

Bog People

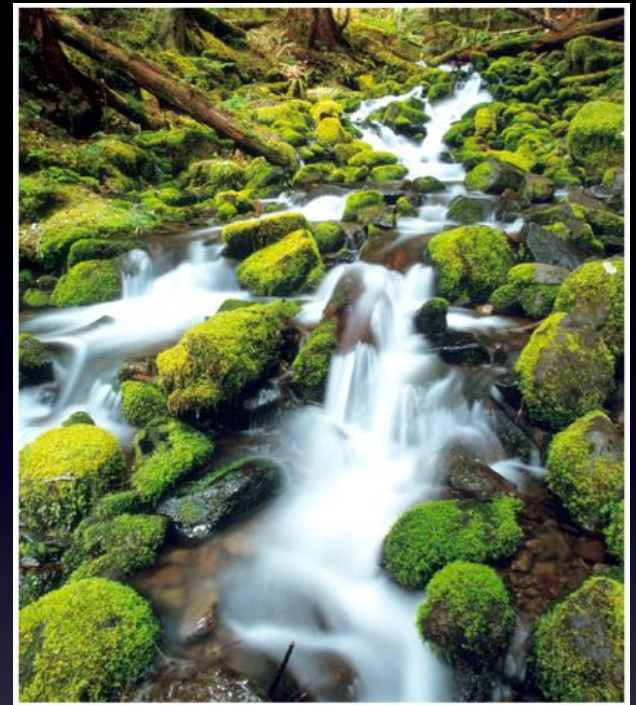


Hanged with a leather cord and cast into a Danish bog 2,300 years ago, Tollund Man was probably a sacrifice. Like other bodies found preserved in Europe's peat bogs, he poses haunting questions.

BRYOPHYTES



- The bryophytes includes the liverworts, hornworts, and mosses
- Found in dry or wet, and warm or cold habitats
- Mostly terrestrial, some aquatic
- Sensitive to air pollution



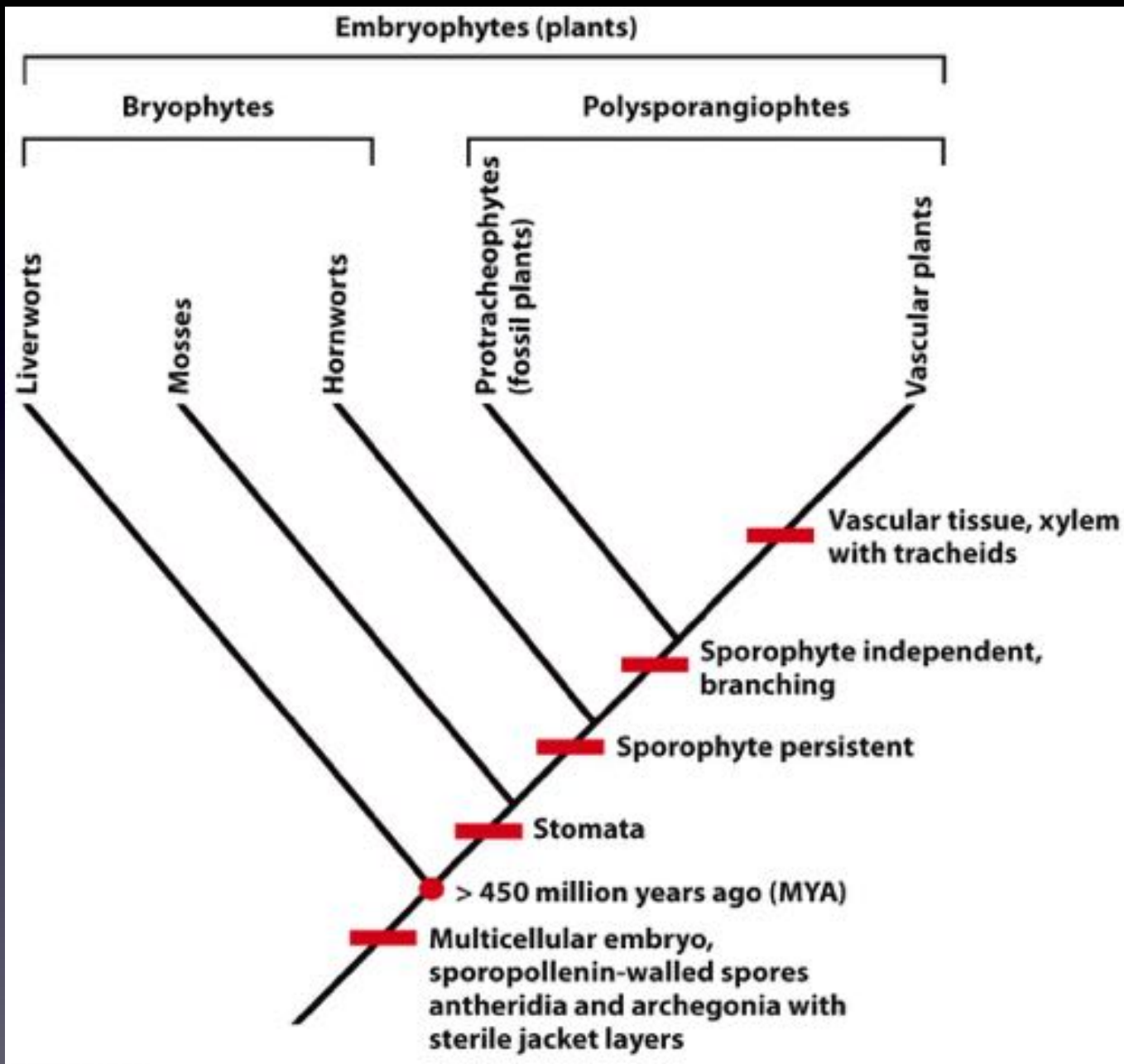
The relationship of Bryophytes to other groups

- They are transitional between charophycean green algae and vascular plants
- Along with charophycean algae the bryophytes are characterized by:
 - Chloroplasts with grana
 - Assymetrical motile cells
 - Breakdown of nuclear envelope during mitosis
 - Presence of phragmoplast
 - Oogamous sexual reproduction
 - Zygotes retained within the parental thallus
 - Cells covering the zygotes and involved in transport of sugars to zygotes

•Bryophytes and vascular plants share:

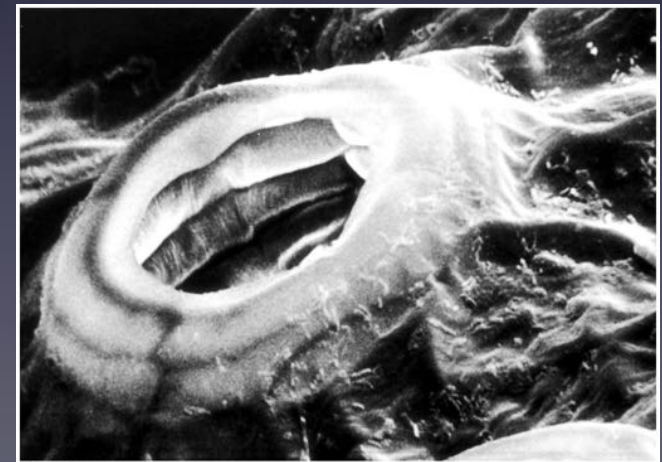
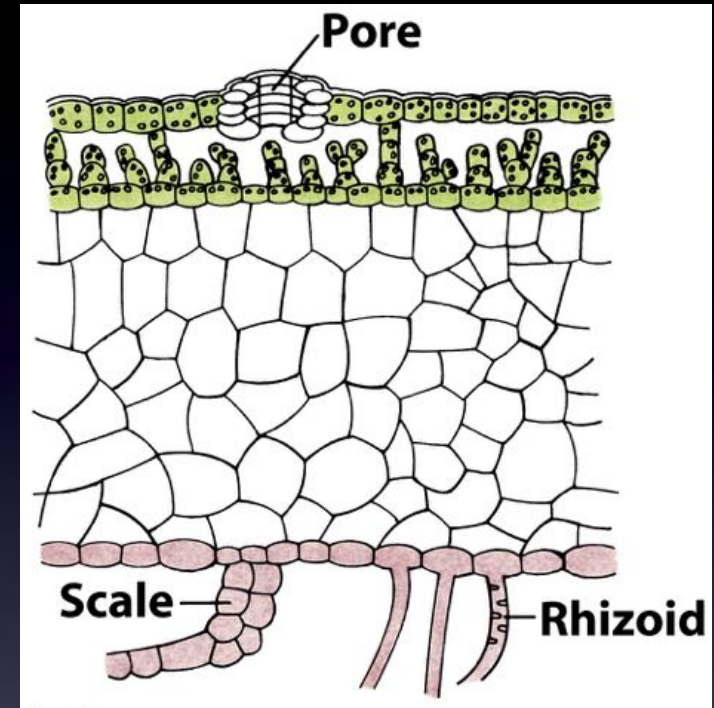
- Presence of male and female gametangia (**antheridia** and **archegonia**) with protective layer or **sterile jacket layer**
- Retention of both the zygote and the developing multicellular **embryo**, or young sporophyte within the archegonium on the female gametophyte
- Presence of a **multicellular diploid sporophyte** with spores
- Multicellular sporangia consisting of a sterile jacket layer and internal spore-producing (**sporogenous**) tissue
- Meiospore with walls containing **sporopollenin**
- Tissues produced by an **apical meristem**

These features are not share with charophycean algae thus, bryophytes and vascular plants are classified together in the **kingdom Plantae**



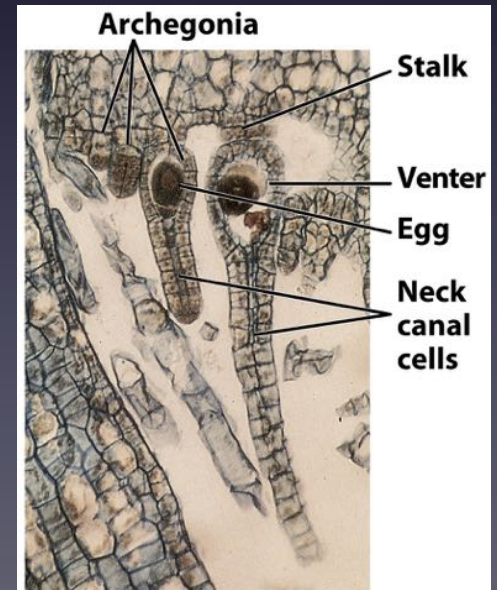
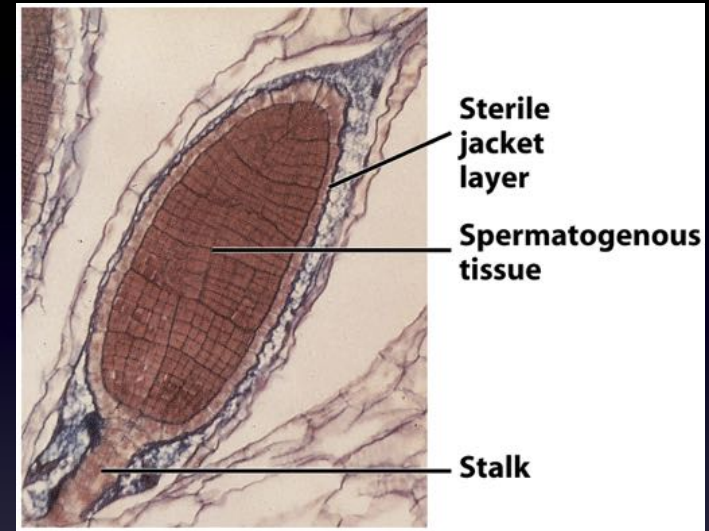
Comparative structure and reproduction of bryophytes

- **Gametophytes** are notable
- Some bryophytes are “**thalloid**”
- With surface **pores**, analogues to stomata
- Other bryophytes are “**leafy**”
- With leaf-like and stem-like features
- “**Cuticle**” also present
- **Rhizoids**: unicellular or multicellular
- Cells with **plasmodesmata**
- Cells with many small, disk-shaped plastids
- Hornworts with only a single large plastid

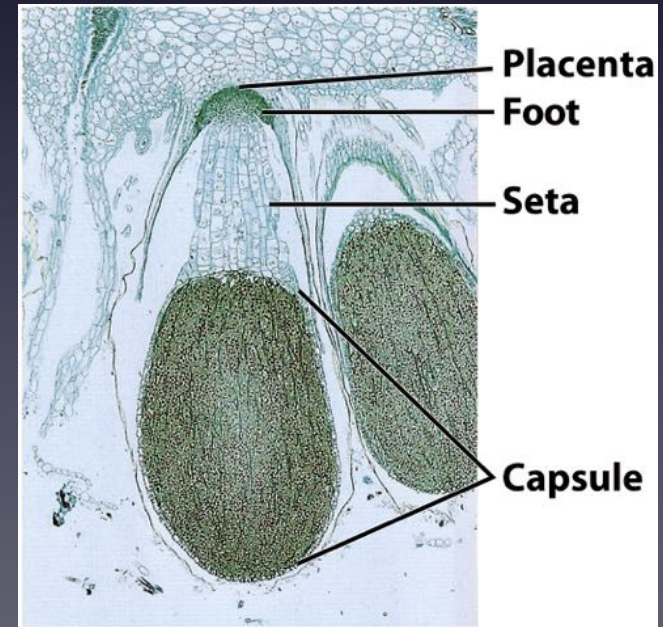
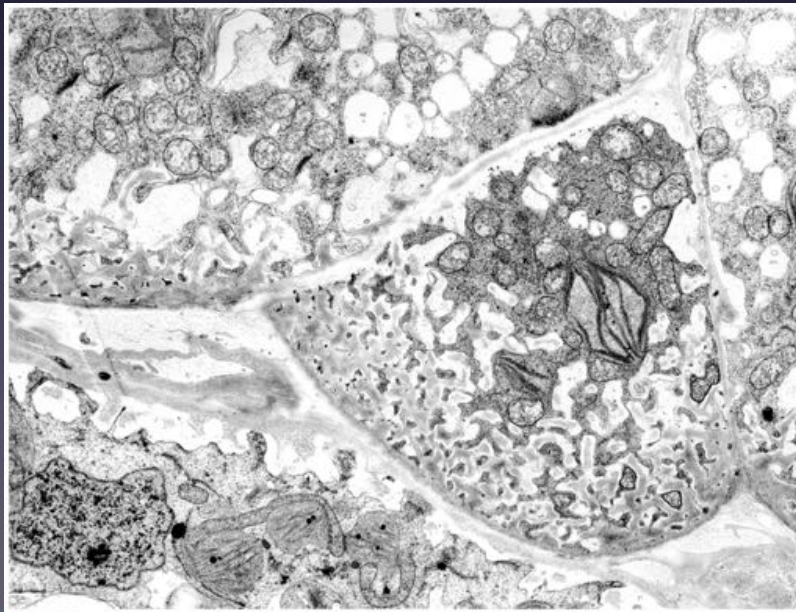
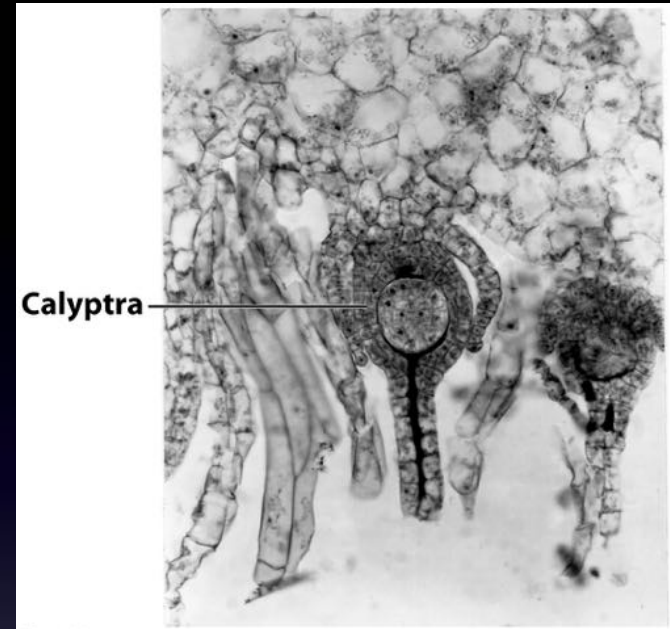


Sperm are the only flagellated cells produced by bryophytes, and they require water to swim to the egg

- Asexual reproduction by **fragmentation**
- **Gemmae**
- Sperm are the only flagellated cells (no zoospores)
- Sexual reproduction with **antheridia** and **archegonia**
- Male and female gametophytes
- Antheridium with a **sterile jacket layer** and **spermatogenous cells**
- Each spermatogenous cell forms a single biflagellated sperm
- Archegonia have a long **neck** and a swollen base or **venter** with a single egg
- **Neck canal cells** disintegrate to form a tube before fertilization



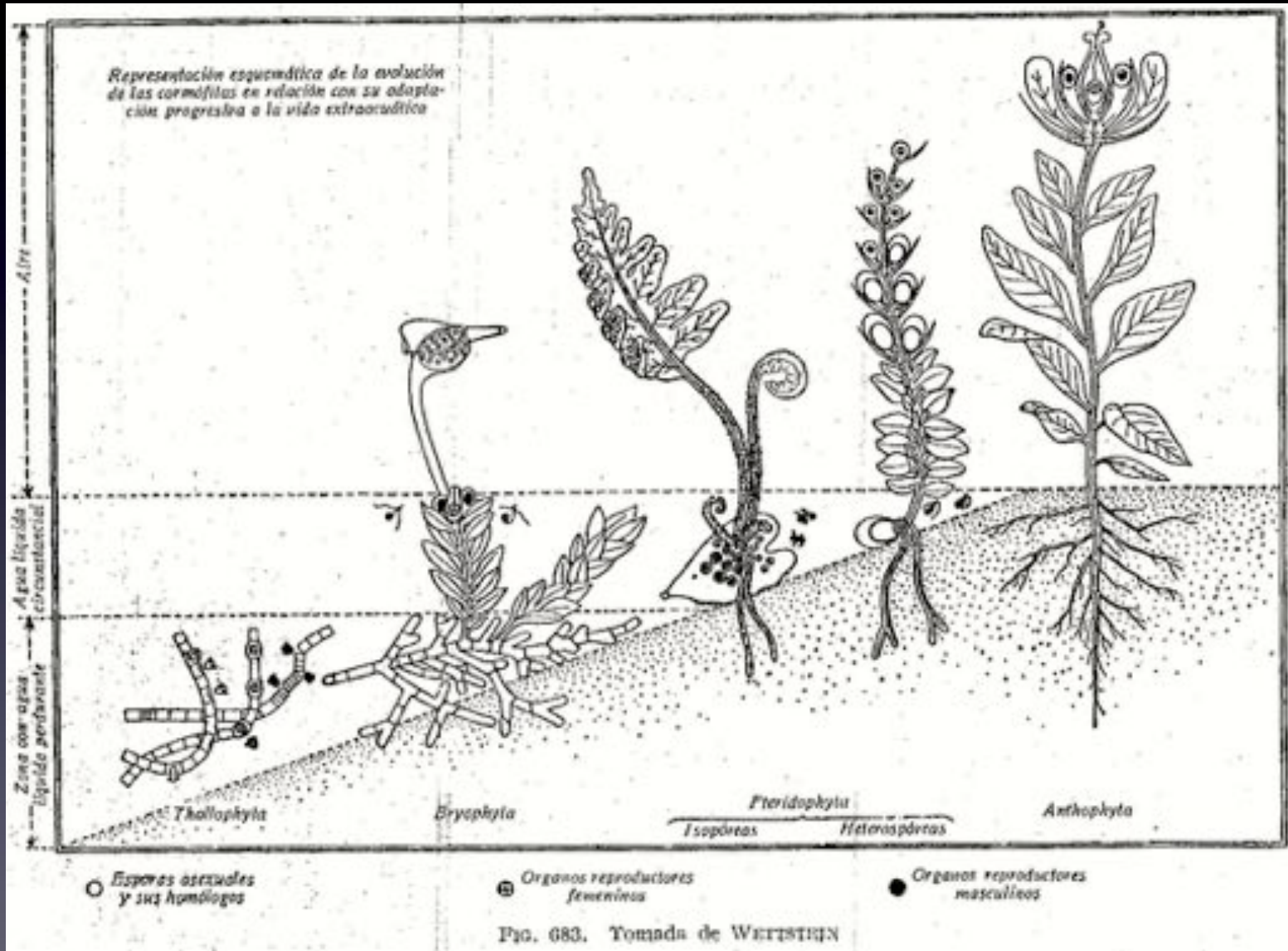
- The **zygote** remain in the archegonium where it receives food from the gametophyte (**matrotrophy**)
- Placenta** with highly branched **transfer cells**
- Food transfer is **apoplastic** (without plasmodesmata)
- Zygote develops into an **embryo**
- Embryo develops into a **sporophyte**
- Venter develops into a **calyptra**
- Mature sporophyte consists of a **foot**, **seta**, and **capsule** or **sporangium**



The term “Embryophytes” is an appropriate synonym for Plants

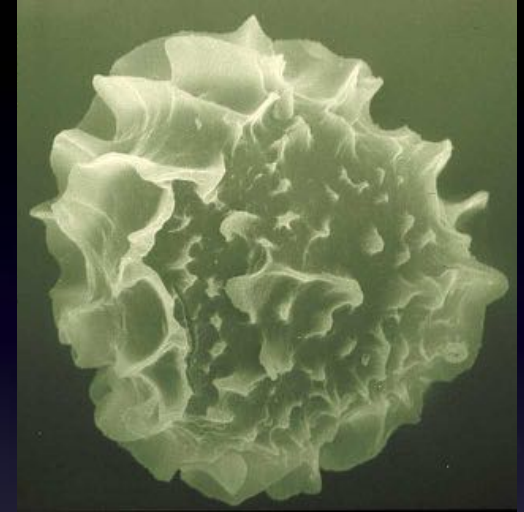
- All embryophytes contain a multicellular, **matrotrophic** embryo, from bryophytes through angiosperms
- The **advantage** of matrotrophy and the plant placenta is that they fuel the production of a many-celled diploid sporophyte
- These cells can be used to produce many genetically diverse haploid spores upon **meiosis** in the sporangium
- Production of greater numbers of spores per fertilization event **compensate** for low fertilization rates when water become scarce

- Throughout the evolutionary history of plants, there is a tendency for sporophytes to become increasingly larger in relation to the gametophytic generation

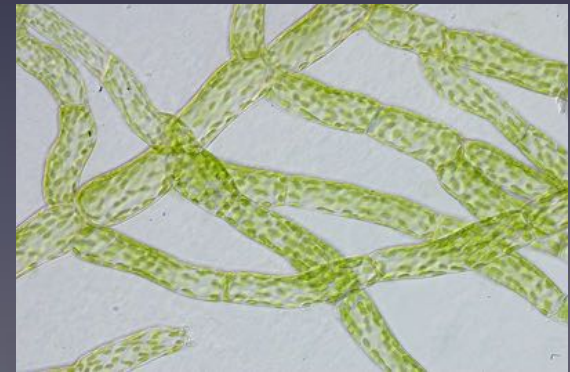


The sporopollenin walls of bryophytes have survival value

- Spores with **sporopollenin** to avoid bacterial degradation and drought
- Spores germinate into **protonemata**



- Bryophytes are classified in three phyla
 - Liverworts: Phylum **Marchantiophyta**
 - Mosses: Phylum **Bryophyta**
 - Hornworts: Phylum **Anthocerotophyta**

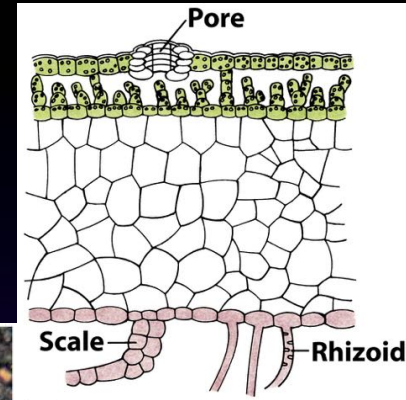


LIVERWORTS: PHYLUM MARCHANTIOPHYTA

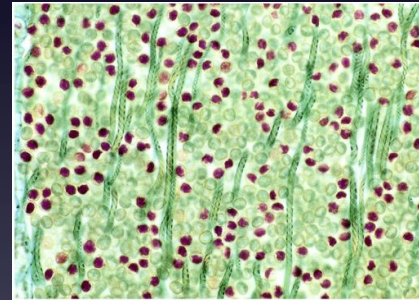
- 5200 species
- Many terrestrial, some aquatic
- “Liverwort” refers to liver shape
- “Doctrine of Signatures”
- Gametophytes develop from spores
- Some may develop from a protonema-like
- Two clades
 - Complex thalloid liverworts with internal differentiation
 - Leafy liverworts

Complex Thalloid Liverworts include *Riccia*, *Ricciocarpus*, and *Marchantia*

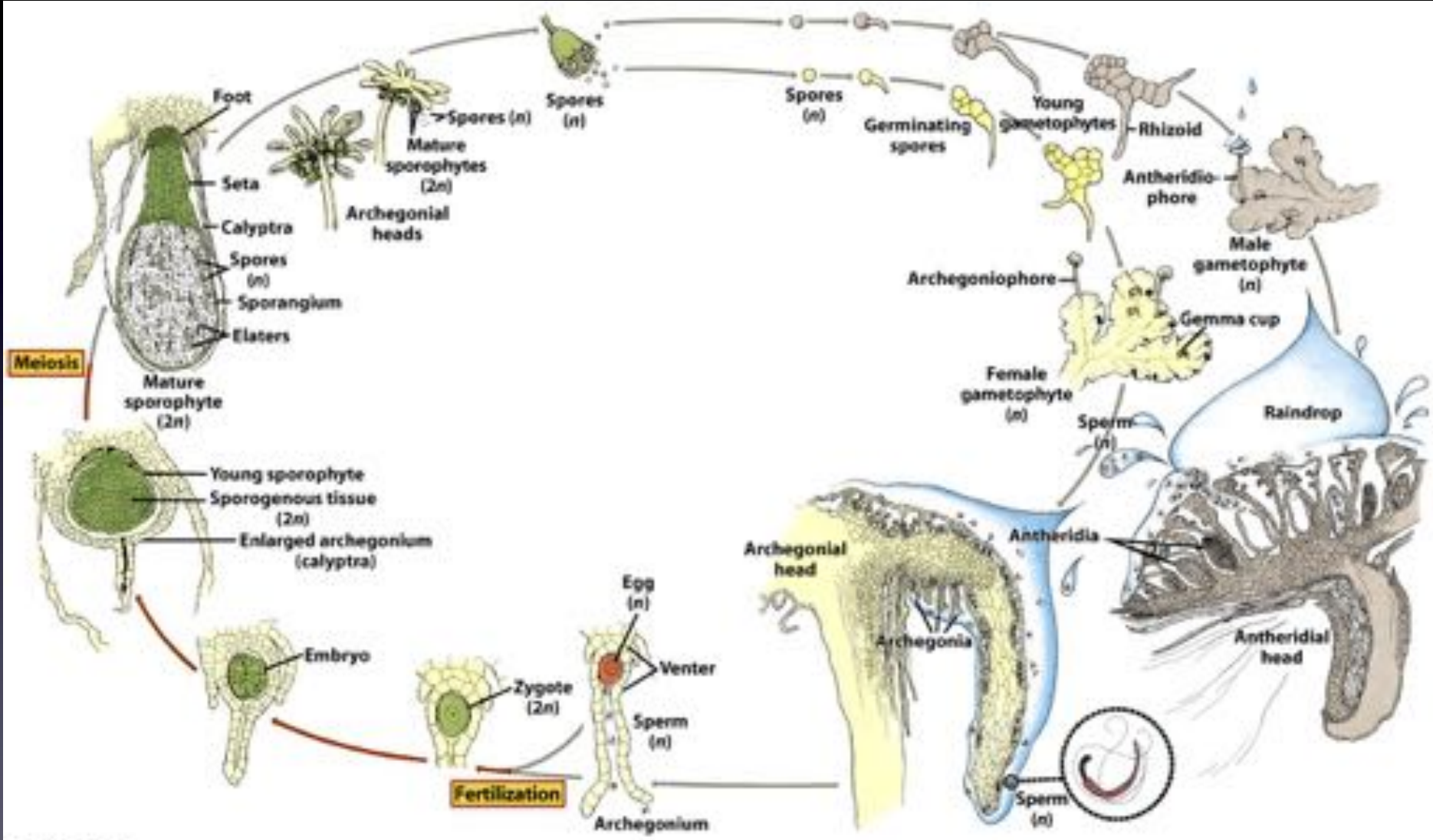
- Found on moist and shaded banks
- Thallus is 10-30 cells in thickness
- **Differentiated** into a thin chlorophyll-rich upper portion and a colorless lower portion
- Lower surface bears rhizoids and **scales**
- Upper surface with a large pore above a **air chamber**
- Sporophyte in *Riccia* and *Ricciocarpus* is simple



- *Marchantia* is dichotomously branched
- Gametangia on specialized structures or **gametophores** or **gametangiophores**
- Gametophytes are **unisexual**
- Antheridia are born on **antheridiophores**
- Archegonia are born on umbrella-like **archegoniophores**
- Sporophyte consists of a **foot**, a short **seta**, and a **capsule**
- Spores are mixed with hygroscopic **elaters**
- **Fragmentation** is common for asexual reproduction
- **Gemma cups** are also present

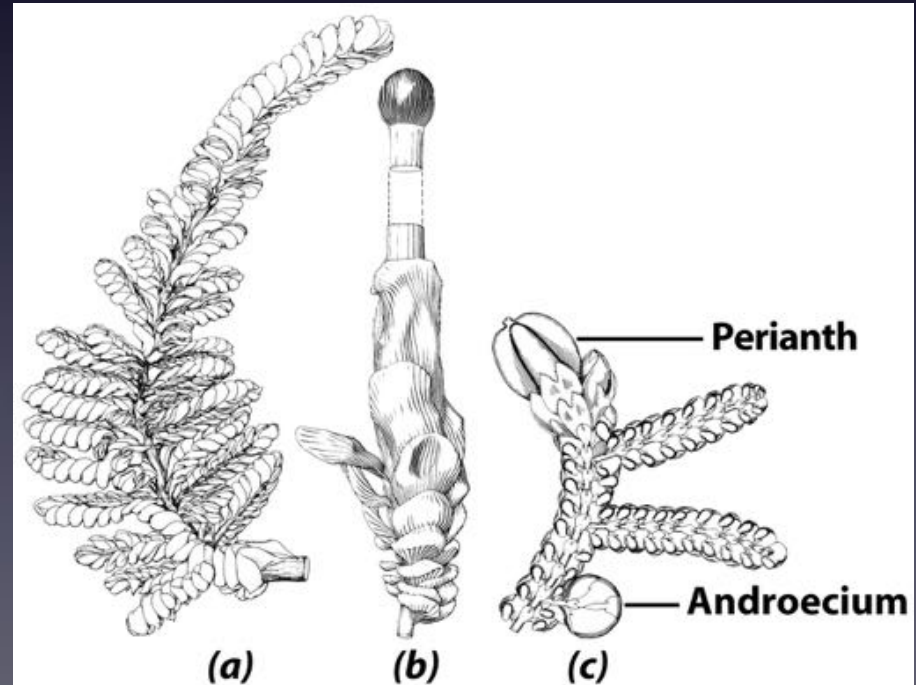


Life cycle of *Marchantia*



Leafy liverworts have a distinctive leaf structure and/or arrangement

- More than 4000 species
- Abundant in tropical rain forests
- **Leaves** with a single layer of cells
- Leaves are arranged in two rows of equal-sized leaves and a third row of smaller leaves on the lower surface
- Antheridia on a short branch called **androecium**
- Sporophyte surrounded by a tubular sheath known as **perianth**



Systematics of Marchantiophyta

1. Marchantiales

- 95 Genera and 2000 spp
- Thallose or blade like, flat, **dorsiventral**
Internal differentiation (**chlorenchyma**,
parenchyma, **air chambers**)
- Sporophyte compact with no seta
- Sporangium with one-layered wall



2. Sphaerocarpales

- Delicate gametophytes, no pores or air chambers
- 2 genera and 20 spp

- *Sphaerocarpus*
 - On soil during fall-winter-spring
 - Thallus **bilateral** with a midportion several cells thick and lateral monostromatic leaflike wings
 - No internal differentiation
 - **Dimorphic** with antheridia and archegonia

- *Riella*
 - Submerged aquatic with **asymmetrical** body
 - Erect branched axis with a lateral *Ulva*-like monostromatic wing
 - Archegonia surrounded by **involucre**s



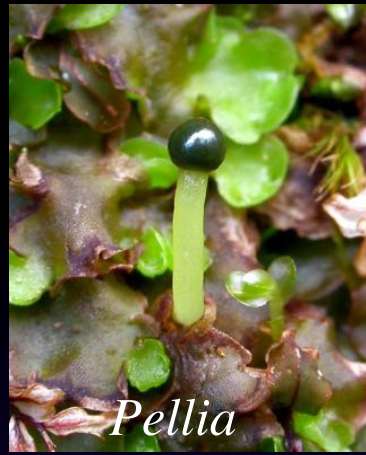
3. Monocleales

- One genus, *Monoclea* and 2 spp
- **Largest** liverwort
- Thallose, with a histologically homogeneous tissue, no air chambers
- Associated with fungi
- Antheridia in moundlike receptacles
- Archegonia covered by an involucrelike flap
- Sporophyte with an elongated seta!



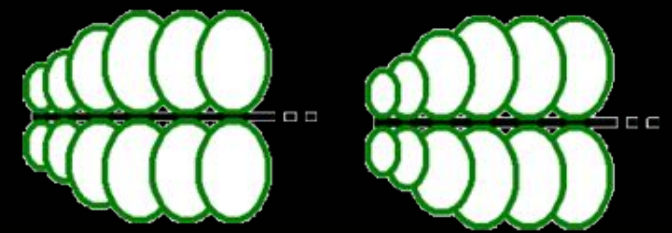
4. Metzgeriales

- 20 genera and 550 spp
- Simple thallose genera that lack air chambers, air pores, ventral scales and pegged rhizoids
- Antheridia and archegonia sessile on the gametophyte
- Sporophyte with elongated seta
- **Anacrogynous**: Apical cell does not become an archegonium and the growth of the branch can continue after the sex organs have matured



5. Jungermanniales

- Largest order, 180 genera and 7500 spp
- “Leafy liverworts”
- **Dorsiventral** with axes with two rows of delicate, monostromatic lateral leaves and often a third row of ventral leaves (**amphigastria**)
- Cell with **oil bodies**
- Leaves **incubous** (lower portion of a leaf is overlapped by the upper portion of the next older leaf below it) or **succubous** (upper portion of a given leaf is overlaid by the lower portion of the next young leaf, just above it)



Incubous and Succubous

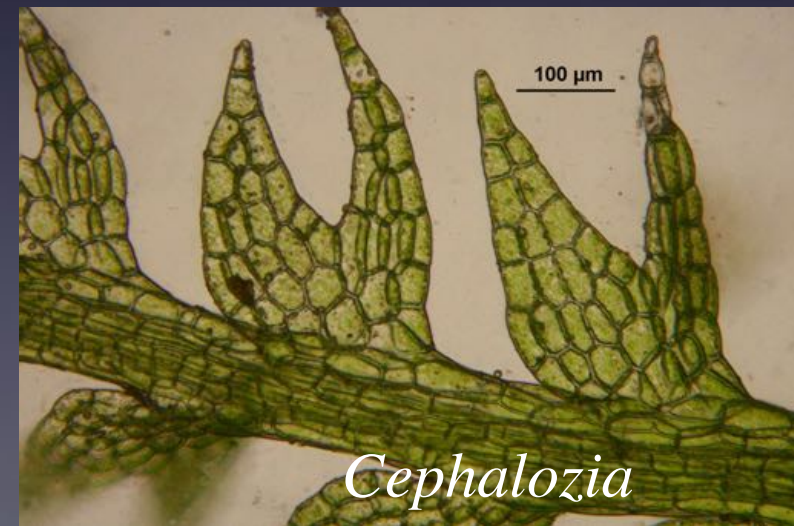


Porella



Ptilidium

500 μm



Cephalozia

100 μm

6. Takakiales

- One genus and 2 spp
- Simple plant with erect delicate branching axes
- **No rhizoids** but associated with fungi
- Smaller branches often called “**phillids**” and resembling leaves
- Either a primitive plant or a highly reduced liverwort!
- With non-living conducting cells with pores!



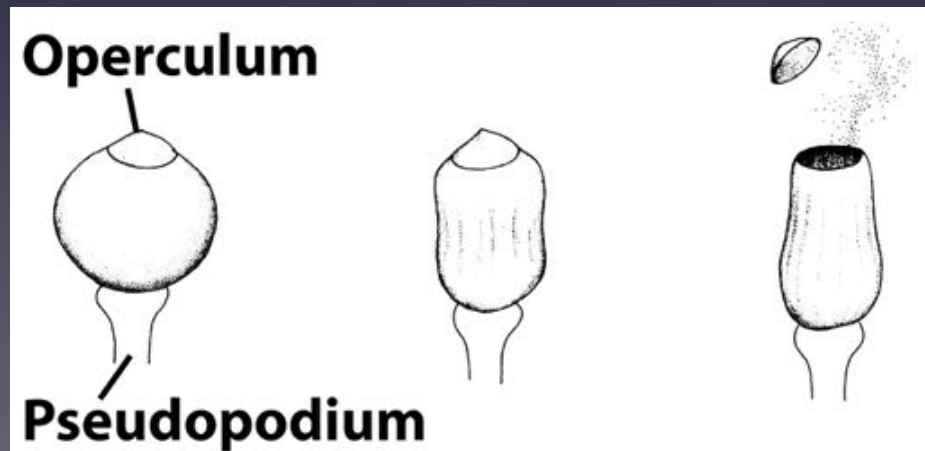
MOSSES: PHYLUM BRYOPHYTA

- There are several classes
 - **Sphagnidae**, the peat mosses
 - **Andreaeidae**, the granite mosses
 - **Bryidae**, the true mosses
- Peat and granite mosses diverged earlier
- Bryidae includes most of the moss species
- 10,000 species of Bryidae



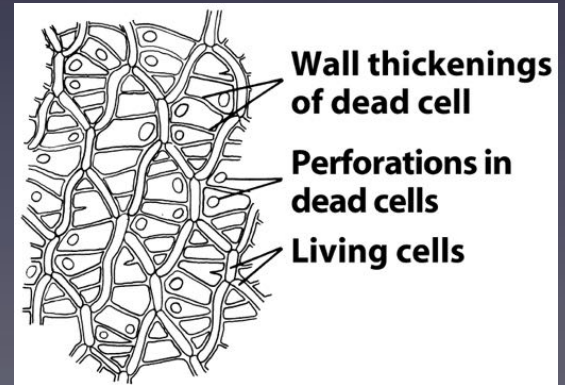
Peat mosses belong to the class Sphagnidae

- One genus, *Sphagnum*
- 400 species
- Known from 290 mya
- In wet areas from bog regions
- Ecologically and economically important
- Antheridia and archegonia at ends of special branches
- Sporophytes are blackish-brown
- **Capsules** on a stalk or **pseudopodium** (gametophytic)
- Ballistic spore discharge through a lidlike **operculum**
- Fragmentation is common



Three features distinguish the Sphagnidae from other mosses

- Unusual protonema:
 - Plate of cells with peripheral meristem
- Gametophyte morphology:
 - Leaves one cell thick with two type of cells (large dead cells and small living cells)
- Explosive operculum



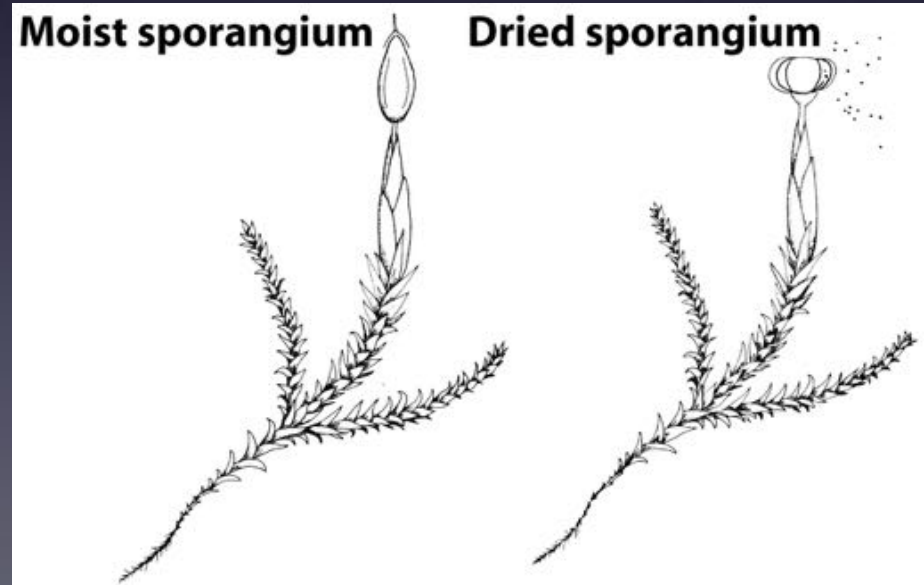
The ecology of *Sphagnum* is of worldwide importance

- **Peatlands** with *Sphagnum* occupy 1% of the world (half the size of USA)
- Peats store lots of **carbon**
- Highly **absorbent** and impregnated with antiseptic **phenol** compounds
- Contribute to the **acidity** of the area
- Widely used as dressing for wounds, packing material, and soil additive
- It is also burned as **industrial fuel** and domestic heating
- Ecological concern from **overharvesting** *Sphagnum* peatlands



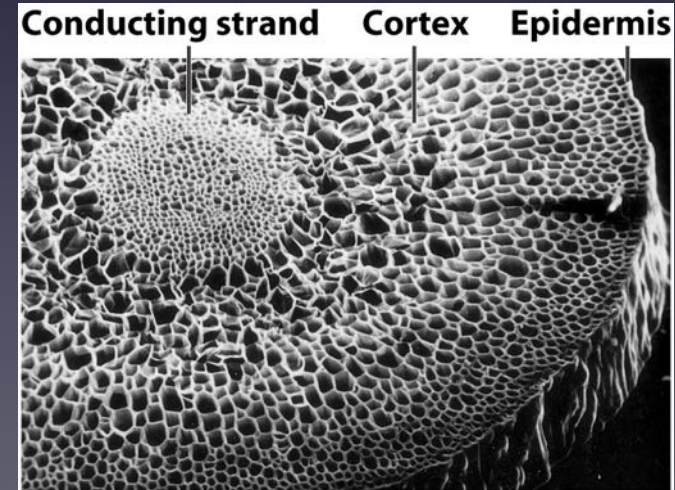
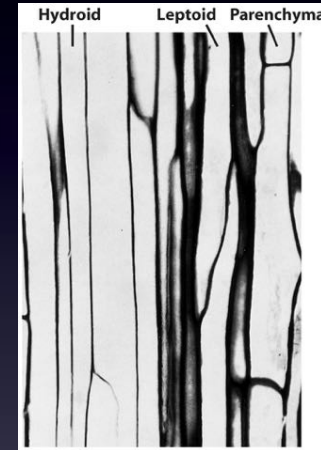
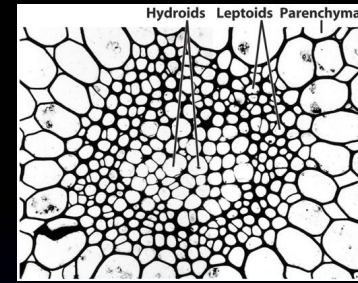
Granite mosses belong to the Class Andreaeidae

- With 2 genera: *Andreaea* and *Andreaobryum*
- *Andreaea* consists of 100 spp of small dark and tufted mosses found on Arctic **granitic** rocks
- *Andreaobryum* (1 sp) is found in NW Canada and Alaska on **calcareous** rocks
- Protonema with two or more rows of cells
- Rhizoids with two rows of cells
- Capsules open through **4 slits** but remain apically attached



“True Mosses” belong to the class Bryidae

- Includes most of the species of mosses
- Protonemata with single row of cells and **slanted** cross walls
- Leafy gametophytes appear from minute budlike structures on **protonemata**
- Tissues specialized for water and food conduction
- **Hadrom**: central water conducting tissue with cells called **hydroids** (dead cells with no lignin)
- **Leptom**: food-conducting tissue with cells named **leptoids**
- Conducting cells similar to fossil **protracheophytes**

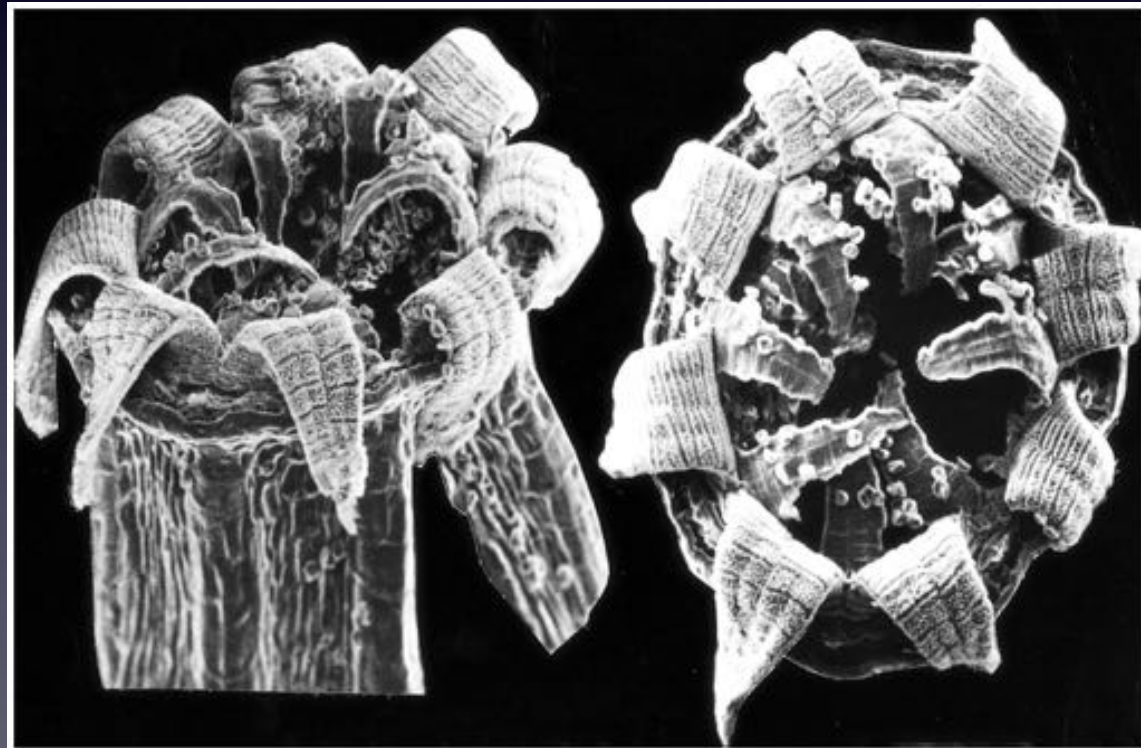
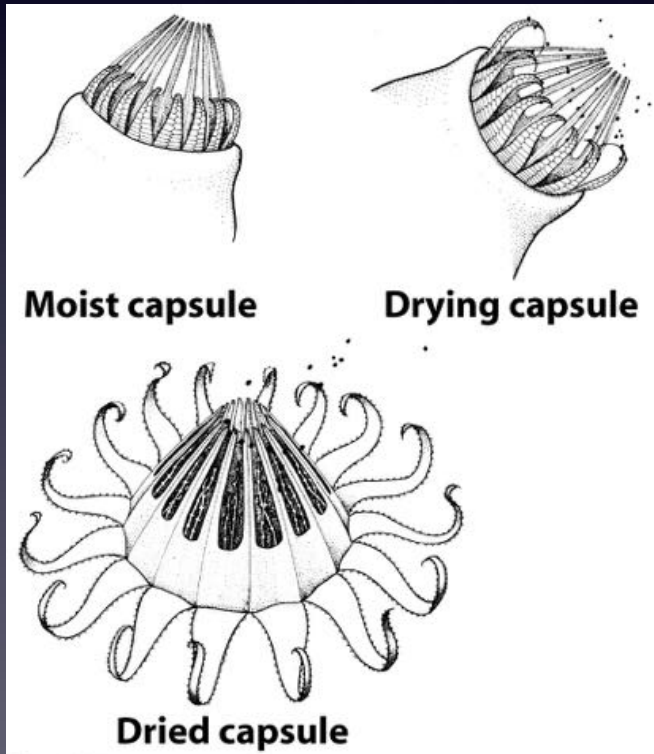


Sexual reproduction in Mosses is similar to that of other Bryophytes

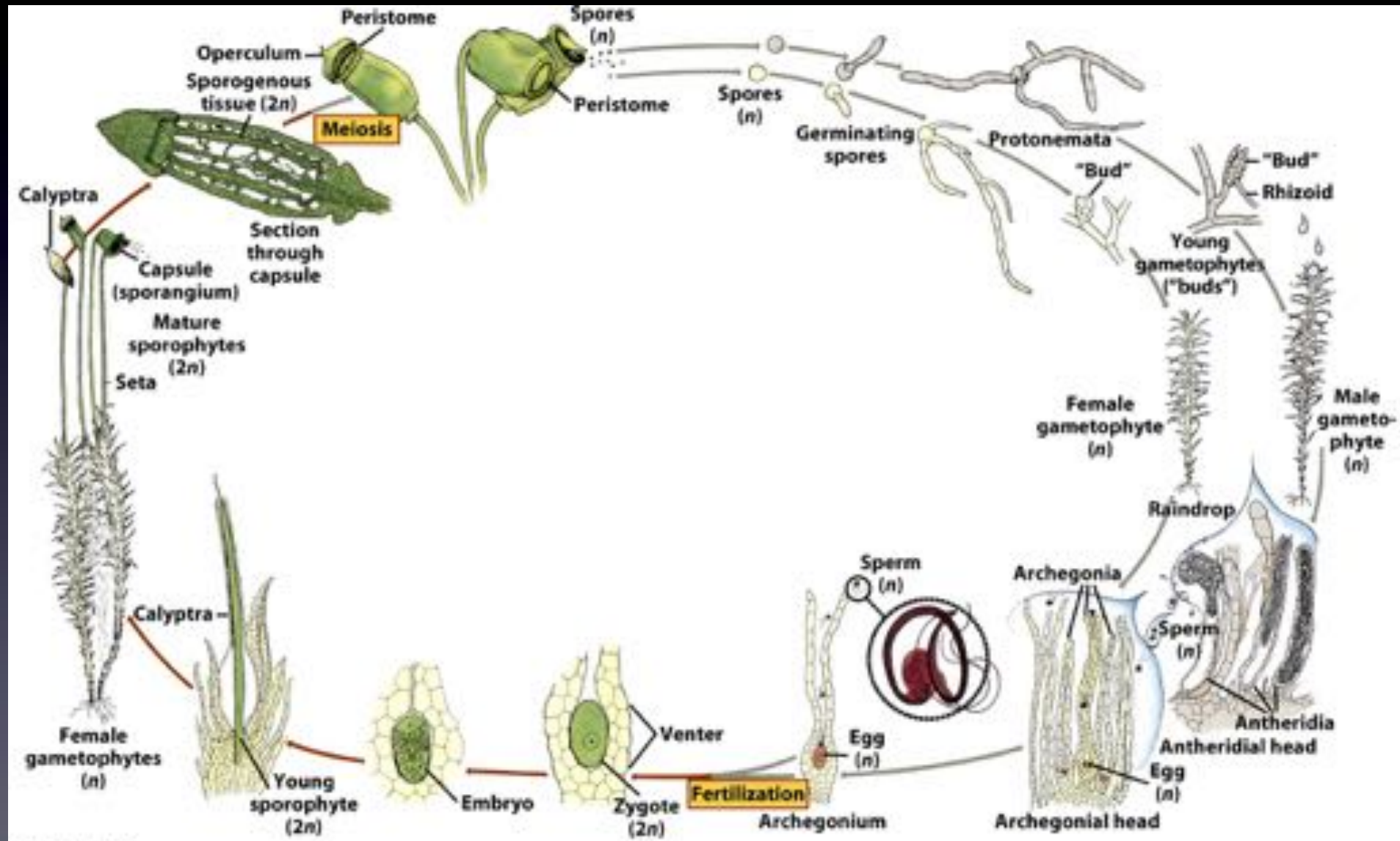
- Involves the production of male and female gametangia, an unbranched matrotrophic sporophytes, and specialized spore dispersal processes
- Gametangia are produced either on the tip of the main axis or on a lateral branch
- Gametophytes unisexual or bisexual
- Antheridia on splash cups



- Sporophytes with short foot, a long seta, and stomata
- Capsule covered by a **calyptra** (remnants of archegonium)
- Operculum is released to reveal the **peristoma**
- **Teeth** can be hygroscopic



Life cycle of a Moss





Moss gardens business

Mosses exhibit “cushiony” or “feathery” growth patterns

- In “**cushiony mosses**” or **acrocarps**, gametophytes are erect and little branched with terminal sporophytes
- In the “**feathery mosses**” or **pleurocarps**, the plants are creeping, highly branched, and sporophytes are borne laterally (in tropical rainforests with humidity)



Fissidens

- In moist habitats
- Leaves in two alternating rows
- Leaves with a dorsal winglike lobe and a midrib
- Sporophyte with single peristome



Physcomitrium or “urn moss”

- On roadsides
- Acrocarpic
- Capsule globose-pyriform
- With operculum but lack peristome



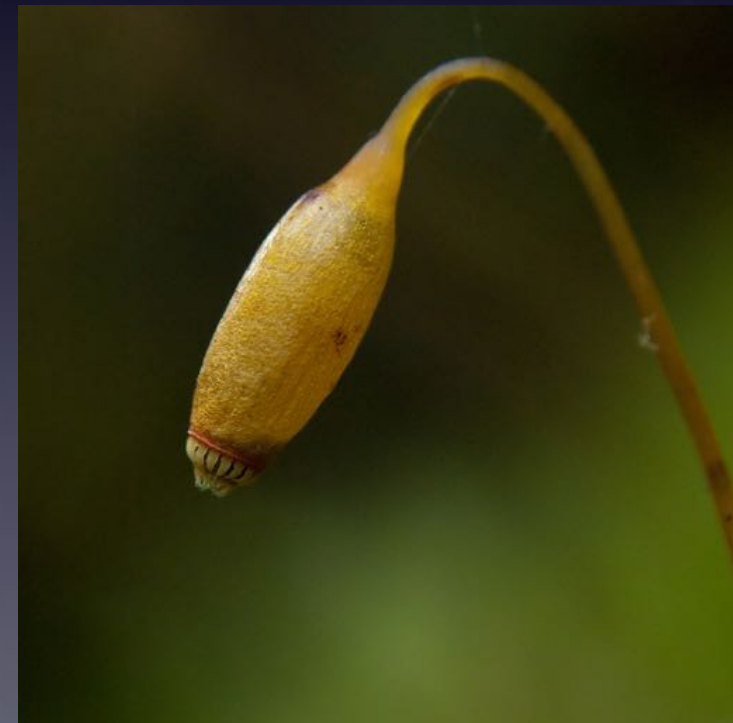
Splachnum or “petticoat moss” or “umbrella moss” or “dung moss”

- Growing on dung or bones
- The base of the capsule, the **hypophysis**, becomes expanded and maybe skirt- or umbrella-like



Mnium

- 80 spp
- Worldwide distribution
- On swamps, soil, rocks or tree bark
- Leafy gametophores with **capsule pendent**
- **Peristome double** and opercula with long beaks



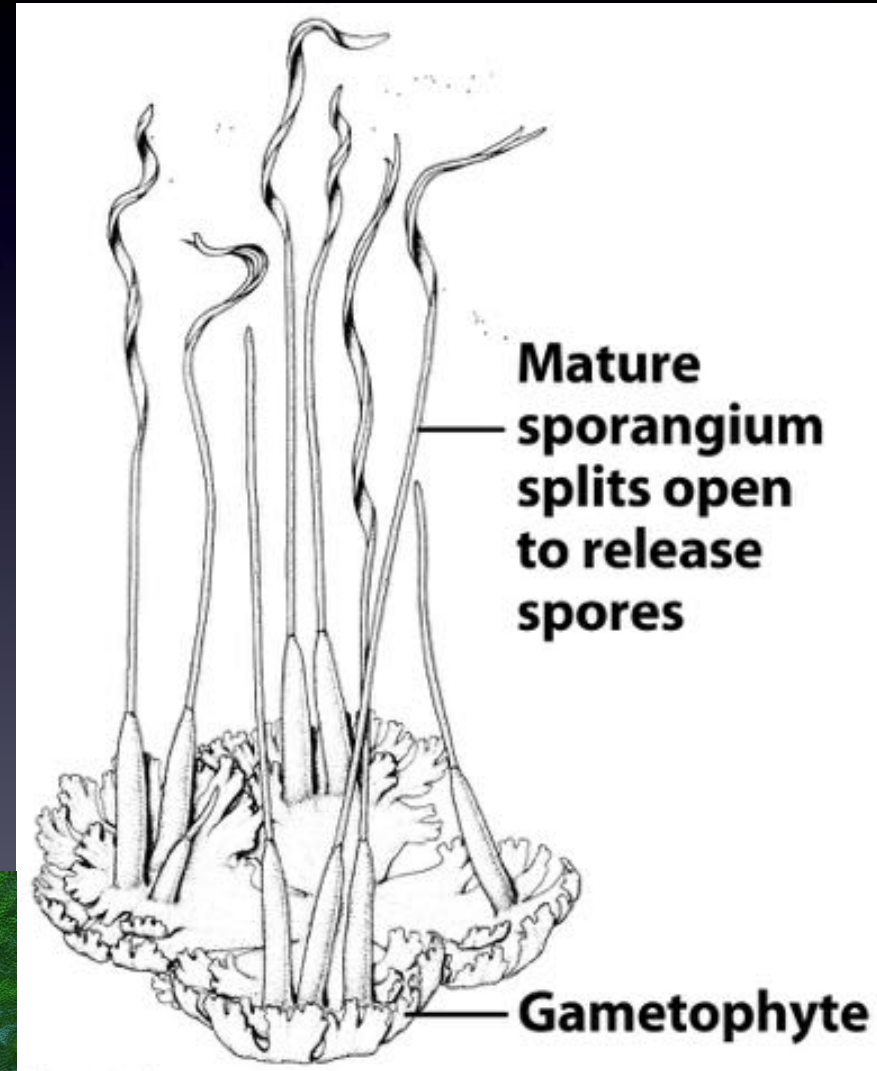
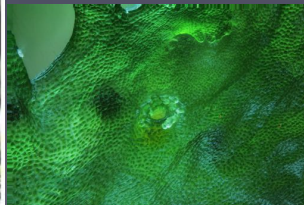
Fontinalis “water moss”

- Aquatic moss with 50 spp
- Leaves three-ranked and without midribs
- Sporophyte almost hidden
- Capsule with double peristome with the inner circle united into a cone-shaped lattice

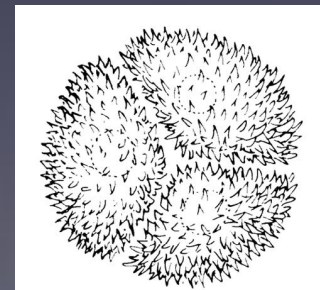
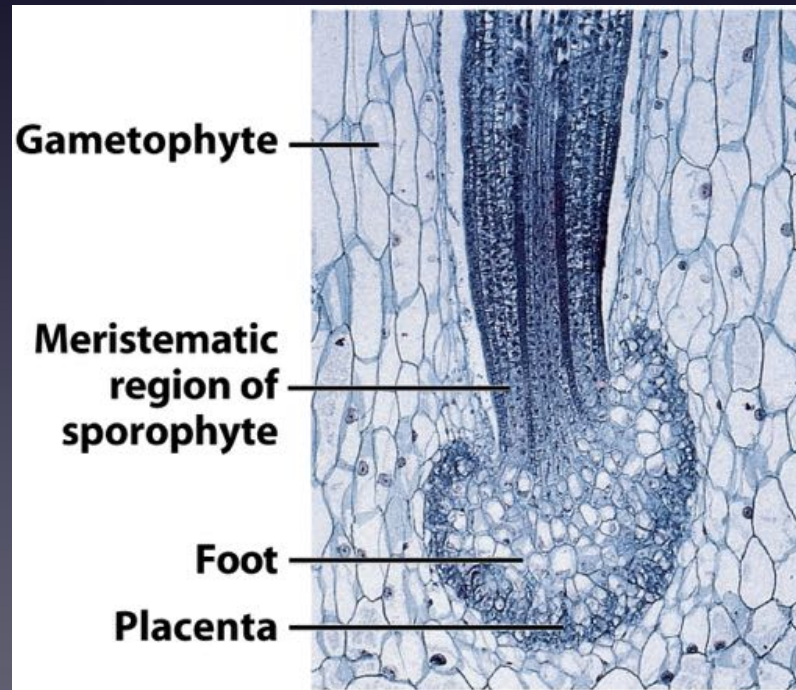
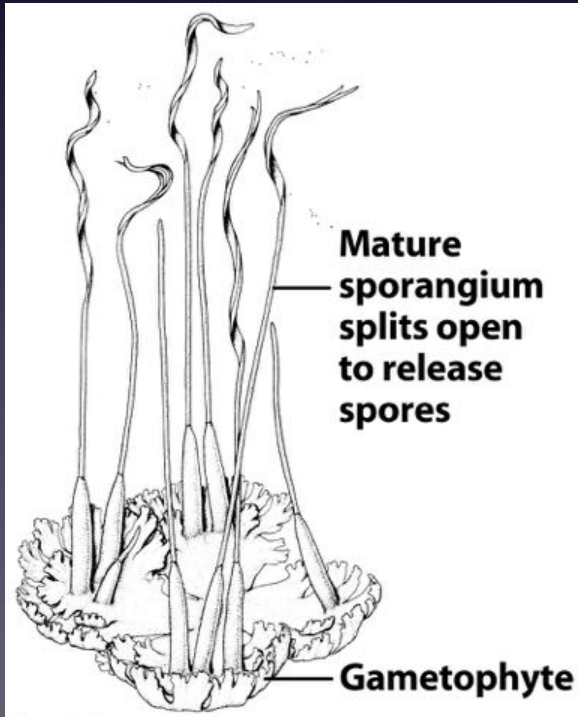
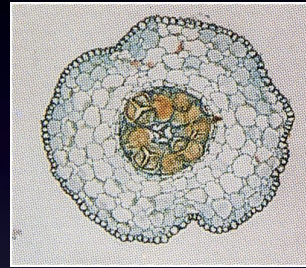
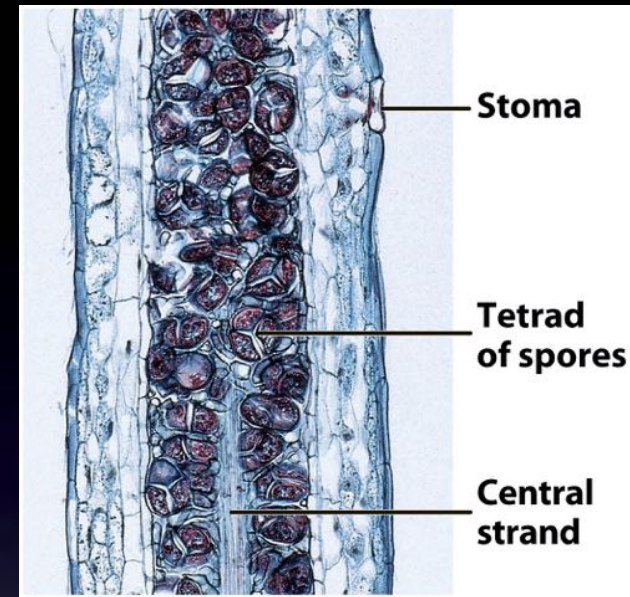


HORNWORTS: PHYLUM ANTHOCEROPHYTA

- 300 species
- *Anthoceros* is common
- Similar to thallose liverworts
- Cells with single large plastid and pyrenoid
- Gametophytes are **rosettelike**
- Internal cavities filled with *Nostoc*
- Uni or bisexual
- Antheridia and archegonia sunken on dorsal surfaces



- Sporophyte is upright and elongated
- It consists of a **foot** and a long cylindrical **capsule** or sporangium
- **Meristem** between foot and sporangium
- Sporophyte covered by **cuticle** and **stomata**
- **Dehiscence** from the apex
- Spores mixed with **elater-like cells**



SUMMARY TABLE Comparative Summary of Characteristics of Bryophyte Phyla

PHYLUM	NUMBER OF SPECIES	GENERAL CHARACTERISTICS OF GAMETOPHYTE	GENERAL CHARACTERISTICS OF SPOROPHYTE	HABITATS
Marchantiophyta (liverworts)	5200	Free-living generation; both thalloid and leafy genera; pores in some thalloid types; unicellular rhizoids; most cells have numerous chloroplasts; many produce gemmae; protonema stage in some; growth from apical meristem	Small and nutritionally dependent on gametophyte; unbranched; consists of little more than sporangium in some genera, and of foot, short seta, and sporangium in others; phenolic materials in epidermal cell walls; lacks stomata	Mostly moist temperate and tropical; a few aquatic; often as epiphytes
Bryophyta (mosses)	12,800	Free-living generation; leafy; multicellular rhizoids; most cells have numerous chloroplasts; many produce gemmae; protonema stage that grows by marginal meristem followed by further growth from an apical meristem in <i>Sphagnum</i> ; growth by apical meristem only in Bryidae; some species have leptoids and nonlignified hydroids	Small and nutritionally dependent on gametophyte; unbranched; consists of foot, long seta, and sporangium in Bryidae; phenolic materials in epidermal cell walls; stomata; some species have leptoids and nonlignified hydroids	Mostly moist temperate and tropical; some Arctic and Antarctic; many in dry habitats; a few aquatic
Anthocerotophyta (hornworts)	300	Free-living generation; thalloid; unicellular rhizoids; most have single chloroplast per cell	Small and nutritionally dependent on gametophyte; unbranched; consists of foot and long, cylindrical sporangium, with a meristem between foot and sporangium; cuticle; stomata; no specialized conducting tissues	Moist temperate and tropical

SUMMARY

- Plants most likely evolved from a Charophycean green alga
- The Bryophytes are the Liverworts, Hornworts, and Mosses
- The sporophytes of the Bryophytes differ from one another
- Bryophytes are important ecologically