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| **iLearn BI 101** | **Tabletop Lab: Plant Diversity** |

Examining plant diversity is challenging in an online class, since observing diversity often requires a variety of plant specimens to examine for comparison. In order to have to a robust tour of the plant kingdom, you will need to tap into several resources that are available to you. Your first and most important resource is the natural habitat around you. Whenever possible, seek out live specimens you are being asked to examine from your surrounding area. It is easiest to make connections to the material with plants that you see and interact with every day. When your best efforts to obtain a live specimen fail, the internet is your second best resource. Search for images as needed, just be sure that you viewing the correct structures.

You will need to collect the following specimens:

* Moss with mature gametophytes
* Fern specimen with mature sporangia
* Male and Female fir cones
* Kitchen knife and cutting board
* 1 fresh lily flower – purchased fresh from grocery store or florist

**Part 1: Seedless Plants**

Plants are multi-cellular, eukaryotic organisms that are capable of photosynthesis; they develop from embryos rather than spores, and experience the phenomenon of "Alternation of Generations" in their life cycle. As a group, plants are diverse, and their evolutionary history has many significant developments such as vascular tissues, seeds, and flowers.

**Activity 1: Mosses**

Mosses are included with the group of plants called bryophytes. ***Bryophytes*** lack true roots and vascular tissues, but are capable of surviving on land. Mosses are among the most common of all plants, but because they lack the more complex adaptations for moisture conservation they are restricted to moist environments.



**I. Moss Life Cycle**

Examine the specimens you collected, as well as the figure in your text book and lecture material. Complete the labeling of the diagram of the moss life cycle below. Numbers in the diagram represent structures and the lettered boxes represent processes that occur throughout the lifecycle of a typical moss species.

Match the terms below to the appropriate numbers in the diagram and record them in the lab report:

* **Structures:** Spores, Sperm, Zygote, Sporophyte, Gametophyte

Match the terms below to the appropriate letters in the diagram:

* **Processes:** Fertilization, Meiosis, Mitosis, Germination

**II. Moss Sporophyte Examination**

One feature mosses share with more advanced plants is separate sexes. The male gametophyte produces sperm while the female gametophyte produces an egg. When a moss reproduces sexually, a moss sperm swims in rainwater to the egg at the end of a leafy branch. The fertilized egg is a zygote. The zygote grows up right at the tip of the branch to become the sporophyte. (For its whole life, the moss sporophyte is a parasite on its green, leafy, gametophyte mother.)

From the moss specimen you collected, remove a mature (well filled out) capsule from the sporophyte. Squash it on a white piece of paper or index card. Examine its contents using your magnifying lens. If you do not have a live specimen with mature sporophytes, do a Google search to find a magnified view of the structure.

Observe and describe below. What do you expect to find inside the capsule on a sporophyte?

Examine the images of the female structure (called an archegonium) and the male structure (called an antheridium) in your textbook. Sketch the respective structures in the space to the right.

Male Female

Antheridium Archegonium

**Activity 2: Ferns**

Ferns differ from mosses in several ways; vascular tissue is present, the gametophyte and sporophyte live separately, and the sporophyte is the dominant form in the life cycle.

**I. Fern Life Cycle**

Examine the specimen available in your lab kit and figure 21.8 in your text book and complete the labeling of the diagram of the fern life cycle below. Numbers in the diagram represent structures and the lettered boxes represent processes that occur throughout the lifecycle of a typical fern species.

**Structures:** Match the terms below to the appropriate numbers in the diagram:

* Spores, Egg, Sperm, Zygote, Sporophyte, Gametophyte

**Processes:** Match the terms below to the appropriate letters in the diagram:

* Fertilization, Meiosis, Mitosis, Germination, Release

**II. Fern Examination**

Ferns have efficient water transport tissues that can move water for long distances. They also have **lignin**, a chemical that strengthens cells walls, making sturdy cells and, in some plants, wood. Examine the fern specimen you collected.

Examine one of the dots from the underside of the fern leaf you collected. Use your magnifying lens. Draw the sporangium (spore case) and, if available, spores. (By spring, the spores may have all dispersed.)

1. How has the presence of vascular tissue affected the fern shape or size, compared to mosses?
2. Familiar **fern** structures are **sporophytes**. Therefore, what reproductive cells do you expect them to produce?

**III. Seedless Plant Compare and Contrast**

Complete the table to sum up what you learned about seedless plants.

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| **Question** | **Moss** | **Fern** |
| Color of gametophyte  (green or non-green) |  |  |
| Color of sporophyte  (green or non-green) |  |  |
| Which stage(s) perform(s) photosynthesis?  (sporophyte and/or gametophyte) |  |  |
| Which stage is larger?  (sporophyte or gametophyte) |  |  |

**Part 2: Seed Plants**

**Introduction:**

The development of the seed is one of the most significant evolutionary developments made by plants. A seed can be distantly dispersed, yet lie dormant until environmental conditions are favorable. It is not surprising to observe that seed plants are the most numerous types of plants, and the most widely distributed. There are two major groups of seed plants, the **gymnosperms** and **angiosperms**. In the gymnosperms the seed is unprotected (without a surrounding wall/fruit) on the surface of the sporophyte. Conifers, aka evergreen trees, are among the most well known gymnosperms. Angiosperms, or flowering plants, enclose the seed within maternal tissues, forming a fruit. Often the fruit is fleshy and edible, but not always e.g. walnut shells are also technically a fruit and are quite inedible.

**Activity 1: Gymnosperms**

1. **Life Cycle:**

In gymnosperms the sporophyte, which is diploid (2 sets of chromosomes in each cell), dominates the life cycle. The gametophyte is haploid (one set of chromosomes) and is represented by male and female portions which are reduced to small clusters of non-photosynthetic cells housed within the male and female cones respectfully.

Study the diagram on the right and the gymnosperm lifecycle diagram in your text and lecture material to identify the following structures and processes.

1. Structure 1: sporophyte or gametophyte?
2. Female structure in 4: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Cell divisions occurring between 4 and 5: mitosis or meiosis?
4. Process occurring between stages 6 and 7: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Structures in 10: \_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. **Cone Anatomy:**

Before proceeding, you will need to obtain male and female cone specimens. If you do not have these types of cones easily obtainable in your area, you will need to do a Google search for images that will help you complete the following activities.

1. Compare the provided male (staminate) cones, the sites of **pollen** production, and female (ovulate) cones, the sites of **ovule** production. The male cones are small, flimsy and short-lived, while the female cones are large, woody and long-lived (these are typical cones used in decorations during the winter holidays). What do you think are the reasons for these differences in cone appearance?
2. Obtain a fresh male cone (or find a magnified view online), and examine it with the magnifying lens – observe the powder that falls from it. Draw a sketch and describe the cone and the pollen in your own words, noting texture, color, size etc.
3. Now do a Google search for a magnified view of a pollen grain. Describe and draw what you find. What is contained inside the pollen?
4. Obtain a fresh female cone, and examine the cone by using your magnifying lens. Sketch the cone in your notes and identify the sites of ovule production. Hint: Look on the dorsal/upper surface of each woody scale.
5. What gamete (reproductive cell) does a pollen grain produce? What gamete does an ovule produce?
6. After fertilization the ovule becomes a **zygote**. After fertilization the seed completes its development. The seed contains tissues from three generations: the parent sporophyte, the parent gametophyte, and the zygote sporophyte. From the time that the female cone first develops, production of mature seeds takes about 1 year. Pointing a female cone upward, you will find two seeds on the upper surface of each woody scale (if seeds have not been shed). Tear several scales from the cone, until you find seeds (which should have thin wings that aid in wind dispersal). Draw a seed in your notes.
7. Are there animals that eat these seeds? If so can you name a couple of examples? Where is the nutrition in these seeds?

**Activity 2: Angiosperms**

1. **Introduction**

Angiosperms are the most successful types of plants; their flowers improve the probability of fertilization and the development of a fruit improves the probability that the seed will be successfully dispersed. It is important to understand that the fruit is not intended to supply nutrients to the seed. The fruit acts as a protective layer and dispersal mechanism for the seed. The endosperm, found in the seed itself, is the nutrient supply for the developing plant embryo.

The flower is the reproductive organ of the flowering plant. It serves to transfer pollen (the male gametophyte) from one flower to another, to permit fertilization of the egg (which is in the ovule) by the sperm (which is inside the pollen).

Most flowers accomplish **pollination** (pollen transfer) with the aid of insects or other animals, but some use wind and a very few use water. After pollination, the flower promotes the growth of the embryo and fruit.

1. **Flower Anatomy:**

The flower consists of four whorls (circles) of flower parts. All flower parts are attached to the **receptacle**, the swollen end of the flower stalk.

1. **Sepals**: The outer whorl of flower parts consists of sepals. They are often green or brown and protect the other flower parts, but some flowers have colorful, petal-like sepals. This is often what we think of as the coverings around the flower “bud.”
2. **Petals**: Next, and just inside the sepals (more interior) are the petals, modified leaves that are usually colorful and map produce scents or nectar (a sugar solution) to attract insects.
3. **Stamens**: The next innermost whorl are the stamens, these are the male reproductive organs. Each stamen consists of a **filament** (a stalk) and an **anther**, a sack that produces the pollen.
4. **Pistil**(s): The innermost part of the flower consists of one or more pistils, the female flower parts. Each pistil consists of an:
   * **ovary** (containing ovules, the female gametophytes),
   * a **style**,
   * and a **stigma**.

The stigma is the top part of the pistil. It is often feathery or sticky to catch pollen. Pollen lands on the stigma, where it germinates (begins growth). The pollen grows a root-like tube down through the style into the ovary and next to an ovule. Then it releases sperm that move into the ovule to fertilize the waiting egg on the inside.

Variations on the theme:

* Flowers may be associated with bracts (modified leaves) E.g. poinsettia flowers (the red portions are not true petals, but are modified leaves that are red like petals.)
* Flower parts may be fused (attached to each other).
* The ovary may be located above the base of the petals (called a superior ovary), or buried in the receptacle for protection from herbivores (called an inferior ovary).
* In horticultural varieties, stamens may be converted to extra petals.

1. **Flower Dissection:**

For this portion of the lab you will need to find or purchase a flower to dissect. DO NOT USE an iris or a composite (sunflower-like). You may check with your instructor to choose a suitable flower. It is recommended that you try to find a lily like flower with large parts. Astralomeria, is a common, grocery store, lily that is fairly inexpensive if you need to purchase a flower. Answer the following questions to the right as you dissect your flower.

1. Draw and name your flower. Label as many of the following parts as possible: receptacle, sepal, petal, stamen, filament, anther, pistil, ovary, style, and stigma. A top view is ideal.
2. Dissect the flower. Use a sharp knife blade to carefully cut the flower in half, lengthwise (a longitudinal section), revealing the ovary or ovaries, and the ovule or ovules within the ovary or ovaries. This should be done so that you have two equal halves of the flower.
3. Draw the longitudinal view in your notes, and label the flower parts including the ovule or ovules. Does the flower have an inferior or superior ovary? Does your flower have more than one ovule? How do you know?
4. After a flower has been fertilized, what does a ripening ovary become?
5. What does a ripening ovule become?
6. **Local Flower Diversity:**

Next, you will need to take a short walk in your neighborhood, to the park, or a nearby garden. Your job is to examine flowers and fill in the table below to describe their traits. You should find 3 different flowers to identify the various parts for, but you need not worry about if you can identify the flower – the dichotomous keys for flowering plants in our region are complex and exceed the scope of this course. Simply label it with a familiar name/phrase that you can identify e.g. “clustered, purple flower growing on a bush”. If a flower has more than 15 petals, you can just write “many.” DO NOT USE irises or composites/sunflower like flowers – these are far more complicated.

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| **Flower name/description** | **# sepals** | **# petals** | **Petals or other parts fused?\***  **(if “yes”, then describe the ways that parts are fused)** | **Ovary inferior or superior?** |
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1. **Floral inflorescence:**

An inflorescence is a cluster of flowers on a single stalk. Often they offer more to pollinators than a single flower alone can, so they are often showy and quite variable.

1. Which do you think is more likely to attract pollinators, a single large flower (like a rose or lily) or one with many clustered flowers that are much smaller? Why do you think so?
2. What are some disadvantages to making flowers very large?
3. A way to get the advantage of both small flowers and large displays is to group many small flowers together. A cluster of flowers is an **inflorescence**. A fragrant hyacinth is an inflorescence. Can you think of 2 or 3 other flowers that you saw on your excursion that might be classified as an inflorescence?
4. **Composite flowers:**

The composite family is one of the largest angiosperm families, with about 25,000 species. Common examples include dandelions, daisies and sunflowers. What all have in common is that each **composite** “flower” is actually an inflorescence containing hundreds of individual, small flowers that are crowded together to form a structure that, from a distance, resembles a single large flower.

The small, individual flowers within a composite may be of two types: **ray** and **disk**. Ray flowers are strap-shaped (like a single long petal), while disk flowers are tubular and on the inner part of the flower, where the bees or butterflies might land. Not all composites contain both ray and disk flowers – dandelions, for example, contain ray flowers only. When both types are present, such as in daisies, the ray flowers are arranged around the perimeter of the composite flower, while the disk flowers are crowded together toward the center. In a daisy, the ray flowers are showy and serve mainly to attract pollinators, while the smaller disk flowers contain the actual reproductive parts.

1. If possible, examine a composite flower containing both ray and disk flowers using your hand lens – note this may not be possible in some seasons, generally daisies and sunflowers are summer time flowers, so if not available, do a web search to find images of sunflower anatomy to see the inner portions of a composite flower.
2. If you are able to obtain a composite flower, carefully remove a ray flower and a disk flower, and examine each individually using the hand lens. Take apart a fertile disk flower to see the small reproductive organs that it contains, if you see a small hair like appendage rising above the small, seed like structure in the center of the disk flowers then recognize that this is a pistil /carpel of the flower awaiting pollination – when fertilized this is what becomes the “sunflower seed” that we eat or use to make oils.
3. Draw a single ray flower and a single disk flower in your notes, and label the parts you can see in each.
4. **Flowers and pollinators:**

Flowers are the reproductive organs of the angiosperms, but they are also frequently dependent upon the animal world to help them complete their reproductive cycle. Pollinators are animal vectors that help move pollen from one plant to the pistil/carpel of another flower (but sometimes on the same tree/flower stalk).

Various flowers have developed special, symbiotic relationships with specific pollinators.

* **Honeybees** are prolific pollinators in the daytime. Their vision is different than ours. They cannot see red, but are attracted to yellow and blue, as well as to ultraviolet light that our eyes cannot see, but that they perceive like glowing lights of an airport landing strip. Bee-pollinated flowers usually have “landing platforms” i.e. sturdy petal for the bees to alight upon, as well as markings called “nectar guides” that show the bees where to go to find their nectar reward (sometimes the guides are only visible in ultraviolet light). Sometimes they will be visible dots or lines that direct the bee to the center of the flower.
* **Butterflies** and **moths** both tend to hover by flowers, so they have no need of landing platforms. They extend a long tongue deep into a floral tube to obtain their nectar reward. Butterflies, active by day, are often drawn to red and orange. Moths, active at night, are drawn to white, strongly scented flowers that are easy to find in the dark. **Bats** are attracted to similar flowers as moths, for the same reasons, but usually they are attracted to the large, higher placed flowers e.g. Banana flowers in the tropics.
* **Hummingbirds** are attracted to bright red flowers, and their long bills can reach down long narrow floral tubes to reach their nectar rewards. (This is why hummingbird feeders are usually red!)
* Many **flies** and **beetles** are attracted by the strong scents of rotting meat, or fermenting plant materials. Accordingly, some flowers produce such smells, including the colossal, 2.5-meter tall inflorescence of Sumatra’s *Amorphophallus titanum*, which smells like rotting fish.

Using your flowers that were identified your Local Flower Diversity table, hypothesize about the pollinators of those flowers.

1. **Fruits**

Fruits are also a “bargain” with the animal world. They are the mature, swollen ovary or receptacle of a flower AFTER it has been pollinated & fertilized. Fruits are highly variable and a topic of study in another General Biology course, so we will not focus on the vast array of different kinds of fruit. Which of the following plant parts do you think may be a fruit?

* The pod around a pea e.g. snap peas
* The winged apparatus that allows a maple seed to fly like a helicopter
* Pineapple
* Apricot
* Hard shell around a hazelnut

Check your answers:

If you chose all of the examples listed, you are correct. Even structures that are not sweet, but protect or help disperse the seeds are considered fruits. Not all fruits are edible, including for instance, the hull around a coconut (the world’s largest seed).

1. Why would plants go to the “trouble” of making large, heavy fruits e.g. a peach or apple? Hint: what is the purpose of making such structures?
2. When you eat a watermelon or a peach, we throw away the seeds or spit them out, but each and every one has potential to become a new plant if it were to find fertile soil and the right growing conditions such as moisture and sun. Why do you think some fruits make so many seeds and others fewer or only one?
3. Some fruits have no seeds on the inside e.g. bananas, research why this is so and report what you found: