

Domain Eukarya
Kingdom Plantae

The Bryophytes

DIVISIONS MARCHANTIOPHYTA (liverworts), BRYOPHYTA (mosses), and ANTHOCEROTOPHYTA (hornworts)

Liverworts, mosses, and hornworts do not form a monophyletic group. However, for ease of communication, we often refer to this paraphyletic grade as bryophytes. The bryophytes are the earliest diverging groups of plants and in many ways are similar to the very first land plants. Bryophytes typically grow in wet environments. One reason for this is their dependence on standing water for their free-swimming sperm to reach the eggs. Bryophytes do not grow very tall. The tallest extant bryophyte, the moss *Dawsonia superba* Grev., reaches a maximum height of only 50 cm. Bryophytes lack both roots and the complex vascular tissue which is present in the other plants. Vascular tissue transports water and nutrients and provides physical support allowing other plants to grow taller.

LIVERWORTS: As you look at the materials of *Marchantia* draw a chart that shows all the relevant structures superimposed on a diagram of the life cycle. Hand this chart in at the end of lab. Liverwort and moss life cycles are nearly identical.



Marchantia thallus

Alternation of generations (sporophyte/gametophyte)

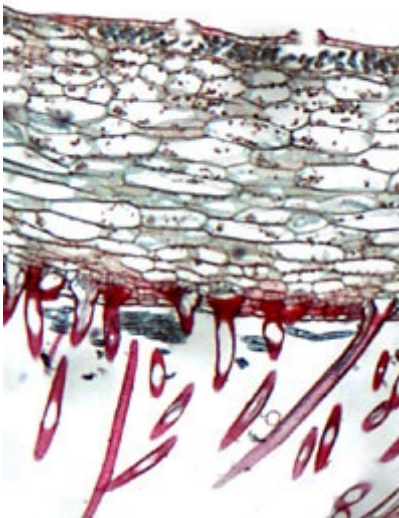
Like all plants, the bryophyte life cycle has an alternation of generations between a diploid sporophyte (2n) and a haploid gametophyte (n). In the bryophytes, unlike the other plants, the dominant, indeterminate generation is the gametophyte, whereas the sporophyte is determinate (once formed, there is no further development) and nutritionally dependent on the gametophyte.

1. diploid **sporophyte** (2n) meiosis produces haploid **spores** (n)
2. haploid spores germinate (mitosis) into haploid **thallus** (n), the **gametophyte**, which can reproduce asexually by **gemmae cups** containing **gemmae** or sexually with **gametangioophores**.
3. fertilization of egg by sperm produces a diploid **zygote** (2n) which divides by mitosis into new sporophyte.

The male gametangiophore is called an **antheridiophore**; it grows up from the thallus and consists of a stalk with a flat-topped head. The flat-top portion is called the **antheridial head**. Imbedded in the upper surface of the antheridial head, there are **antheridia** full of flagellated sperm; when it rains, the sperm are spilled out onto the surface and washed off onto the ground. The female gametangiophore is called an **archegoniophore**; it grows up from the thallus and consists of a stalk and an archegonial head with pendant (hanging) lobes or fingers. On the underside of the head are **archegonia**, each of which is like an inverted vase and holds a single haploid egg. Rain drops hit the ground and splash water carrying sperm up to the archegonia, which face downwards. The sperm swim up the tube of the archegonium and fertilize the egg. The **zygote** (fertilized egg) divides by mitosis, and a diploid **sporophyte** plant grows. Nutrients are supplied to the developing sporophyte by the gametophyte. A large, egg-shaped sporangium forms at the apex of the sporophyte. Meiosis occurs inside the **sporangium** and hundreds of haploid **spores** are produced. When the spores are released, they disperse. The spores that land in a suitable habitat germinate and grow the next generation of gametophytes. Thus, the cycle continues.

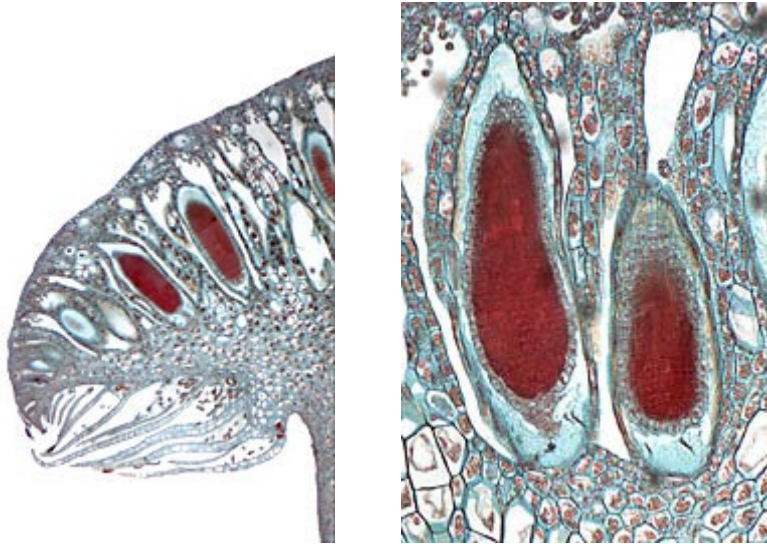
Division Marchantiophyta—Liverworts, genus *Marchantia*. Slides:

Marchantia thallus x.s. The thallus of the haploid gametophyte (n) grows flat on moist ground, and it is many-cells thick. Pores to permit gas exchange are in the top surface, and there are air spaces within the top zone of the thallus. Water is absorbed throughout the surface. Extending into the ground under the thallus are tapering chains of cells called **scales** and twisting cells called **rhizoids**, which protect and anchor the plant to the soil. It is easy to tell which way is up.



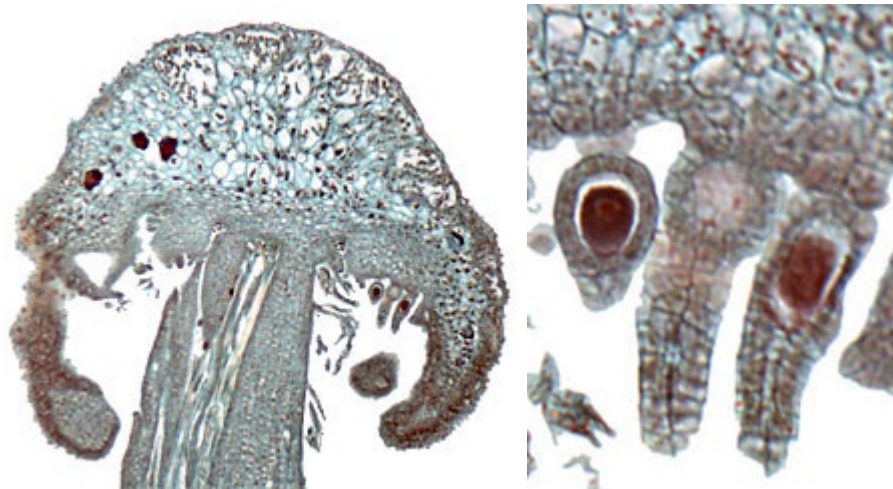
Marchantia thallus cross section

Marchantia antherids l.s. This is the male reproductive structure (antheridiophore) that grows up from the thallus. Identify the antheridia (singular, antheridium), chambers full of sperm, that open onto the flattened top surface of the head.



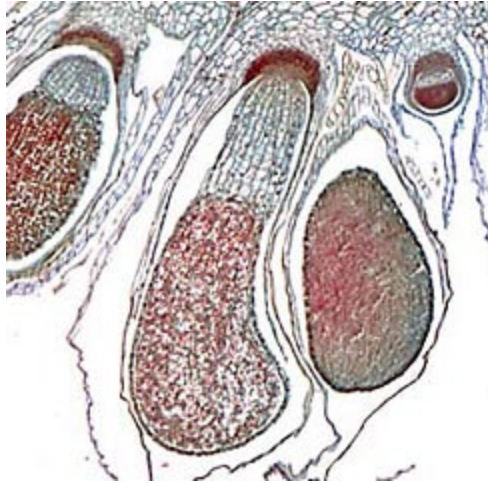
Portion of an antheridiophore of *Marchantia* and close-up of 2 antheridia

Marchantia: archeogones l.s. This is the female reproductive structure (archegoniophore) that grows up from the thallus. Identify the archegonia (singular, archegonium), which are vase shaped and hang down with their tubular openings facing the ground. Each archegonium contains a single egg.



Marchantia archegoniophore and close-up of three archegonia with eggs (two visible).

Marchantia: differentiating sporophyte. The diploid sporophyte ($2n$) is surrounded by the enlarged archegonium called the calyptra and is dependent on the haploid tissue of the archegoniophore for nutrients and water. The sporophyte consists of a foot where it attaches to the gametophyte, a stalk called the seta, and a large egg-shaped sporangium, in which haploid spores are produced through meiosis.



Marchantia with developing sporophytes

live specimen: *Marchantia* thallus (see also image above). Note the general shape and flatness. Look on the top surface for gemmae cups containing gemmae, tiny green discs of haploid cells. Gemmae are asexual propagules. When a raindrop lands in the gemmae cup (also called a splash cup), the gemmae are splashed out and dispersed to grow gametophytes elsewhere. Since gemmae are asexual propagules, the new gametophytes are genetically identical to the parent gametophyte, i.e. they are clones.



Marchantia thallus with gemmae cups

Division **Bryophyta**—Mosses. Slides:

Mnium archegone l.s. Archegonia are at the upper tip of the moss, and the tubular openings face up. When the egg is fertilized, the sporophyte will develop and grow there.

Mnium antherids near-median l.s. Antheridia are at the top of broad, flat tips of the male moss stem. The tip is surrounded by leaf-like scales to form a cup. When it rains, the sperm empty into the cup and raindrops splash them out. Archegonia on female moss point up to receive the sperm-laden droplets.

live specimens: *Mnium*, a moss. Fruiting moss shows the brown stalk and sporangium of the mature diploid sporophyte. Note that it is growing right out of the tip of a female moss; as in liverworts the diploid sporophyte is nutritionally dependent on the haploid gametophyte.



Moss at base of tree trunk. The green leafy structure is the gametophyte. The red-brown structures are the sporophytes.