PLANTS, PLANTS, EVERYWHERE!

- More than 280,000 species of plants inhabit Earth today.
- Most plants live in ***terrestrial*** environments, including deserts, grasslands, and forests.
    - Some species, such as sea grasses, have returned to aquatic habitats.
- Land plants (including the sea grasses) evolved from a certain green algae, called charophyceans.
- Plant kingdom characteristics:
    - ***Photoautotrophs***
    - ***Cell walls of cellulose***
    - ***Chlorophyll a and b in chloroplasts***
    - ***Non-motile eukaryotes***
    - ***Multicellular with tissues and organs***

Land Plants: The "Main Players"

- There are four main groups of land plants: ***bryophytes***, ***pteridophytes*** (seedless vascular plants), ***gymnosperms***, and ***angiosperms***.
- The most common bryophytes are mosses.
- The pteridophytes include ferns.
- The gymnosperms include pines and other conifers.
- The angiosperms are the flowering plants.
- Bryophytes, pteridiophytes, gymnosperms, and angiosperms demonstrate ***four great episodes*** in the evolution of land plants:

    1. ***the origin of bryophytes from algal ancestors***
    2. ***the origin and diversification of vascular plants***
    3. ***the origin of seeds***
    4. ***the evolution of flowers***

Evolution of Land Plants: Land plants evolved from Charophytes (green algae)

- Land plants share ***two*** key ultrastructural features with their closet relatives, the algal group called charophyceans.
    - The plasma membranes of land plants and charophytes contain ***rose shape arrays of proteins*** that synthesize the cellulose microfibrils of the cell wall.
    - A second ultrastructural feature that both charophytes and land plants have is the presence of **peroxisomes**.
- In those land plants that have flagellated sperm cells, the structure of the sperm resembles the sperm of charophytes.
- Lastly, certain details of cell division are common only to land plants and the most complex charophyte algae.

Several terrestrial adaptations distinguish land plants from charophycean algae

- Several characteristics separate the four land plant groups from their closest algal relatives, including:
  - apical meristems
  - multicellular embryos dependent on the parent plant
  - alternation of generations
  - sporangia that produce walled spores
  - gametangia that produce gametes
- In terrestrial habitats, the resources that a photosynthetic organism requires are found in two different places.
  - Light and carbon dioxide are mainly above ground.
  - Water and mineral resources are found mainly in the soil.
- Therefore, plants show varying degrees of structural specialization for subterranean and aerial organs - roots and shoots in most plants.
- The elongation and branching of the shoots and roots maximize their exposure to environmental resources.
- This growth is sustained by **apical meristems**, which are localized regions of cell division at the tips of shoots and roots.
  - Cells produced by meristems differentiate into various tissues, including surface epidermis and internal tissues.
- Multicellular plant embryos develop from zygotes that are retained within tissues of the female parent.
- This distinction is the basis for a term for all land plants, **embryophytes**.
- The parent provides nutrients, such as sugars and amino acids, to the embryo.
- All land plants show **alternation of generations** in which two multicellular body forms alternate.
- One of the multicellular bodies is called the **gametophyte** with haploid cells.
  - Gametophytes produce gametes, egg and sperm.
  - Fusion of egg and sperm during fertilization form a diploid zygote.
- Mitotic division of the diploid zygote produces the other multicellular body, the **sporophyte**.
  - Meiosis in a mature sporophyte produces haploid reproductive cells called **spores**.
  - A ***spore*** is a reproductive cell *that can develop into a new organism* ***without*** *fusing with another cell.*
- Mitotic division of a plant spore produces a new multicellular gametophyte.
- Unlike the life cycles of other sexually producing organisms, alternation of generations in land plants (and some algae) ***results in both haploid and diploid stages that exist as multicellular bodies.***
  - For example, humans do not have alternation of generations because the only haploid stage in the life cycle is the gamete, which is single-celled.

- Plant spores are haploid reproductive cells that grow into a gametophyte by mitosis.
  - Spores are covered by a polymer called **sporopollenin**, the most durable organic material known.
  - This makes the walls of spores very tough and resistant to harsh environments.
- Multicellular organs, called **sporangia**, are found on the sporophyte and produce these spores.
- Within a sporangia, diploid **spore mother cells** undergo meiosis and generate haploid spores.
- The outer tissues of the sporangium protect the developing spores until they are ready to be released into the air.
- The gametophytes of bryophytes, pteridophytes, and gymnosperms produce their gametes within multicellular organs, called **gametangia**.
- A female gametangium, called an **archegonium**, produces a single egg cell in a vase-shaped organ.
  - The egg is retained within the base.
- Male gametangia, called **antheridia**, produce many sperm cells that are released to the environment.
  - The sperm cells of bryophytes, pteridiophytes, and some gymnosperms have flagella and swim to eggs.
- A sperm fuses with an egg within an archegonium and the zygote then begins development into an embryo.
- In most land plants, the epidermis of leaves and other aerial parts is coated with a **cuticle** of polyesters and waxes.
  - The cuticle protects the plant from microbial attack.
  - The wax acts as waterproofing to prevent excessive water loss.
- Pores, called **stomata**, in the epidermis of leaves and other photosynthetic organs allow the exchange of carbon dioxide and oxygen between the outside air and the leaf interior.
  - Stomata are also the major sites for water to exit from leaves via evaporation.
  - Changes in the shape of the cells bordering the stomata can close the pores to minimize water loss in hot, dry conditions.
- Except for bryophytes, land plants have true roots, stems, and leaves, which are defined by the presence of vascular tissues.
  - Vascular tissue transports materials among these organs.
- Tube-shaped cells, called **xylem**, carry water and minerals up from roots.
  - When functioning, these cells are dead, with only their walls providing a system of microscopic water pipes.
- **Phloem** is a living tissue in which nutrient-conducting cells arranged into tubes distribute sugars, amino acids, and other organic products.
- Land plants produce many unique molecules called secondary compounds.
  - These molecules are products of “secondary” metabolic pathways.
  - These pathways are side branches off the primary pathways that produce lipids, carbohydrates, and other compounds common to all organisms.

- Examples of secondary compounds in plants include alkaloids (quinine-used to treat malaria), terpenes, tannins, and phenolics such as Flavonoids (anti-cancer drug).
  - Various secondary compounds have bitter tastes, strong odors, or toxic effects that help defend land plants against herbivorous animals or microbial attack.
  - Flavonoids absorb harmful UV radiation.
  - Other flavonoids are signals for symbiotic relationships with beneficial soil microbes.
  - ***Lignin***, a phenolic polymer, hardens the cell walls of "woody" tissues in vascular plants, providing support for even the tallest of trees.