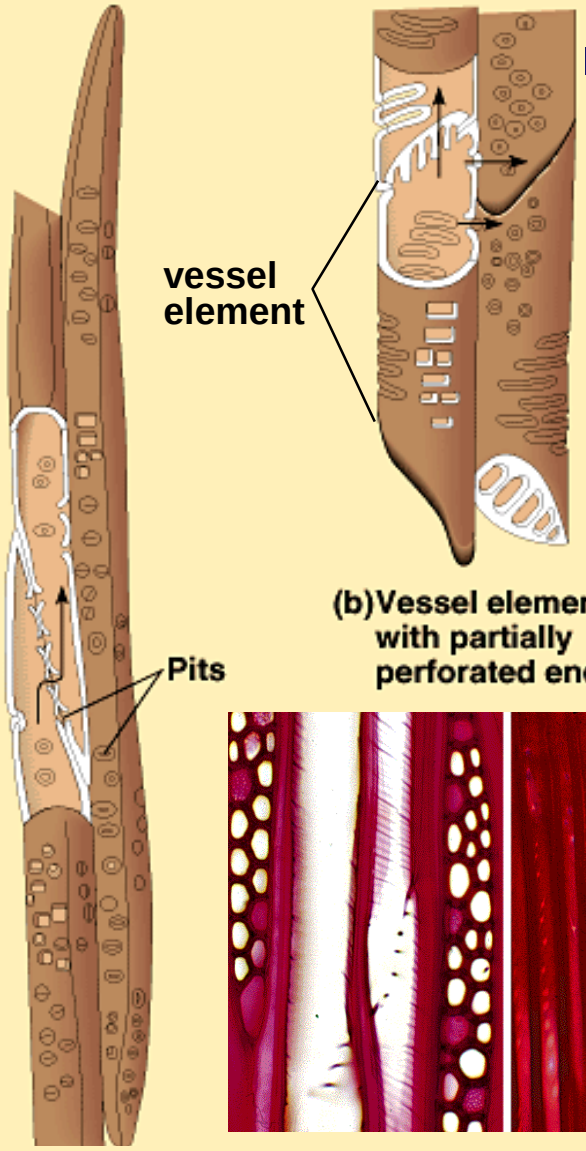
- H_2O & minerals
  - transport in xylem
  - transpiration
    - evaporation, adhesion & cohesion
    - negative pressure
- Sugars
  - transport in phloem
  - bulk flow
    - Calvin cycle in leaves loads sucrose into phloem
    - positive pressure
- Gas exchange
  - photosynthesis
    - CO_2 in; O_2 out
    - stomates
  - respiration
    - O_2 in; CO_2 out
    - roots exchange gases within air spaces in soil



Vascular tissue

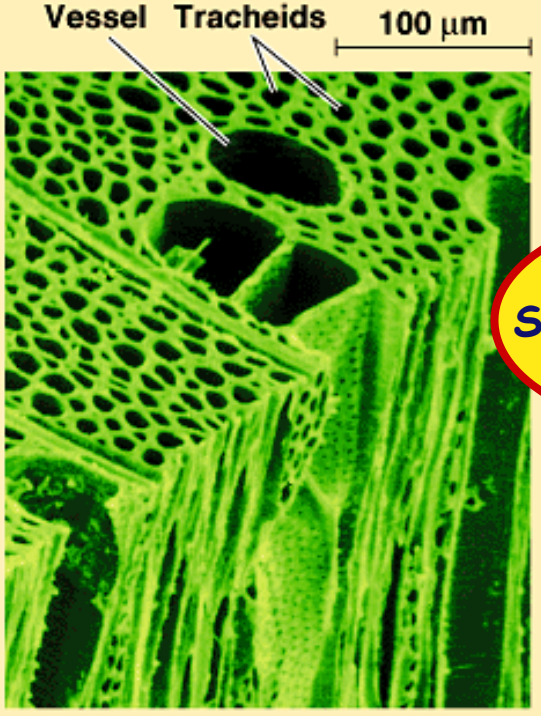
vessel elements

- Xylem
  - move water & minerals up from roots
  - dead cells at functional maturity
    - only cell walls remain
    - need empty pipes to efficiently move H_2O
    - transpirational pull



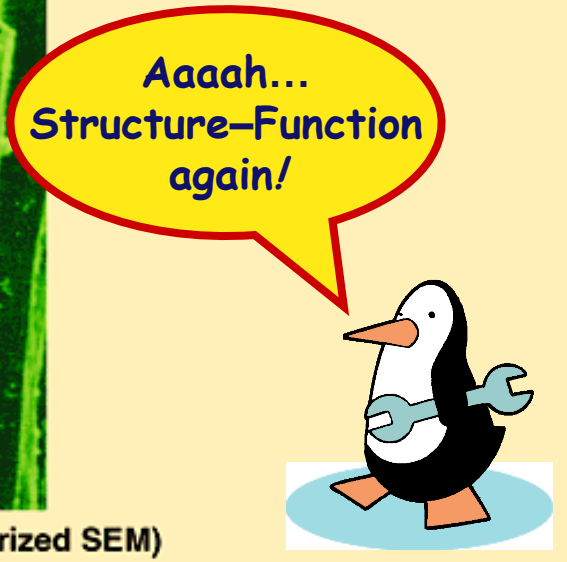
(b) Vessel elements with partially perforated end walls

tracheids



(c) Tracheids and vessels (colorized SEM)

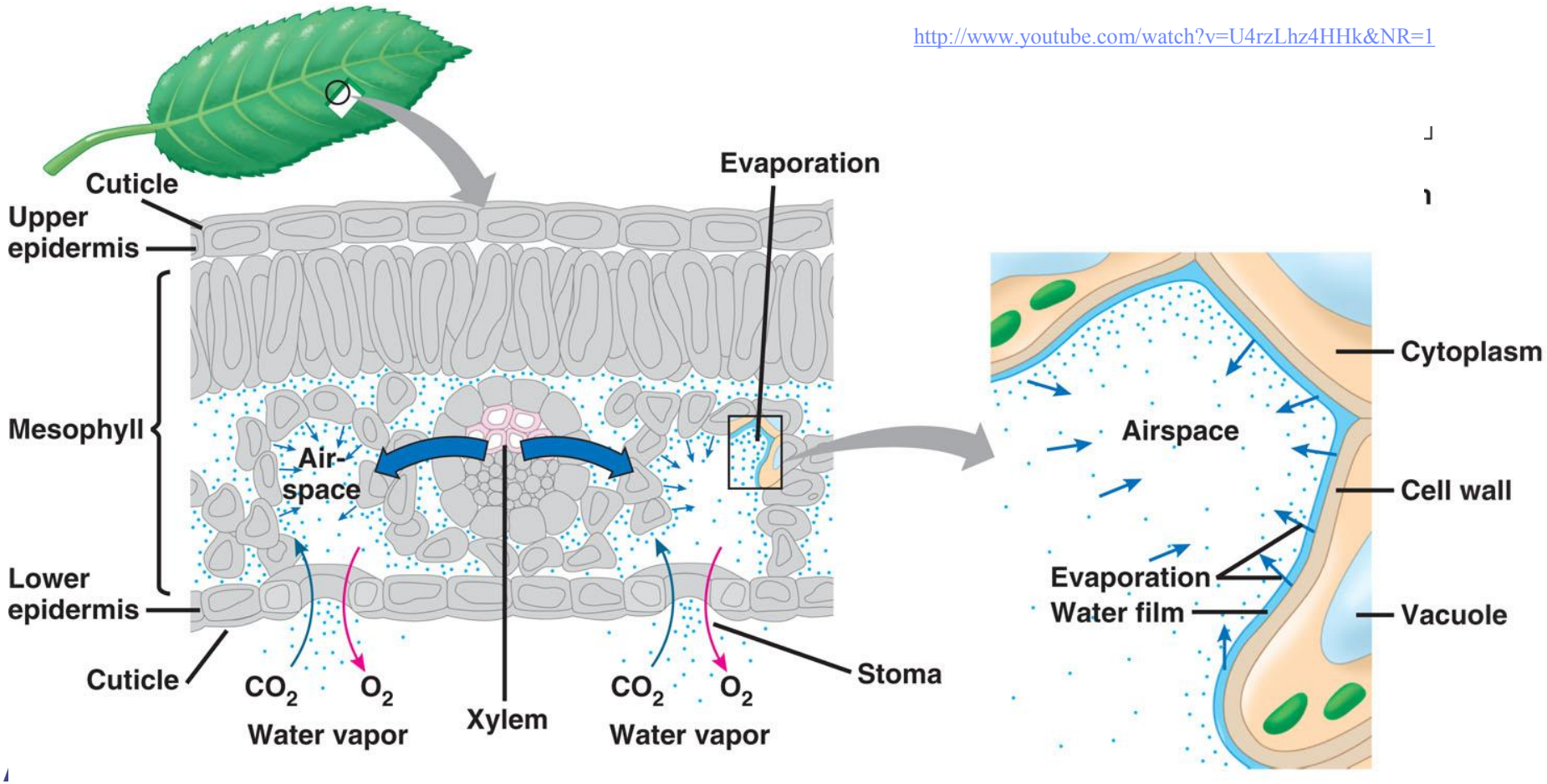
dead cells



Ascent of xylem fluid

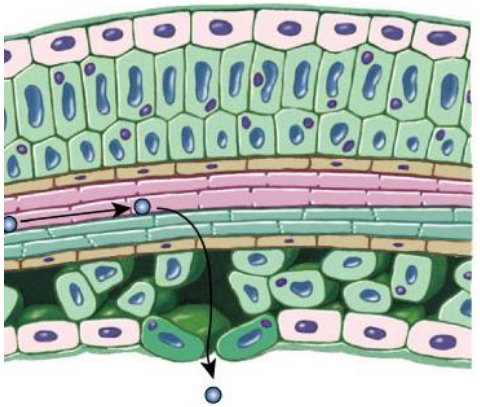
Transpiration pull generated by leaf

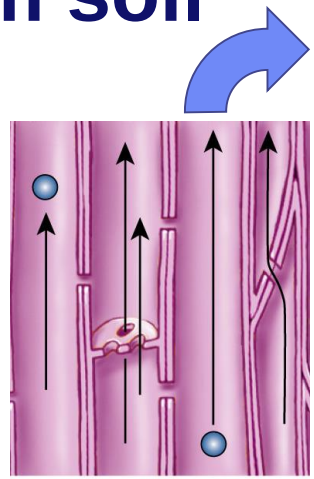
http://www.youtube.com/watch?v=U4rzLhz4HHk&NR=1

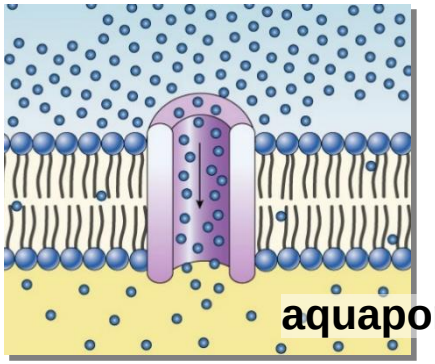


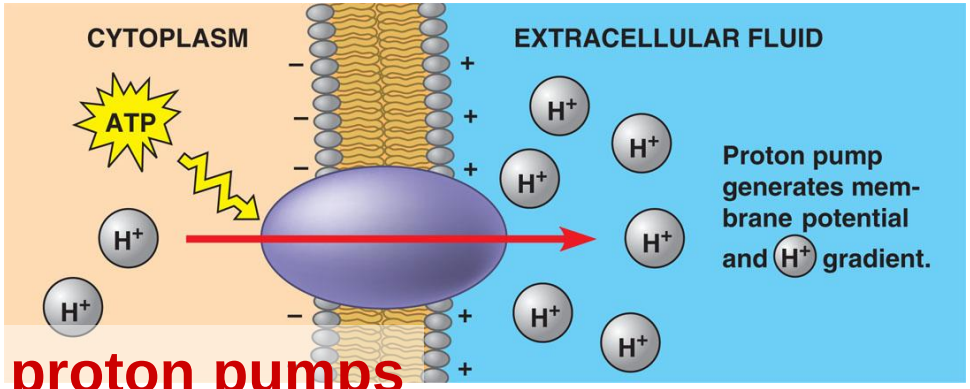
Water & mineral absorption

- Water absorption from soil
  - osmosis
  - aquaporins
- Mineral absorption
  - active transport
  - proton pumps
    - active transport of H^+

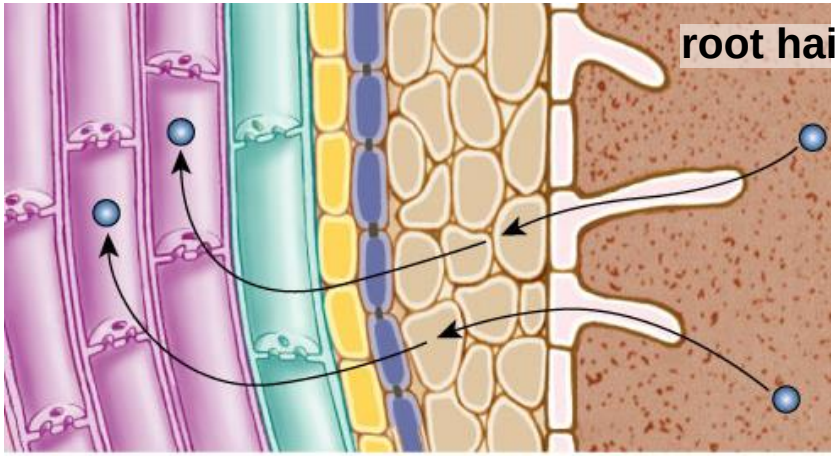






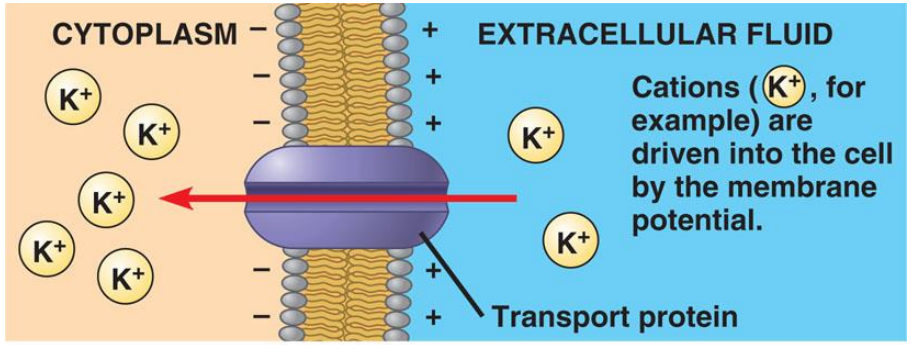


proton pumps

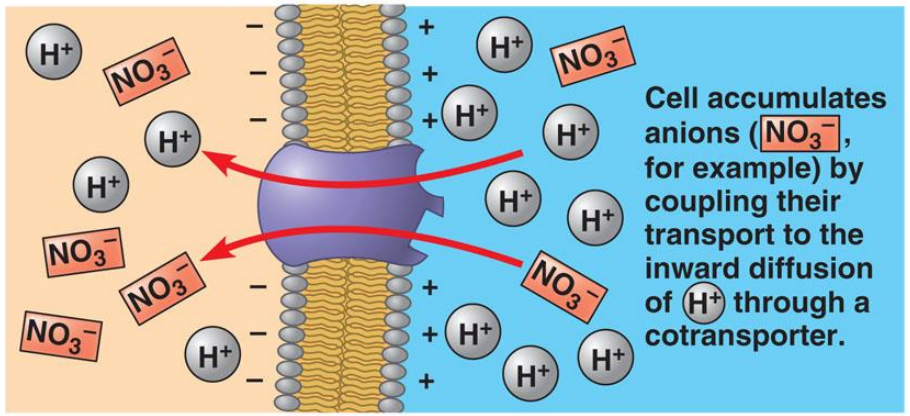


Mineral absorption

- **Proton pumps**
  - active transport of H^+ ions out of cell
    - chemiosmosis
    - H^+ gradient
  - creates membrane potential
    - difference in charge
    - drives cation uptake
  - creates gradient
    - cotransport of other solutes against their gradient



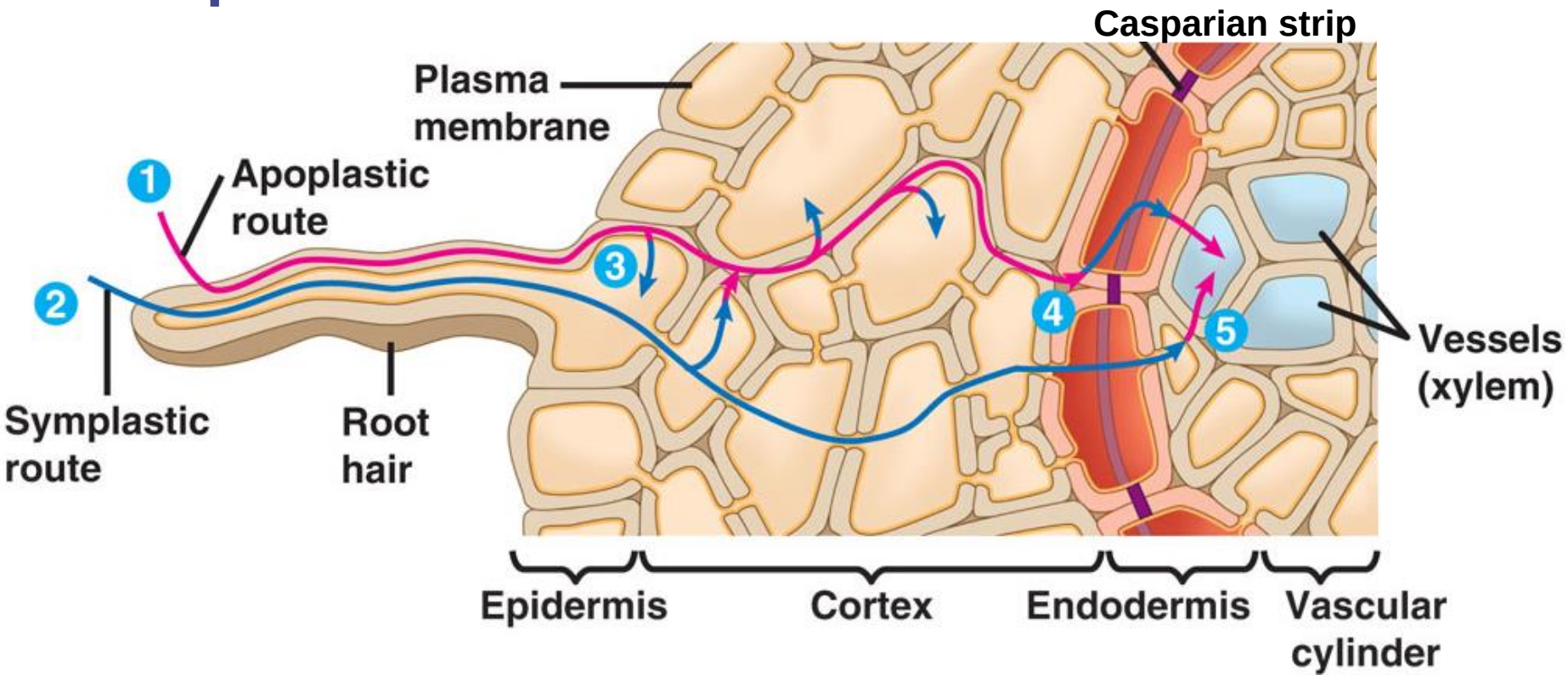
(a) Membrane potential and cation uptake



(b) Cotransport of anions

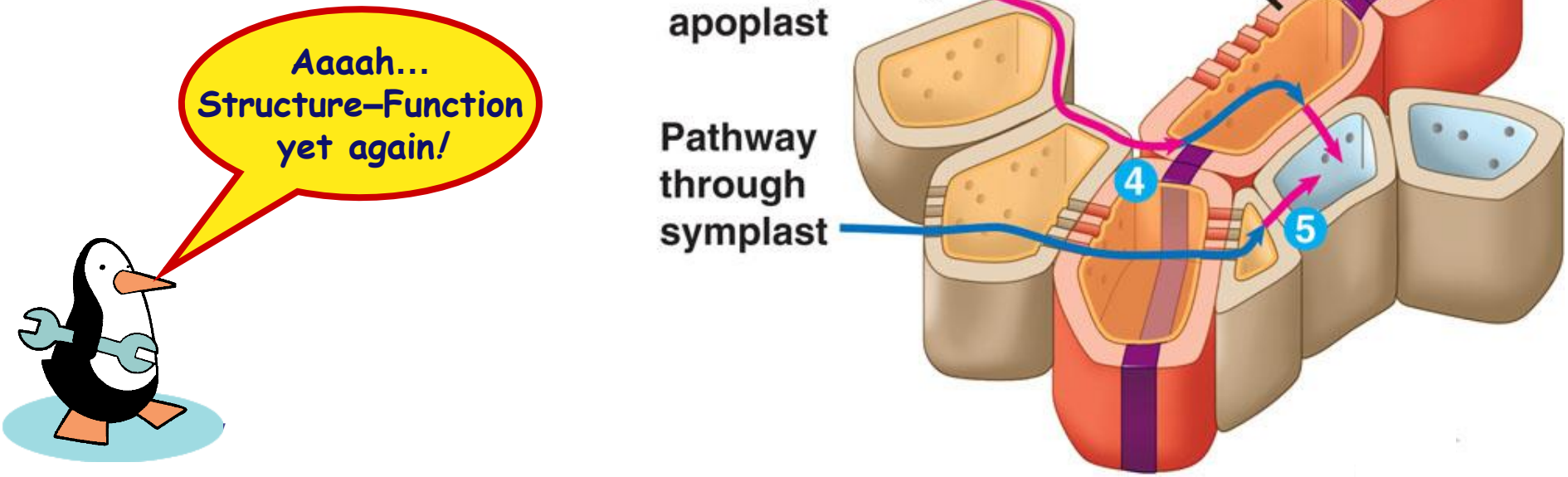
Water flow through root

- **Porous cell wall**
  - water can flow through cell wall route & not enter cells
  - plant needs to force water into cells

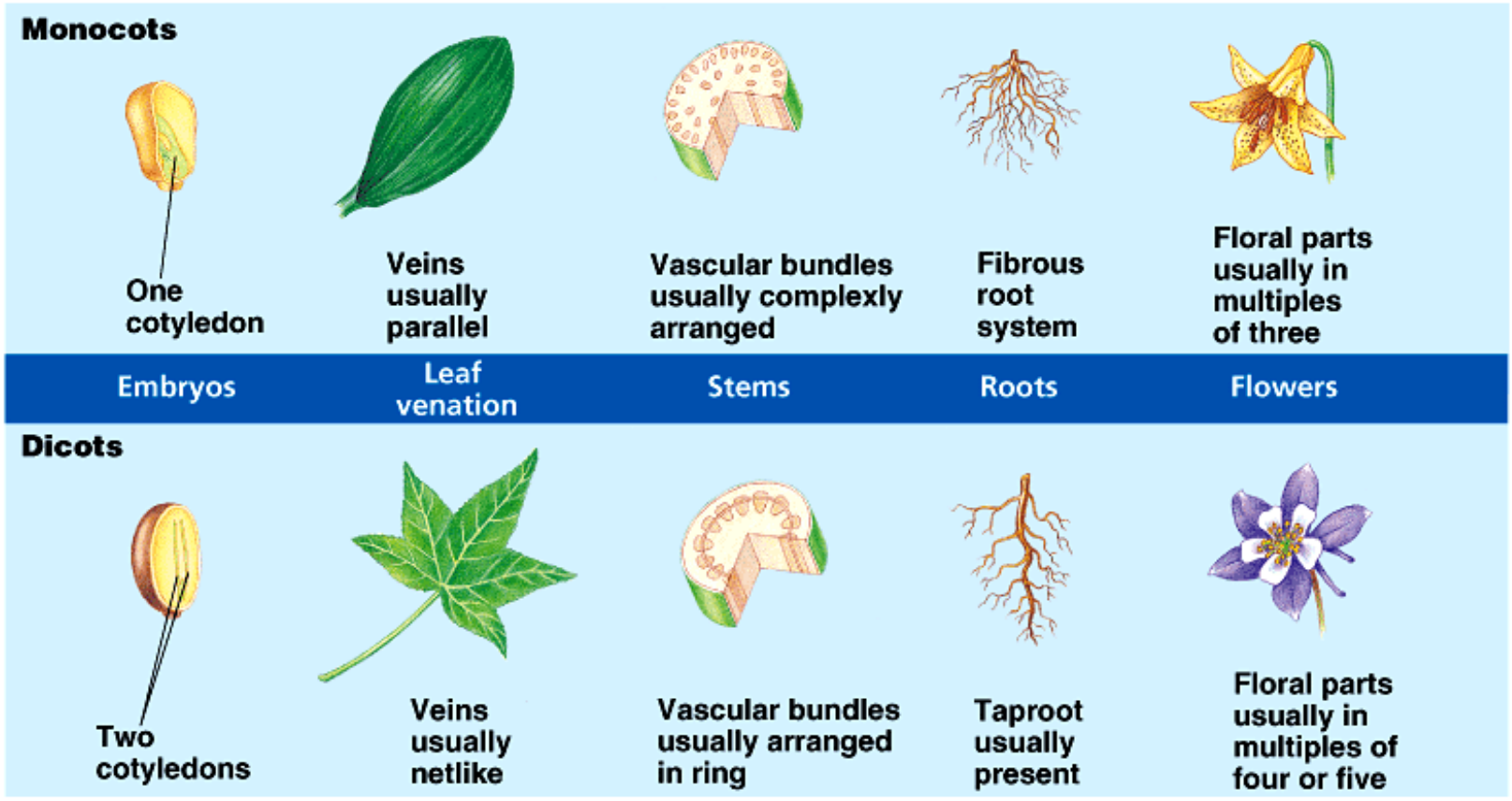


Controlling the route of water in root

- **Endodermis**
  - cell layer surrounding vascular cylinder of root
  - lined with impermeable **Casparian strip**
  - forces fluid through selective cell membrane
    - filtered & forced into xylem cells

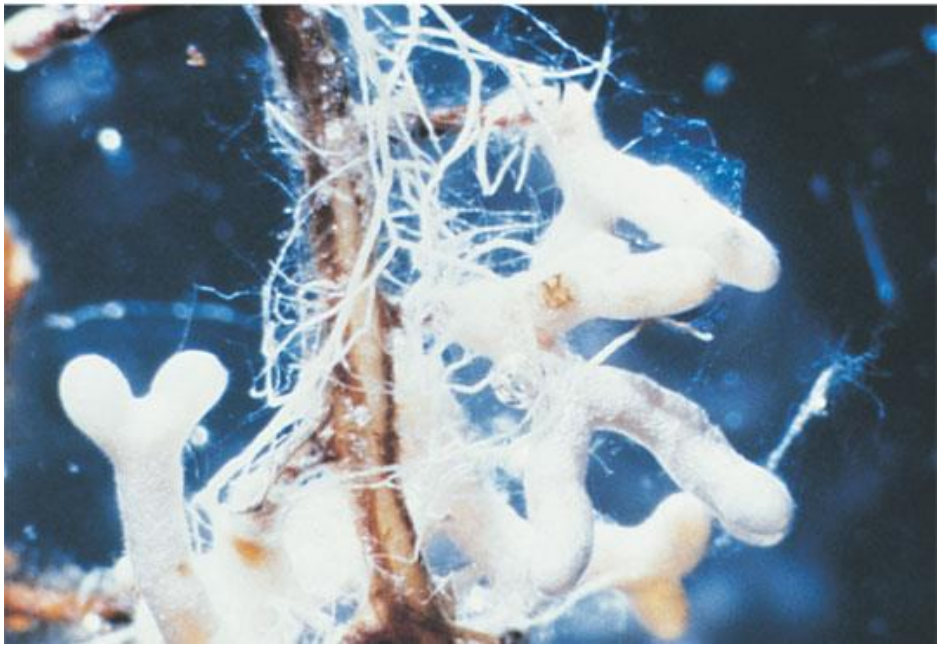


Monocots vs Dicots

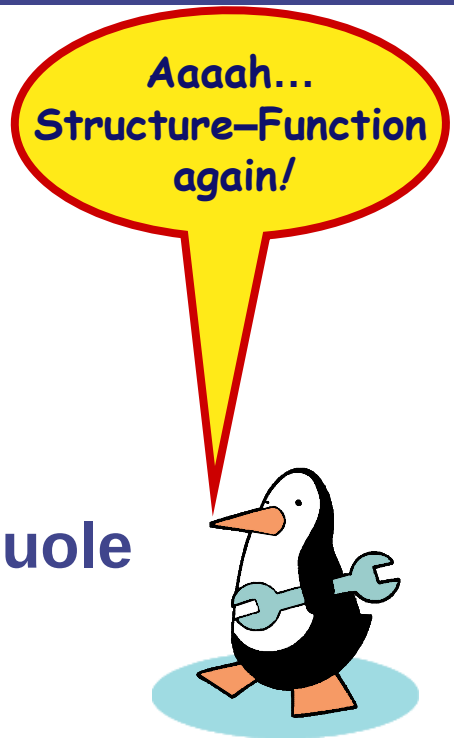


Mycorrhizae increase absorption

- **Symbiotic relationship between fungi & plant**
  - **The fungi colonize the root system of a host plant, providing increased water and nutrient absorption capabilities**
  - **The plant provides the fungus with carbohydrates formed from photosynthesis.**



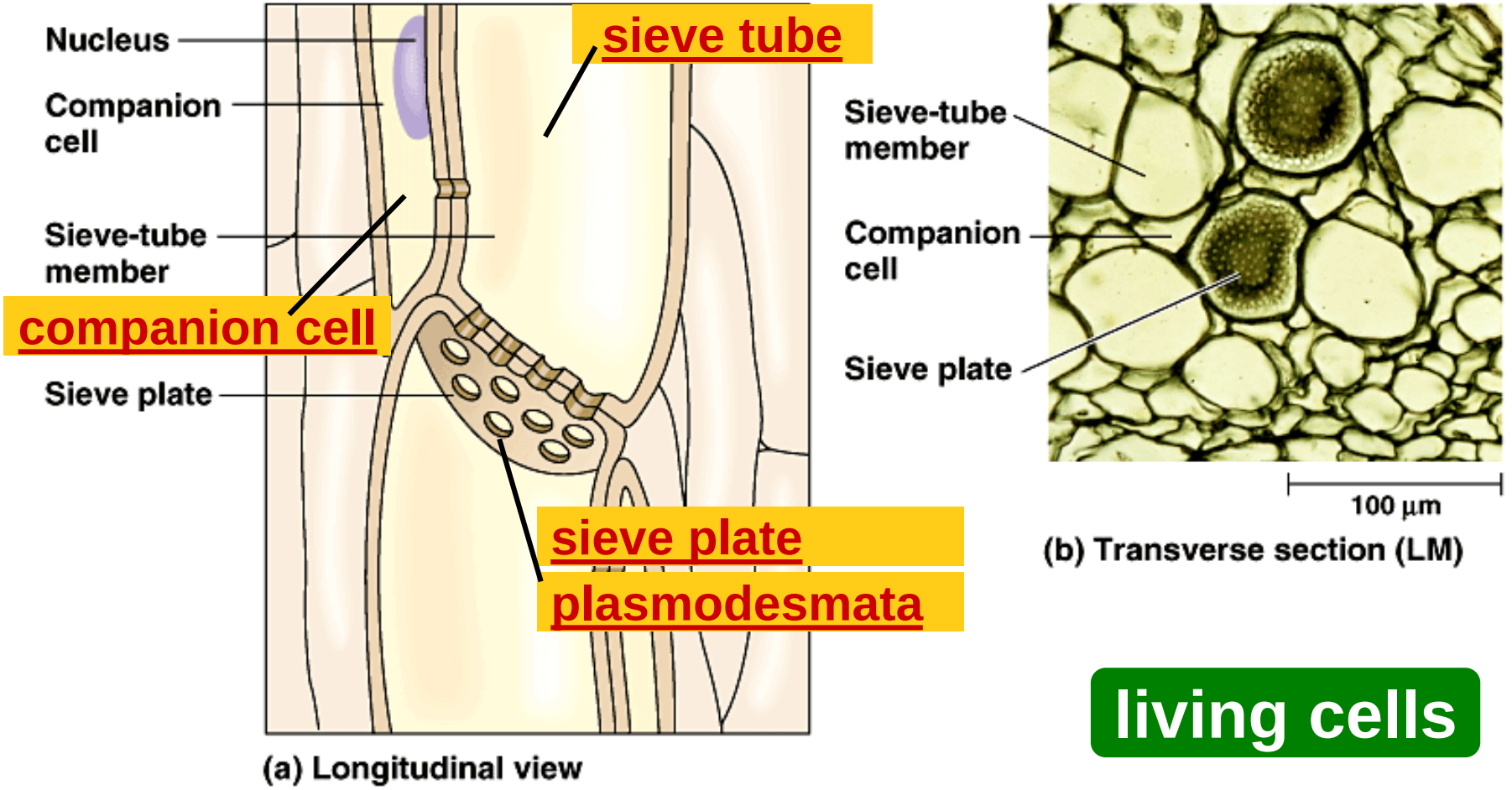
Phloem



- Living cells at functional maturity
  - cell membrane, cytoplasm
    - control of diffusion
  - lose their nucleus, ribosomes & vacuole
    - more room for specialized transport of liquid food (sucrose)
- Cells
  - sieve tubes
    - sieve plates — end walls — have pores to facilitate flow of fluid between cells
  - companion cells
    - nucleated cells connected to the sieve-tube
    - help sieve tubes

Phloem: food-conducting cells

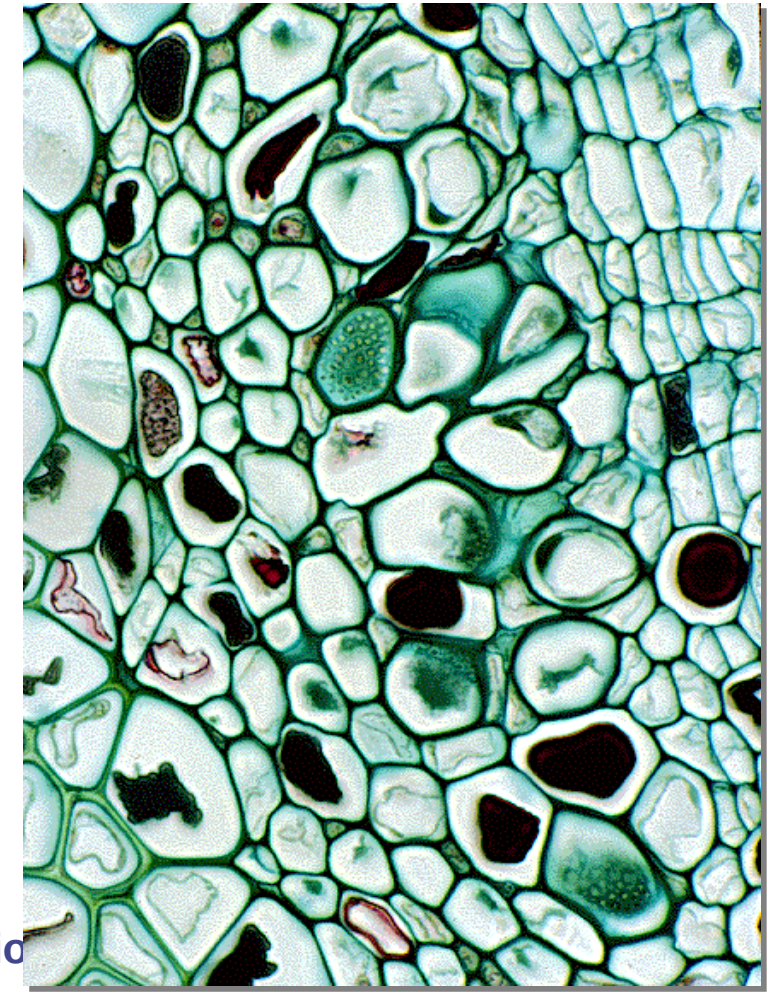
- carry sugars & nutrients throughout plant

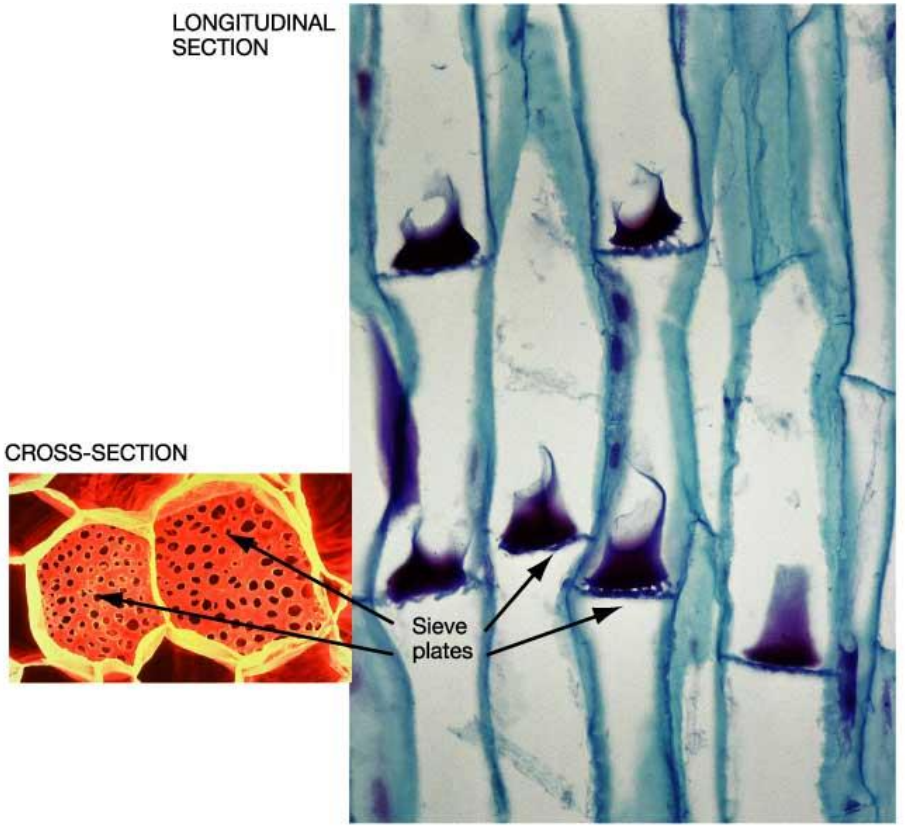


living cells

Phloem: food-conducting cells

- sieve tube elements & companion cells

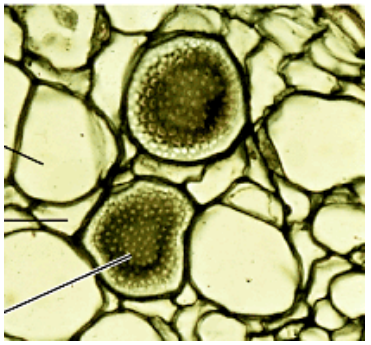




Pressure flow:
http://bcs.whfreeman.com/thelifewire/content/chp36/36020.html

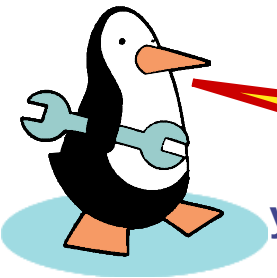
Transport of sugars in phloem

- **Loading of sucrose into phloem**
  - **flow through cells via plasmodesmata**
  - **proton pumps**
    - **cotransport of sucrose into cells down proton gradient**



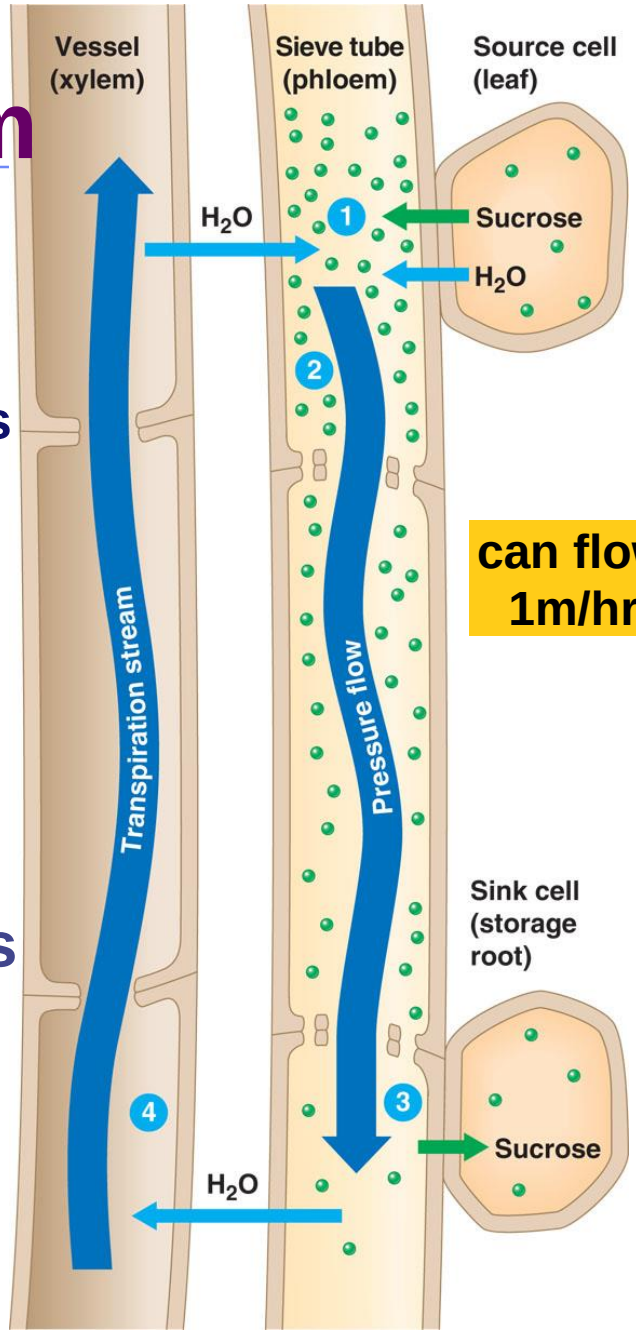
Pressure flow in phloem

- Mass flow hypothesis
  - "source to sink" flow
    - direction of transport in phloem is dependent on plant's needs
  - phloem loading
    - active transport of sucrose into phloem
    - increased sucrose concentration decreases H_2O potential
  - water flows in from xylem cells
    - increase in pressure due to increase in H_2O causes flow



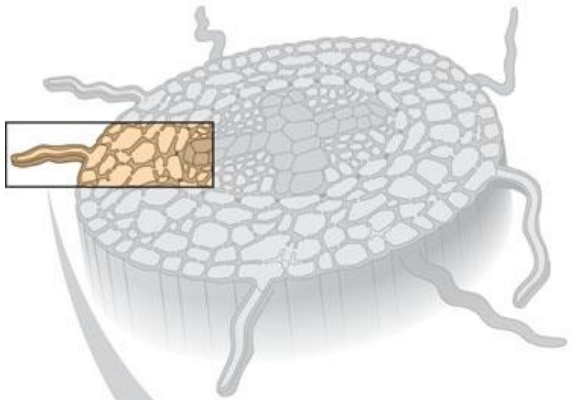
On a plant…
What's a source…What's a sink?

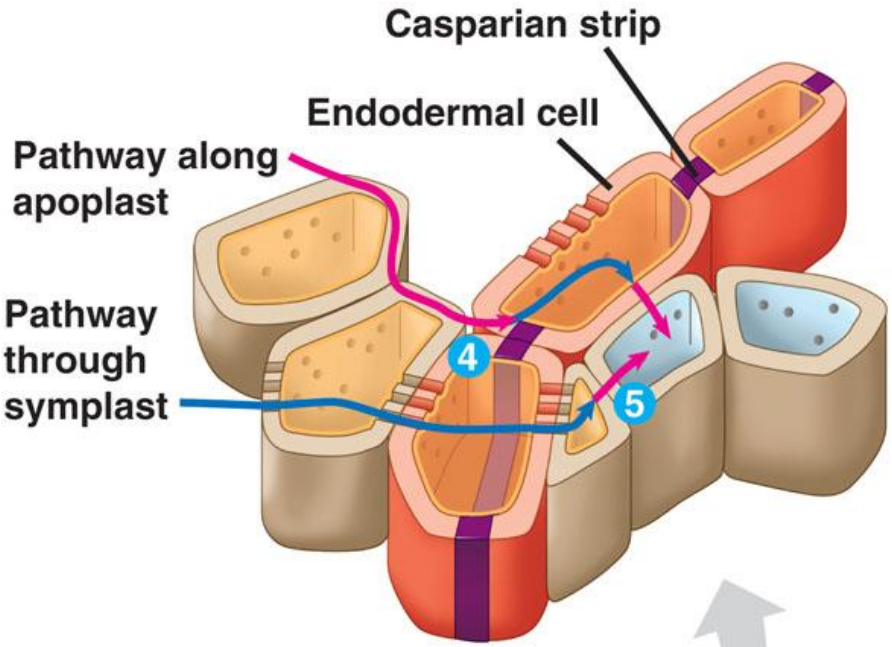
y

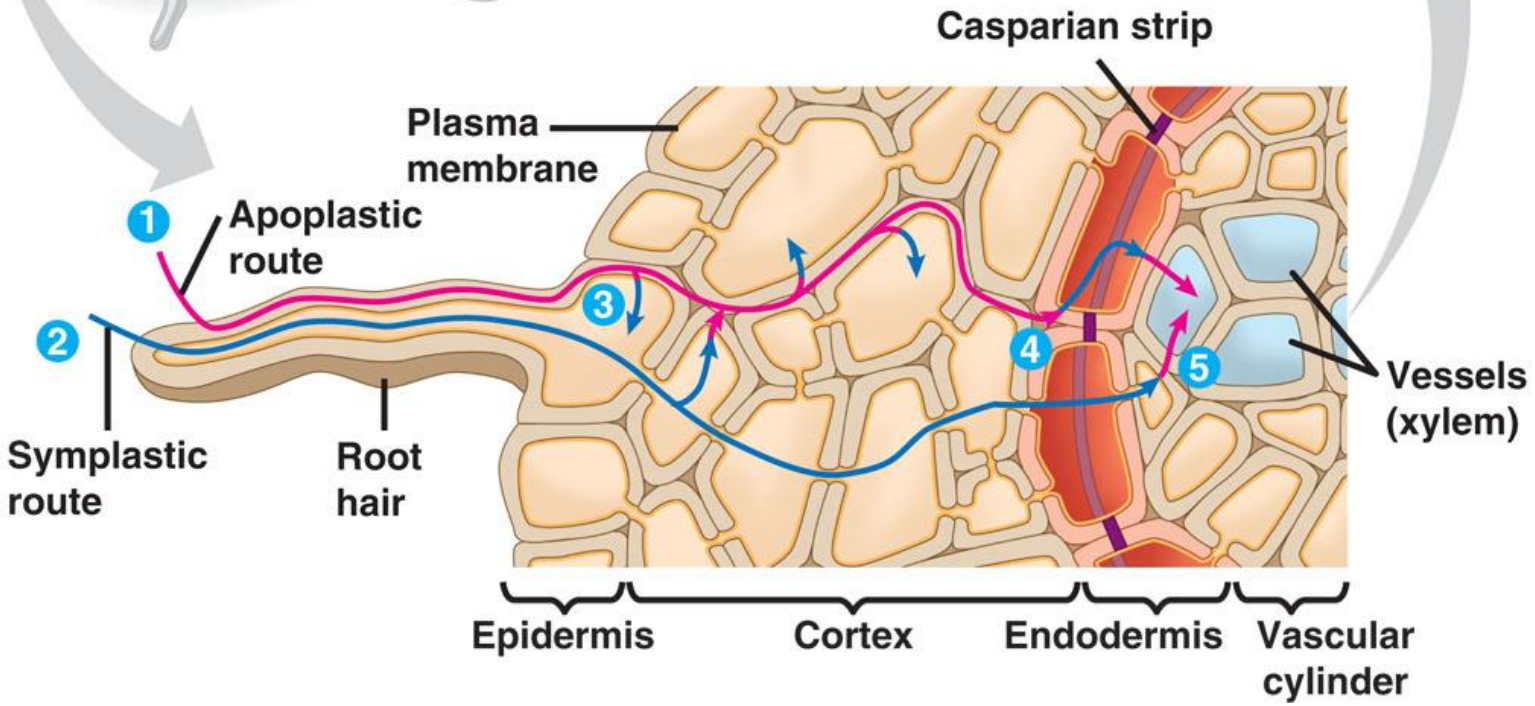


can flow 1m/hr

Endodermis & Casparian strip



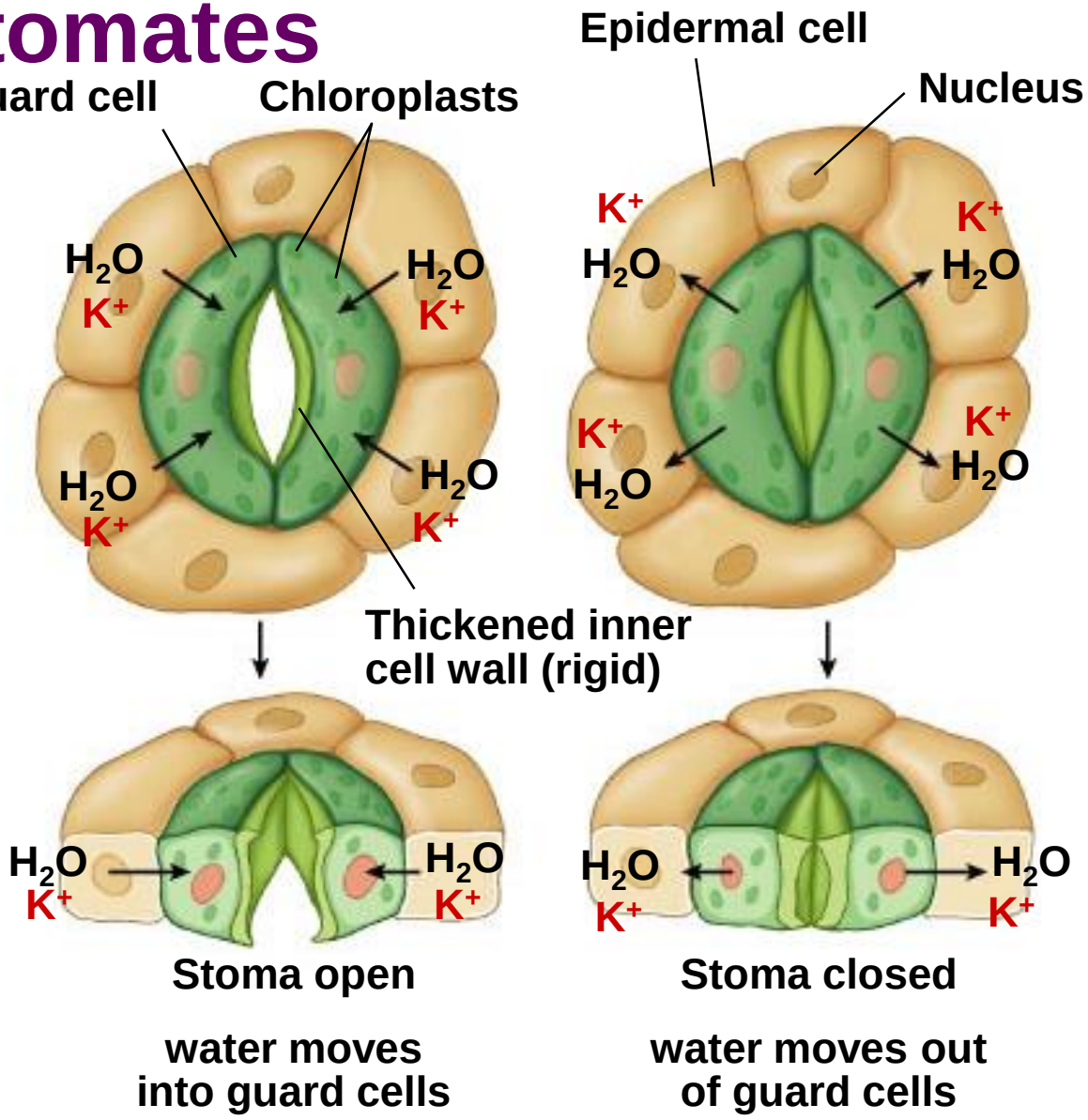




Stomata:
http://www.youtube.com/watch?v=IlmgFYmbAUg&feature=related

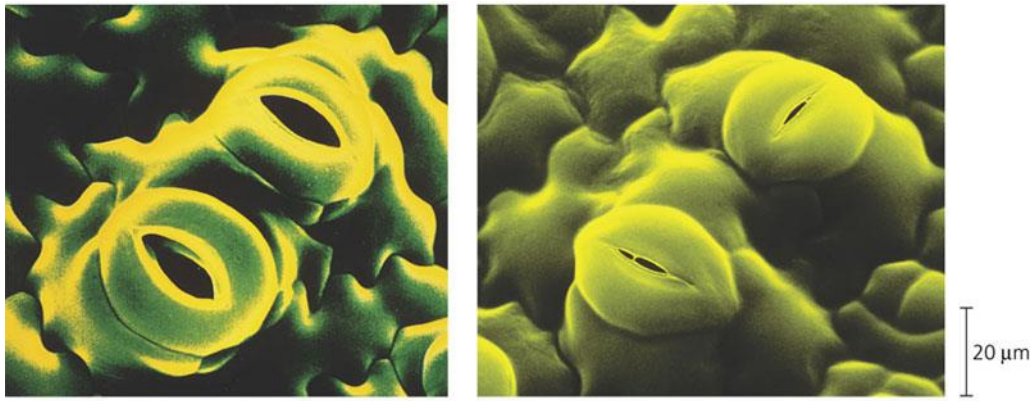
Control of Stomates

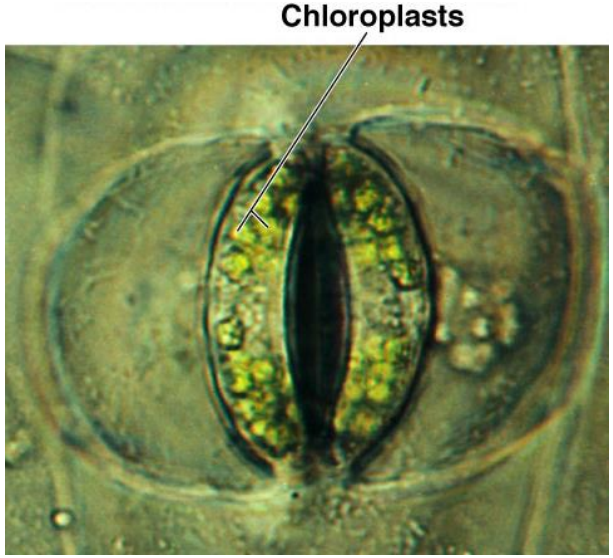
- Uptake of K^+ ions by guard cells
  - proton pumps
  - water enters by osmosis
  - guard cells become turgid
- Loss of K^+ ions by guard cells
  - water leaves by osmosis
  - guard cells become flaccid



Control of transpiration

- **Balancing stomate function**
  - **always a compromise between photosynthesis & transpiration**
    - **leaf may transpire more than its weight in water in a day…this loss must be balanced with plant's need for CO_2 for photosynthesis**

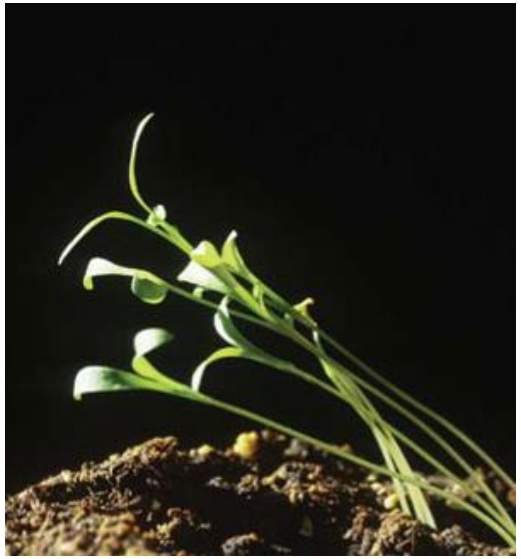




Plant Growth

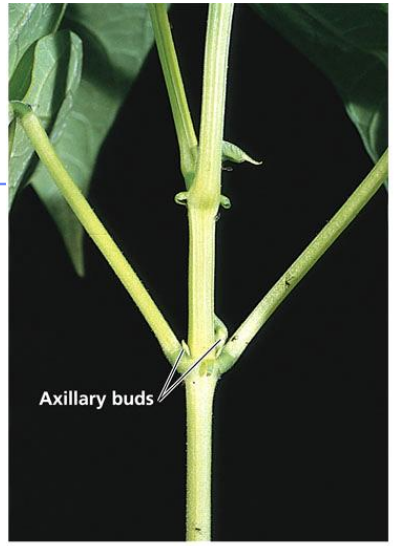
Plant hormones

- auxin
- gibberellins
- abscisic acid
- ethylene
- and more…



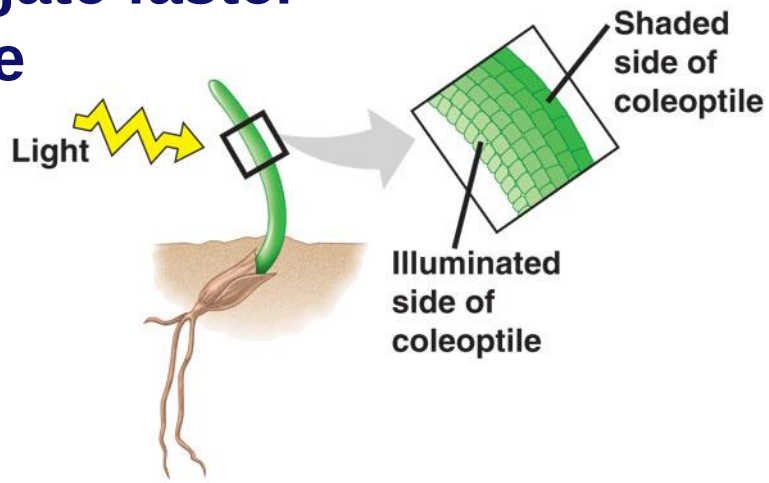
Auxin (IAA)

- Effects
  - controls cell division & differentiation
  - phototropism
    - growth towards light
    - asymmetrical distribution of auxin
    - cells on darker side elongate faster than cells on brighter side
  - apical dominance



(a) Intact plant

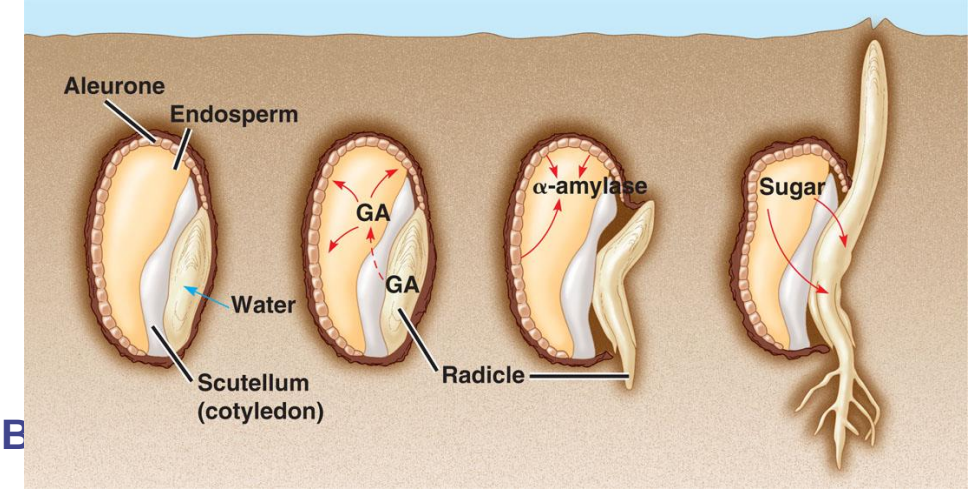
(b) Plant with apical bud removed



Gibberellins

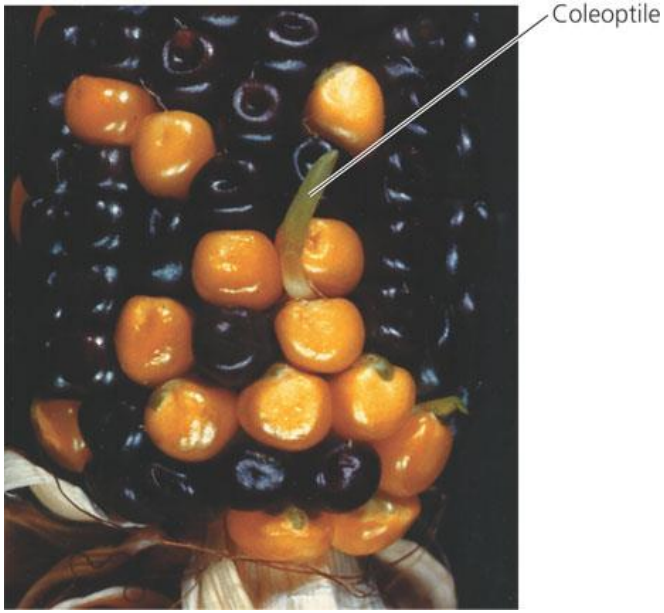
- **Family of hormones**
  - over 100 different **gibberellins** identified
- **Effects**
  - stem elongation
  - fruit growth
  - seed germination

plump grapes in grocery stores have been treated with gibberellin hormones while on the vine



Abscisic acid (ABA)

- **Effects**
  - slows growth
  - seed dormancy
    - high concentrations of abscisic acid
      - germination only after ABA is inactivated or leeched out
    - survival value: seed will germinate only under optimal conditions
      - light, temperature, moisture



Ethylene

- Hormone gas released by plant cells
- Effects
  - fruit ripening
  - leaf drop
    - like in Autumn
    - apoptosis

Fruit ripening

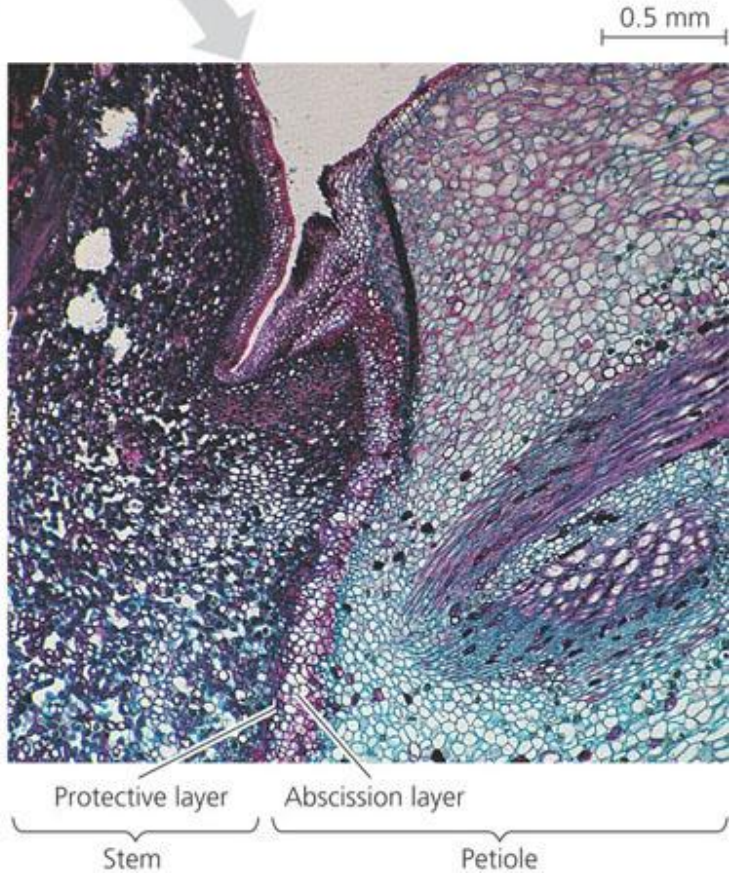
- **Adaptation**
  - hard, tart fruit protects developing seed from herbivores
  - ripe, sweet, soft fruit attracts animals to disperse seed

- **Mechanism**
  - triggers ripening process
    - breakdown of cell wall
      - softening
    - conversion of starch to sugar
      - sweetening
  - positive feedback system
    - ethylene triggers ripening
    - ripening stimulates more ethylene production

Apoptosis in plants

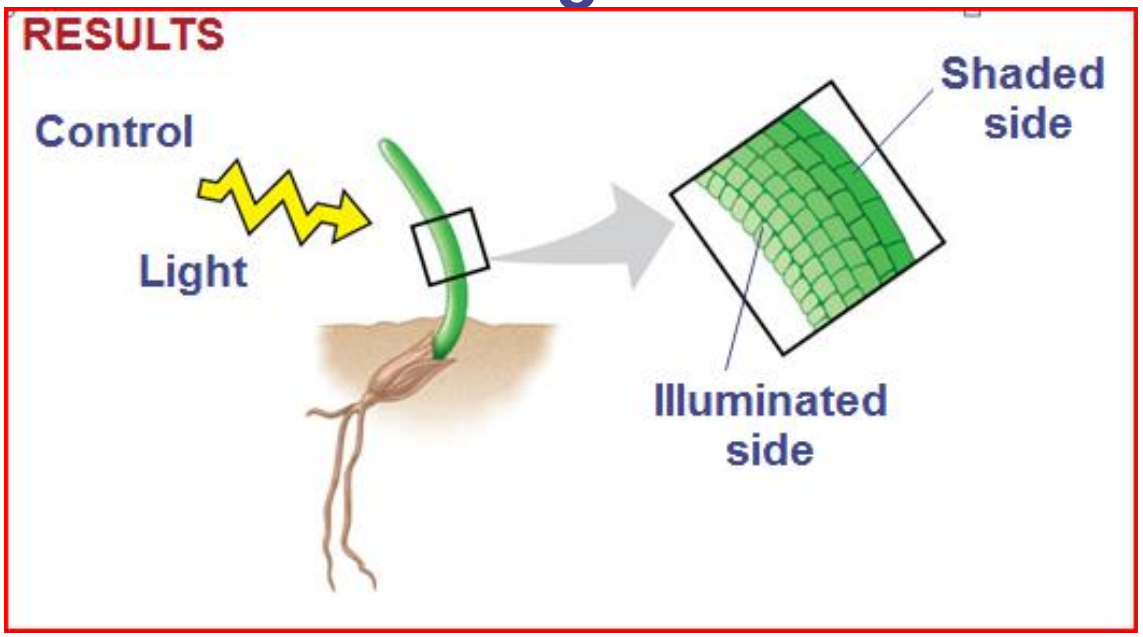
- Many events in plants involve apoptosis
  - response to hormones
    - ethylene
    - auxin
  - death of annual plant after flowering
    - senescence
  - differentiation of xylem vessels
    - loss of cytoplasm
  - shedding of autumn leaves

What is the evolutionary advantage of loss of leaves in autumn?

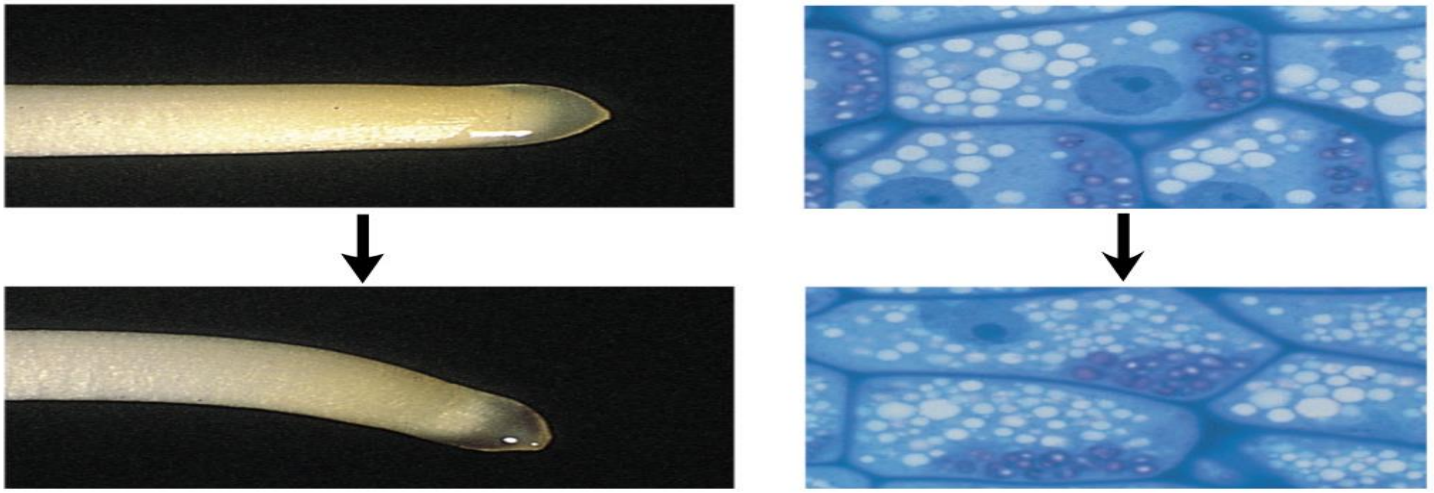


Responses in Plants

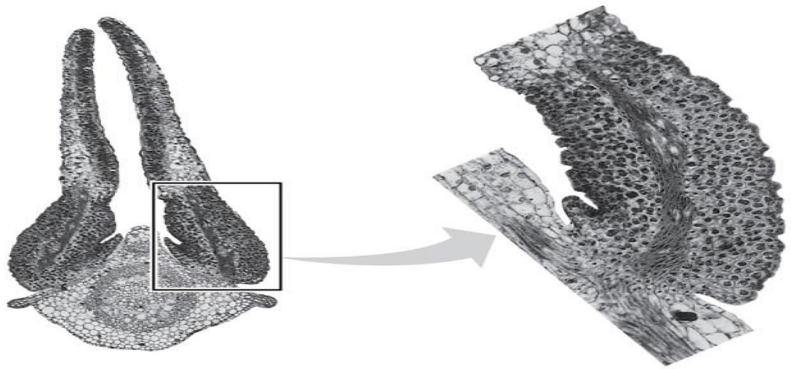
- Phototropism (Auxin involved)
  - Auxin will accumulate in the cells that are NOT in the light causing the plant to bend toward the light.



- **Gravitropism (involves Auxin)**
  - **Amyloplasts (starch-containing organelles) sink to the bottom of the cell and auxin builds up causing growth**



- **Thigmotropism- a response to touch**

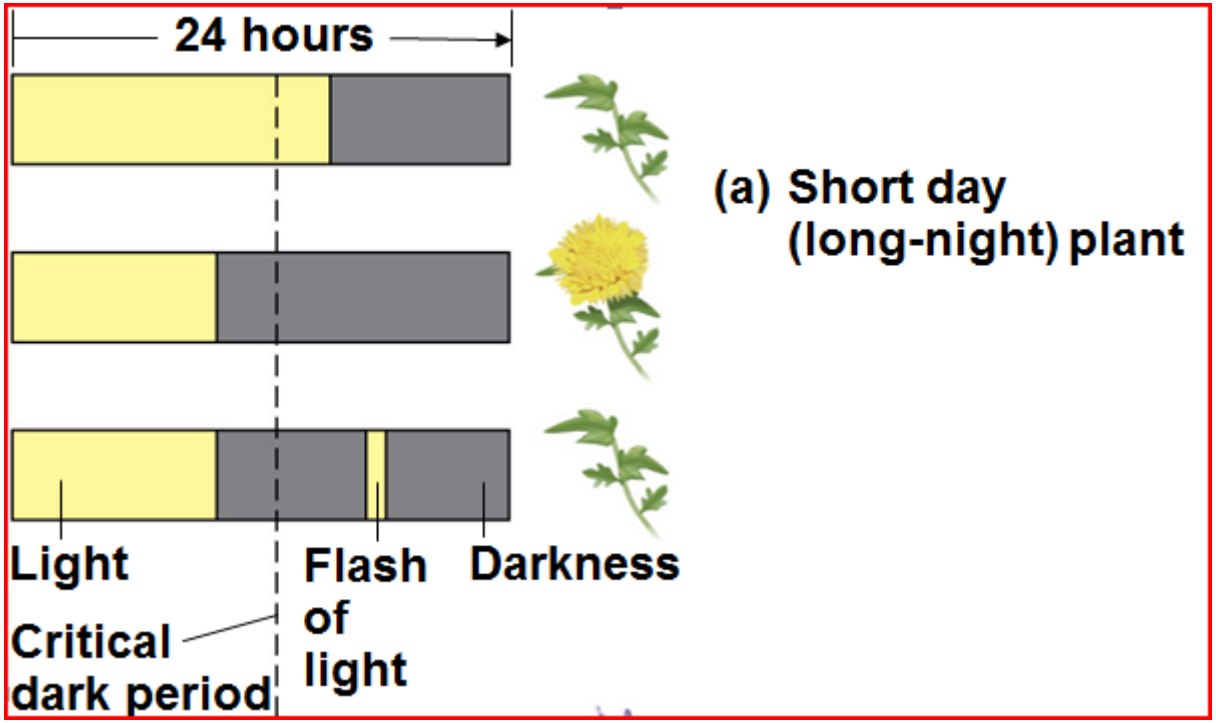


Photoperiodism

- A response of plants due to changes in the photoperiod or relative length of daylight and night.

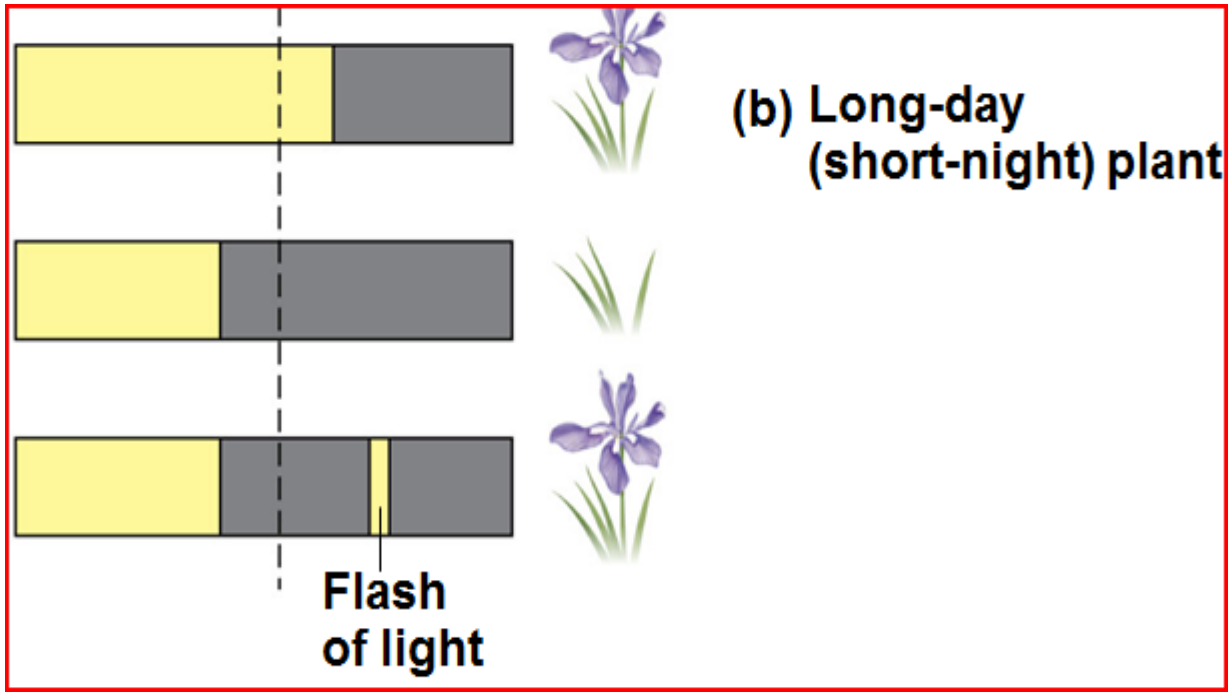
Short Day Plants (aka Long Night)

- Plants that flower when a light period is shorter than a critical length.



Long Day Plants (aka Short Night)

- Plants that flower when a light period is longer than a certain number of hours

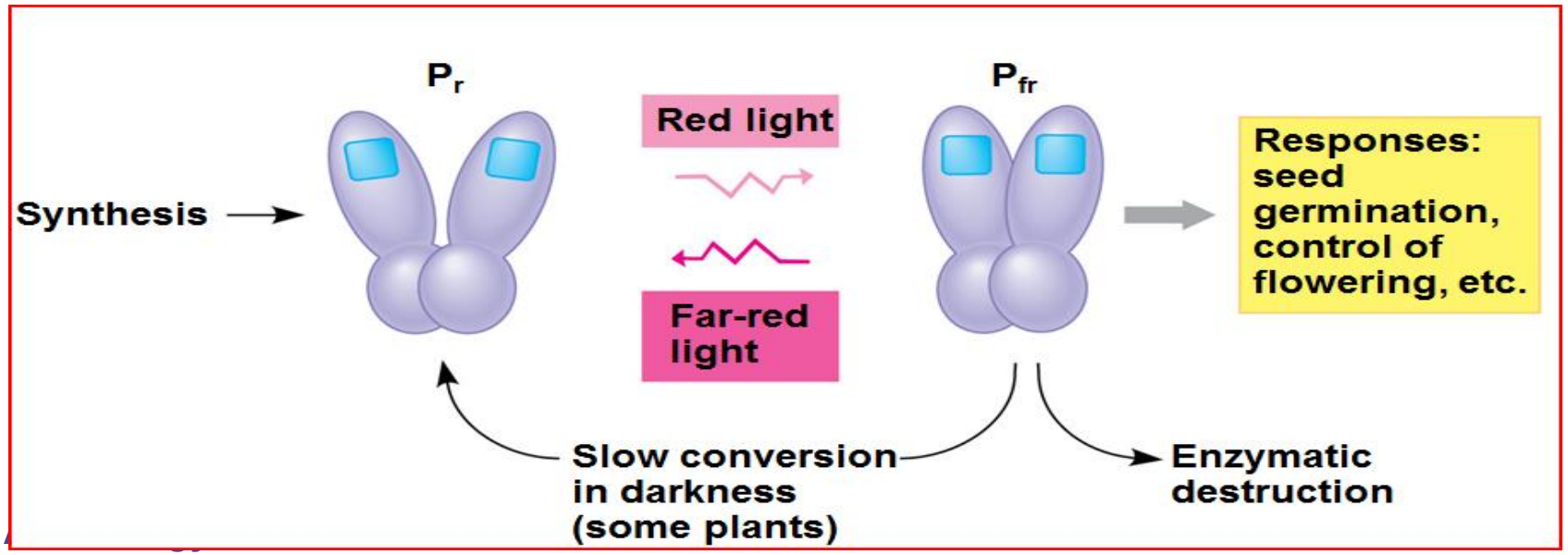


Day- Neutral Plants

- Flowering is controlled by plant maturity, NOT photoperiod
  - Temperature
  - Water
  - Other nutrients

Circadian Rhythms

- **Phytochrome- light absorbing protein**
  - When Pr is exposed to red light (sunlight) it is converted to Pfr (active form)
  - When Pfr is exposed to far-red light it is converted back to Pr



Any Questions??