Week Two: Algae, Seedless Plants, and Gymnosperms

1. Pre-Lab Reading

Chapter 23 "Protists" Biology2e, OpenStax College

Chapter 25 "Seedless Plants" Biology2e, OpenStax College

2. Purpose and Objectives

The purpose of this investigation is to examine representatives of various types of photosynthetic eukaryotes.

Upon completion of this exercise, you should be able to:

1. Describe the distinguishing characteristics of algae
2. Identify representatives of several algal phyla
3. Describe the morphological characteristics, life cycles and reproductive structures of mosses, ferns and gymnosperms.
4. Discuss similarities and differences between these plants and others you have studied.
5. Explain how various adaptations allow some photosynthetic eukaryotes to grow on land.

You will work independently in this exercise.

3. Safety Guidelines

1. Carry microscopes and stereoscopes with two hands.
2. Before examining any specimens, make sure that the microscope is set on the lowest power objective.
3. Clean and replace all equipment.
4. Wash your hands before leaving the lab.

4. Background Information

The photosynthetic eukaryotes include organisms as diverse as simple unicellular algae and complex flowering plants such as roses and maple trees. This lab will examine organisms that are, in some ways, less complex than the familiar angiosperms or flowering plants. The different forms seen represent, to some extent, the evolutionary stages that are thought to have preceded the development of angiosperms. These groups include the Algae, a diverse group of mostly aquatic organisms, the Bryophytes, which are seedless, nonvascular land plants, the ferns, which are seedless, vascular land plants, and the Gymnosperms, which are vascular land plants that produce "naked" seeds.

The first photosynthetic eukaryotes were most likely Algae. **Algae** (singular alga) is a general term that refers to photosynthetic eukaryotes that are not considered plants. Like the Protozoa, the Algae do not constitute a monophyletic group. Algae have a variety of body plans and may be **unicellular**, **colonial**, or **multicellular** organisms. Although some multicellular algae resemble plants, they differ from land plants in several important ways. The algae lack true vascular tissues and can therefore only live in aquatic or very moist terrestrial environments. In addition, whereas the land plants all have reproductive life cycles that produce both multicellular diploid and multicellular haploid stages (called "**Alternation of Generations**"), the algae group includes organisms that have **haplontic** life cycles (the only multicellular form is haploid), organisms that have **diplontic** life cycles (the only multicellular form is diploid) as well as organisms whose life cycles demonstrate alternation of generations.

The algae are grouped into several different clades. Major groups of algae are distinguished from one another based on the following characteristics: the types of pigments present, composition of the cell wall (if present), how they store food, and cellular organization. All algae species have the photosynthetic pigment chlorophyll a plus either chlorophyll b, c or d and other accessory pigments. It is the accessory pigments that often determine the color of the algae. Several species of algae resemble

plants and are commonly called **seaweeds**. Microscopic algae are constituents of **phytoplankton** and are important primary producers in most aquatic ecosystems.

In this lab exercise, we will examine representatives of the following algal groups: Chlorophytes (green algae), **Phaeophytes** (brown algae) and **Rhodophytes** (red algae). Table 1 summarizes some of the basic characteristics of each group. The algae observed may be **unicellular**, **filamentous** (cells are joined end-to-end forming long chains or filaments), **colonial** (cells are attached and usually form some simple geometric pattern) or **multicellular** (resembling plants).

Table 1: Summary of major algal groups and their characteristics

CLADE	CELL ORGANIZATION	ADDITIONAL PIGMENTS	FOOD STORAGE	CELL WALL
Alveolates Dinoflagellates	unicellular (primarily)	chlorophyll c carotenoids	starch	cellulose
Stramenopila Phaeophytes	filamentous, multicellular	chlorophyll c fucoxanthin	lamarin (lipid) mannitol	cellulose alginates
Plantae Rhodophytes	filamentous multicellular	chlorophyll d phycobilins	modified starch	cellulose agar carrageenan calcium carbonate
Plantae Chlorophytes	unicellular filamentous colonial multicellular	chlorophyll b carotenoids	starch (oil)	mainly cellulose

5. Chlorophytes (green algae)

Green algae are a very diverse group of mostly aquatic algae with over 7,000 freshwater and marine species identified so far. Other environments where green algae can be found include snow, tree trunks or soils. In addition, they can be found living symbiotically with protozoa, hydras, corals and lichen-forming fungi. Typically, they are green in color but can appear more yellowish or blackish, depending on the type of

accessory pigment present. It is believed that green algae and plants share a common ancestor. Many texts now include all or part of the green algae in the group *Plantae* and divide the green algae into several taxa, only one of which retains the name Chlorophytes.

The life cycles of green algae consist of both sexual and asexual stages. Sexual reproduction usually involves the formation of motile biflagellate gametes and fertilization requires the presence of water. Asexual reproduction occurs by mitosis.

Procedure

1. Prepare a wet-mount slide of the "Green Protist" culture.

2. Identify three organisms, one of each of the following: **unicellular, filamentous, and colonial** organisms. Draw and record your observations of these algae either under 100x or 400x magnification. Label with the Genus name and describe the body form (unicellular, filamentous, colonial), shape, size and color and whether these algae exhibit any independent movement. With filamentous or colonial species, label a single cell.

3. Don't forget to indicate the total magnification used!

6. Phaeophytes (brown algae)

Brown algae are the largest and most complex algae. They are found in cold and temperate marine waters throughout the world. While some species are microscopic, forming branched filaments, most are macroscopic. Kelps can grow up to 100 meters in length. The body of a large alga is called the **thallus** and typically consists of a **holdfast** (anchors the alga) and a **stipe** (supports leaflike **blades**).

The *Dictyota* genus includes numerous species. These multicellular brown algae are common in shallow marine waters where they can be found attached to rocks or coral

reefs. Most are small, ranging in size from a few centimeters to about 20 cm. The thallus consists of flat, “ribbon-like” forked branches.

Procedure

1. Obtain a sample of the macroalga *Dictyota*.

2. Draw and record your observations concerning the shape, size, color and growth pattern of the alga.

7. Rhodophytes (red algae)

Red algae differ from other algae in that they have no flagellated stages in their life cycles. Most species are found in marine habitats, though some are also found in soil and freshwater. The red color of these algae is due to the accessory pigment **phycoerythrin** which absorbs light energy in the blue and green ranges. Not all red algae appear red: the color can vary depending on where they are found. In very deep waters, they may appear almost black, while in shallow water the red accessory pigment can be masked by the abundance of chlorophyll. Some red algae are important in building reefs. Called **coralline algae**, they have cell walls composed in part of calcium carbonate.

Since red algal gametes lack flagella, they rely on water currents for fertilization to take place. **Alternation of generations** is common, a pattern of reproduction also found in plants.

Procedure

1. Prepare a wet-mount slide of *Callithamnion* and view at 100-400x magnification.

2. Draw the alga, noting that it consists of branching filaments. How are the size and shape of cells in these filaments different from those found in the filamentous chlorophytes observed earlier?

8. Introduction to the Land Plants

What is a plant? If you consulted a dictionary, you would come up with something like "a photosynthetic, eukaryotic multicellular organism of the Kingdom Plantae characterized by producing embryos, containing chloroplasts, having cellulose containing cell walls and lacking the power of locomotion." (http://dictionary.reference.com) Your text uses the terms "land plant" and "embryophyte", a photosynthetic organism that develops from a protected embryo, to distinguish these organisms from the green algae. All land plants have life cycles with multicellular haploid (**gametophyte**) and diploid (**sporophyte**) generations. When plants adapted to terrestrial environments, protection of the embryo, which develops following fertilization, was vital to survival. Various strategies for accomplishing this can be seen when examining the great variety of plants. In this part of the lab, you will examine species of **nonvascular plants, seedless vascular plants and gymnosperms**.

The **nonvascular land plants** include the **mosses**, liverworts and hornworts. These are seedless, nonvascular (true for most) plants that are relatively small and inconspicuous when compared to other types of plants. We will examine the mosses (Bryophytes).

Ferns are also seedless, but do possess vascular tissues.

As in other land plants, the life cycle of bryophytes and ferns occurs by alternation of generations. Bryophytes differ from other land plants (including ferns, gymnosperms and angiosperms) in that the more dominant generation is the gametophyte generation.

Sexual reproduction in both bryophytes and ferns involves flagellated sperm formed in the **antheridia** of the male gametophyte swimming through a film of water to reach the eggs in the **archegonium** of the female gametophyte. Fertilization results in

the formation of a zygote which then produces the sporophyte. In bryophytes, the sporophyte remains attached to and nutritionally dependent on the gametophyte. The sporophytes of both bryophytes and ferns produce spores that develop into gametophytes. Unlike the bryophytes, in ferns the dominant generation is the sporophyte**.**

Gymnosperms and Angiosperms are seed plants. Embryo development in these organisms stops while the embryo is still very small. The embryo enters a dormant phase where it is protected by a seed coat formed from parent tissues. Seeds provide an obvious survival advantage for land plants, which encounter rapidly changing environments, because they can remain viable when conditions are unfavorable.

Gymnosperms bear seeds on scale-like structures called **cones**. The term gymnosperm literally means "naked seed" and describes plants that produce seeds lacking the protective enclosure provided by ovaries in which angiosperm seeds develop. As for ferns, the dominant generation is the sporophyte. Gametophytes of gymnosperms are microscopic and completely dependent on the sporophyte. Unlike the algae and the seedless plants, some gymnosperms (conifers) do not require water for fertilization. The male gametes are released in the form of pollen grains, which usually reach the structures enclosing the female gametes by means of wind currents. Gymnosperms include four phyla, or divisions: Cycadophyta, Ginkophyta, Gnetophyta and Coniferophyta.

9. Nonvascular Land Plants (mosses)

Mosses are the most familiar of the nonvascular seedless plants. The plant body (**thallus**) grows very close to the ground with many individual plants forming tightly packed mats. These mats have a spongy quality that allows them to soak up and store water. Mosses lack true roots, stems or leaves. Elongated cells form **rhizoids** that anchor the moss gametophyte to its substrate.

Procedure

A. General Morphology

1. Observe the moss plant provided. The "leafy" green portions of the moss are the haploid gametophytes. These may be either male, which produce sperm in structures called antheridia or female, which produce eggs in structures called archegonia. As in the algae, fertilization requires water because the biflagellate sperm must swim to reach the eggs. Describe the moss – **how tall is it**?

2. Extending from the tip of the gametophyte are developing sporophytes. The stalks (**seta**) support a **capsule** (**sporangium**) where haploid spores develop.

3. At the tip of mature capsules is a cap called the **operculum**. In the proper weather conditions, the operculum pops off allowing the spores contained within the capsule to scatter. Determine whether or not this structure is present. **Draw and label** a sporophyte attached to a gametophyte. Make sure to include labels for sporophyte, gametophyte, seta, and capsule.

10. Seedless Vascular Plants (ferns)

A. Ferns

The seedless vascular plants include club mosses, horsetails and ferns. Ferns are found in both temperate and tropical regions. Most are terrestrial though some aquatic species also exist.

Unlike bryophytes, in ferns the sporophyte is the dominant generation. Leaves of ferns are called **fronds** and are generally lobed or compound where each leaf is divided into several leaflets. A new, emerging frond is called a **fiddlehead** which gradually uncurls to give rise to the mature leaf.

Haploid spores are formed in **sporangia**, often found clustered on the underside of the frond in groups known as **sori (sorus, s.).** The fern gametophyte is small in size and bisexual. Once fertilization has taken place, the sporophyte plant emerges from the parent gametophyte. The sporophyte forms a **rhizome** that functions like a root to anchor the plant. Roots arise from the rhizome.

Procedure

1. Examine the fern specimen provided. Do not remove parts from the plant! This is the mature sporophyte. Notice the leaf-like structures called **fronds**. The frond consists of a **blade** that may be lobed or divided into leaflets (frondlets?). The lobes of the blade are called **pinnae**. The fern fronds are attached to underground stems called **rhizomes** by a **stalk**. Rhizomes are readily visible on the rabbit's foot fern because they are above ground. For other ferns these are underground. A developing frond is called a **fiddlehead**.

2. Look at the underside of the fronds and locate the **sori** if present. These are groups of sporangia where haploid spores are formed.

3. **Draw and label** a fern frond and rhizome (if visible). Label the blade, petiole, and rhizome. Label sori if they are present.

11. Gymnosperms: Phylum Coniferophyta

Members of this phylum are commonly referred to as **conifers**. The most recognizable members probably belong to the genus *Pinus*. However, there are many other types of conifers including yews, spruces, firs, hemlocks, cedars, redwoods and junipers. While most conifers retain their leaves (**needles**) throughout the year, a few species are **deciduous** and shed their leaves at the end of the growing season. These include the bald cypress (a member of the redwood family) and the American larch.

Procedure

A. The Pine Sporophyte

1. Examine the branch of *Pinus* having leaves (needles) and a terminal bud. Notice that the leaves are borne on dwarf branches only a few millimeters long and occur in bundles. This distinguishes the pine from other conifers in which the leaves are attached individually to branches. The length and number of leaves can be used to differentiate among the many species of *Pinus*.

2. Draw a portion of a branch and several leaf bundles. Include the following observations in your lab book:

- How many leaves are in a bundle (usually 2 or 5, depending on species)?
- How are the leaf bundles arranged?
- Describe how pine leaves differ from those of most deciduous plants.

3. Examine the mature female cones provided by your instructor. Can you locate any seeds? Where are the seeds located? How do the various cones differ?

B. Examples of Other Conifers

1. The Yew Family (Taxaceae)

In this family, the seeds are not borne in cones. They are surrounded by a fleshy cup, the **aril**, each of which holds only one seed. Seeds are dispersed by animals that eat the cups.

Procedure

1. Examine the branches of yew provided by your instructor. How do the leaves of the yew differ from those found in *Pinus* (describe shape, attachment to the branch)?

2. Draw a small yew branch.

3. Look for sporophylls and sporangia on the yew branches. Yews are dioecious (separate male and female plants) and the ovules and sporophylls are found on separate plants.

2. The Cedar Family

1. Examine the branches of cedar. How do the leaves of cedar differ from those of the yew and pine?

2. Are any reproductive structures present? Are they male or female reproductive structures?

3. Are any "fruits" present? Describe them.

12. Gymnosperms: Phylum Cycadophyta

Cycads flourished during the Mesozoic Era,150 million years ago. Today, only 100 species remain. Resembling palms, cycads can be found on every continent except Antarctica and Europe. They live in tropical, subtropical and warm temperate regions and grow in a variety of habitats, including the forest understory in rainforests and seasonally dry forests or in grasslands.

Cycads are dioecious and the male and female cones often differ in size (which can be very large), shape and sometimes color. Sperm are flagellated, so water is required for fertilization to take place. Leaves are evergreen and very tough

Procedure

1. We will examine cycads on our trip to the Botanical Garden.

13. Gymnosperms: Phylum Ginkgophyta

Only one species of this phylum exists today: *Ginkgo biloba* (Maidenhair tree). Once thought to be extinct, living species were found being cultivated in temple gardens in China and Japan. As with cycads, *Ginkgo* flourished in the Mesozoic Era. Today, they are widely planted as ornamental trees, especially in urban areas because of their tolerance to pollution.

Ginkgo is a dioecious species and fertilization of the ovules may not occur until after the ovules have fallen from the tree. The fleshy coat that surrounds the seeds has an extremely unpleasant odor, so male trees are usually favored for cultivation. Leaves of *Ginkgo* are fan-shaped and lobed. Unlike most gymnosperms, *Ginkgo* is deciduous, and the leaves turn a brilliant yellow in the fall.

Procedure

1. Examine the preserved Ginkgo leaf and seed and draw the leaf in your lab book.

14. Conclusion and Summary

1. Name a characteristic that distinguishes algae from each of the following: bacteria, protozoa, and land plants.

2. How do mosses and ferns differ? How are they similar?

3. How do mosses and ferns differ from gymnosperms?

4. How do gymnosperms differ from angiosperms?

5. What are the advantages of possessing vascular tissues for land plants? What are the advantages of seeds?

6. Describe three ways to extend these investigations and explain how each would increase your knowledge of these organisms.

Bibliography

1. www.seaweed.ie
2. www.nmnh.si.edu/botany/projects/algae
3. https://www.livescience.com/54979-what-are-algae.html

NOTES: