BIOL 227 - FINAL

WEEK 1: PROCARYOTES

Events of Earth's history

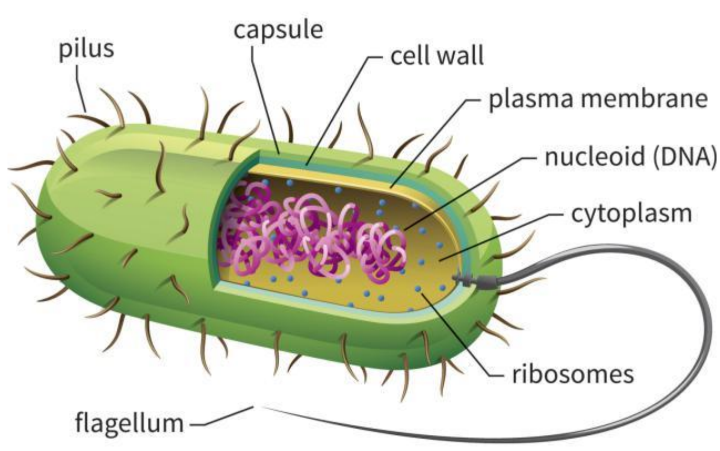
- Hadean (4600-3850 mya)
  - 4600 mya: Origin of Earth
  - 3850 mya: Oldest rocks on Earth's surface
- Archean (3850-2500 mya)
  - 3500 mya: Oldest fossil of cells
  - 2700 mya: Concentration of atmospheric oxygen begins to increase
- Proterozoic (2500-542 mya)
  - Edicarian (2500-542) Oldest fossils of eukaryotic cells & origin of soft bodied invertebrate animals
  - Edicacaran biota (565)
- Phanerozoic (542-0.001 mya)
  - Paleozoic (542-251)
    - Diversity in animal phyla (Cambrian explosion), Colonization of land, Diversification of early vascular plants, Diversification of bony fishes & first tetrapods and insects, First seed plants & origin of reptiles (Amphibians dominant). Extinction of many marine and terrestrial organisms.
    - Cambrian Explosion (535-525)
    - Early land animals (365)
  - Mesozoic (251-65.5)
    - Gymnosperms dominate, origin of mammals. Dinosaurs become extinct at end of period.
  - Cenozoic (65.5-0.01)
    - Origins of many primate groups, earliest direct human ancestors. Appearance of bipedal human ancestors. Ice ages; origin of genus Homo.

- Orthologous genes are homologous genes found in different species as a result of speciation
  - Distantly related species can have orthologous genes.
- Paralogous genes are homologous genes within a species that result from gene duplication; such genes can diverge and potentially take on new functions.

WEEK 2: BACTERIA

Structural and functional adaptations that contribute to prokaryotic success

- Pilus: Hair like appendage that helps adhere to other cells or substrates. Also have a sex pilus that helps conjugation
- Capsule: Sticky layer of polysaccharide
- Internal organisation: No nucleus or other membrane bounded organelles.
- Circular chromosome: Often accompanied by smaller rings called plasmids.



Prokaryotes reproduce quickly by binary fission, some form endospores. Genetic diversity arises form transformation, conjugation or transduction. Nutritional diversity is great, they perform all four modes (photoautotrophy, chemoautotrophy, photoheterotrophy &

chemoheterotrophy). Some are obligate aerobes (require O_2), obligate anaerobes or facultative anaerobes. Some can convert atmospheric nitrogen to ammonia (nitrogen fixation). Some bacteria can metabolically cooperate by forming a biofilm.

Archea and bacteria have different membrane lipids, both lack membrane-enclosed organelles but archea does not have peptidoglycan in cell wall.

- Proteobacteria: Very diverse, gram-negative.
  - Alpha: Many closely associated with eukaryotic. Scientists hypothesized that mitochondria evolved from aerobic alpha-proteobacteria through endosymbiosis.
    - Rhizobium & Agrobacterium
  - Beta: Nutritionally diverse
    - Nitrosomonas that recycle nitrogen.
  - Gamma: Autotrophic and heterotrophic pathogens
    - Salmonella & E. coli
  - Delta: Slime secreting myxobacteria
  - Epsilon: Pathogenic to humans or other animals
    - Campylobacter & H. pylori
- Chlamydias: Gram-negative. Parasites can survive only within animal cells because depends on host for basic ressources, such as ATP. Gram-negative walls unusual because lack peptidoglycan.
- Spirochetes: Helical heterotrophs with flagellum-like filaments. Some are free-living other parasitic.
- Cyanobacteria: Photoautotrophs that have chloroplasts.
- Gram-Positive Bacteria: Appear purple after Gram stain, because of thick peptidoglycan layer in bacterial cell wall.

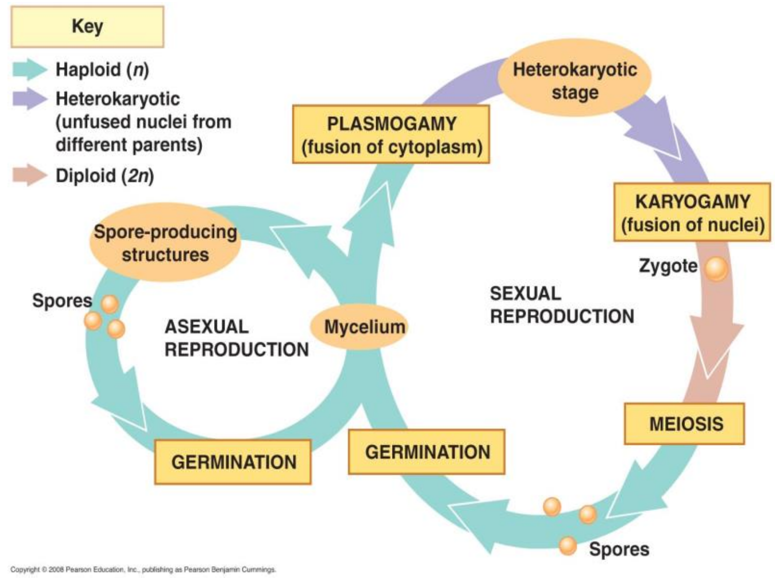
<u>WEEK 3: PROTISTS</u>

- Excavata: Groove on one side of body.
  - Diplomonads & Parabasalids: Modified mitochondria
  - Euglenozoa: Spiral or crystalline rod inside flagella
- Chromatoalveolata: Group may have originated by an ancient secondary endosymbiosis event. Includes photosynthetic organisms.
  - Alveolates: Membrane-bound sacs (alveoli) beneath plasma-membrane
    - Dinoflagellates, Apicomplexans, Cilliates,
  - Stramenopiles: 2 flagella, one hairy and one smooth flagella
    - Diatoms, Golden Algae, Brown Algae & Oomycetes
- Rhizaria: Contains many species of amoebas, most of which have thread-like pseudopodias, used for movement and prey capture.
  - Cercozoans: Ameobas and flagellated protists with threadlike pseudopodia
  - Forams: Amoebas with threadlike pseudopodia and porous shell
  - Radiolarians: Amoebas with threadlike pseudopodia radiating from central body
- Archaeplastida: Includes red algae, green algae and land plants. Key photosynthetic species, multicellular or unicellular. Land plants not protista.
  - Red algae: Phycoerythrin, accessory pigment.
  - Green algae (Chlorophytes & Charophytes): Plant-like chloroplasts
- Unikonta: Includes amoebas that have lobe- or tube-shaped pseudopodia, as well as animals, and non-amoeba protists that are closely related to animals or fungi (Opisthokonts).
  - Amoebozoans: Amoebas with lobe-shaped pseudopodia

  - Slime moulds, Gymnamoebas & Entamoebas,
- Opisthokonts (Kingdom Fungi): Nucleariids & Chanoflagellates

WEEK 4: FUNGI

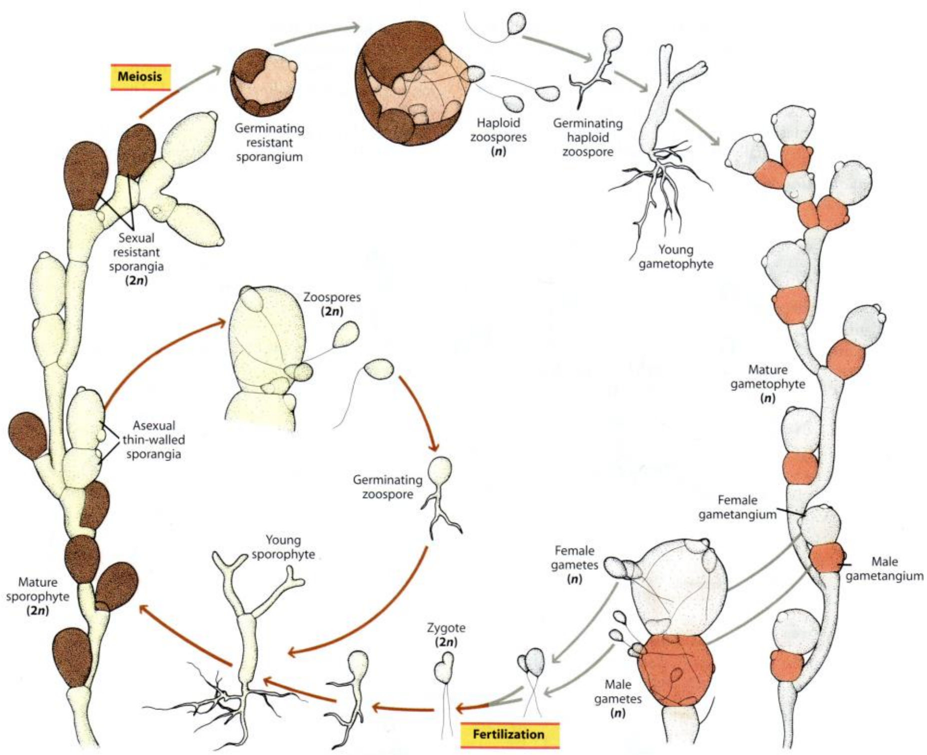
Opisthokonts: Heterotrophs that feed by absorption, cell-walls of chitin. Have posterior flagellum & flat mitochondrial christae. Many fungi secrete enzymes that break down complex moleculesé



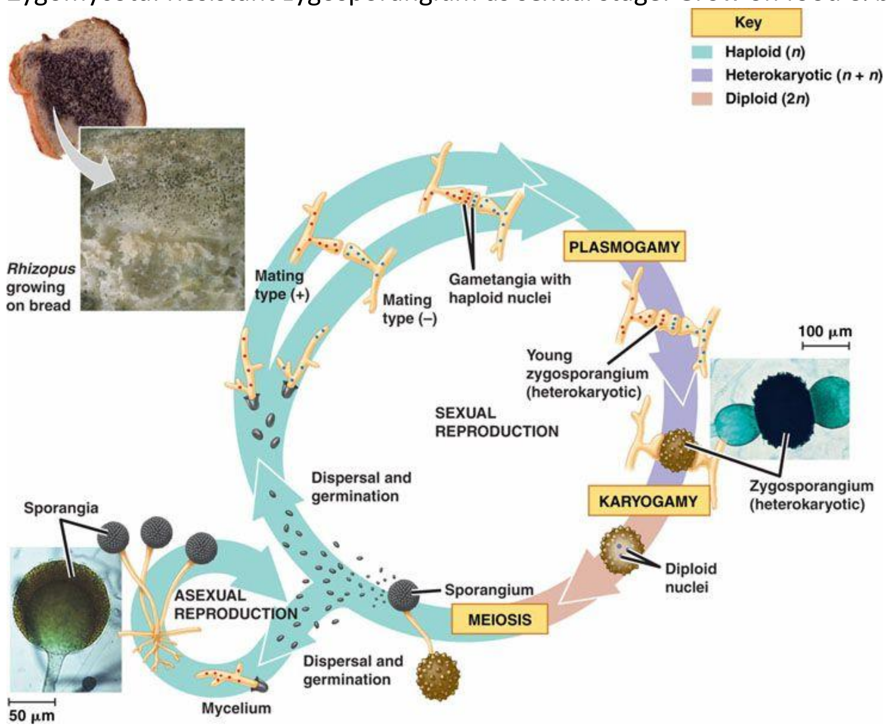
Most fungi grow as thin, multicellular filaments called hyphae; some others grow as single-celled (yeasts). In their multicellular form, fungi consists of mycelia networks of branched hyphae.

Sexual cycle involves cytoplasmic fusion (plasmogamy) and nuclear fusion (karyogamy). The diploid cells resulting from karyogamy are short-lived and undergo meiosis, producing haploid spores.

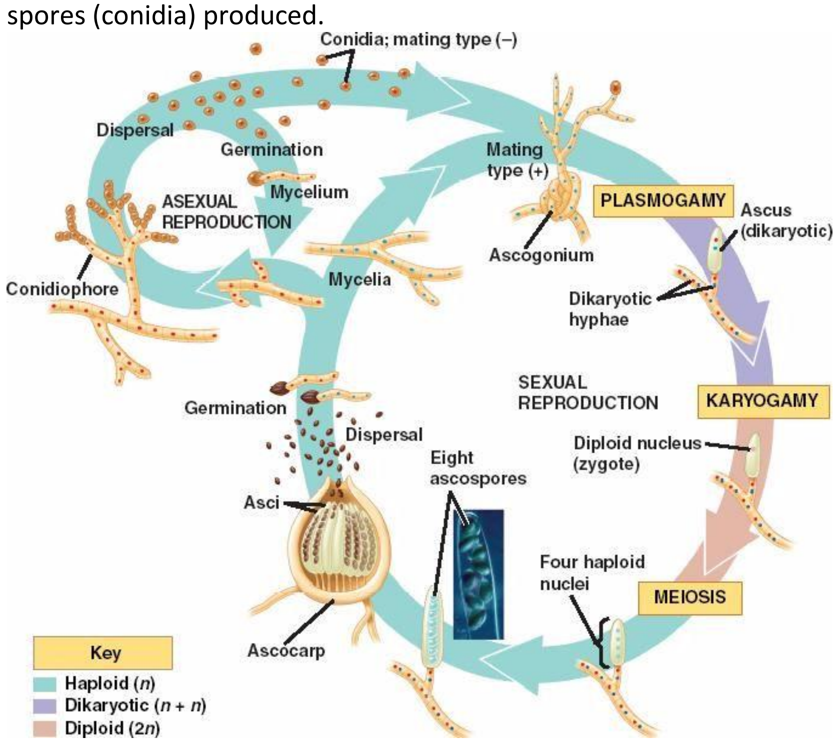
- Chytridiomycota: Flagellated spore (Zoospore)



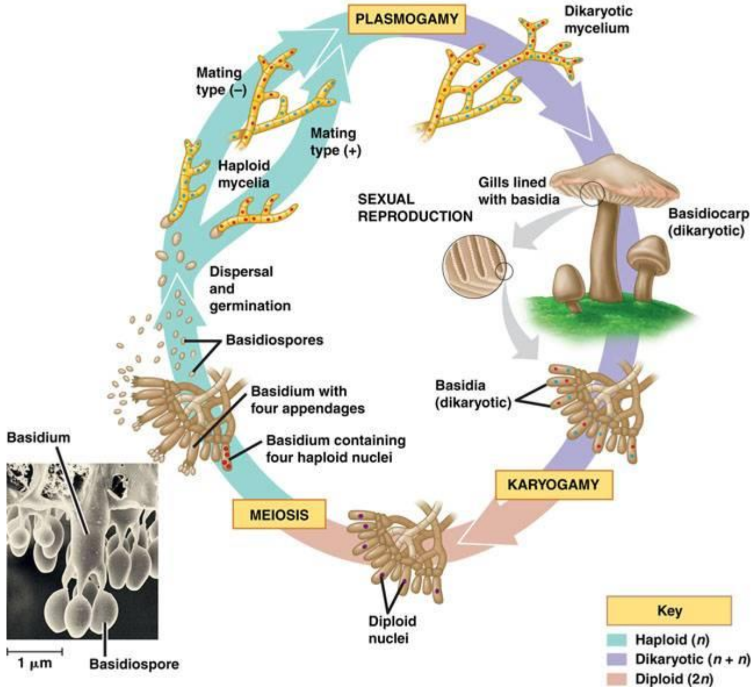
- Zygomycota: Resistant zygosporangium as sexual stage. Grow on food & bread.



- Glomeromycota: Arbuscular mycorrhizae formed with plants
- Ascomycota: Sexual spores (ascopores) borne internally in sacs called asci; vast numbers of asexual spores (conidia) produced.



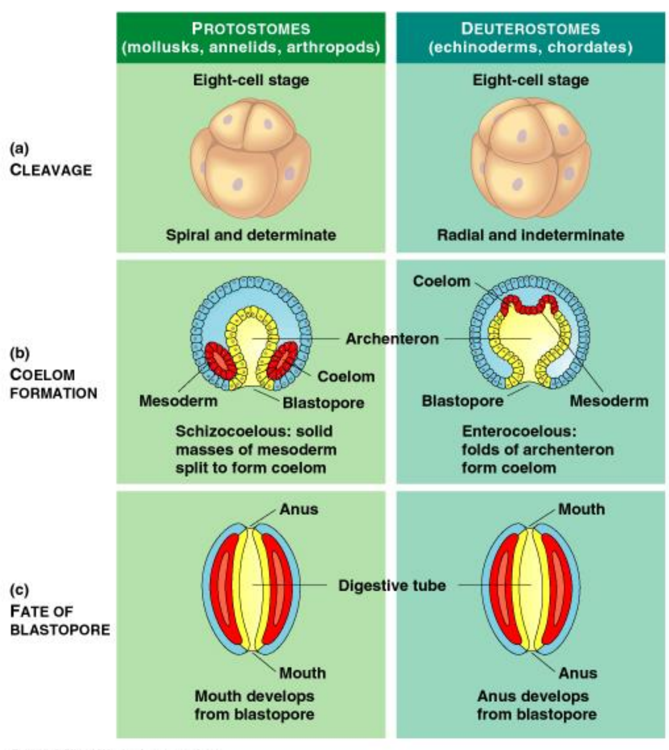
- Basidiomycota: Elaborate fruiting body (basidiocarp) containing many basidia that produce sexual spores



Note about fungi: Key metabolic genes in yeast are more similar to the domain Bacteria than Archea, possibly indicating the importance of horizontal gene transfer, possibly indicating more than a single Eukaryotic common ancestor.

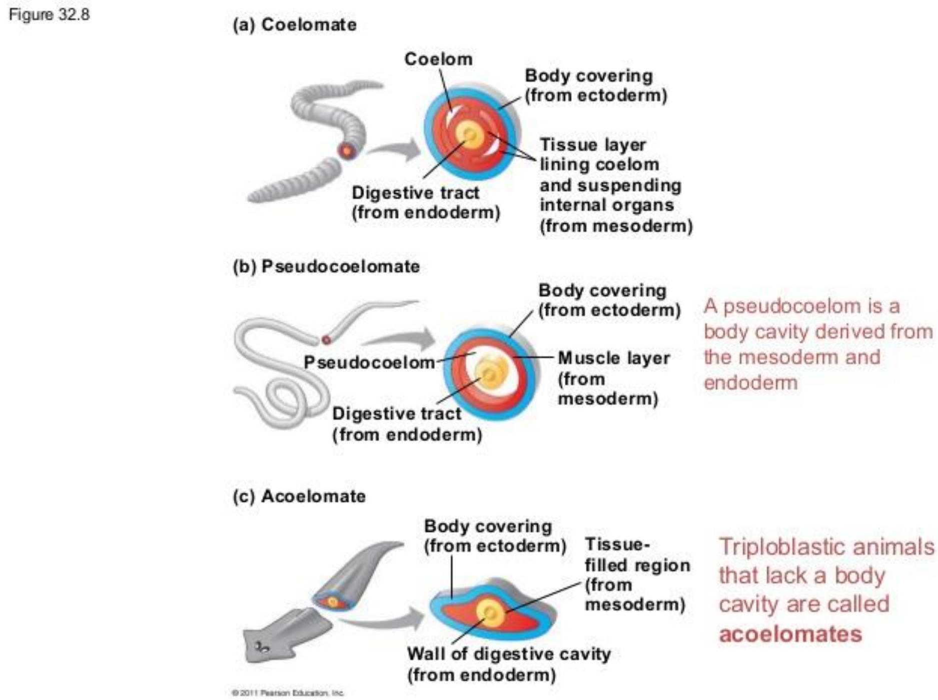
WEEK 5: ANIMAL DIVERSITY

Animals are multicellular, heterotrophic eukaryotes with tissues that develop from embryonic layers.

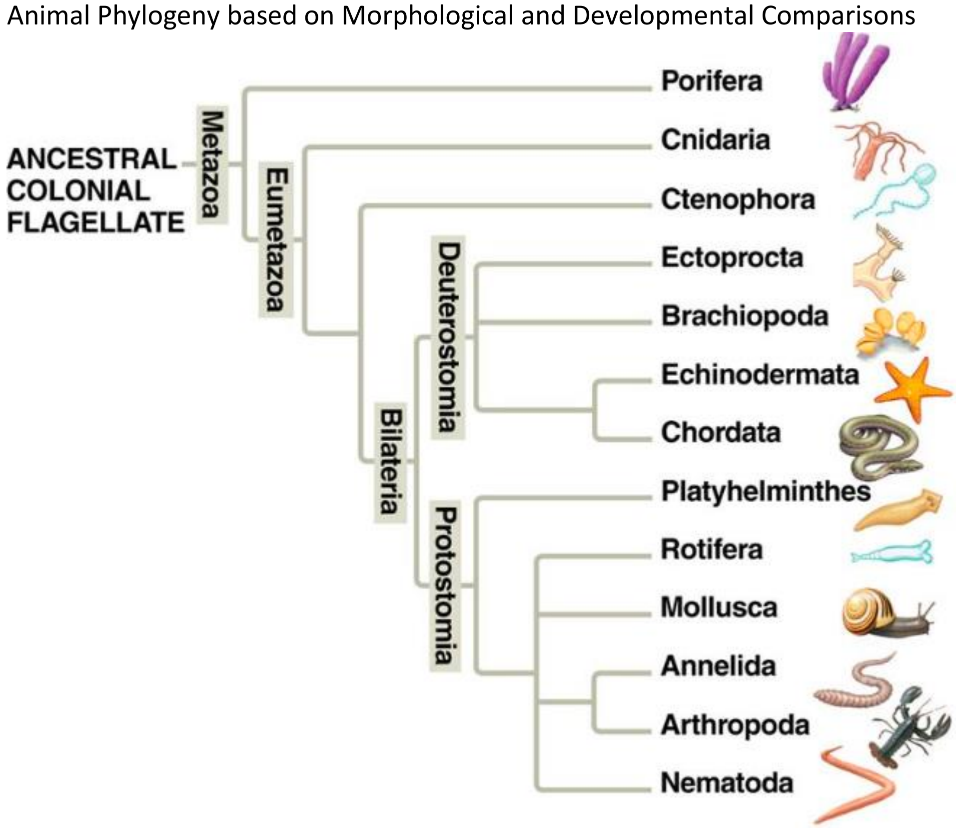


Animals can be characterized by "body plans", exhibiting either radial or bilateral symmetry.

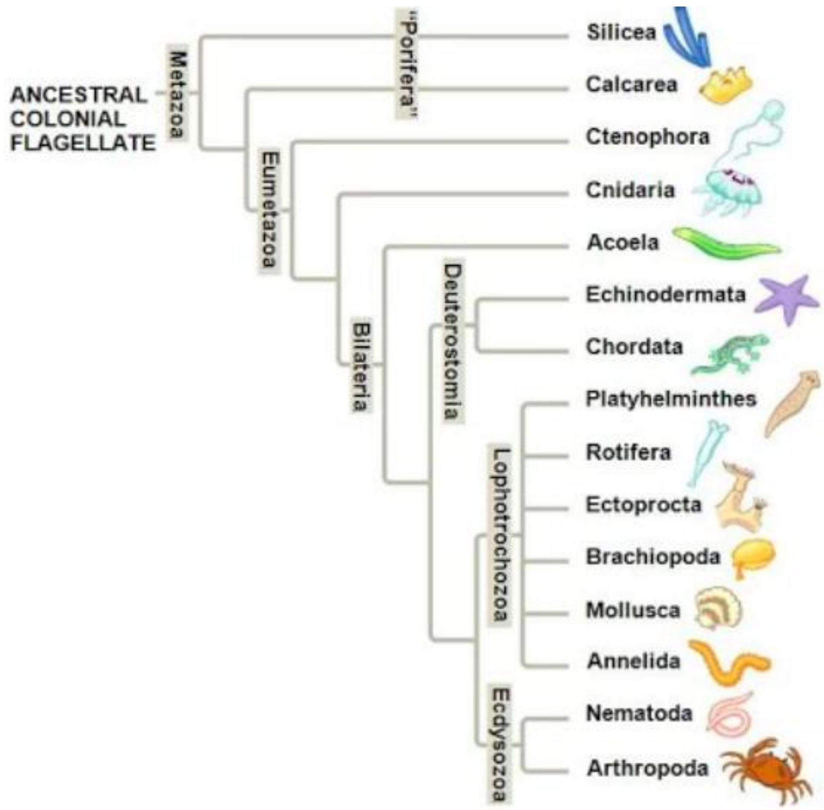
Body cavities of triploblastic animals



Animal Phylogeny based on Morphological and Developmental Comparisons



Animal Phylogeny based on Molecular Data (based on Hox genes)



Difference between molecular data and morphological is that

- Arthropods and annelids not closely related
- New group called Acoela (acoelomate flatworms) in molecular data
- Ectoprocta and Braciopoda (in Deuteristomia in morphological) are in Ecdysozoans and Lophotrochozoans, so two taxa instead of one.

Notes on Diversity of Animal Phylums

- Porifera (Sponges): Are basal animals that lack true tissues. They have choanocytes and flagellated cellsto ingest food.
- Cniderians: Ancient phylum of eumetazoans. They have unique stinging structures (nematocysts) housed in specialized cells (cnidocytes). Digestive compartment with a single opening.
- Platyhelminthes: Dorsoventrally flattened, unsegmented acoelomates with gastrovasular cavity but no digestive tract
- Rotifera: Pseudocoelomates with alimentary canal (digestive tube, mouth, anus); jaws in pharynx and head with ciliated crown
- Ectoprocta & Brachiopoda: Coelomates with lophohores, feeding structures bearing ciliated tentacles.
- Mollusca: Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom is reduced, most have hard shell made of calcium carbonate.
- Annelida: Coelomates with segmented body wall and internal organs (except digestive tract that is unsegmented)

- Nematoda: Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory systems; undergo ecdysis.
- Arthropoda: Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin.
- Echinodermata: Coelomates with bilaterally symmetrical larvae and five-part body organization as adults. Unique water vascular system and endoskeleton.
- Chordata: Coelomates with notochord, dorsal nerve chord, pharyngeal gill slits and post-anal tail.

WEEK 6: INVERTEBRATE DIVERSITY AND LOCOMOTION

Some animals also have life cycles with alternation of generations (Hydrozoa). Polyps that lack tentacles are specialized for reproduction and produce tiny medusa by budding. Medusae will grow and reproduce sexually, once its egg/sperm fertilizes, the zygote will restart a new asexual reproduction cycle.

Most bilaterian have a life cycle with a transient, single celled haploid stage and some variation on diploid multicellular larvae.

Eventual cell lineage may be grouped into a 4-step process

- Pattern formation: Cell proliferation, cell specialization, cell interaction and cell movement forming body plan.
- Morphogenesis: Origin and development of morphological characters
- Segment development
- Limb or organ differentiation in each segment

The production of embryonic tissue layers and establishment of the major body axes is determined in utero and is related to the expression of Homeotic/Hox genes in specific regions of the developing embryo.

- The body plan of invertebrates is similar to that of vertebrates organic systems arranged in same order.
- Homeotic (Hox) genes have the same order of activation and their transcription is collinear with the body axis.
- Hox genes are found in all animal phyla although they may be duplicated and regulated differently.

Cladogram Building

- Similarities in cladistics can be due to
  - Homoplasty: Correspondence between the parts or organs of different species acquired as the result of parallel evolution or convergence
  - Homology: The existence of shared ancestry between a pair of structures or genes in different species.
    - General homologous traits (plesiomorphic): Useful in defining outgroups
    - Special homologous traits: Shared by several but not all taxa (synapomorphic), useful for constructing phylogenies.
    - Uniquely homologours traits: Define species
- Coelom, pseudocoelom & acoelomate are homologous characters
- Segmentation is a homoplastic character
- Locomotion using muscles and some sort of skeleton is a general homologous character among eumetazoans.

<u>WEEK 7: ARTHROPOD AND MOLLUSC CLASSIFICATION</u>

Arthropoda and Mollusca are the most species-rich animal phyla, both have pre-Cambrian origins. In molecular phylogenies, they are considered monophyletic but should be divided into two major clades. Lophotrochozoa (Molluscs, Platyhelminths and Annelids) and Ecdysozoa (Nematodes and Arthropods).

Molluscs are coelomates, and their bodies that three main parts: a muscular foot, usually used for movement; a visceral mass containing most of the internal organs; and a mantle, a fold of tissue that drapes over the visceral mass and secretes a shell. In many molluscs, mantle extends beyond, producing a water-filled chamber (mantle cavity). Many molluscs feed by using a radula to scrape up food.

Most molluscs have an open circulatory system (except cephalopods), a heart that pumps hemolymph and a nervous system that consists of a nerve ring around the esophagous, from which nerve cords extend.

- Polyplacophora (Chitons)
  Oval-shaped body and shell of 8 articulating plates. Mostly marine. Flat creeping foot and poorly developed head.
- Gastropoda
  Many are herbivores, carnivores or parasite or semi-autotroph. Most are marine, but also freshwater species. 180 degrees torsion of body, causing anus to be above head. Shell is single, spiralled and for retreat. Most gastropods have heads with eyes at tips of tentacles.
  - Terrestrial snails lack the gills typical of most aquatic gastropods. Instead, the lining of their mantle cavity functions as a lung, exchanging respiratory gases with the air.
- Cephalopoda
  Marine predators that use tentacles to grasp prey, jaws to bite and poison in tentacles to immobilize. Foot modified into a muscular excurrent siphon and part of the tentacles. Shell is reduced and internal, planar coiled shell. Cephalopods are the only molluscs with a closed circulatory system in which blood remains separate from hemolymph.
- Bivalvia
  All aquatic. Shell divided into two halves. Halves are hinged and powerful abductor muscles draw them tightly together to protect animal’s soft body. No distinct head, no radula. Some bivalves have eyes and sensory tentacles along outer edge of mantle. Mantle cavity contains slits, they are suspension feeders and can secrete strong threads that tether them to rocks, boats, etc.

Arthropod body completely covered by the cuticle, an exoskeleton formed by layers of protein and chitin. Exoskeleton allows protection but also point of attachment for muscles and allows avoidance of dessication. Anthropods have well-developed sensory organs at anterior end. Segmentation is key character.

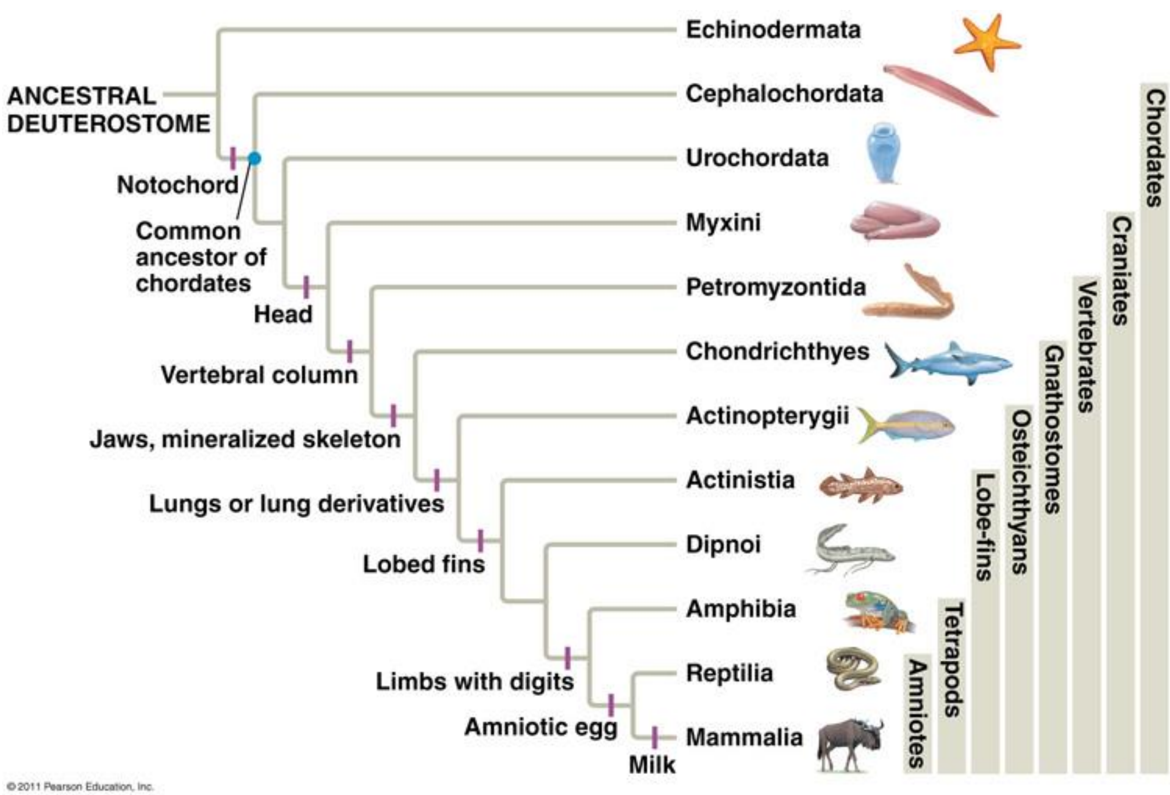
Arthropods have open circulatory system, where heart pumps hemolymph. Most aquatic species have gills with thin extensions and terrestrial arthropods have internal surfaces specialized for gas exchange.

- Chelicerates
  Have clawlike feeding appendages, anterior cephalothorax and posterior abdomen. Lack antennae and have simple eyes (single lens). Pedipals are appendages that function is sensing, feeding or reproduction. Spiders have book lungs, stacked plate-like structures contained in an internal chamber.
- Myriapods

Terrestrial. Head has pair of antennae and three pairs of appendages including mandibles. Large number of legs. Unlike millipedes, centipedes are carnivore.

- Hexapods
  Insects have complex internal organs including malpighian tubes for metabolic waste excretion, tracheal tubes for gas exchange and a nervous system composed of nerve cords, ganglia and cerebral ganglion. Hexapods (insects) have wings and are capable of metamorphosis.
- Crustaceans
  Marine and freshwater species with highly specialized appendages. Crustaceans only arthropod with two pairs od antennae. Walking legs present on throax and also have appendages on abdomen. Small crustaceans exchange gases across thin areas of exoskeleton, larger species have gills and also glands that regulate salt balance of hemolymph. Sexes are separate. Barnacles have calcium carbonate shell.

WEEK 8: CHORDATE HOMOLOGY AND DIVERSIFICATION

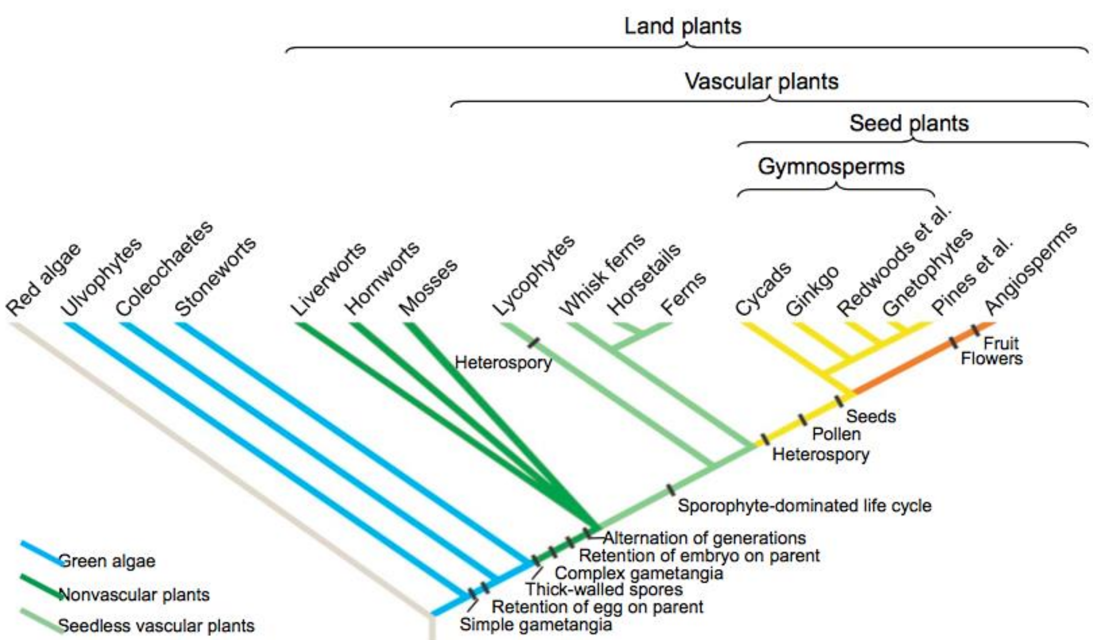


- Chordates: Notochord, dorsal nerve chord & pharyngeal gill slits
  - Cephalochordata (lancelets)
    - Basal chordates; marine suspension feeders that exhibit four key derived characters of chordates.
  - Urochordata (tunicates)
    - Marine suspension feeders; larvae display derived traits of chordates.
- Craniates: Two sets of Hox genes, neural crest
  - Myxini (hagfish)

- Jawless marine organism; have head that includes a skull & brain, eyes and other sensory organs.

- Vertebrates: Dlx gene duplication, backbone of vertebrae
  - Petromyzontida (lampreys)
    - Jawless vertebrates; typically feed by attaching to a live fish and ingesting its blood.
- Gnathostomes: Hinged jaws, four sets of Hox genes
  - Chondrichthyes (sharks, rays, skates, ratfishes)
    - Aquatic gnatostomes; have cartilaginous skeleton, a derived trait formed by the reduction of an ancestral mineralized skeleton.
- Osteichthyans: Bony skeleton
  - Actinopterygii (ray-finned fishes)
    - Aquatic gnathostomes; have bony skeleton and manoeuvrable fins supported by rays.
- Lobe-fins: Muscular fins or limbs
  - Actinistia (coelacanths)
    - Ancient lineage of aquatic lobed-fins still surviving in Indian Ocean
  - Dipnoi (lungfishes)
    - Freshwater lobe-fins with lungs and gills (Sister group of tertrapods)
- Tetrapods: Four limbs, neck, fused pelvic girdle
  - Amphibia (salamanders, frogs, caecilians)
    - Four limbs descended from modified fins, most have moist skin for gas exchange.
- Amniotes: Amniotic egg, rib cage ventilation
  - Reptilia (tuataras, lizards & snakes, crocodilians, birds)
    - Key adaptations for life on lands
  - Mammalia (monotremes, marsupials, eutherians)
    - Evolved from synapsid ancestor; include egg-laying monotremes; pouched marsupials and eutherians (placental mammals)

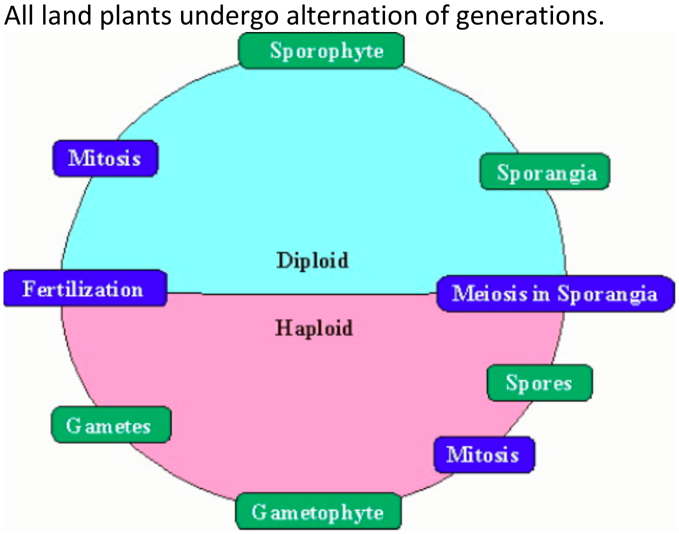
<u>WEEK 9: PLANT REPRODUCTIVE AND VASCULAR DIVERSITY</u>



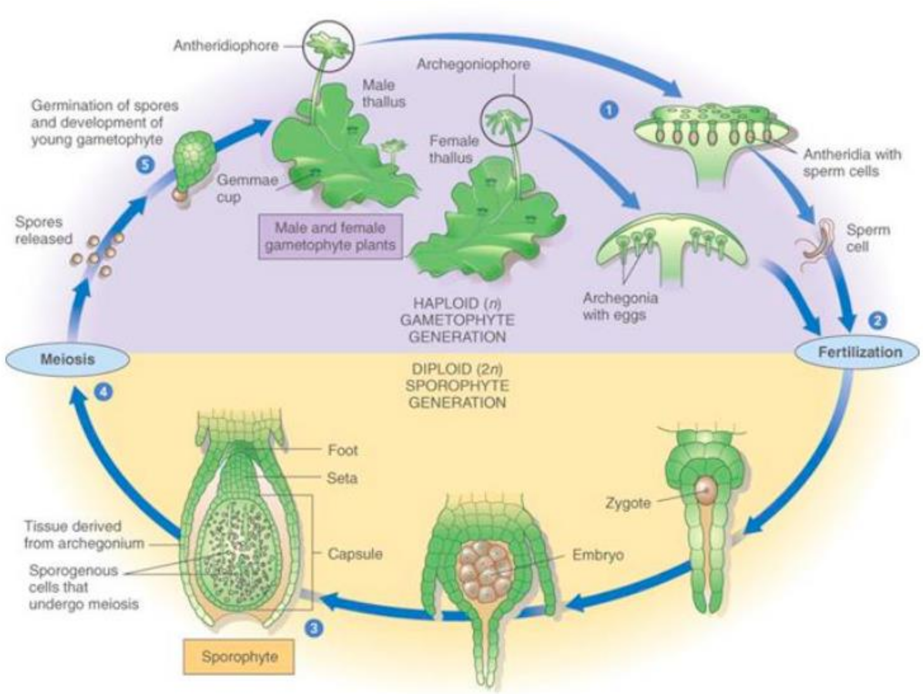
- Origin of lands plants (475 mya)
  First evidence of land plats were cuticle, spores and sporangia
- Silurian-Devonian explosion (444-359 mya)
  Most major morphological innovations: stomata, vascular tissue, roots & leaves
- 359-299 mya
  Lycophytes and horsetails abundant
- 299-145 mya
  Gymnosperms abundant
- 145 mya to present
  Angiosperms abundant

The tree supports the hypothesis that water conducting cells and tissue evolution starts with specialized cells and gradually with time, more complex water conducting organs were seen in the fossil record, or simpler vascular systems proceed more complex ones.

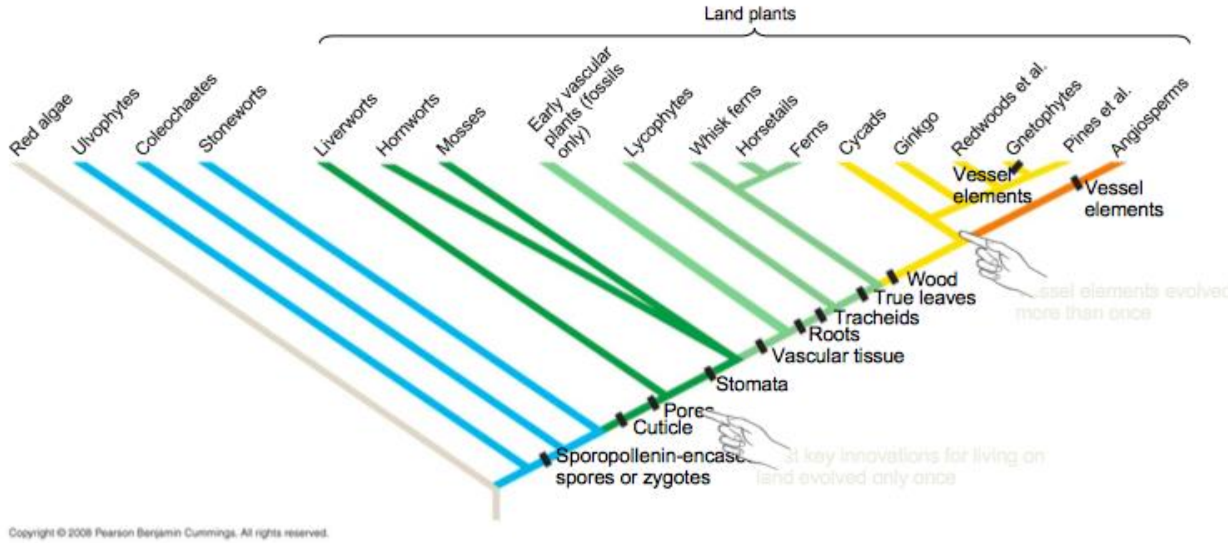
- Green algae and land plants share photosynthetic pigments (1), retention of egg cells within sterile prenatal tissue prior to fertilization (2) and enclosure of gamete-producing structures within protective sterile tissue (3).
- All land plants undergo alternation of generations.



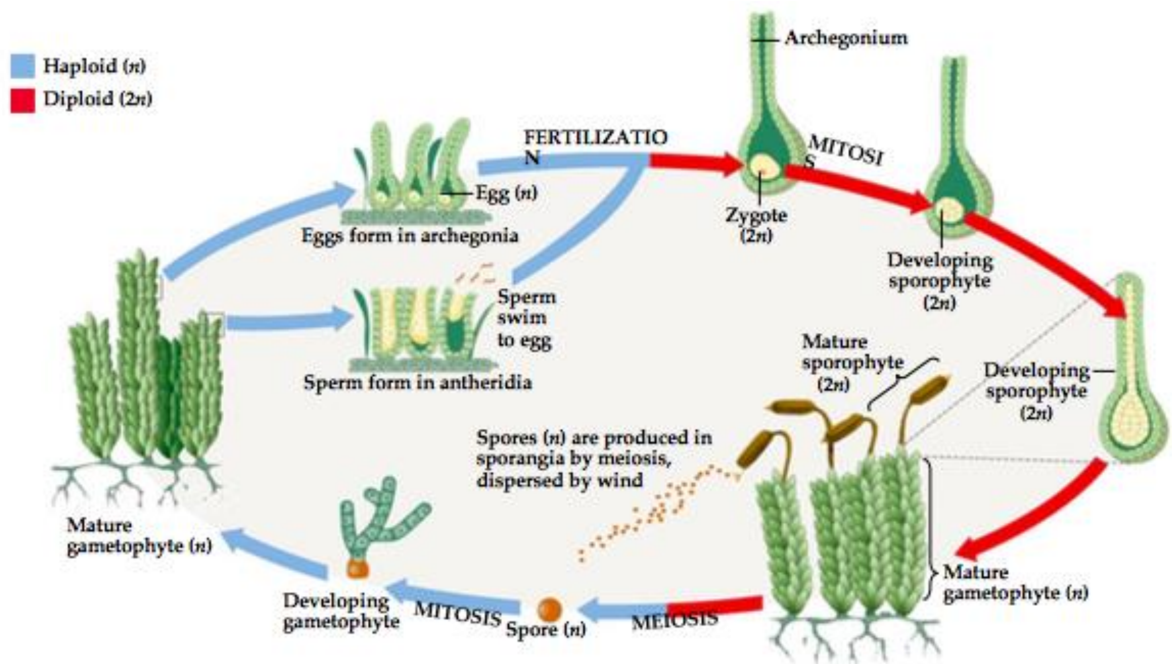
- Liverworts life cycle



- Liverworts have pores, Hornworts have stomata & both have a cuticle.
  Innovations that allow plants to adapt to life on land

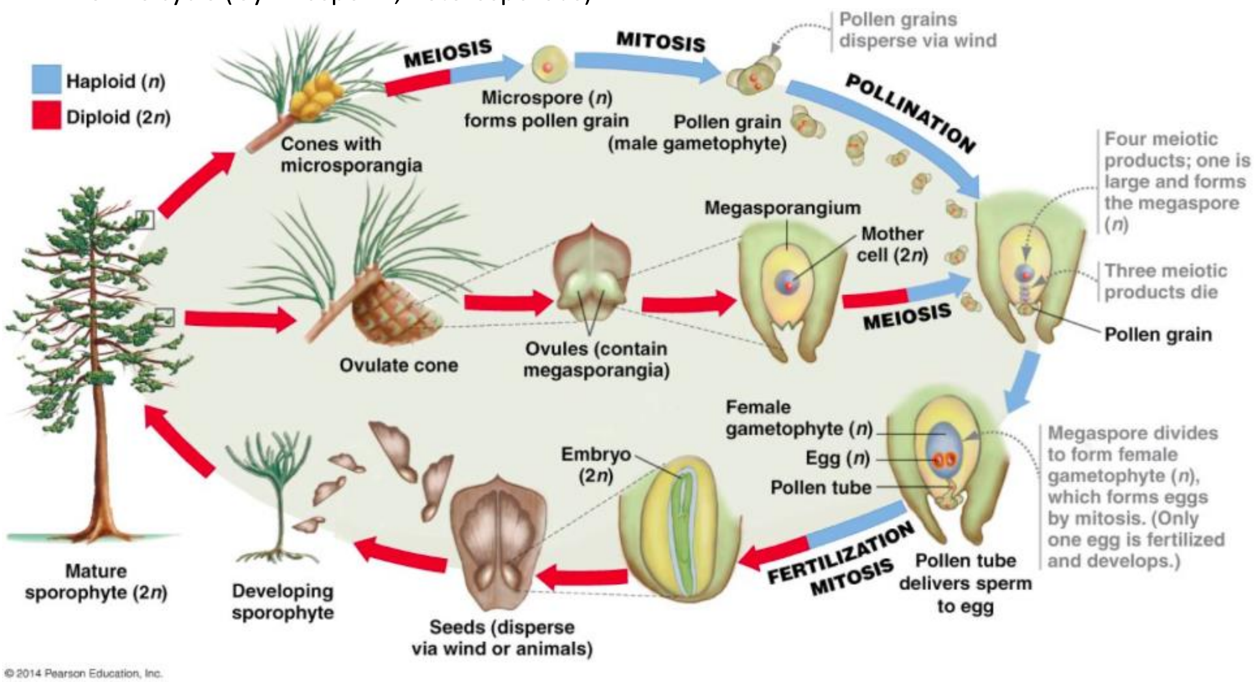


- In mosses, gametophyte stage is dominant. Prior to that, dominant stage is sporophyte.

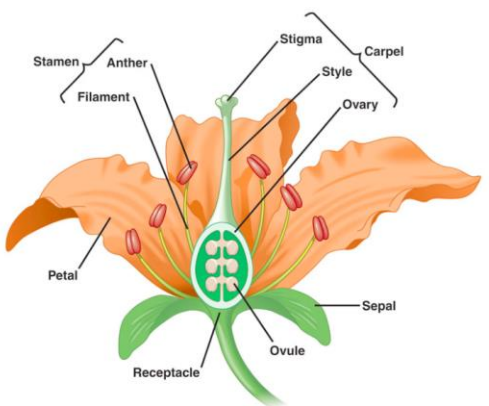


- Vascular tissue most likely evolved in a series of gradual steps among diverse plants providing an increasing level of structural support, allowing plants to grow more upright and compete for access to sunlight.
  - Evolutionary sequence in water conducting cells
    - Simple water conducting cells with cellulose primary wall > first vascular tissue, cell strengthen with lignin > tracheids with secondary cell wall > vessel elements with gaps through primary and secondary cell walls.

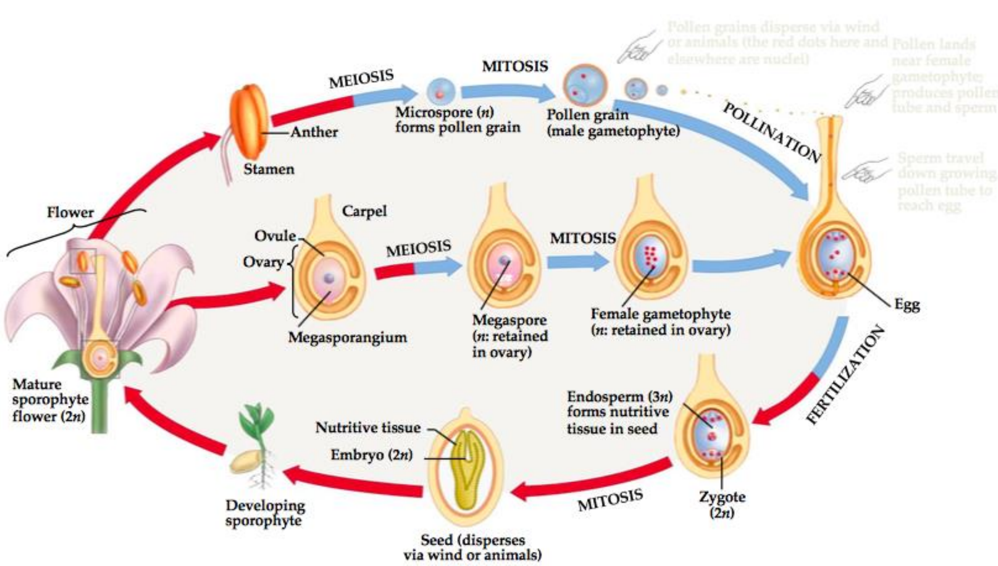
- Pine Life cycle (Gymnosperm, heterosporous)



- Angiosperms (Flower that produces both pollen and eggs). Stamen is male, Carpel (or Pistil) is female.



- Heterospory in Angiosperms



- Non vascular plants and most seedless vascular plants are homosporous.
  - Sporangium > Spores > Bisexual gametophyte > Sperm & Eggs
- Seed plants are heterosporous
  - Microsporangia > Microspores > Male gametophyte > Sperm
  - Megasporangia > Megaspores > Female gametophyte > Eggs

<u>WEEK 10: SEED PLANT CELLS, TISSUES AND ORGANS</u>

Hierarchical organization: cells > tissues > organs (leaves, stems & roots).

- Leaves:
  - » Main photosynthetic organ: surface area absorbs photons
  - » Blade: expanded portion
  - » Stalk/Petiole: Stem
- Stem:
  - » Nodes: points at which leaves are attached
  - » Internodes: segments between nodes
  - » Auxiliary bud: Junction of stem and petiole (potential lateral shoot or branch)
    - (a) Apical dominance: Maintain dormancy in most auxiliary buds
  - » Apical bud: Located near shoot tip, causes elongation of young shoot

Taproot system: Taproot, lateral roots or branch roots

Fibrous root system: Adventitious roots, lateral roots arise from adventitious roots.

- Shoot system: Acquires CO_2 and light from atmosphere
  - » Connected by vascular system, depends on root system to get water and minerals.
- Root System: Take up water and dissolved nutrients from the ground
  - » Depends on shoot system. Rely on the sugar produced by photosynthesis.
    - (a) Root: Anchors plant, stores carbohydrates, absorbs minerals and water.
    - (b) Can be modified for functions other. Modified roots (some do gas exchange).

MONOCOTS	EUDICOTS
Seed	
One seed leaf that does not contain endosperm	Two seed leaves that contain endosperm
Germination	
Produces single leaf, long and narrow	Produces two seed leaves, fatter shape
Leaves	
Veins in straight line, parallel to one another	Veins go from central midrib to edges
Stem & Roots	
Unbranched and fleshy, do not grow thicker	Usually tough, grows wider and is branched
Flower	
In threes, sepals same color as petals, which makes It look like there are six petals. Usually same number of stamens as petals	In fours or fives, calyx is a separate ring of sepals under the corolla, and is usually green
Seedpod	
Three parts, often large and fleshy	More than three seeds, very variable appearance
Roots	
A core of parenchyma cells is surrounded by rings of xylem then phloem	Xylem is star-like in appearance with phloem between the ‘arms’
Vascular Bundles	
Scattered throughout the ground tissue	Arranged in a ring around the stem’s perimeter

Epidermis

- Spines/Trichomes: Bumps to hairs on surface with diverse form and function, usually chemical/physical defense

Ground Tissue Cells
Have primary and/or secondary cell walls

- Primary walls: Think, plastic, highly hydrated cellulose, hemicellulose and pectin structures
  - Not elastic but allow growth through cell expansion
- Secondary walls: Thicker, elastic. Lignin provides strong & elastic support. Cells no longer expand.
  - Compressive and tensile strength but not extensibility
- Parenchyma: Think primary walls, storage, totipotent, have large vacuoles
- Collenchyma: Slightly plasmolyzed (unevenly thickened walls due to pectins), non-lignified, flexible primary cell walls. Plastic rather than elastic.
- Sclerenchyma: Fibers (long and elastic, usually associated with the vascular bundle) and schlerids (shorter, thinker but dead at maturity). Develops secondary lignified walls.
  - Sclereids are often embedded in tissue (skeletal element)

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Vascular Tissues

- Xylem
  Vessel members evolved from tracheids, occur in Gnetales & Dicots except most basal monocotyledons, some ferns and Selaginella and Equisetum, suggesting they evolved indep.
  - Tracheary elements, Tracheids (d) & Vessel elements (a/b/c): Conduction of water and minerals
  - Fibers (e/f): Support; sometimes storage
  - Parenchyma: Storage
    - Pits: Area without secondary walls
    - Perforations are areas without primary & secondary walls
      - After the secondary wall has formed and lignified, the primary cell wall begins to break down and after the perforations are formed the protoplast breaks down. The primary wall is derived into a membrane in the pits.
- Phloem
  Transports organic nutrients from where they are made to where they are needed
  - Sieve-tube elements: Long-distance transport of food materials and signaling molecules. Have anucleate, living protoplasts when they are mature. Usually associated with specialized parenchyma called companion cells.

  - With albuminous cells: Seive cells of gymnosperms are associated with specialized parenchyma cells (albuminous cells) with same role as companion cells. Difference is that do not have same origin.
  - With companion cells: which retain their nucleus and are connected by plasmodesmata. In angiosperms.
- Sclerenchyma, Fibers & Sclereids: Support; sometimes storage
- Parenchyma: Storage

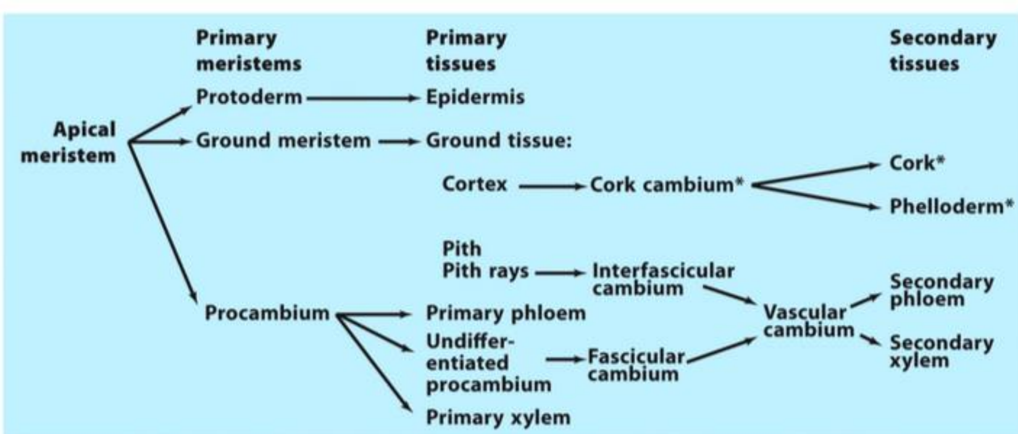
Plant Organs Root and Shoot – Stem and Leaf
As the root grows longer, the cap secretes mucilage as it is pushed into the soil. The outside mucilage-secreting peripheral cells on the root cap are released (border cells). These cells continue to metabolize for weeks, and may contribute to over 90% of carbon rich material in the soil rhizosphere (soil immediately around the root).

- Rootcap also transmits signals to the meristem and controls the direction of root growth.
- Inactive center of the apical meristem is key to organization, repair and development

Summary of components of secondary growth:

Region	Tissue Type	Cell Composition	Function
Bark (arises from and includes cork cambium)			
	Cork	Cork cells	Protection
	Cork cambium	Meristematic cells	Production of cork and phelloderm
	Phelloderm	Parenchyma cells	Synthesis and storage
Secondary phloem (arises from vascular cambium)			
	Phloem	Parenchyma cells (sieve-tube members, companion cells) and sclerenchyma cells (fibres, sclereids)	Transport of sugars, amoni acids, hormones, etc.; support
Secondary xylem* (arises from vascular cambium)			
	Xylem	Tracheids, vessels, parenchyma cells (arranged in rays) and sclerenchyma cells (fibres)	Transport of water and ions; support

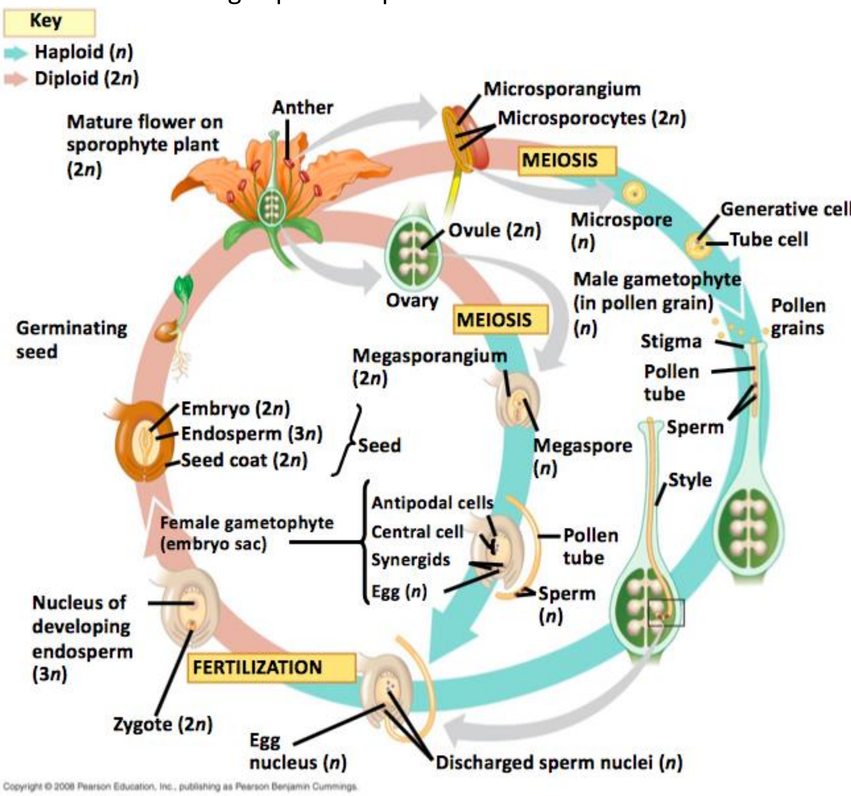
Secondary growth results from cell division in lateral meristems, vascular cambium and cork cambium. It adds transport tissue and provides structural support. Secondary growth allows trees to get bigger in diameter and it occurs in dicots and gymnosperms. Secondary growth is not present in monocots.



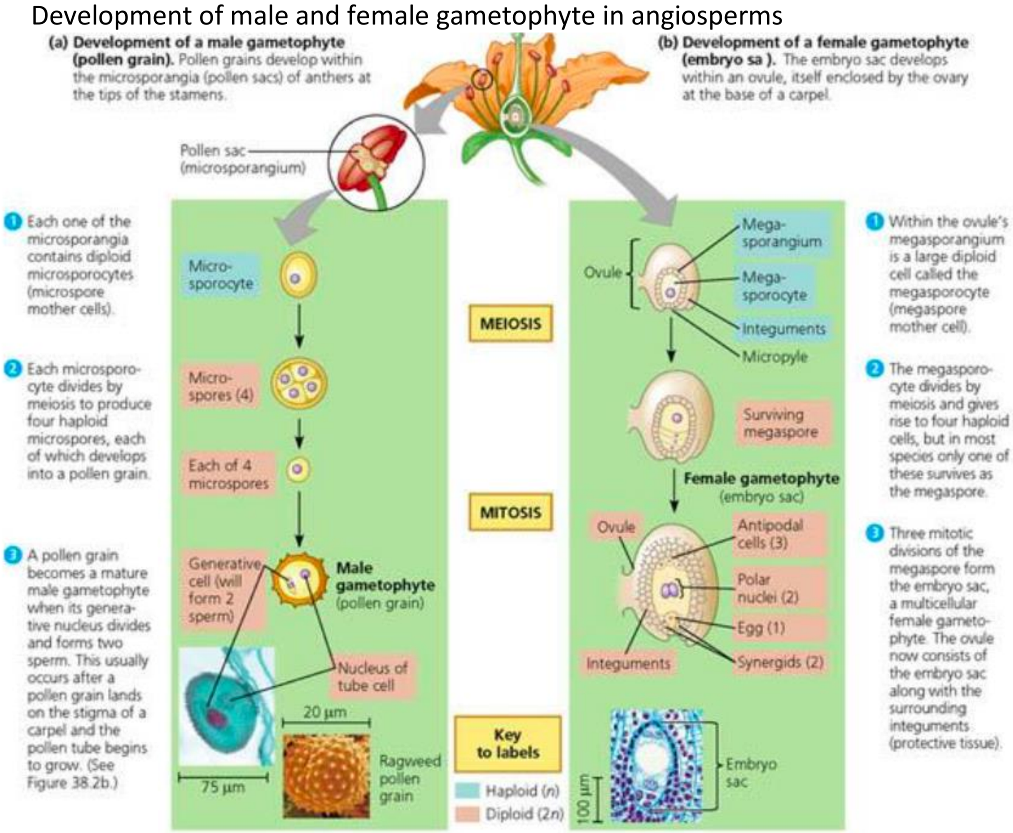
*Collectively constitute the periderm

WEEK 11: PLANT ORGANS IN IDENTIFICATION, PHYLOGENY AND FOOD

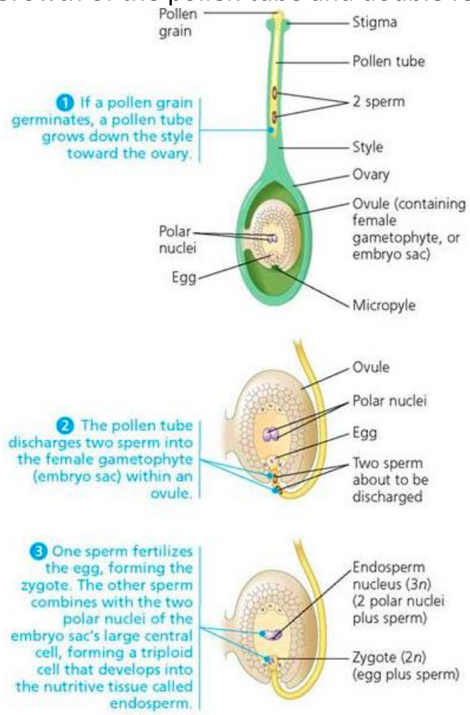
- Overview of angiosperms reproduction



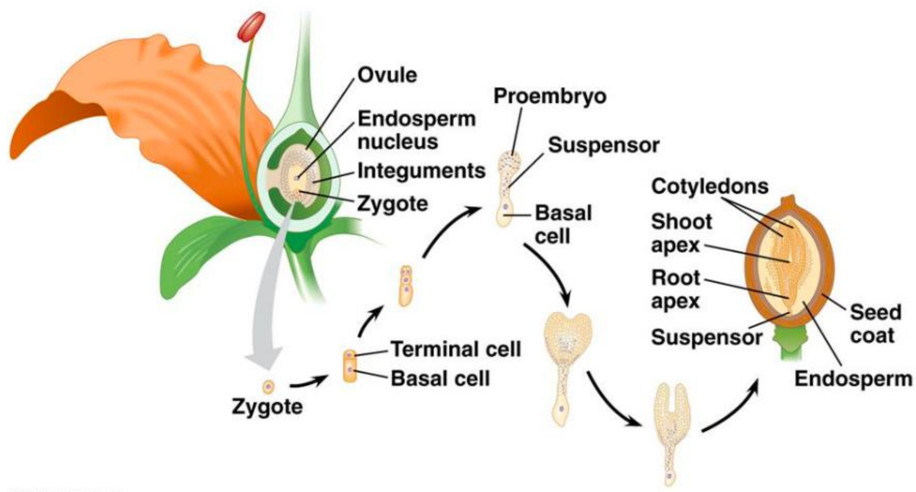
- Development of male and female gametophyte in angiosperms



- Growth of the pollen tube and double fertilization



- Development of a eudicot plant embryo

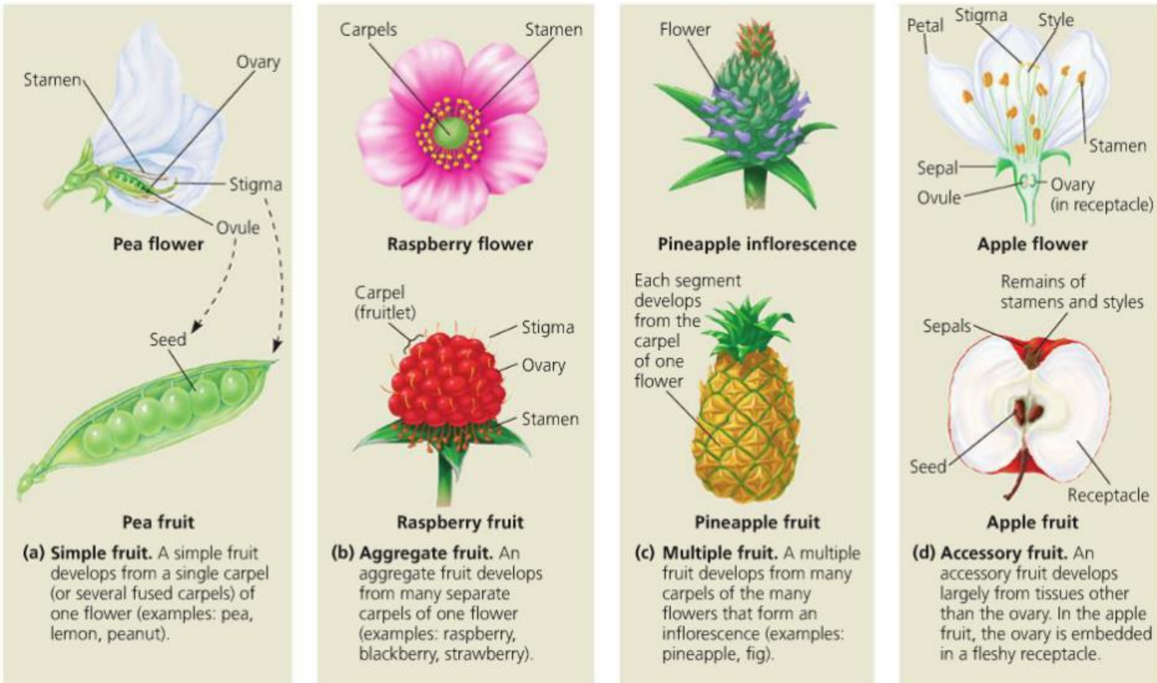


- Modified Stems
  - Runners: Prostrate above ground stems and produce adventitious roots at nodes
  - Stolons: Horizontal underground stems, spreading horizontally
  - Rhizomes: Thickened underground stems, which acts as food storage
  - Tubers: Enlarged fleshy end of an underground stolon.
  - Corms: Develop lateral buds at the base of the stem into thick fleshy stem enlargements
  - Bulbs: Very short stems wrapped in thickened fleshy bulbs scales (modified leaves)
  - Cladophylls: Thinkened green leaf stems of plants with highly reduced leaf blades (spines if present)

- Modified Roots
  - Tap roots, Fibrous roots & Tuberous roots

In the flowering plants (angiosperms), seeds develop inside a protective structure called a carpel, but vary in how well carpels are protected. These tissues develop into fruit.

- Developmental Origin of Fruits



(a) Simple fruit. A simple fruit develops from a single carpel (or several fused carpels) of one flower (examples: pea, lemon, peanut).

(b) Aggregate fruit. An aggregate fruit develops from many separate carpels of one flower (examples: raspberry, blackberry, strawberry).

(c) Multiple fruit. A multiple fruit develops from many carpels of the many flowers that form an inflorescence (examples: pineapple, fig).

(d) Accessory fruit. An accessory fruit develops largely from tissues other than the ovary. In the apple fruit, the ovary is embedded in a fleshy receptacle.

- Fruit classification

Fruit Key

A) Simple Fruit- pericarp becomes leathery papery or woody.

Dehiscent-opens when ripe

Follicle*- develops from *a simple pistil, opens on one side only.

Legume- develops from ***a simple pistil, opens on two sides.***

Capsule- develops from ***a compound pistil*** (> 2 carpels), opens in different ways.

Indehiscent-fruit does not open at maturity.

Achene – small one seeded, **seed coat does not adhere to *pericarp***

Grain*- seed coat is fused with the *pericarp

Samara- key fruit – one seeded **wing extension of pericarp**

Nut – large, 1-2 seeded, ***bracts usually enclose the hard, stony or woody pericarp***

Simple Fleshy Fruit – a portion or all of the pericarp is fleshy

Berry – always develops from **a superior ovary, entire pericarp is fleshy at maturity**.

a) Hesperidium – pericarp leathery, pulpy, juice sacs develop from inner carpel walls

Drupe – **pericarp divided into 3 parts:** outer ***exocarp***, middle fleshy ***mesocarp***, and inner ***endocarp or a stone or pit enclosing a seed.***

Simple Accessory Fruits- fruit includes the ovary wall and other flower parts, mostly developing inferior ovaries.

a) ***False Berries*** - entire fruit ripens fleshy.

b) ***Pome*- fleshy receptacle. *Exocarp, mesocarp and endocarp leathery.***

B) Aggregate Fruit – arises from **a number of separate ovaries attached to a single receptacle** of a flower.

C) Multiple Fruits – develop from a number of individual ovaries grouped closely together, with a fruit developing from each flower, but remaining **on a single mast, core or stem.**

Note on Angiosperm Reproduction
Asexual reproduction enables plants to proliferate quickly. Sexual reproduction generates the most genetic variance that makes evolutionary adaptation possible. Plants have evolved many mechanisms to avoid self-fertilization, including dioecy (male and female flowers on different individuals), nonsynchronous production of male and female parts within a single flower, and self-incompatibility reactions in which pollen grains that bear an allele identical to one of female are rejected.

WEEK 12: PHOTOSYNTHESIS

Photosynthesis is the process that converts soar energy into chemical energy; occurs in plants, algae, certain protists and some prokaryotes. Autotrophs do photosynthesis, heterotrophs do not.

Process of using sunlight to produce carbohydrate, process requires sunlight, CO_2 and water and produces oxygen as by-product. Overall reaction:

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

In autotrophic eukaryotes, photosynthesis occurs in chloroplasts, organelles containing thylakoids. Stacks of thylakoids form grana. Chloroplasts split water into hydrogen and oxygen, incorporating the electrons of hydrogen into sugar molecules. Photosynthesis is a redox process, where H_2O is oxidized and CO_2 is reduced.

- The light reactions in the thylakoid membranes split water, releasing O_2, producing ATP and forming NADPH. The Calvin cycle in the stroma forms sugars from CO_2, using ATP for energy and NADPH for reducing power.

Light is an electromagnetic wave, which produces energy. Visible light is wavelength of colors we can see.

Pigments (cholorophyll & carotenoids, etc.) are substances that absorb visible light. Different pigments absorb different wavelengths; those that aren't absorbed are reflected or transmitted.

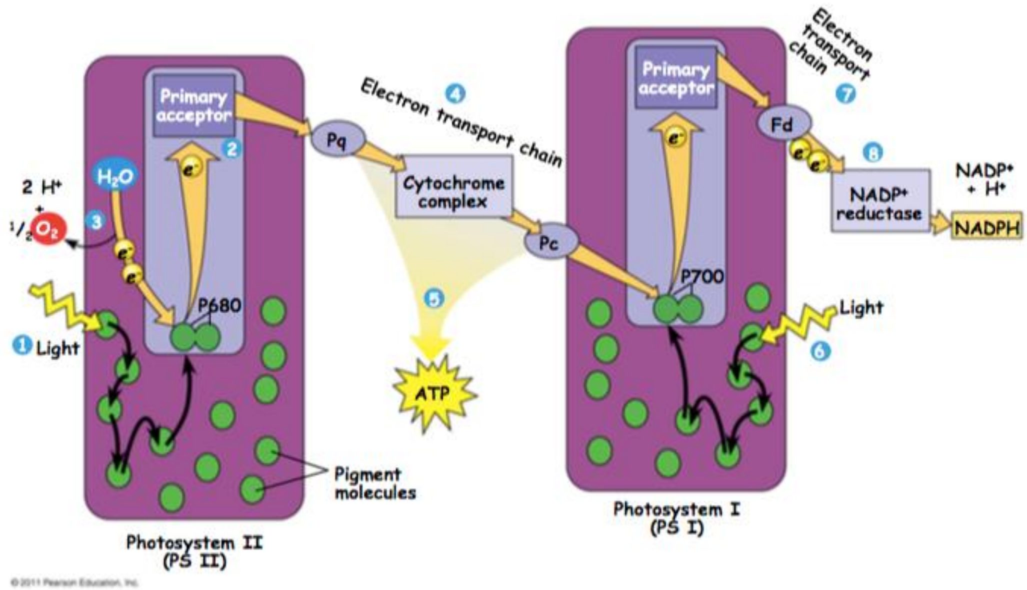
- Chlorophyll a is main photosynthetic pigment
  - Accessory pigments such as chlorophyll b broaden the spectrum of photosynthesis
    - Absorbs blue and red light, transmits green light
      - Pigments that absorb blue and red photons are trigger photosynthesis the most
  - Accessory pigments called carotenoids absorb excessive light that would damage chlorophyll
    - Absorb blue and green light, transmits yellow, orange and red.

Plants do not use green light efficiently.

- When a pigment absorbs light, it goes from a ground state to an excited state, which is unstable
- When excited e- fall back to the ground state, photons are given off (creates fluorescence)
- If illuminated, an isolated solution of chlorophyll will fluoresce, giving off light & heat
- A photosystem is composed of a reaction-centre complex surrounded by light harvesting complexes that funnel the energy of photons to the reaction-center complex.
  - PS II: Functions first and is best at absorbing 680 nm, reaction-center chlorophyll a of PS II is P680
  - PS I: Functions best at 700nm, reaction center chlorophyll a PS I is P700

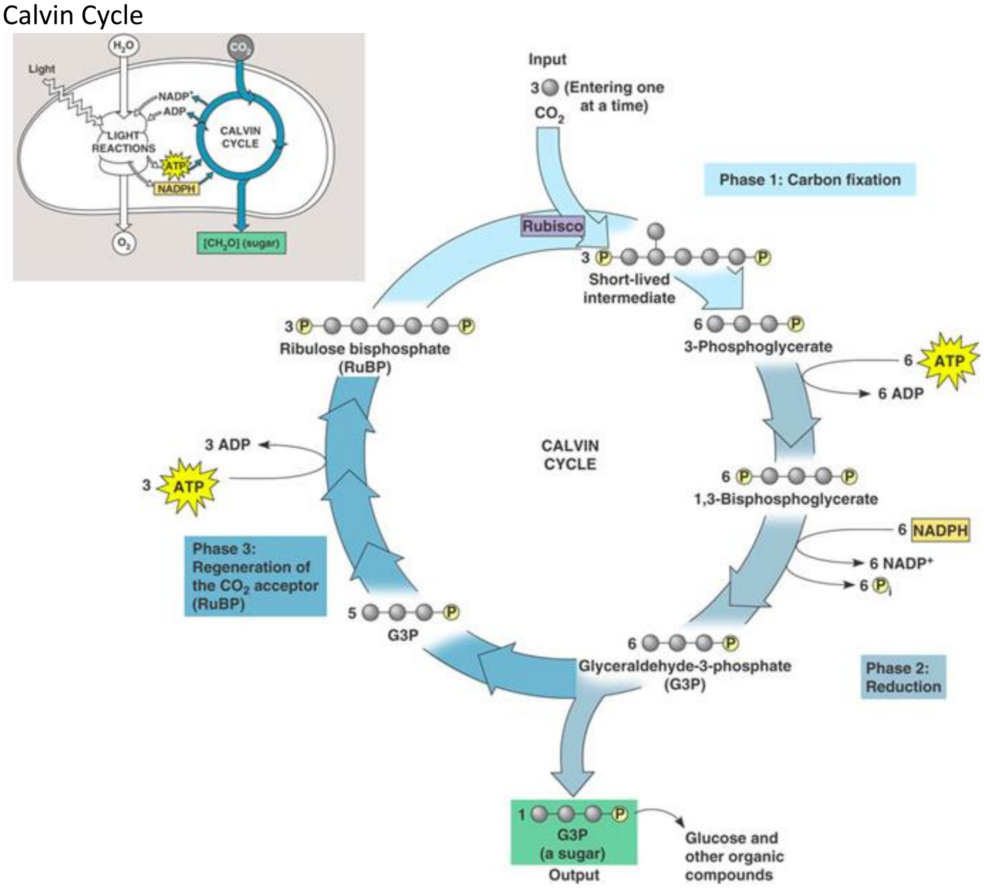
Electron Flow

- Linear: Primary pathway involves PS II and PS I and produced ATP and NADPH using light. Photon hits pigment and energy is passed among pigment molecules until it excited P680. Excited electron from P680 transferred to primary electron acceptor.



- Circular: Involved only PS I and produces only ATP. No oxygen is released and cyclic electron flow generates surplus ATP. During chemiosmosis in both mitochondria and chloroplasts, electron transport chains generate a proton gradient across a membrane. ATP synthase uses this proton-motive force to make ATP.

Calvin Cycle



Alternative mechanisms of carbon fixation have evolved in hot, arid climates

- C3 Plants
  - Close stomata in hot days to conserve water. Oxygen from light reactions builds up. In photorespiration, O_2 substitutes from CO_2 in the active site of rubisco. This process consumes organic fuel and releases CO_2 without producing ATP or carbohydrate. Photoprotective role of photosynthesis.
- C4 Plants
  - Minize the cost of photorespiration by incorporating CO_2 into four-carbon compounds in mesophyll cells. These compounds are exported to bundle-sheath cells, where they release carbon dioxide for use in the Calvin cycle.
- CAM Plants
  - Open their stomata at night, incorporating CO_2 into organic acids, which are sotred in mesophyll cells. During the day, the stomata closes and the CO_2 is released from the organic acids for use in the Calvin cycle.

FEATURE	C3 PLANTS	C4 PLANTS	CAM PLANTS
Pathway of CO_2 fixation	C3 cycle only	C3 and C4	C3 and C4 cycles, in different parts of the same cell and different times.
Normal diurnal occurrence	Daytime	Daytime	C4 at night C3 in daytime
Initial CO_2 acceptor	RuBP	PEP	PEP at night RuBP in daytime
CO_2 fixing enzyme	Rubisco	PEPcase	PEPcase at night Rubisco in daytime
Cells involved	Mesophyll cells	C4 in the mesophyll cells and C3 in the bundle sheath cells	C3 and C4 in mesophyll cells
Energy needed for complete reduction of one CO_2 molecule	3 ATP, 2 NADPH	5 ATP, 2 NADPH	
Favoured environmental conditions for photosynthesis	Moderate conditions	Hot, dry conditions	Extremely dry conditions
Photorespiration	Yes	Absent of suppressed	Absent or suppressed