Plant Diversity Lecture Guide

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*Number in outline corresponds to slide number the PowerPoint presentation.

1. The Diversity of Plants

2. Ecological Importance
- **a.** The plant kingdom is by far the most easily identifiable organisms on the planet. There are very few natural habitats that are not dominated by the vast diversity of this group. As we have learned already this term, plants play a crucial role in several nutrient cycles, and without them much of the life on the planet could not exist. Let's review some of the important ecological roles that plants play.
  - **1)** Plants provide nutrients and energy for nearly every other living organism that shares its habitat, either through photosynthesis, or by absorbing nutrients from the soil via their root system.
  - **2)** Plants supply oxygen, another essential element to support most life on this planet.
  - **3)** When plants die, they decompose and become part of the soil, recycling nutrients that were tied up in their permanent living tissues, building up soil fertility.
  - **4)** Aside from the obvious source of food, humans use plants for shelter, fuel, medicine, basically in every aspect of your lives. If we removed all the plant products from our surroundings right now, we would find ourselves outside, naked. And many of us wouldn't be here at all because of the medicine we rely on to prevent disease and keep us healthy.

3. Invading the Land
- **a.** The common ancestor to all plants is now believed to be a species of green algae called charophyceans. This particular species of algae have very similar DNA structure, the same type of photosynthetic and very similar cell structure as plants, much more so than other types of algae.
- **b.** This type of green algae, known by its common name of stoneworts, are entirely aquatic, so it makes sense that the earliest forms of plants were also at least somewhat restricted to aquatic habitats.

4. Unique Plant Adaptations
- **a.** As plants slowly begin the invasion of dry land there are several adaptations that they developed to deal with some of the unique challenges of dry land. Lack of water and gravity were the big roadblocks to overcome in the land invasion. There are 6 adaptations that characterize the complete domination of land and allowed plants to cut all ties to aquatic habitats. Some of the more ancestral forms of plants such as mosses, do not have all of these features, but clearly demonstrate an intermediary between the ancestor (stoneworts) to the more derived species such as cone and flower producing plants.
  - **1)** Roots help combat both gravity and lack of water. They anchor the plant to the ground and remain upright, compensating for the effects of gravity that are not felt in water. Roots also helped plants obtain water and nutrients. In aquatic habitats, plants can just simply absorb these molecules directly through its leaf tissue. But on dry land, roots allow plants to extract water and nutrients from the soil, eliminating the need to be entirely surrounded by water.
  - **2)** Plants developed two adaptations to help conserve water, those being the cuticle and the stomata. The cuticle is a waxy coating that is secreted by cells in the leaf and stem cells. This coating minimizes the evaporation of water directly from its cells.
  - **3)** Stomata are pores that are found on the surface of green leafy structures in the plant. These pores are where gas exchange happens: bringing CO_2 in and O_2 out. Plants have strict control over these pores and can close them when water is limited.
  - **4)** Along with a root system, plants also developed stems to resist the effects of gravity. These structures are composed of cells that have a sturdy cell wall that is built of a stuff molecule called lignin. Lignin allows the stems to have the rigidity needed to grow upwards as it competes for sunlight.

5) Now that we have a root system, and a stem system that allows the plant to potentially grow to great heights, (hundreds of feet in the example of a giant redwood tree, the plant had to figure out transport water and nutrients up to these heights, in direct opposition to gravity. That is where a vascular system came to be. The vascular system is a series of vessels, or tubes that can move these essential molecules from root to shoot, or vice versa. Water and nutrients need to move up the plant, but sugar, produced in the leaves via photosynthesis need to move down. Vascular tissue accomplishes both of these tasks, while minimizing the amount of energy expended to make it happen. It the case of moving water up a plant, this process doesn't require any energy at all, which is quite possibly the move amazing feature of the plant kingdom, defying gravity at no cost to the plant whatsoever.

6) The last tie to cut from the plant's reliance on an aquatic habitat is to eliminate the need for water to spread its sex cells. Instead of spreading gametes using water, most of the plant kingdom use things such as the wind or animals to spread their sex cells to complete their reproductive life cycle.

5. The Plant Kingdom

- **a.** Before we dive into the details, let's be sure we have a strong understanding of the key features that define the plant kingdom. In order to be classified as a plant, you must multicellular, and you must have the photosynthetic pigment known as chlorophyll. Keep in mind that neither of these traits is exclusive to the plant kingdom, but in order to be considered a plant, you must have both.
- **b.** Another defining trait is the type of embryo a plant makes. When a plant reproduces, the newly formed offspring at its youngest is multicellular, and it must receive energy and nutrients from the parent plant. This characteristic sets the plant kingdom apart from multicellular protists such as kelp and seaweed. These types of organism have a very different reproductive strategy, and therefore are not part of the plant kingdom.

6. Alternation of Generations

- **a.** Plants have a unique reproductive life cycle called the alternation of generations. There are two main phases of a plant's life, and each one is dominated by the development and maintenance of a different structure. In the phase that produces that multicellular dependent embryo, that embryo eventually becomes what is called a sporophyte.
- **b.** In the other phase of the cycle, the plant's energy is focused on creating the reproductive structures of the plant. These structures are what make the sperm and the egg, or the gametes. For this reason this structure is called the gametophyte.

7. Alternating Generations

- **a.** Plants that are the most ancestral (the first to arise in evolutionary history, mosses for example) are dominated by the gametophyte phase. Meaning that the majority of its life cycle is spent as a gametophyte. When you are examining a moss for instance, the green leafy structure that makes up the bulk of the green plant body is the gametophyte.
- **b.** For plants classified as gymnosperms (Cone producing plants) and angiosperms (Flowering plants) the bulk of that plant: The leaves, stems, tree trunk, etc. is the sporophyte, and the cone or the flower is the gametophyte. So the more derived a plant is, the more recently it evolved, the more dominated it is by the sporophyte phase.

8. Major Plant Phyla

- **a.** There are 5 major plant phyla. 2 of these: liverworts and mosses are classified as nonvascular plants, and we will address these as one group. The other three: ferns, gymnosperms and angiosperms are all considered vascular plants and will be addressed later in this lecture. We will start at the bottom of the clade with the more ancestral forms of plants and work our way up to the pinnacle of plant evolution: flowering plants.

b. The things you are responsible for knowing about each group is the following:
   1) The relative spot in evolutionary history the group falls (i.e. moss came before ferns, ad ferns came before gymnosperms, etc.)
   2) Which, if any, of the adaptations for dry land each groups has.
   3) The names of the reproductive structures (i.e. antheridia, cone or flower)
   4) Which structure, the sporophyte or the gametophyte, is more dominant

9. Mosses & non-vascular plants
   a. Nonvascular plants such as mosses don't have many of the features that we discussed help plants move inland. Mosses do not have roots, stems, vascular tissue, and most do not have cuticles or stomata. This means that most species are still restricted to a habitat that is at the very least moist. Recall that the bulk of the green leafy moss body is the gametophyte. There are two types of gametophytes, one responsible for making sperm: Antheridia, and one responsible for making eggs: Archegonia.

10. Moss Life Cycle
   a. To make an embryo, sperm must be released from the antheridium, dispersed through water until it finds a archegonium in need of fertilization. The sporophyte is the structure that results from fertilization (the meeting of sperm and egg), and are small capsules that grow out of the gametophyte. It is from these structures that spores are produced and released, to be disbursed and establish a new individual.
   b. So, to sum up, sperm and egg meet to form a spore, and that spore go out and becomes a newly established plant to start the cycle all over again.

11. Vascular Plants
   a. Ferns are examples of the first vascular seedless plants to arise. From this point on in the plant kingdom, all adaptations for dry land are present in all groups that we will talk about.

12. Fern Life Cycle
   a. Their life cycle is very similar to mosses in that they have archegonia and antheridia, and reproduce using spores. The main difference we see between fern and moss is the fern has a longer sporophyte phase that is much more dominant in terms of visible, recognizable structures such as stems and fronds.
   b. The fronds are where you will find the structures called sporangia. This is where the spores are produced and released, much like the capsules in mosses. Spores are dispersed by either wind or water, loosening the ties to aquatic habitats. Bur ferns are still more likely to be found in moist and humid habitats.

13. Seed-Producing Vascular Plants
   a. Now we move on to the seed plants! We have now reached the point in evolutionary history that the sporophyte is the dominant structure, and the gametophyte remains small and inconspicuous.
   b. Just as in ferns and mosses, seed plants have a male gametophyte responsible for producing sperm and a female gametophyte, responsible for producing eggs.
   c. The male gametophyte is pollen, that pesky substance responsible for causing allergies and hay fever in many people. Pollen allows a plant to reproduce without the presence of water, so we now have no more reliance on water to complete their life cycle.
   d. The female gametophyte is called an ovule. The ovule is where the egg is produced, and is often contained within an ovary that contains many ovules.

14. What are seeds?

- **a.** When sperm, contained in the pollen grain, meets an egg that is contained within the ovule, this is called fertilization. The resulting structure is a seed. There are three major parts that make up a seed.
  - **1)** There is the embryo (baby plant).
  - **2)** There is what is called an endosperm, which is the stored nutrition that feeds the embryo until the seed germinates.
  - **3)** And there is the seed coat, which helps conserve water and protect the embryo from harsh environmental conditions. So in a sense you can think of a seed as a baby plant with a sack lunch and jacket!

15. Gymnosperms

- **a.** There are two types of seed plants: Those that reproduce using cones and those that use flowers. Let's start with the cone producers, AKA gymnosperms. Male cones are responsible for making pollen. Male cones are typically are small, flimsy, and found at the top of the tree.
- **b.** The female cones are what you think of as the traditional pine cone. These rigid woody cones help protect female gametophyte (ovule), capture the pollen, and are the site of seed production. Gymnosperms rely entirely on wind to disperse the pollen and fulfill the plant's reproductive cycle.

16. Conifer Characteristics

- **a.** Of the major gymnosperm groups that are still extant, conifers are the best known. Conifers typically reproduce very slowly, which puts them at a disadvantage in habitats that are well suited for flowering plants but because of their hardy, woody cones, the farther away from the equator you get, the more dominant this group becomes. They are also more likely to dominate at higher elevations and other harsh environment.

17. Flowers!

- **a.** Finally we have come to the pinnacle of plant evolution. The flowering plant! This group is immense, with over 200,000 species identified and more added every day. Angiosperms have been the dominant plant group for the better part of 100 million years and can attribute its success the relationship they have formed with animals. Flowers have allowed plants to reach every habitat on the planet, using animals to aide in pollen distribution.
- **b.** Flowering plants reproduce using pollen, ovules, and seeds like gymnosperms, but they replace the cone of gymnosperms with flowers. Flowers come in every shape, color, and size imaginable, and are usually designed based upon the pollinator that plant attracts.

18. Anatomy of a Flower

- **a.** Let's look at the basic anatomy of a flower. Most flowers house the male and female reproductive parts in the same structure, although there are many that have separate flowers for each. Kiwis and marijuana are 2 examples.
- **b.** The male portion of a flower is called the stamen. This consists of the anther, which is the site of pollen production, and the filament. The filament is basically just a stem like structure that holds the anther up, making in easily accessible to pollinators coming to collect pollen or nectar.
- **c.** The female portion consists of the ovary which houses the ovules(s) (Remember, many ovaries contain several ovules), the stigma, which is a sticky pad that grabs onto passing pollen grains, and the style, which is the tube that the sperm travels down to gain access to the ovule and fertilize the egg contained within.

19. Fertilization in Angiosperms

- **a.** Fertilization in plants is a unique process that is worthy of mention. In every pollen grain, there are two sperm cells, and the ovule contains to egg cells. This means that fertilization is the result of two events of combining genetic material. One sperm and egg join to create the embryo, while the other set of egg and sperm join to form the endosperm (remember the sack lunch?) This process is known as double fertilization.

20. Fruit: Agents of Dispersal

- **a.** Once fertilization occurs, the flower dies, and the plant puts its energy into producing fruit. Fruit serves two purposes. First, it protects the fragile seed as it develops and prepares for germination and it also aides in the dispersal of the seeds contained within the fruit.
- **b.** Do not make the mistake, however, of thinking fruit is there to provide nourishment for the seed. This is a common misconception. The seed already has its built in nutrition in the form of the endosperm. With the evolution of fruit, plants can utilize animals in two ways. Animals can act as pollinators, bringing pollen from flower to flower to facilitate fertilization, but also to disperse seeds.
- **c.** And it is important to note that fruit does not always imply that it is an edible structure like those that you find at your local grocery store. A fruit is any structure that aides in the two processes named. So things like burrs that stick to your clothes when you hike through the forest, or the white wispy things that you blow off of a dandelion, these are considered fruit just as much as an apple or a blackberry.

21. Flower to Fruit

- **a.** One final note on flowers and fruit. Let's take a step back at take the time to really digest what these structures are. The flower is essentially the reproductive organ of the plant, since it is the structure that produces sperm and eggs. If fulfills the same functions that our ovaries and testicles serve. And the fruit is the structure that develops from the ovary of the plant, almost acting like the uterus of the plant. So, next time you stop to smell a flower, or bite into a big juicy apple, think about these little factoids ☺