

## UNIT-III

**Bryophytes** ([/ˈbraɪ.ə faɪts/](#))<sup>[1]</sup> are a group of [land plants](#), sometimes treated as a taxonomic [division](#), that contains three groups of [non-vascular](#) land plants (embryophytes): the [liverworts](#), [hornworts](#), and [mosses](#).<sup>[2]</sup> In the [strict sense](#), the division **Bryophyta** consists of the mosses only. Bryophytes are characteristically limited in size and prefer moist habitats although some species can survive in drier environments.<sup>[3]</sup> The bryophytes consist of about 20,000 plant species.<sup>[4][5]</sup> Bryophytes produce enclosed reproductive structures (gametangia and sporangia), but they do not produce [flowers](#) or [seeds](#). They reproduce sexually by [spores](#) and asexually by fragmentation or the production of [gemmae](#).<sup>[6]</sup> Though bryophytes were considered a [paraphyletic](#) group in recent years, almost all of the most recent [phylogenetic](#) evidence supports the [monophyly](#) of this group, as originally classified by [Wilhelm Schimper](#) in 1879.<sup>[7]</sup> The term *bryophyte* comes from [Ancient Greek](#) [βρύον](#) (*brúon*) 'tree moss, liverwort' and [φυτόν](#) (*phutón*) 'plant'.

### Features

[\[edit\]](#)

The defining features of bryophytes are:

- Their life cycles are dominated by a multicellular [haploid gametophyte](#) stage
- Their [sporophytes](#) are [diploid](#) and unbranched
- They do not have a true [vascular tissue](#) containing [lignin](#) (although some have specialized tissues for the transport of water)<sup>[8]</sup>

### Habitat

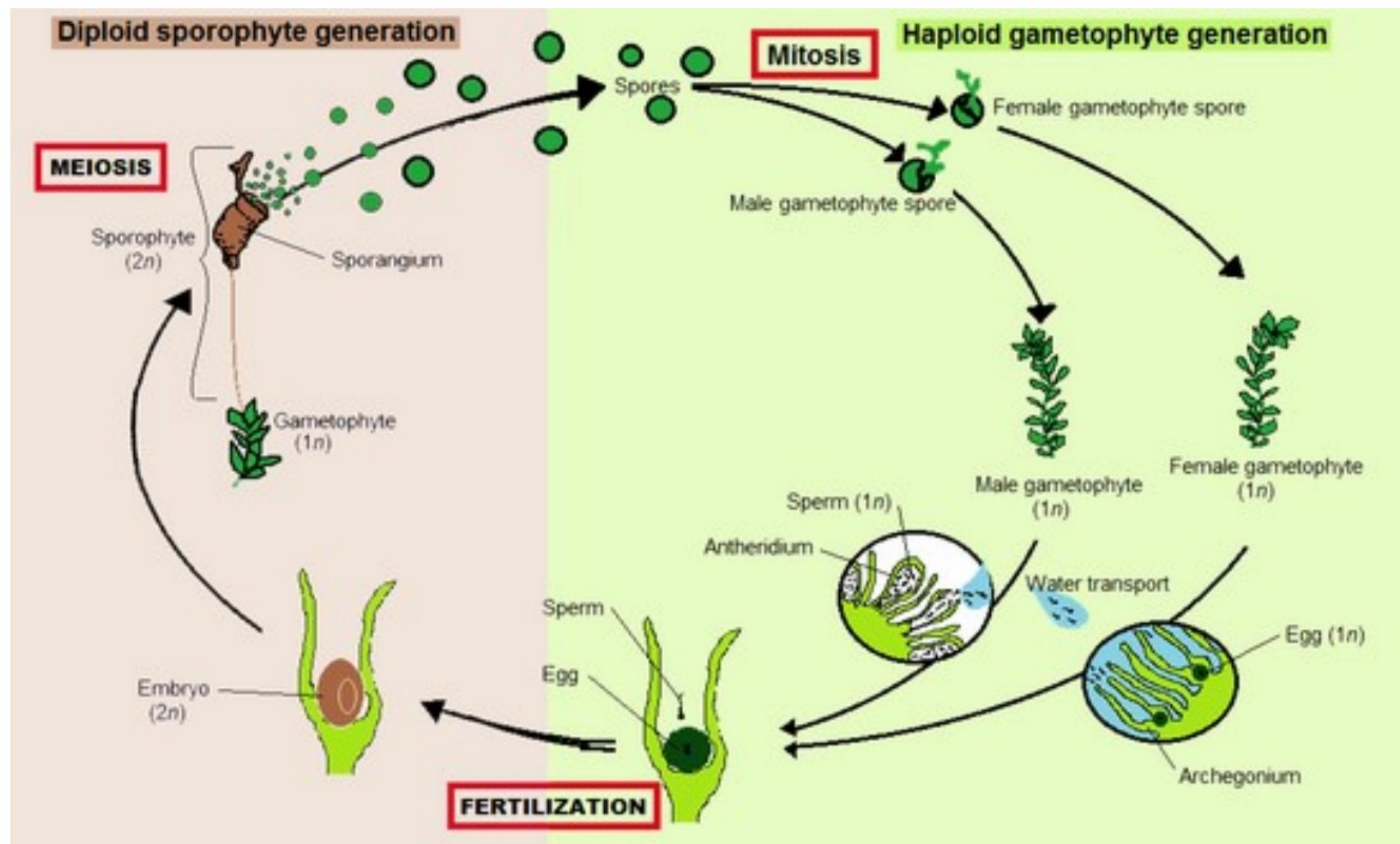
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Bryophytes exist in a wide variety of habitats. They can be found growing in a range of temperatures (cold arctics and in hot deserts), elevations (sea-level to alpine), and moisture (dry deserts to wet rain forests). Bryophytes can grow where vascularized plants cannot because they do not depend on roots for uptake of [nutrients from soil](#). Bryophytes can survive on rocks and bare soil.<sup>[9]</sup>

### Life cycle

[\[edit\]](#)

See also: [Alternation of generations](#)



The life

cycle of a dioicous bryophyte. The gametophyte (haploid) structures are shown in green, the sporophyte (diploid) in brown.

Like all land plants (embryophytes), bryophytes have [life cycles](#) with [alternation of generations](#).<sup>[10]</sup> In each cycle, a haploid gametophyte, each of whose cells contains a fixed number of unpaired [chromosomes](#), alternates with a diploid sporophyte, whose cells contain two sets of paired chromosomes. Gametophytes produce haploid sperm and eggs which fuse to form diploid zygotes that grow into sporophytes. Sporophytes produce haploid spores by [meiosis](#), that grow into gametophytes.

Bryophytes are gametophyte dominant,<sup>[11]</sup> meaning that the more prominent, longer-lived plant is the haploid gametophyte. The diploid sporophytes appear only occasionally and remain attached to and nutritionally dependent on the gametophyte.<sup>[12]</sup> In bryophytes, the sporophytes are always unbranched and produce a single [sporangium](#) (spore producing capsule), but each gametophyte can give rise to several sporophytes at once.

Liverworts, mosses and hornworts spend most of their lives as gametophytes. [Gametangia](#) (gamete-producing organs), [archegonia](#) and [antheridia](#), are produced on the gametophytes, sometimes at the tips of shoots, in the axils of leaves or hidden under thalli. Some bryophytes, such as the liverwort [Marchantia](#), create elaborate structures to bear the gametangia that are called gametangiophores. Sperm are flagellated and must swim from the antheridia that produce them to archegonia which may be on a different plant. Arthropods can assist in transfer of sperm.<sup>[13]</sup>

Fertilized eggs become zygotes, which develop into sporophyte embryos inside the archegonia. Mature sporophytes remain attached to the gametophyte. They consist of a stalk called a seta and a single sporangium or capsule. Inside the sporangium, haploid spores are produced by [meiosis](#). These are dispersed, most commonly by wind, and if they land in a suitable environment can develop into a new gametophyte. Thus

bryophytes disperse by a combination of swimming sperm and spores, in a manner similar to [lycophytes](#), [ferns](#) and other [cryptogams](#).

The sporophyte develops differently in the three groups. Both mosses and hornworts have a [meristem](#) zone where cell division occurs. In hornworts, the meristem starts at the base where the foot ends, and the division of cells pushes the sporophyte body upwards. In mosses, the meristem is located between the capsule and the top of the stalk (seta), and produces cells downward, elongating the stalk and elevating the capsule. In liverworts the meristem is absent and the elongation of the sporophyte is caused almost exclusively by cell expansion.<sup>[14]</sup>

*Further information:* [Liverwort § Life cycle](#), [Moss § Life cycle](#), and [Hornwort § Life cycle](#)

## Sexuality

[\[edit\]](#)

The arrangement of [antheridia](#) and [archegonia](#) on an individual bryophyte plant is usually constant within a species, although in some species it may depend on environmental conditions. The main division is between species in which the antheridia and archegonia occur on the same plant and those in which they occur on different plants. The term [monoicous](#) may be used where antheridia and archegonia occur on the same [gametophyte](#) and the term [dioicous](#) where they occur on different gametophytes.<sup>[15]</sup>

In [seed plants](#), "[monoecious](#)" is used where flowers with [anthers](#) (microsporangia) and flowers with [ovules](#) (megasporangia) occur on the same [sporophyte](#) and "[dioecious](#)" where they occur on different sporophytes. These terms occasionally may be used instead of "monoicous" and "dioicous" to describe bryophyte gametophytes.

"Monoecious" and "monoicous" are both derived from the Greek for "one house", "dioecious" and "dioicous" from the Greek for two houses. The use of the "-oicy" terminology refers to the gametophyte sexuality of bryophytes as distinct from the sporophyte sexuality of seed plants.<sup>[15]</sup>

Monoicous plants are necessarily hermaphroditic, meaning that the same plant produces gametes of both sexes.<sup>[15]</sup> The exact arrangement of the antheridia and archegonia in monoicous plants varies. They may be borne on different shoots (autoicous), on the same shoot but not together in a common structure (paroicous or paroecious), or together in a common "inflorescence" (synoicous or synoecious).<sup>[15][16]</sup> Dioicous plants are **unisexual**, meaning that an individual plant has only one sex.<sup>[15]</sup> All four patterns (autoicous, paroicous, synoicous and dioicous) occur in species of the moss genus [Bryum](#).<sup>[16]</sup>

## Classification and phylogeny

[\[edit\]](#)



Hornworts (Anthocerotophyta) were once believed to be the



closest living relatives of the vascular plants.  
group of bryophytes.

Mosses are one

Traditionally, all living land plants without vascular tissues were classified in a single taxonomic group, often a [division](#) (or phylum). The term "Bryophyta" was first suggested by Braun in 1864.<sup>[17]</sup> As early as 1879, the term Bryophyta was used by German bryologist Wilhelm Schimper to describe a group containing all three bryophyte clades (though at the time, hornworts were considered part of the liverworts).<sup>[18][7]</sup> [G.M. Smith](#) placed this group between Algae and [Pteridophyta](#).<sup>[19]</sup> Although a 2005 study supported this traditional monophyletic view,<sup>[20]</sup> by 2010 a broad consensus had emerged among systematists that bryophytes as a whole are not a natural group (i.e., are [paraphyletic](#)).<sup>[21][22][23]</sup> However, a 2014 study concluded that these previous phylogenies, which were based on nucleic acid sequences, were subject to composition biases, and that, furthermore, phylogenies based on amino acid sequences suggested that the bryophytes are monophyletic after all.<sup>[24]</sup> Since then, partially thanks to a proliferation of genomic and transcriptomic datasets, almost all phylogenetics studies based on nuclear and chloroplastic sequences have concluded that the bryophytes form a monophyletic group.<sup>[24][25][18][26][27][28][29][30][31]</sup> Nevertheless, phylogenies based on mitochondrial sequences fail to support the monophyletic view.<sup>[32]</sup>

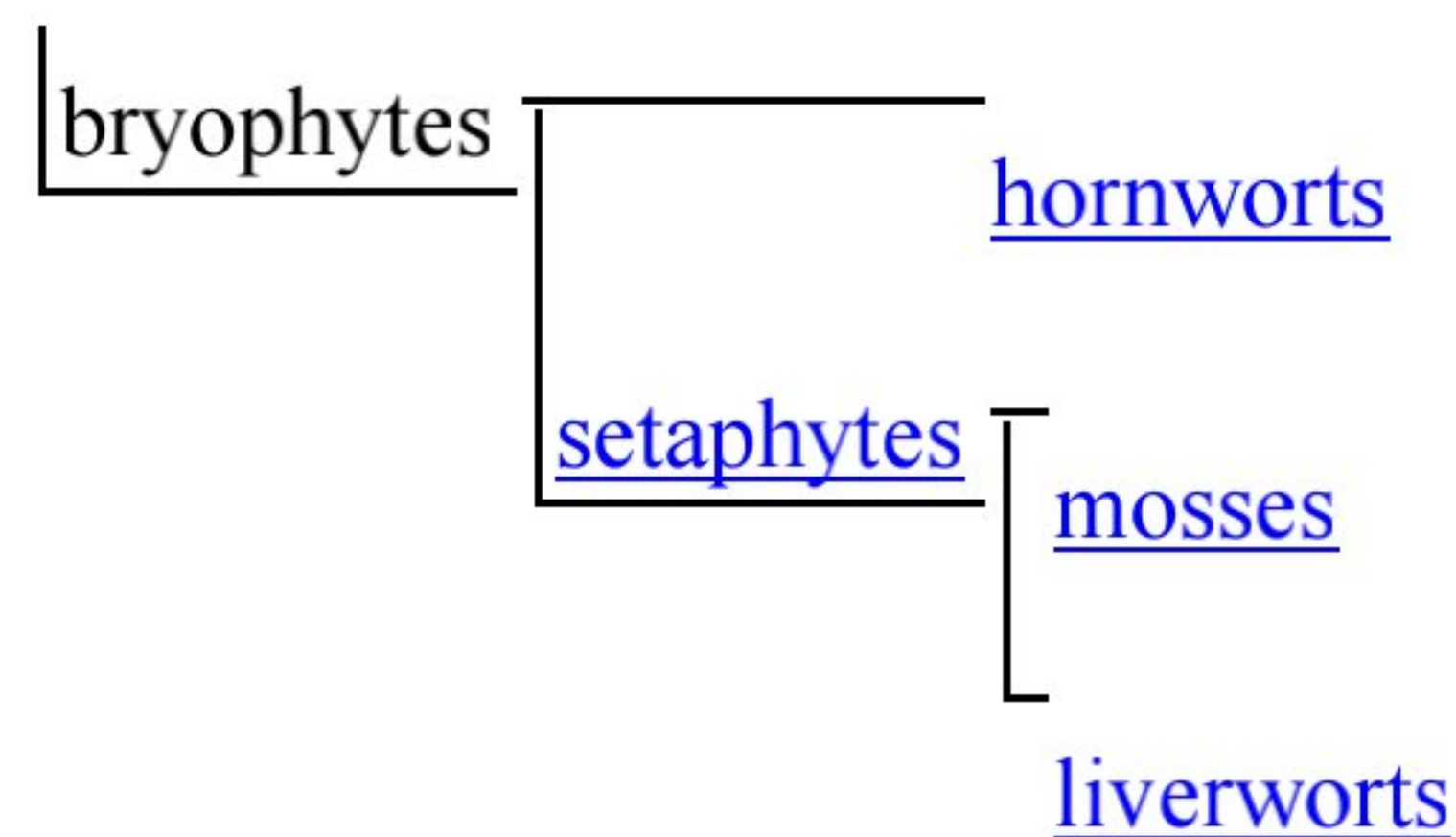
The three bryophyte [clades](#) are the [Marchantiophyta](#) (liverworts), [Bryophyta](#) (mosses) and [Anthocerotophyta](#) (hornworts).<sup>[33]</sup> However, it has been proposed that these clades are de-ranked to the classes Marchantiopsida, Bryopsida, and Anthocerotopsida, respectively.<sup>[18]</sup> There is now strong evidence that the liverworts and mosses belong to a monophyletic clade, called [Setaphyta](#).<sup>[25][32][34]</sup>

## Monophyletic view

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The favored model, based on amino acids phylogenies, indicates bryophytes as a monophyletic group:<sup>[24]</sup>

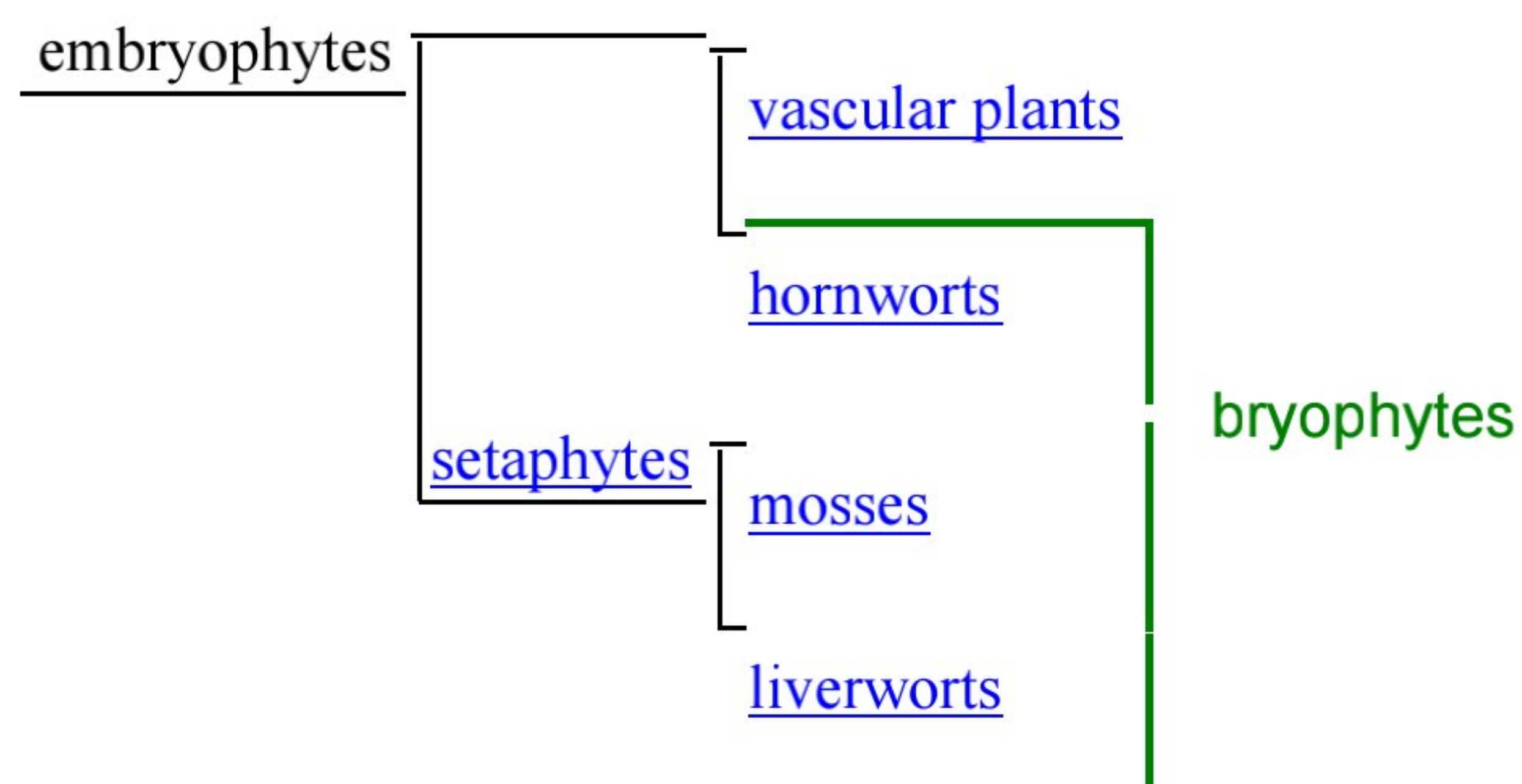
[embryophytes](#) \_\_\_\_\_



Consistent with this view, compared to other living land plants, all three lineages lack vascular tissue containing lignin and branched sporophytes bearing multiple sporangia. The prominence of the gametophyte in the life cycle is also a shared feature of the three bryophyte lineages (extant vascular plants are all sporophyte dominant). However, if this phylogeny is correct, then the complex sporophyte of living vascular plants might have evolved independently of the simpler unbranched sporophyte present in bryophytes.<sup>[24]</sup> Furthermore, this view implies that [stomata](#) evolved only once in plant evolution, before being subsequently lost in the liverworts.<sup>[25][28]</sup>

### Paraphyletic view

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Liverworts are included in the bryophyte group

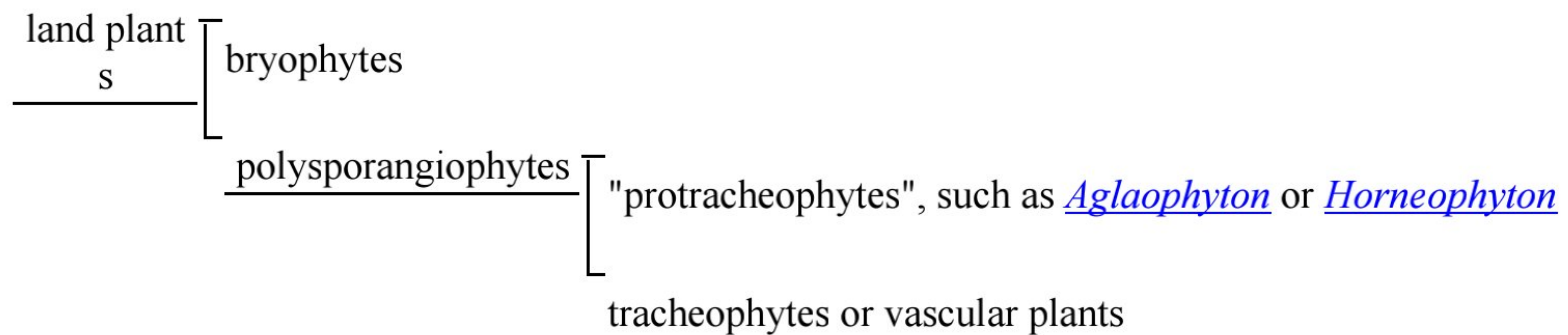
In this alternative view, the Setaphyta grouping is retained, but hornworts instead are sister to vascular plants.<sup>[34]</sup> (Another paraphyletic view involves hornworts branching out first.)<sup>[32]</sup>

### Traditional morphology

[\[edit\]](#)

Traditionally, when basing classifications on morphological characters, bryophytes have been distinguished by their lack of vascular structure. However, this distinction is problematic, firstly because some of the earliest-diverging (but now extinct) non-bryophytes, such as the [horneophytes](#), did not have true vascular tissue, and secondly because many mosses have well-developed water-conducting vessels.<sup>[35][36]</sup> A more useful distinction may lie in the structure of their [sporophytes](#). In bryophytes, the sporophyte is a simple unbranched structure with a single spore-forming organ

([sporangium](#)), whereas in all other land plants, the [polysporangiophytes](#), the sporophyte is branched and carries many sporangia.<sup>[37][38]</sup> The contrast is shown in the cladogram below:<sup>[39]</sup>



## Evolution

[\[edit\]](#)

There have probably been several different terrestrialization events, in which originally aquatic organisms colonized the land, just within the lineage of the [Viridiplantae](#).<sup>[40]</sup> Between 510–630 million years ago, however, land plants emerged within the [green algae](#).<sup>[41]</sup> Molecular phylogenetic studies conclude that bryophytes are the earliest diverging lineages of the extant land plants.<sup>[21][2][42][43]</sup> They provide insights into the migration of plants from aquatic environments to land. A number of physical features link bryophytes to both land plants and aquatic plants.<sup>[44]</sup>

### Similarities to algae and vascular plants

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Green algae, bryophytes and vascular plants all have chlorophyll a and b, and the chloroplast structures are similar.<sup>[45]</sup> Like green algae and land plants, bryophytes also produce starch stored in the plastids and contain cellulose in their walls.<sup>[45]</sup> Distinct adaptations observed in bryophytes have allowed plants to colonize Earth's terrestrial environments. To prevent desiccation of plant tissues in a terrestrial environment, a waxy cuticle covering the soft tissue of the plant may be present, providing protection. In hornworts and mosses, stomata provide gas exchange between the atmosphere and an internal intercellular space system. The development of gametangia provided further protection specifically for gametes, the zygote and the developing sporophyte.<sup>[46]</sup> The bryophytes and vascular plants ([embryophytes](#)) also have embryonic development which is not seen in green algae.<sup>[45]</sup> While bryophytes have no truly vascularized tissue, they do have organs that are specialized for transport of water and other specific functions, analogous for example to the functions of leaves and stems in vascular land plants.<sup>[45]</sup>

Bryophytes depend on water for reproduction and survival. In common with ferns and [lycophytes](#), a thin layer of water is required on the surface of the plant to enable the movement of the flagellated sperm between gametophytes and the fertilization of an egg.<sup>[46]</sup>

## Comparative morphology

[\[edit\]](#)

Summary of the morphological characteristics of the [gametophytes](#) of the three groups of bryophytes:

	<b>Liverworts</b>	<b>Mosses</b>	<b>Hornworts</b>
<b>Structure</b>	<a href="#">Thalloid</a> or foliose	Foliose	Thalloid
<b>Symmetry</b>	<a href="#">Dorsiventral</a> or <a href="#">radial</a>	Radial	Dorsiventral
<b><a href="#">Rhizoids</a></b>	Unicellular	Pluricellular	Unicellular
<b>Chloroplasts/cell</b>	Many	Many	One
<b><a href="#">Protonemata</a></b>	Reduced	Present	Absent
<b>Gametangia (<a href="#">antheridia</a> and <a href="#">archegonia</a>)</b>	Superficial	Superficial	Immersed

Summary of the morphological characteristics of the [sporophytes](#) of the three groups of bryophytes:

	<b>Liverworts</b>	<b>Mosses</b>	<b>Hornworts</b>
<b><a href="#">Stomata</a></b>	Absent	Present	Present
<b>Structure</b>	Small, without chlorophyll	Large, with chlorophyll	Large, with chlorophyll
<b>Persistence</b>	Ephemeral	Persistent	Persistent
<b>Growth</b>	Defined	Defined	Continuous
<b>Apical growth<sup>[47]</sup></b>	Absent	Present	Absent
<b><a href="#">Seta</a></b>	Present	Present	Absent
<b><a href="#">Capsule</a> form</b>	Simple	Differentiated ( <a href="#">operculum</a> , <a href="#">peristome</a> )	Elongated
<b>Maturation of spores</b>	Simultaneous	Simultaneous	Gradual

<b>Dispersion of spores</b>	<a href="#">Elaters</a>	Peristome teeth	Pseudo-elaters
<a href="#">Columella</a>	Absent	Present	Present
<a href="#">Dehiscence</a>	Longitudinal or irregular	Transverse	Longitudinal

## Uses

[\[edit\]](#)



This article is in **list** format but may read better as **prose**. You can help by [converting this article](#), if appropriate. [Editing help](#) is available. (April 2017)

### Environmental

- Soil Conditioning
- Bioindicators
- Moss gardens
- Pesticides

Characteristics of bryophytes make them useful to the environment. Depending on the specific plant texture, bryophytes have been shown to help improve the water retention and air space within soil.<sup>[48]</sup> Bryophytes are used in pollution studies to indicate soil pollution (such as the presence of heavy metals), air pollution, and UV-B radiation.<sup>[48]</sup> Gardens in Japan are designed with moss to create peaceful sanctuaries.<sup>[48]</sup> Some bryophytes have been found to produce natural pesticides. The liverwort, *Plagiochila*, produces a chemical that is poisonous to mice.<sup>[48]</sup> Other bryophytes produce chemicals that are antifeedants which protect them from being eaten by slugs.<sup>[48]</sup> When *Phythium sphagnum* is sprinkled on the soil of germinating seeds, it inhibits growth of "damping off fungus" which would otherwise kill young seedlings.<sup>[49]</sup>



Moss peat is made from *Sphagnum*

### Commercial

- Fuel
- Packaging
- Wound Dressing

[Peat](#) is a fuel produced from dried bryophytes, typically [Sphagnum](#). Bryophytes' antibiotic properties and ability to retain water make them a useful packaging material for vegetables, flowers, and bulbs.<sup>[48]</sup> Also, because of its antibiotic properties

A **sporangium** (from [Late Latin](#), from [Ancient Greek](#) [σπορά](#) (*sporá*) 'seed' and [ἀγγεῖον](#) (*angeíon*) 'vessel'); pl.: **sporangia**)<sup>[2]</sup> is an enclosure in which [spores](#) are formed.<sup>[3]</sup> It can be composed of a [single cell](#) or can be [multicellular](#). Virtually all [plants](#), [fungi](#), and many other groups form sporangia at some point in their [life cycle](#). Sporangia can produce spores by [mitosis](#), but in land plants and many fungi, sporangia produce genetically distinct [haploid](#) spores by [meiosis](#).

## Fungi

[\[edit\]](#)

In some phyla of fungi, the sporangium plays a role in [asexual reproduction](#), and may play an indirect role in [sexual reproduction](#). The sporangium forms on the sporangiophore and contains [haploid nuclei](#) and [cytoplasm](#).<sup>[4]</sup> [Spores](#) are formed in the sporangiophore by encasing each haploid nucleus and cytoplasm in a tough outer [membrane](#). During asexual reproduction, these spores are dispersed via wind and [germinate](#) into haploid [hyphae](#).<sup>[5]</sup>

Although sexual reproduction in fungi varies between phyla, for some fungi the sporangium plays an indirect role in sexual reproduction. For [Zygomycota](#), sexual reproduction occurs when the haploid hyphae from two individuals join to form a [zygosporangium](#) in response to unfavorable conditions. The haploid nuclei within the zygosporangium then fuse into [diploid](#) nuclei.<sup>[6]</sup> When conditions improve, the zygosporangium germinates, undergoes meiosis and produces a sporangium, which releases spores.

## Land plants

[\[edit\]](#)

In mosses, liverworts and hornworts, an unbranched [sporophyte](#) produces a single sporangium, which may be quite complex morphologically. Most non-vascular plants, as well as many [lycophytes](#) and most ferns, are [homosporous](#) (only one kind of spore is produced). Some lycophytes, such as the [Selaginellaceae](#) and [Isoetaceae](#),<sup>[7]:7</sup> the extinct [Lepidodendrales](#),<sup>[8]</sup> and ferns, such as the [Marsileaceae](#) and [Salviniaceae](#) are [heterosporous](#) (two kinds of spores are produced).<sup>[7]:18</sup> These plants produce both [microspores](#) and [megaspores](#), which give rise to gametophytes that are functionally male or female, respectively. Most heterosporous plants there are two kinds of sporangia, termed [microsporangia](#) and megasporangia.

Sporangia can be terminal (on the tips) or lateral (placed along the side) of stems or associated with leaves. In [ferns](#), sporangia are typically found on the [abaxial](#) surface (underside) of the leaf and are densely aggregated into clusters called [sori](#). Sori may be covered by a structure called an indusium. Some ferns have their sporangia scattered along reduced leaf segments or along (or just in from) the margin of the leaf. Lycophytes, in contrast, bear their sporangia on the [adaxial](#) surface (the upper side) of

leaves or laterally on stems. Leaves that bear sporangia are called [sporophylls](#). If the plant is heterosporous, the sporangia-bearing leaves are distinguished as either microsporophylls or megasporophylls. In seed plants, sporangia are typically located within [strobili](#) or flowers.

[Cycads](#) form their microsporangia on microsporophylls which are aggregated into strobili. Megasporangia are formed into ovules, which are borne on megasporophylls, which are aggregated into strobili on separate plants (all cycads are dioecious). [Conifers](#) typically bear their microsporangia on microsporophylls aggregated into papery pollen strobili, and the ovules, are located on modified stem axes forming compound ovuliferous cone scales. Flowering plants contain microsporangia in the anthers of [stamens](#) (typically four microsporangia per anther) and megasporangia inside [ovules](#) inside ovaries. In all seed plants, spores are produced by meiosis and develop into gametophytes while still inside the sporangium. The microspores become microgametophytes (pollen). The megaspores become megagametophytes (embryo sacs).

## Eusporangia and leptosporangia

[\[edit\]](#)

Categorized based on developmental sequence, *eusporangia* and *leptosporangia* are differentiated in the vascular plants.

- In a leptosporangium, found only in leptosporangiate ferns, development involves a single initial cell that becomes the stalk, wall, and spores within the sporangium. There are around 64 spores in a leptosporangium.
- In a eusporangium, characteristic of all other vascular plants and some primitive ferns, the initials are in a layer (i.e., more than one). A eusporangium is larger (hence contain more spores), and its wall is multi-layered. Although the wall may be stretched and damaged, resulting in only one cell-layer remaining.

## Synangium

[\[edit\]](#)

A cluster of sporangia that have become fused in development is called a **synangium** (pl. **synangia**). This structure is most prominent in [Psilotum](#) and [Marattiaceae](#) such as [Christensenia](#), [Danaea](#) and [Marattia](#).

## Internal structures

[\[edit\]](#)

A [columella](#) (pl. columellae) is a sterile (non-reproductive) structure that extends into and supports the sporangium of some species. In fungi, the columella, which may be branched or unbranched, may be of fungal or host origin. [Secotium](#) species have a simple, unbranched columella, while in [Gymnoglossum](#) species, the columella is branched. In some [Geastrum](#) species, the columella appears as an extension of the stalk into the spore mass ([gleba](#)).<sup>[9]</sup>