

## Topic 21. The Non-Vascular Plants

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Plants are **eukaryotic**, **photosynthetic** organisms with **chlorophylls a and b**, **xanthophylls** and **carotenoids**. they have **cell walls with cellulose**, and store food as **starch localized in plastids**. As is found in the **charophycean** green algae, cytokinesis is accomplished by means of a **phragmoplast**. As we learn more about the green algae and the plants, it is becoming clear that plants are a phylogenetic group within the green algae which have colonized the land.

Plants are more structurally complex than the green algae. This is certainly due to the environmental pressures associated with **life on land**. The most structurally simple plants have a sterile jacket of cells (dermal tissue) surrounding the sexual structures protecting the gametes from dehydration. Eggs are contained in an **archegonium**, and developing sperm in an **antheridium** (these have been lost in some of the more structurally complex lineages of plants). The vascular plants have tissues specialized for the transport of water and photosynthate, which allow them to tap underground water and mineral resources and to support themselves in competition for light.

All plants are **oogamous** and have a **heteromorphic alternation of generations** with **sporic meiosis**, and **gametic mitosis**. This means, that in the plants, gametes are always produced by mitosis, and spores are always produced by meiosis. All plants have embryos. The **embryo** is an early sporophytic (diploid) stage that is nourished by the gametophytic generation. An alternate name for the clade is **embryophyta**.

**The non-vascular plants** are simply the plants without xylem and phloem, and do not constitute a phylogenetic group. Mosses do have cells specialized for the movement of water and photosynthate, which may be homologous to xylem and phloem of vascular plants. The three phylogenetic groups of non-vascular plants are unique among living plants in that the dominant generation is the gametophyte. In each case, the sporophyte is dependent on the gametophyte for survival for the duration of its life's span.

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**Domain: Eukarya - Organisms with nucleated cells**

**Kingdom: Plantae**

**Liverworts**

**Genus: *Ricciocarpus***

**Genus: *Marchantia***

**Hornworts**

**Mosses**

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## I. The Liverworts.

Structurally these are the simplest plants. The group lacks vascular tissues and stomata (there are air pores, but these are not associated with guard cells). As with the other bryophytes, the gametophytic generation is the dominant generation being free-living and photosynthetic. The sporophytes are both totally dependent on the gametophyte for survival, and, inconspicuous. The tissues of the gametophyte are undifferentiated. A body composed of simple, undifferentiated tissues, like those of liverworts, is termed a **thallus**.

### Ia. *Ricciocarpus*.

Observe the living liverworts at the front. Note the relative simplicity of form where the entire plant grows prostrate on the substrate. These are gametophytes which are haploid and which produce eggs and sperm by mitosis.

- Based on your observations, where does growth occur in these plants?

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- Based on your observations, how does branching occur in these plants?

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The eggs are contained in an **archegonium**. The sperm are formed in an **antheridium**. In both cases, a sterile tissue layer surrounds these structures limiting dehydration of the developing sperm and egg. In *Riccia*, the archegonia and antheridia are located on the the plant which is in contact with the substrate.

- As plants are oogamous, how is the location of the archegonium and antheridium near the ground adaptive?

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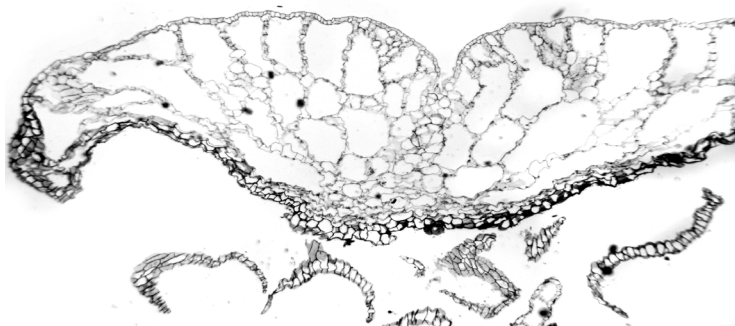
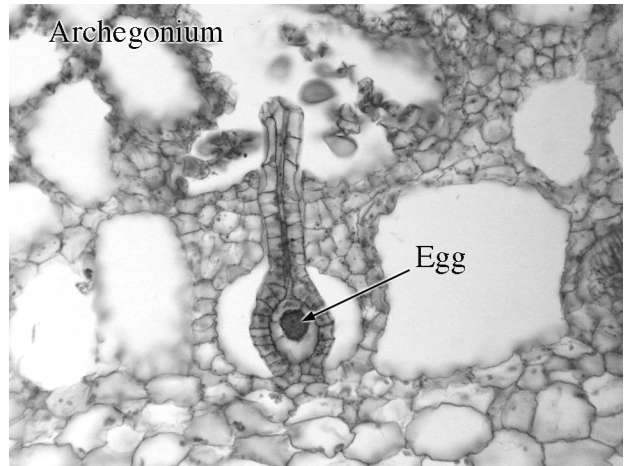
**Fertilization** results in the formation of a diploid cell called a **zygote**. The zygote resides inside the base of the archegonium (the **venter**) where the zygote undergoes **mitosis** and grows into a multicellular diploid embryo. The mature sporophyte mostly consists of one large sporangium which produces spores by meiosis.

Observe the demonstration slides of *Riccia* at the front, and the figures on the next page. Try to integrate what was outlined about its life cycle with the structures viewed. In these views, recognize diploid vs. haploid cells. Identify the venter and neck of the archegonium, and the embryo in the venter of the archegonium.

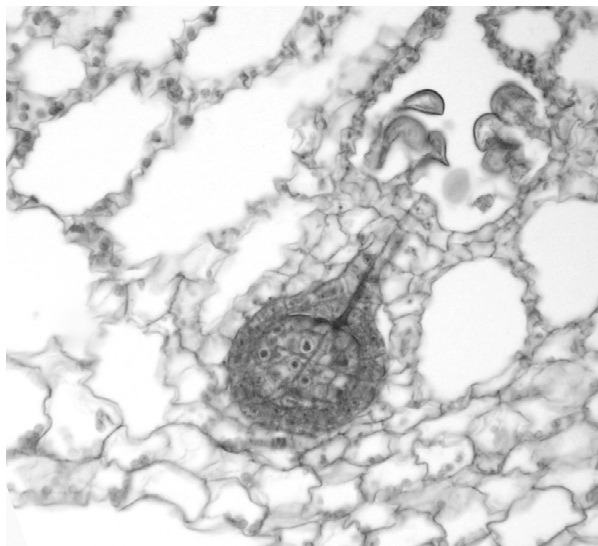
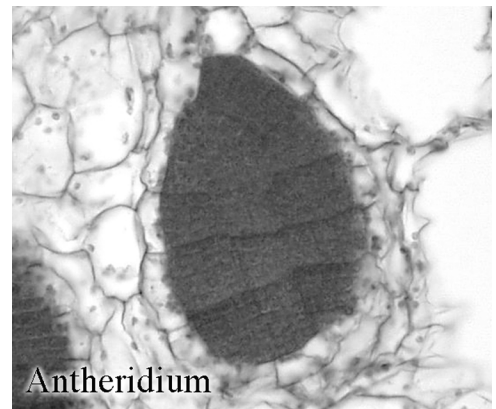
# Various Views of *Ricciocarpus*



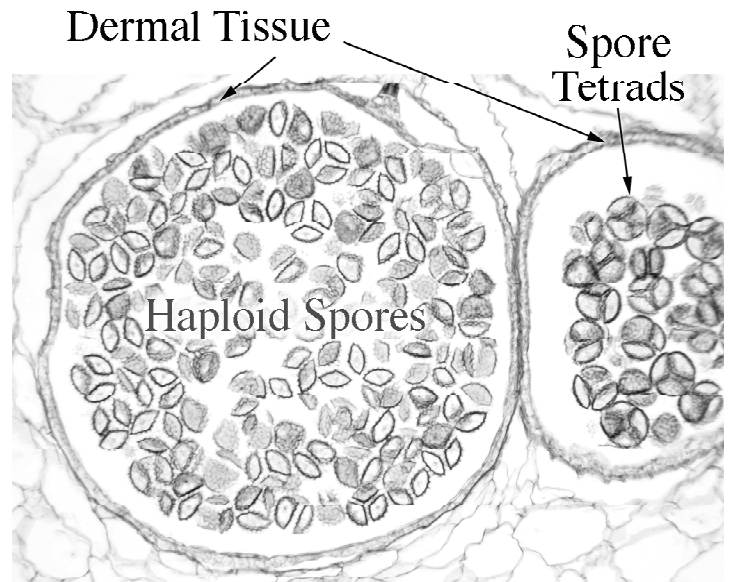
Gametophytes of *Ricciocarpus*



Cross Section of Gametophyte of *Ricciocarpus*



*Ricciocarpus*-Young Embryo



Mature Sporophytes

## Ib. *Marchantia*.

*Marchantia* differs from *Riccia* in that the archegonia and the antheridia are not borne near the substrate. Archegonia (and the sporophytes formed in those archegonia) are elevated on gametophytic tissue called **archegoniophores**. The antheridia are also elevated on other structures of the gametophyte called **antheridiophores**.

### Ib1. The Gametophyte of *Marchantia*

#### The vegetative thallus

Observe the *Marchantia* culture at the front of the room, and take a petri dish of *Marchantia* to your seat.

The non-reproductive portion of the plant grows firmly attached to its substrate.

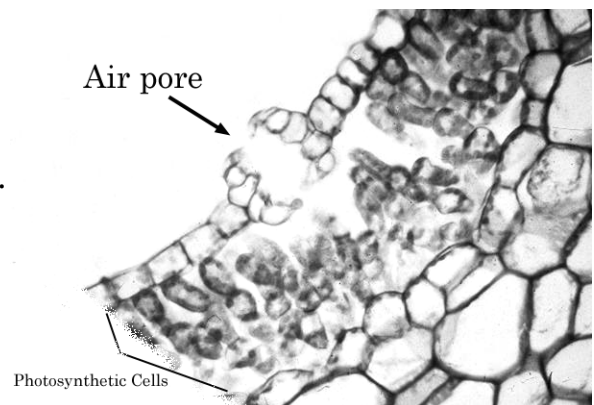
**Where does growth occur and, how does the thallus branch as it grows?**

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- Using a dissecting scope observe the surface of the thallus in your petri dish. Note the air pores that appear as dots on the top surface.
- Take the prepared slide of a cross section of the thallus and observe with your microscope.
- Note the relatively undifferentiated nature of this plant body. There are no vascular tissues of any kind. Also note that only cells at the top portion of the thallus are photosynthetic.
- Look closely at a cross section of an air pore and note the absence of guard cells.



## Sexual Structures.

Observe the elevated umbrella-like structures growing from the thallus. Note that there are two types. One has spokes radiating from the stalk like the ribs of an umbrella, the other has a stalk terminating in a disc. The structure with the spokes is an **archegoniophore** and bears **archegonia**. The structure with the disc is an **antheridiophore** and bears **antheridia**. In each case, these structures are made up of gametophytic tissue.



Archegoniophores



Antheridiophores

## Archegoniophores.

Take the prepared slide labeled “*Marchantia* Archegonia”. This is a longitudinal section through an archegoniophore. Compare it with the live material in your petri dish. Place it on your microscope and locate the archegonia.

**Draw an archegonium: label egg, venter and neck. Indicate above where the archegonia are located on the archegoniophore. There is a lot of various in our slides. If these are not clear to you ask your TA for assistance.**

**Antheridiophores.**

Take an antheridiophore and rub the top of its disc in a drop of water on a microscope slide. Make a wet mount and look for swimming sperm. If you locate any tell your TA and share this slide with your neighbors.

Take a prepared slide labelled “*Marchantia* Antheridia”. This is a longitudinal section through an antheridiophore. Compare it with the antheridiophore in your petri dish, then place it on your microscope. Locate the antheridia embedded in the disk of the antheridiophore.

**Draw a antheridium: label spermatogenous tissue and sterile jacket layer of cells.**

**Specifically how might the structure of the archegoniophore be adaptive to *Marchantia*? See the movie of sperm exchange on the monitor**

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**Specifically how might the structure of the antheridiophore be adaptive to *Marchantia*?**

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**What type of nuclear division results in the production of the sperm and egg nuclei in *Marchantia*?**

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## Ib2. The Sporophyte of *Marchantia*.

The sporophyte develops surrounded and nourished by the tissues of the gametophyte. **This is a fundamental characteristic of all plants.** However, in the non-vascular plants, the sporophyte never becomes independent from the gametophyte. The mature sporophytes of *Marchantia* can be found hanging from the older archegoniophores.

**Take a petri dish with preserved sporophytes to your seat** and observe the underside of the archegoniophores with a dissecting microscope. Note the bumps which are the mature sporophytes.

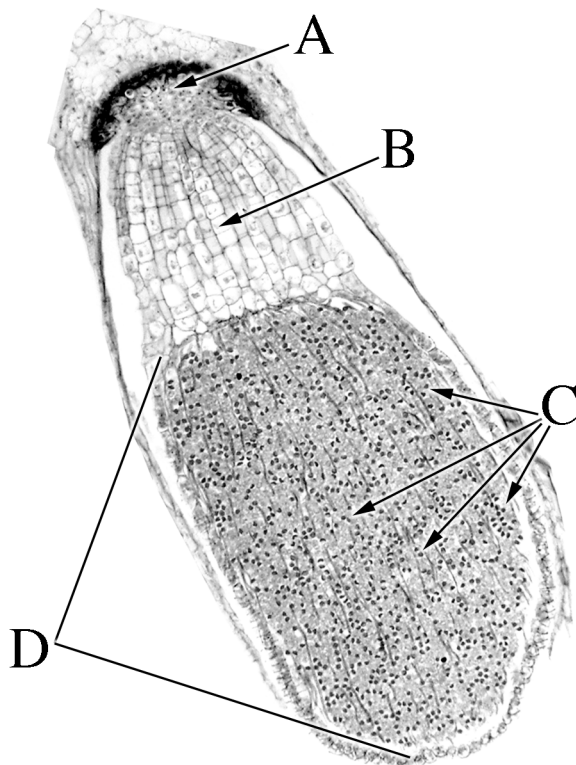
Now take the prepared slide labelled "*Marchantia*: Mature Sporophyte", and observe using your microscope. Identify the **foot**, **stalk (seta)**, **sporangium**, and the **spores** in the sporangium. Label the figure below:

A = \_\_\_\_\_

B = \_\_\_\_\_

C = \_\_\_\_\_

D = \_\_\_\_\_



Note the unlabelled arrow indicating the calyptra. This tissue is derived from the venter that enclosed the developing embryo.

**What nuclear division produces the spore nuclei?**

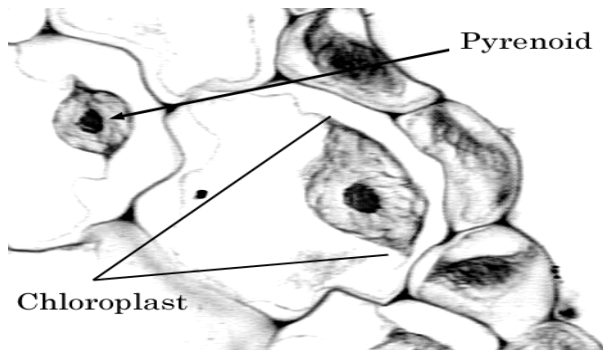
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**How might the elevation provided by the archegoniophore be adaptive to the sporophyte?**

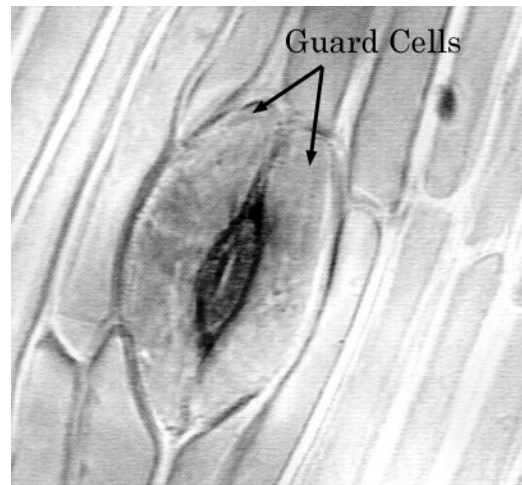
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## II. The Hornworts.

This group is superficially similar to the liverworts. Like liverworts, there is little tissue differentiation in the gametophyte and the gametophyte grows in contact with the substrate. The cellular structure is different, however. Indeed hornwort cells are uniquely different from all other plant cells. Typically plant cells have numerous, disk-shaped chloroplasts, but Hornwort cells have one, central, algal-like chloroplast with a **pyrenoid**. Also, unlike liverworts, the hornworts have stomata. The sporophytes of the hornworts have **guard cells** associated with the openings in its surface layer of tissues. This marks these openings as being true **stomata**.



Cells of *Anthoceros* Gametophyte



Stoma of *Anthoceros* Sporophyte

**IIa. Live Colony.** Observe the living material on the side bench. The **gametophyte** is a flat sheet-like thallus. The **sporophytes** are the “horns” growing on the gametophyte.

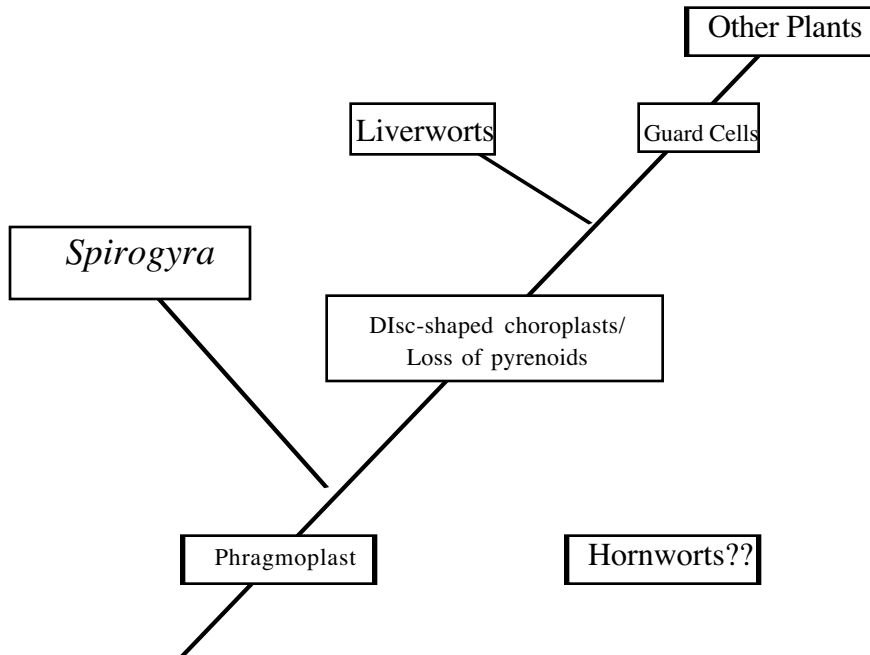
**IIb. Gametophyte.** Make a wet mount of the gametophytic tissue and **draw a cell. Label a chloroplast with a pyrenoid.**

**IIc. Sporophyte.** Observe the demonstration slide of a stoma at the front bench.

**IId. Consider the following two evolutionary schemes.**



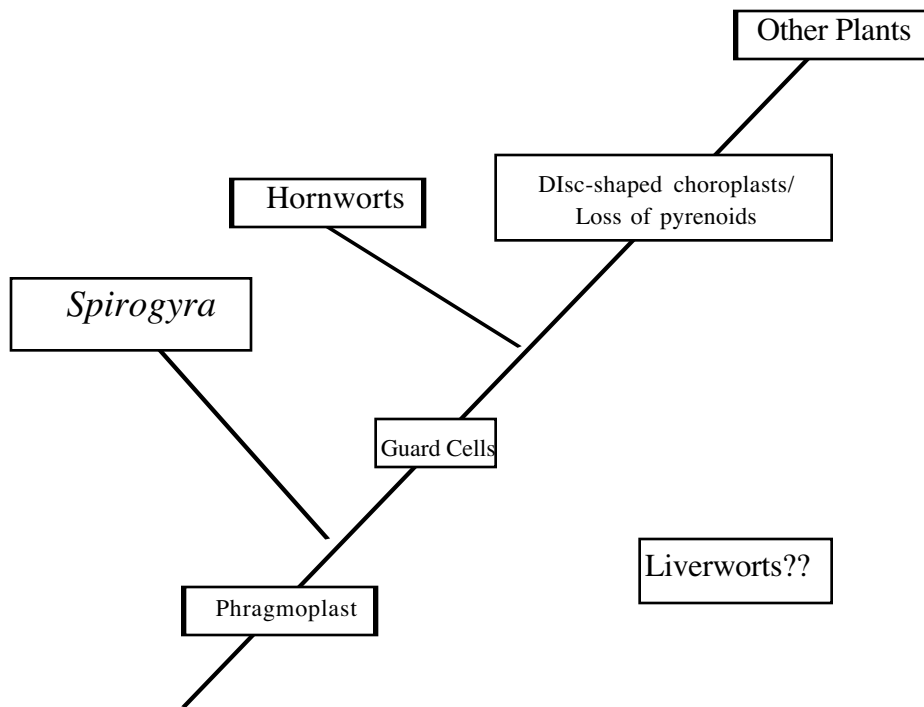
Scenario I



Modify this below to include the hornworts.

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Scenario II

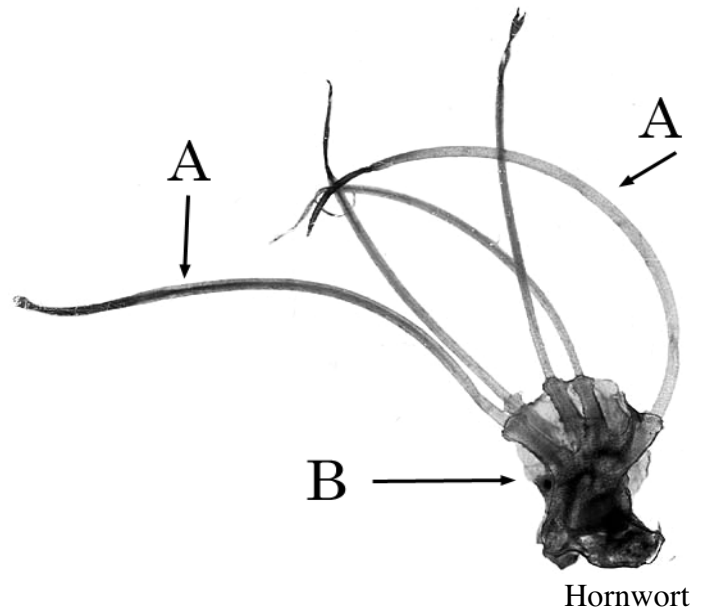


Modify this below to include the liverworts.

Label the figure.

A = \_\_\_\_\_

B = \_\_\_\_\_



### III. The Mosses.

Of all the non-vascular plants, the mosses have the clearest affinity to the vascular plants. Mosses have specialized cells that conduct water, and others that conduct photosynthate. Further, these cells appear to be homologous to similar tissues in the vascular plants. Unlike the vascular plants, however, in the mosses, the gametophytic generation is the dominant generation, the sporophyte is dependent all its life on the gametophyte for survival. The mosses also have disc shaped chloroplasts, lack pyrenoids and have stomata.

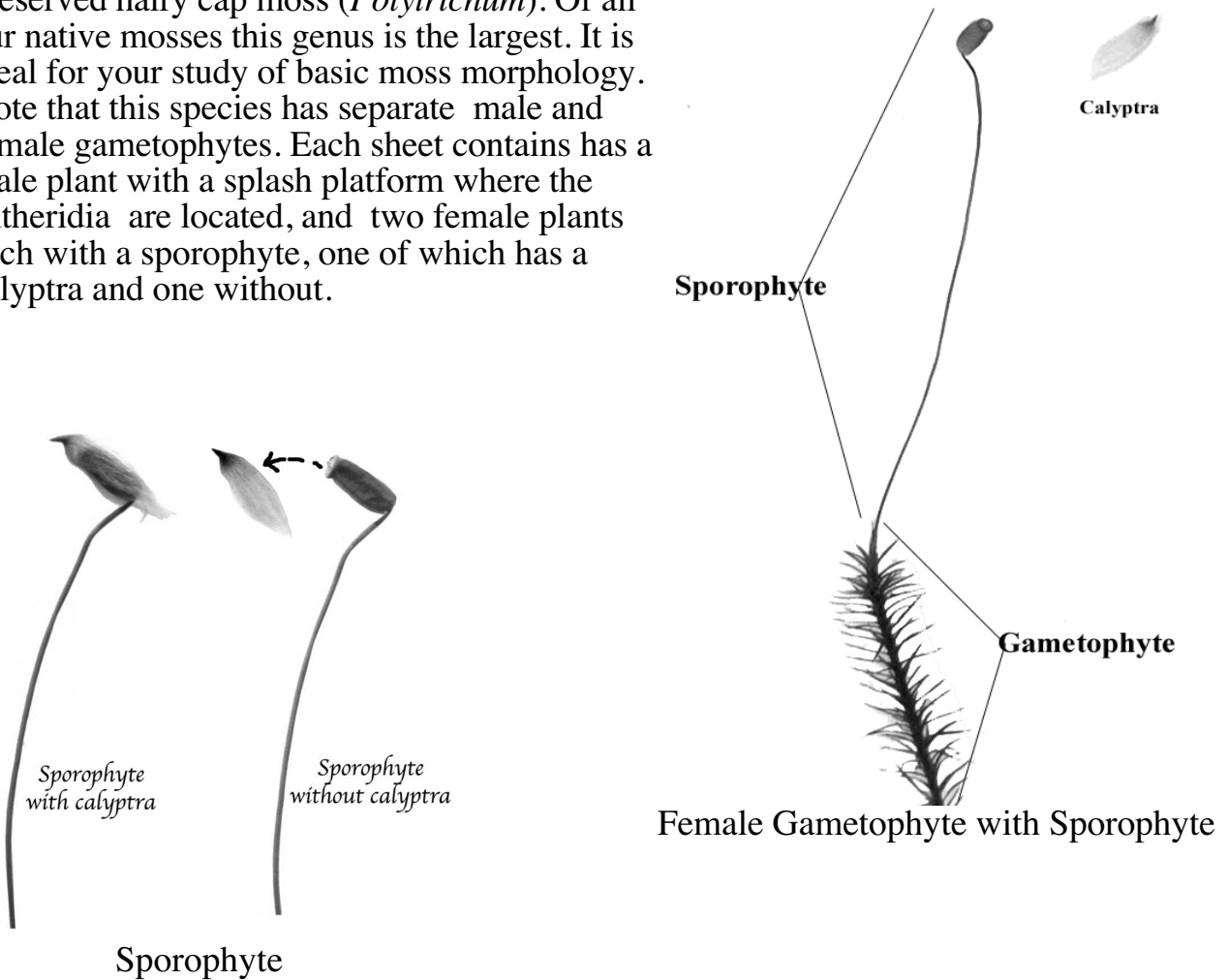
#### IIIa. View the Colonies on Demonstration

Of all the non-vascular plants, these are the ones, undoubtedly, with which you are most familiar. Mosses grow everywhere where there is moisture to support them. Most mosses are very similar in form. Most have gametophytes consisting of a central axis with leaf-like structures attached. The structures that appear to be sporangia are actually the sporophytic generation.

**Draw any moss on demonstration with sporophytes. Label both gametophyte and sporophyte.**

### IIIb. Hairy Cap Moss.

Take a herbarium sheet from the front with preserved hairy cap moss (*Polytrichum*). Of all our native mosses this genus is the largest. It is ideal for your study of basic moss morphology. Note that this species has separate male and female gametophytes. Each sheet contains has a male plant with a splash platform where the antheridia are located, and two female plants each with a sporophyte, one of which has a calyptra and one without.



Male Colony

### **IIIc. Prepared Slides of *Mnium* Archegonia and Antheridia.**

*Mnium* moss is similar to hairy cap moss in that it has separate male and female gametophytes. The antheridia on the male plants are also clustered into splash platforms as observed in hairy cap moss. Hence, use the material from “IIIb” as a reference while viewing these slides.

#### ***Mnium*: Antheridium:**

Take the slide labeled “*Mnium*: Antheridium” and hold it to the light and compare with the male plant of hairy cap moss. Note the slide is a longitudinal section through the central axis of the tip of the male gametophyte. Place the slide under your microscope and observe the antheridia.

**Draw an antheridium; label spermatogenous tissue and sterile jacket layer.**

#### ***Mnium* Archegonium**

Take the slide labeled “*Mnium* Archegonium” and hold it to the light. Note the slide is a longitudinal section through the central axis of the tip of the female gametophyte. Place the slide under your microscope and observe the archegonia. Note that because of the length of the archegonium it is next to impossible to see one intact. You will either see a venter with an egg without a neck, or, towards the top, necks without venters.

**Make a composite drawing of an archegonium; label venter, egg and neck.**

### IIIId. Moss Protonemata

When moss spores germinate they form a filamentous structure called a **protonema** (plural **protonemata**). Protonemata are like branched filamentous green algae except that the cells have numerous disc shaped chloroplasts.

Make a wet mount of the liquid culture of germinated hairy cap moss spores and observe with your microscope.

**Draw a moss protonema.**

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### Discussion Topics:

A **clade** is a group of organisms that share a set of common characteristics due to direct linear descent from a common ancestor that had those characters.

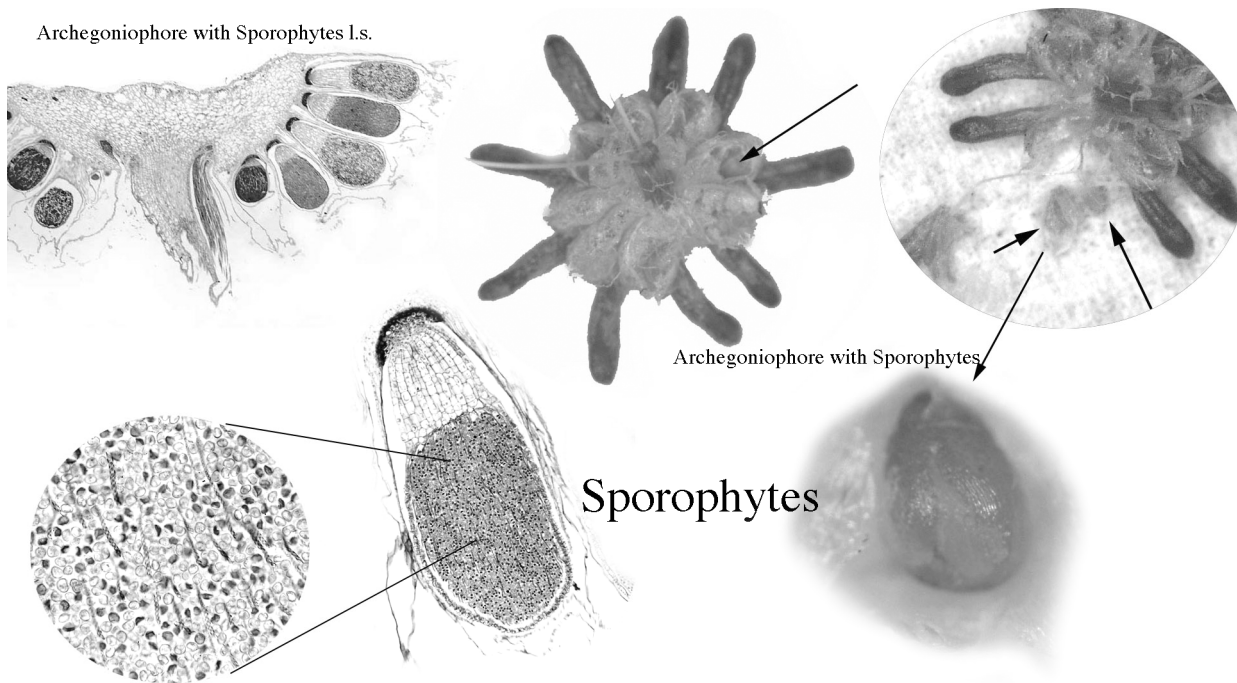
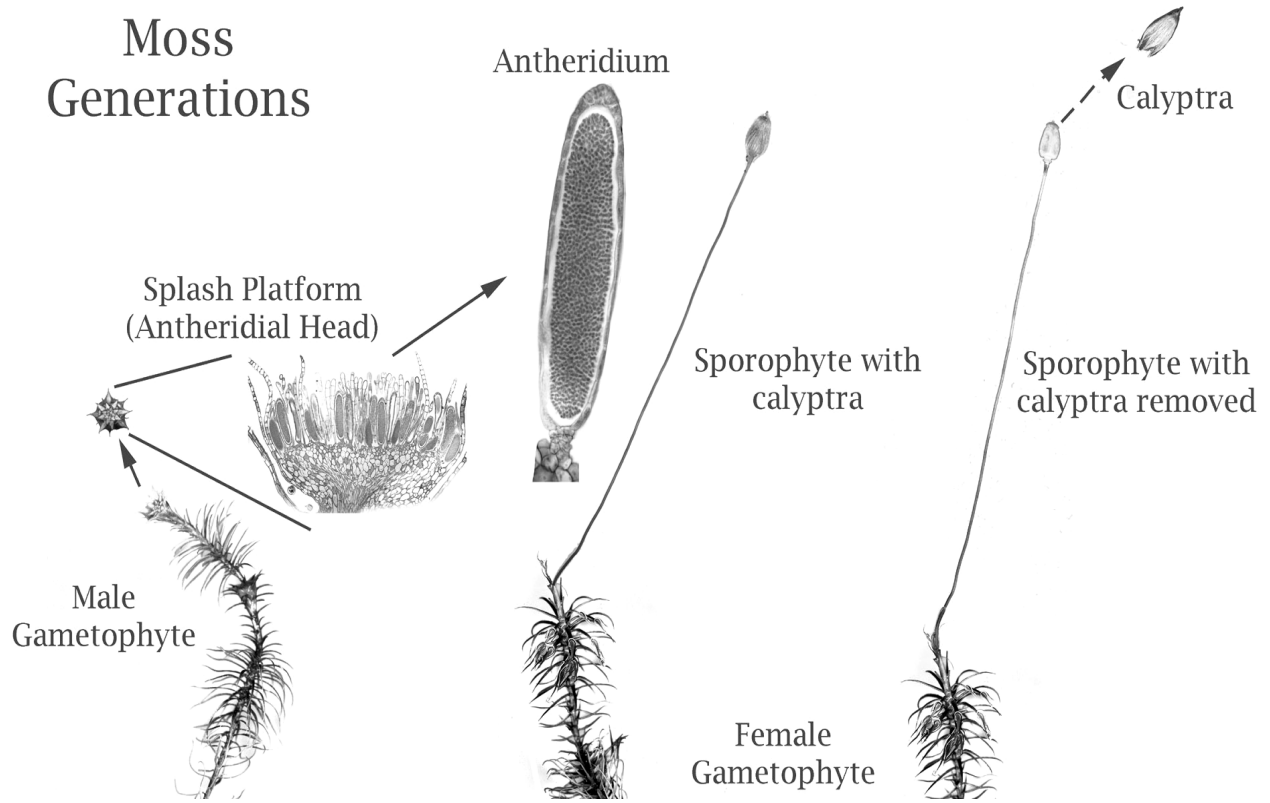
A **grade** is a group of unrelated organisms grouped due to their superficial similarities, often because the members are rather simple in structure.

1. Are non-vascular plants a grade or a clade? Why ?

2. Are the mosses a grade or a clade? Why?



# Moss Generations



## *Marchantia*