

Domain Eukarya
Kingdom Plantae

The Bryophytes

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

Liverworts, mosses, and hornworts are referred to 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.

Alternation of generations in Bryophytes (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 **gametangiophores**.
3. fertilization of egg by sperm produces a diploid **zygote** (2n) which divides by mitosis into new sporophyte.

The male gametangiophore (the structure that produces gametes) 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.



Marchantia thallus

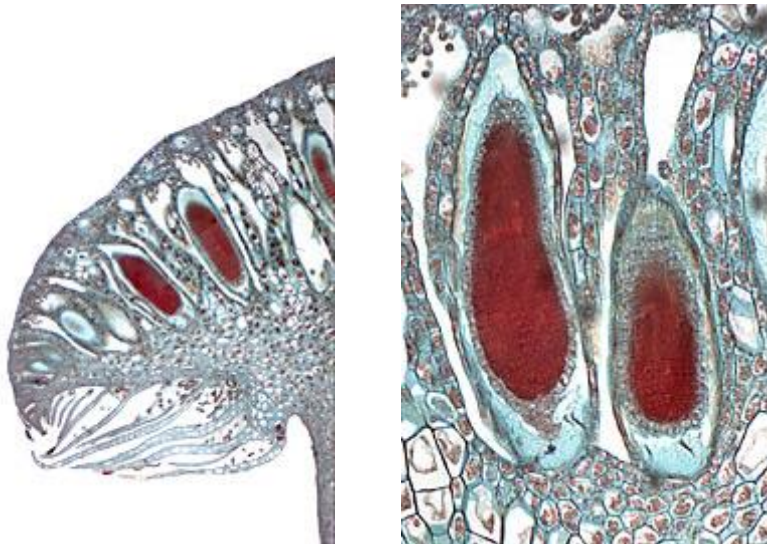
Division Marchantiophyta—Liverworts, genus *Marchantia*. Slides:

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.



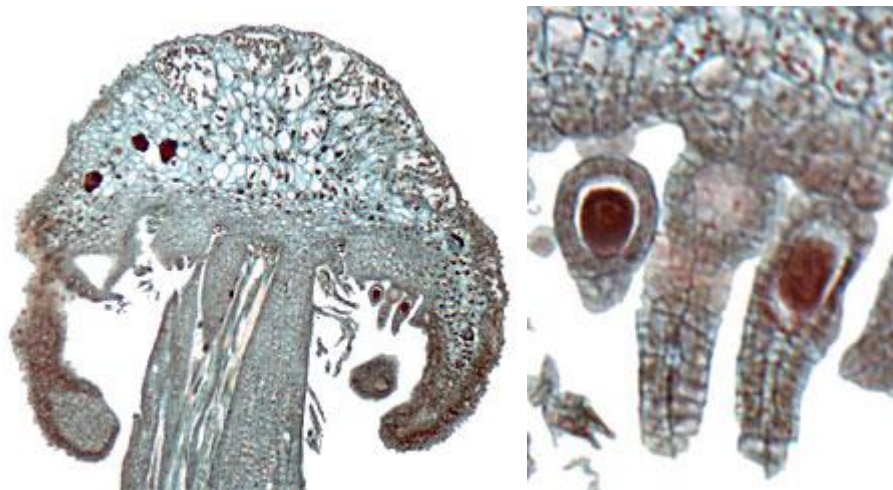
Marchantia thallus cross section

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: archegones 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.

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DIVISION PTEROPHYTA

ferns and allied divisions

As you look at the materials of the pterophytes, keep in mind the comparison of ferns with *Marchantia* in terms of alternation of generations and the various structures. Ferns have both **xylem** and **phloem**, the transport tissues for water and nutrients that are characteristic of all upstanding land plants. The gametophyte generation is small but still depends on water for gamete fertilization. Ferns are tough colonists of disturbed environments.

Other divisions of primitive vascular plants include:

- Division Sphenophyta (horsetails): preserved *Equisetum*.
- Division Lycophyta (club mosses): preserved *Lycopodium* and *Selaginella*
- Division Psilophyta (whisk ferns): preserved *Psilotum* and slide.

Alternation of generations in Pterophytes(sporophyte/gametophyte)

Sporophyte. The diploid sporophyte (2n) is the plant that you call a fern. There are several live examples in pots in the room. One of them has many runners, each of which would root in moist soil; this is a means of asexual reproduction.



The sporophyte consists of a root and a shoot with upright leaves called **fronds**. Some ferns have a **rhizome**, a horizontal stem from which the true roots extend. Most ferns are much taller than either liverworts or mosses because fern plants are sporophytes, which have **vascular tissue**; mosses and liverworts are gametophytes, which lack vascular tissue. Vascular tissue consists of two kinds of cells. **Xylem** vessels transport water up from the roots; **phloem** sieve-tube members transport nutrients made in the leaves to other parts of the plant.

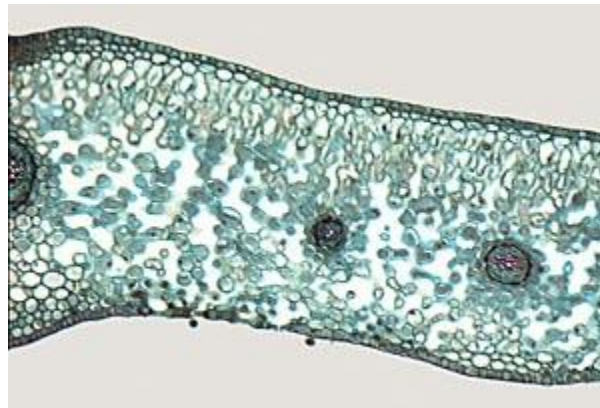
Slide: *Pteris* rhizome x.s. Several oval **vascular bundles** encircle a central pair. Large, thick-walled cells in the center of each bundle are **xylem** tubes; they are probably stained pink.

Surrounding them are small, thin-walled **phloem** cells, also tubular; they are probably stained green. Outside the bundles are zones of brown cells called **sclerenchyma**, a strengthening tissue.



The mature sporophyte forms **sporangia**, and within them **meiosis** occurs to produce haploid **spores** (n). The sporangia are grouped together in clusters called **sori** (sorus, singular) on the undersides of the leaves. They look like rusty brown rosettes.

Look at the cross section of the leaf itself. The top and bottom are defined by cellular layers called **upper** and **lower epidermis**. The inside of the leaf is called **mesophyll**; it is divided into two parts, closely packed tall cells above that maximize light collection for photosynthesis--**palisade mesophyll**--and a meshwork of cells with open spaces below for gas exchange--**spongy mesophyll**. Openings into the air spaces are through stomata in the lower epidermis. Recall that the pores and air spaces in *Marchantia* were at the top, because that plant lies on the ground.

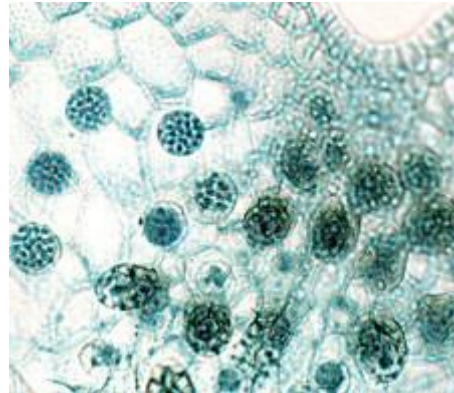


Slide: *Cyrtomium falcatum*: sorus on leaf, median l.s. You can see that each sorus has a central axis to which the sporangia are attached; in this example there is a common covering underneath the sporangia, and it is called an **indusium**. Each sporangium is encircled by a thick-walled ring of cells called the **annulus**. The annulus is hygroscopic (readily absorbs and retains water); as the annulus dries out, tension develops until the structure bursts open and the spores are flung out as if by a catapult. This aids in dispersal of the tiny haploid spores so ferns can take over the world.



Gametophyte: The haploid spores germinate into a haploid **prothallus** (n), the **gametophyte**. It is a small, heart shaped plant which is photosynthetic. There are preserved examples; living specimens are on the soil in the terrarium.

Slide: Fern prothallium, male & female. **Rhizoids** extend from the underside into the soil. Antheridia are scattered toward the edge of the underside; these appear as multi-celled spheres and produce flagellated sperm. When it rains, sperm swim to the eggs in **archegonia** that are located near the cleft of the heart shape. Each archegonium contains one egg.



Slide: Fern prothallium, young sporophyte. When fertilization takes place, a diploid zygote (2n) forms. The zygote germinates and divides by **mitosis** to produce a new sporophyte plant. The young sporophyte consists of a primary root pointing down and a primary leaf pointing up. The bifurcating vascular bundle, a characteristic of sporophytes, is visible in the leaf. The sporophyte grows on the site of the archegonium as in *Marchantia*, but it is an independent plant, because it forms roots and photosynthetic green leaves.



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