Bryophytes: The Non-Vascular Plants

Introduction
There are about 20,000 species of Bryophytes, plants that lack vascular tissue. They are found throughout the world. Although more prevalent in moist and shady areas, Bryophytes can be found in alpine and arctic regions, where they are subjected to freezing, and some in deserts, where they are desiccated most of the time. One of the most abundant Bryophytes, *Sphagnum*, is found in bogs worldwide, and forms peat, a source of fuel when compacted, and a soil texturizer when less "decomposed". Associations of Bryophytes with mycorrhizae are common. The three phyla of Bryophytes are distinguished from each other on variations of sporophyte structure and gametophyte morphology. All Bryophytes have a predominant gametophyte generation.

Bryophyta: The Mosses
Examine the number of different mosses available. The "leafy" plants are the gametophytes, which are the photosynthetic, assimilative stage of all Bryophytes.

Most mosses have radial symmetry. The gametophyte has a stem like axis with spirally arranged "leaves" that are properly called phyllodes. (A true leaf, by definition, has vascular tissue.) Moss "leaves" have a costa (midrib).

Mosses attach to their substrate with multicellular rhizoids. Their "stems", properly called an axis, can be erect or prostrate (axis along the ground). Mosses absorb water and minerals across their surface cells. Many mosses can desiccate, or dehydrate for long periods without permanent damage.

Identify the axis, phyllodes and rhizoids. Note the spiral arrangement of phyllodes along the axis.

Make a wet mount of several different moss phyllodes and observe the costa on each.

Look for clusters of terminal antheridia, the male gametangia and immature archegonia, the female gametangia on the gametophyte plants. You will observe the microscopic structure of antheridia and archegonia later in the laboratory period.

You may also see moss sporophytes, which are embedded in the gametophyte plant. The sporophyte is an elongated structure elevated above the gametophyte. Mosses generally have separate male and female gametophytes, though gender is not readily obvious to the untrained eye.
Sexual Reproduction in Mosses.
Water is required for transfer of the motile sperm to egg. Antheridia are typically found in terminal disk-shaped clusters on the gametophyte to facilitate water capture for sperm transfer. Archegonia produce one egg each. After fertilization, the sporophyte grows out of the archegonium, and nutrients for the developing sporophyte are provided by the gametophyte.

Examine the prepared slides of moss antheridia and moss archegonia. Antheridia and archegonia are surrounded by sterile hairs, called paraphyses. Antheridia are club-shaped and contain many motile sperm. Archegonia are vase-shaped, with a stalk embedded into the gametophyte, a ventor that contains the egg, and a neck through which the sperm travels.

The sporophyte consists of a foot, anchored in the archegonium, a seta, or stalk, which elevates the sporangium, or capsule. Typically, a portion of the gametophyte, called the calyptra, protects and covers the developing capsule.
Meiosis in the capsule produces haploid spores. When spores are mature, the lid of the capsule, called the operculum, opens, and a row or rows of hygroscopic teeth, the peristome, respond to changes of humidity to open and release spores. Examine the moss sporophyte prepared slide. Note the many spores inside.

Look at the assorted mosses with sporophytes available. Identify the protective calyptra on immature sporophytes, as well as the operculum, peristome, and seta of mature sporophytes.

Place a capsule in a culture dish on moist toweling and cover the dish with saran wrap. After a few minutes, remove the saran wrap and place the capsule under the dissecting microscope. Gently remove the operculum to expose the peristome. With “luck” you may see the response of the peristome to the change in humidity.

Each moss spore germinates and divides to form a filamentous protonema, which develops into the gametophyte. Examine a prepared slide of moss protonema. Its resemblance to filamentous green algae is striking.

Before leaving the mosses, observe the sphagnum moss and peat moss provided. Bog ecology centers around this one moss, Sphagnum. About 1% of the world's land mass is sphagnum bogs. Sphagnum cells have specialized water holding capacity and many air spaces. Partially decomposed Sphagnum forms peat, and when thoroughly compressed, a form of lignite coal. Peat is used for fuel, mulch and packing materials.

Observe the prepared slide of Sphagnum "leaves". Note the water-holding structure of the phyllodes.
Hepatophyta (Liverworts)
There are two distinctive groups of liverworts, the commonly studied thallose liverworts and the less conspicuous leafy liverworts, sometimes called scale mosses.

Most liverworts have a flattened, typically prostrate dorsal–ventral orientation. In the thallose liverworts this forms a thallus (sheet-like) shape. The leafy liverworts exhibit the dorsal ventral flattening on either side of a central axis. Liverworts attach to their substrate with unicellular rhizoids.

We will look at the two groups of liverworts separately.

Thallose Liverworts
Thallose liverworts are common in the Pacific Northwest in moist lowland woodlands and moist areas of lawns, particularly around foundations of buildings. As the liverwort gametophytes grow, they branch dichotomously, forming the distinctive lobes from which the common name is derived. Apical meristems are located at the notches in the thallus lobes. The upper surface of the liverwort contains visible pores for gas exchange. Some have a cuticle to minimize dehydration.

Observe the variety of thallose liverworts on display. A common genus is Marchantia.

![Thallose Liverwort Gametophytes](image1)

Look for gemmae cups on the display liverworts. Gemmae, propagules formed in gemmae cups, are a significant means of vegetative reproduction in the liverworts. Examine, too, the prepared slide of gemmae cups.

![Gemmae](image2) ![Gemmae, ls](image3)
Some thallose liverworts have surface air pores for gas exchange and produce a cuticle.

Liverworts are typically heterothallic. Meiosis produces half male and half female spores, so that a gametophyte is either male or female. In *Marchantia*, for example, the archegonia and the antheridia are elevated above their respective thallus structures on stalks called archegoniophores and antheridiophores. Several archegonia and antheridia are found in each stalk. Other thallose liverworts may have the antheridia and archegonia embedded in the thallus tissue, rather than on stalks.

Are there archegoniophores and antheridiophores on the display liverworts? Examine the prepared slides of *Marchantia* archegonia and antheridia.

The liverwort sporophyte is a simple club-shaped sporangium that grows from a basal foot embedded in the archegonium. At maturity, the sporangium splits open to release spores. The release of spores is assisted by special hygroscopic hairs, called elaters. Observe the prepared slides of *Marchantia* sporangia and of *Marchantia* spores.
Leafy Liverworts
A leafy liverwort grows along an axis with its flattened "leaves" overlapping in pairs along the axis. The "leaves" are lobed-shaped, often just one or two cells thick, and almost translucent. They lack a midrib, called a costa in mosses. Leafy liverworts are frequently mistaken for mosses, but they are more delicate, and mosses rarely have the flattened shape. Leafy liverworts are prevalent epiphytes in the warm, moist tropics. They are not uncommon in the Pacific Northwest, and reasonably abundant in the PNW rain forest. Leafy liverworts can be found in the late spring, when the sporophytes mature. One common species grows on cottonwood bark. Bonus points are given to students who find and bring in leafy liverworts. Those with sporophytes earn even more bonus points. Observe the leafy liverwort plants on display.

The leafy liverwort sporophyte capsule, found on the surface of the gametophyte is "ephemeral". The colorless, translucent seta, the sporophyte stalk, elongates rapidly bearing the typically globular, sporangium at its tip. The darkly pigmented sporangium matures rapidly, splits open to disperse spores, and dies. A sporophyte may be as much as a centimeter in length, and the sporangium about the size of a pinhead.
**Anthocerophyta (Hornworts)**
Hornworts have rounded, small, (about one centimeter in diameter) thallose-like gametophytes that are found in moist shaded soils. The gametophytes may be unisexual or bisexual, depending on the species. The sporophyte is "horn-shaped", and grows from a basal sheath beneath the surface of the gametophyte thallus. The sporophyte continues to grow from a basal meristem, producing spores clustered around a central stalk. The sporophyte tip splits releasing spores. Spores continue to mature for some time, and the Sporophyte continues to split.

Hornworts are less common than liverworts or mosses, with only about 100 species identified. Hornworts are found in Washington. They, like the leafy liverworts, are more common in the rainforest, although rumor has it, that they can be found in moist ditches in the Preston area. If available, observe the hornworts on display.

![Hornwort Gametophytes with Sporophytes](image)

**General Life History of the Bryophytes (Moss Illustrated)**

- Zygote retained in archegonium after fertilization
- Sporophyte essentially dependent on gametophyte for nutrients

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- 7 -