I. **Kingdom Plantae – general characteristics**

- eukaryotic, multicellular, with cell walls rich in **cellulose**
- most are photosynthetic, with chloroplasts containing chlorophylls $a$ and $b$ and carotenoids
- all have alternation of generations (sporic meiosis)
  - Draw a simplistic figure depicting this:

- dominate nearly all terrestrial communities (exceptions in tundra); major producers in most of these habitats
- source of food, shelter, clothing, much of the atmosphere’s oxygen
- ~300,000 described living species in 10 phyla
- two groups:
  - nonvascular plants (a grade) and vascular plants (a clade)
  - vascular plants divided into those without seeds (a grade) and those with seeds (a clade)
II. Evolutionary origin and adaptations to land

A. Plants are related to green algae
   - chloroplast similarity
   - Plants have cell walls made of cellulose.
     - So do green algae, dinoflagellates, and brown algae.
   - Plants have chloroplasts with chlorophyll $a$ and $b$.
     - So do green algae, euglenids, and a few dinoflagellates.
   - cellulose in cell walls
   - starch as energy reserve
   - formation of cell plate during division (found in plants and some green algae)
   - genetic similarities (especially ribosomal RNA sequence); plant clade is ~500 million years old
   - distinguished from green algae because diploid form always begins development within tissues of a haploid form, and always have heteromorphic (different-looking) haploid and diploid forms
   - also distinguished by adaptations to survival on land, including protecting embryos

B. Classification of plants
   - What exactly is the line dividing land plants from algae and what is the taxonomy?
   - In this course we will adopt the traditional scheme, which equates the kingdom Plantae with embryophytes (plants with embryos).
   - Traditional land plants together with some green algae apparently form a monophyletic group called Streptophyta. Some botanists now propose that the plant kingdom should be renamed the kingdom Streptophyta and expanded to include the charophyceans and a few related groups.
   - Others suggest the kingdom Viridiplantae, which includes chlorophytes as well as plants. Cladistic analysis shows no clear division between plants (traditional Kingdom Plantae) and green algae (traditional Phylum Chlorophyta)

C. Adaptations to land
   - plants are primarily terrestrial – few aquatic species
   - plants likely first terrestrial organisms
   - cell wall helps prevent water loss (desiccation)
   - embryos (young sporophyte plants) protected by some sort of covering to protect against things like desiccation
   - most plants have a waxy cuticle – on exposed surfaces, relatively impermeable; prevents most water loss
   - cuticle creates a problem with gas exchange, so most plants have stomata (singular: stoma)
     - pores that can be opened and closed for gas exchange
BIOL 1030 – TOPIC 4 LECTURE NOTES

- up to thousands per square centimeter on leaves
- closing helps prevent water loss
- must open to let carbon dioxide in, oxygen out

- mycorrhizal relationships with fungi
  - found in about 90% of plant species, some absolutely required
  - may help some with water uptake
  - help tremendously with nutrient uptake

- other adaptations in some plants
  - vascular tissue and related structures (roots, shoots, leaves)
  - seeds
  - flowers and fruits

III. **Plant Life Cycles**

A. alternation of generations – mitosis in both haploid and diploid generations

- All land plants show alternation of generations in which two multicellular body forms alternate.
- This life cycle also occurs in various algae, however, alternation of generations does not occur in the charophyceans, the algae most closely related to land plants.
- In alternation of generations, one of the multicellular bodies is called the **gametophyte** (multicellular) and has haploid cells.
- Gametophytes produce gametes, egg and sperm, by mitosis.
  - Fusion of egg and sperm during fertilization form a diploid zygote.
  - gametophyte produces haploid **gametes** in special **gametangia** structures in some plants
    - **antheridium** – male gametangia, make sperm
    - **archegonium** – female gametangia, make eggs
    - sperm and egg fuse inside archegonium to form diploid **zygote**
- Mitotic division of the diploid zygote produces the other multicellular body, the **sporophyte** (also multicellular) (young sporophyte = embryo).
  - **Meiosporangia** in sporophyte produces diploid **meiospore mother cells** (**meiosporocytes**).
  - Meiosporocyte undergoes meiosis to produce four haploid reproductive **spores** (**meiospores**).
  - All the prefixes “meio-” above are often left off since there are no **mitospores**; thus, we simply refer to the various stages as “sporangia, spore mother cells, sporocytes, and 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.

Plants make meiospores, but never mitosores.

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.

B. evolutionary trend from “lower” to “higher” plants is a reduction of the gametophyte generation and an expansion of the sporophyte generation, with more protection of the embryo

- nonvascular plants (mosses, liverworts, hornworts) – gametophyte is green, free-living, dominant generation
- seedless vascular plants (ferns and fern allies) – gametophyte is usually green and free-living, but sporophyte is dominant generation
- vascular seed plants (gymnosperms and angiosperms) – gametophyte is nutritionally dependent on sporophyte, or may be saprobic (deriving energy from nonliving organic matter); sporophyte is dominant generation

IV. Nonvascular Plants - Bryophytes

- Plants with an absence of an extensive system of vascular tissue, cells joined into tubes that transport water and nutrients throughout the plant body.
- Gametophytes photosynthetic and free-living; dominant generation
- Sporophytes are attached to and dependent on gametophytes
- Primitive; likely the modern plants most similar to the “first plants”
- Require external water for sperm to reach eggs for sexual reproduction (swimming sperm)
- No true leaves, stems, or roots (vascular tissue required for true leaves, stems, and roots)
- Small; rarely more than 7 cm tall
- Most common in and mostly limited to moist places
- Informally called bryophytes

Three phyla of bryophytes:

1. Phylum Hepaticophyta – liverworts
2. Phylum Anthocerotophyta – hornworts
3. Phylum Bryophyta – mosses

Note that the name Bryophyta refers only to one phylum, but the informal term bryophyte refers to all nonvascular plants.

V. Phylum Hepaticophyta – liverworts

A. some with flattened bodies (thalli) with lobes resembling liver; “wyrt” is old English for plant; thus, “liverwort”
B. thalloid forms only 20% of phylum; rest look like mosses

C. simpler than mosses
   1. gametophytes develop almost directly from spores (reduced protonema)
   2. gametophyte growth is prostrate (flat), not erect
   3. rhizoids are one-celled

D. sexual reproduction similar to that in mosses; two small differences:
   1. antheridia on stalks called **antheridiophores**
   2. archegonia on stalks called **archegoniophores**

E. asexual reproduction occurs in thalloid forms from **gemmae** splashed out of **gemma cups** on “leaves”

F. about 9,000 living species

VI. **Phylum Anthocerotophyta** – hornworts

A. thalloid gametophytes (look much like thalloid liverworts)

B. cells typically have a single chloroplast, very much like the chloroplast of green algae

C. sporophyte partially independent from gametophyte
   1. green; photosynthetic
   2. functional stomata
   3. still embedded in gametophyte, gets some nutrition from it

D. about 100 living species

VII. **Phylum Bryophyta** - mosses

A. small “leaves” arranged spirally or alternately around a stem-like axis

B. “leaves” not true leaves; only one cell thick, except at midrib

C. anchored to substrate with root-like **rhizoids** (not true roots; no vascular tissue, little water absorption)

D. most water travels up outside of plant by capillary action

E. sexual reproduction
   1. male **antheridia** and female **archegonia** on same or separate plants
   2. sperm made in antheridia swim to archegonia (using flagella to move through dew or rainwater)
   3. sperm unites with egg in archegonium, forming diploid zygote
   4. zygote undergoes mitotic divisions and develops into sporophyte
      - slender stalk with swollen **capsule** (**sporangium**) at tip
      - base imbedded in gametophyte
      - dependent on gametophyte for nutrients
   5. spore mother cells in sporangium produce haploid spores
   6. at maturity, outer covering of sporangium pops off, releasing spores

5 of 7
7. spores in right (mainly damp) environment grow into protonemata (singular protonema)
8. buds from a protonema become new gametophyte plants

F. importance/ecology:
1. about 15,000 living species
2. can survive some drought conditions, but not found in deserts
3. most are very sensitive to air pollution, good indicators of air quality
4. important producers in some habitats such as bogs, Arctic and Antarctic
5. most abundant plants in Arctic and Antarctic
6. peat mosses (Sphagnum) found in peat bogs
   • bogs are wetlands with very acidic, water-logged soils
   • in bogs where Sphagnum grows abundantly, dead Sphagnum builds up as peat
   • “peat bogs” are abundant:
• about 1 billion acres of peat bogs in world (northern hemisphere mostly)
• ~1% of Earth’s land surface!

• harvesting peat is an important industry in northern temperate zone (Canada, Denmark, Sweden, etc.)
  • peat is used as a soil conditioner or potting mix for good water-holding capacity (peat absorbs 25x weight in water)
  • peat can also be used as fuel
  • peat industry is worth many millions of dollars a year

• slow decomposition in peat bogs make them excellent archeological sites
  • bodies and artifacts buried in bogs are often well-preserved (“Bog people”)
  • allows archeologists to study vanished societies