

# The Nonvascular Plants & Seedless Vascular Plants

## Laboratory

### 4

## Introduction

Members of kingdom Plantae are all multicellular organisms exhibiting **cellulose** cell walls, an **alternation of generations life cycle** and the presence of photosynthetic pigments such as chlorophyll. As photosynthetic autotrophs, plants use solar energy to produce organic compounds from carbon dioxide and water. The plant kingdom consists of four major groups: the nonvascular plants, the seedless vascular plants, the gymnosperms and the angiosperms.

The **nonvascular plants**, such as mosses and liverworts, are one of the simplest groups of the true plants. Considered the earliest transitional terrestrial plants, these species exhibit close evolutionary ties to the green algae. Lacking specialized **vascular** (transport) tissues (**xylem and phloem**), these plants are dependent upon diffusion and osmosis for the movement of water and minerals, consequently restricting their ecological distribution to moist environments. Also, without an extensive means of internal transport, nonvasculars lack true roots, stems or leaves and tend to be small, inconspicuous plants. Finally, these plants are **gametophyte dominant**, meaning that the recognizable stage of these plants is the haploid gametophyte generation.

The **seedless vascular plants**, which include ferns and fern allies, possess several adaptations lacking in nonvascular plants. Xylem and phloem are present to efficiently transport water and sugars, respectively throughout the plant body. Additionally these vascular tissues provide strength and support, allowing the plants to grow tall and upright. With the presence of vascular tissues, all ferns and fern allies have true stems with most having true roots and leaves. As is true of all vascular plants, the seedless vascular plants are **sporophyte dominant**, with the recognizable stage being the diploid sporophyte generation.

This lab will consider three phyla of Kingdom Plantae:

### **Kingdom Plantae**

#### Nonvascular Plants

**Phylum Bryophyta - mosses**

**Phylum Hepatophyta - liverworts**

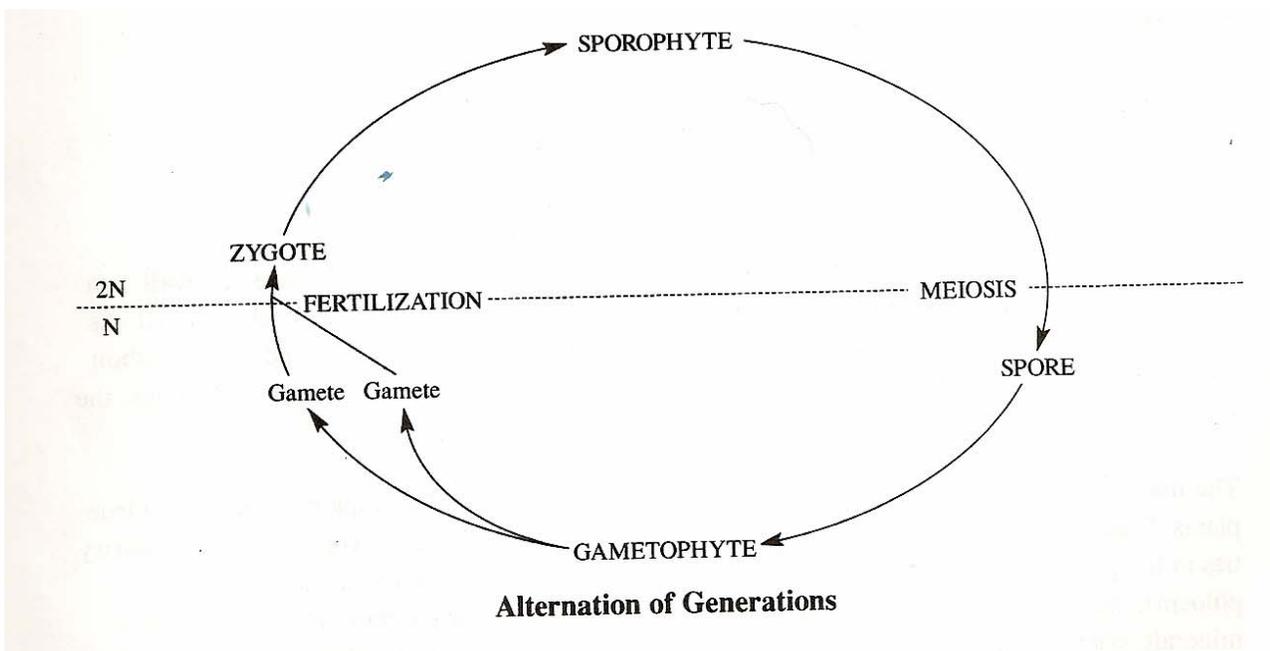
#### Seedless Vasculars Plants

**Phylum Pterophyta - ferns**

## Alternation of Generations

The alternation of generations can be described as the plant possessing two stages during its life cycle, alternating between a multicellular, diploid ( $2n$ ) stage and a multicellular, haploid ( $1n$ ) stage.

The diploid plant is called the **sporophyte**, meaning "spore-producing plant". The sporophyte generation produces a **sporangium** which contains the diploid spore mother cells that will undergo meiosis to form haploid spores. These released spores will, under the correct environmental conditions, germinate and grow mitotically into the haploid gametophyte. The **gametophyte** is the "gamete-producing plant" that produces male reproductive structures called **antheridia**, which produce sperm, and female reproductive structures called **archegonia**, which produce eggs. When a sperm cell fertilizes an egg inside the archegonium, a diploid zygote is formed. The zygote divides by mitosis and eventually develops into a mature sporophyte.



**Study tip:** You should be familiar with the characteristics of the nonvascular plants, the seedless vascular plants as well as the alternation of generations.

# STATION 1A: Phylum Bryophyta

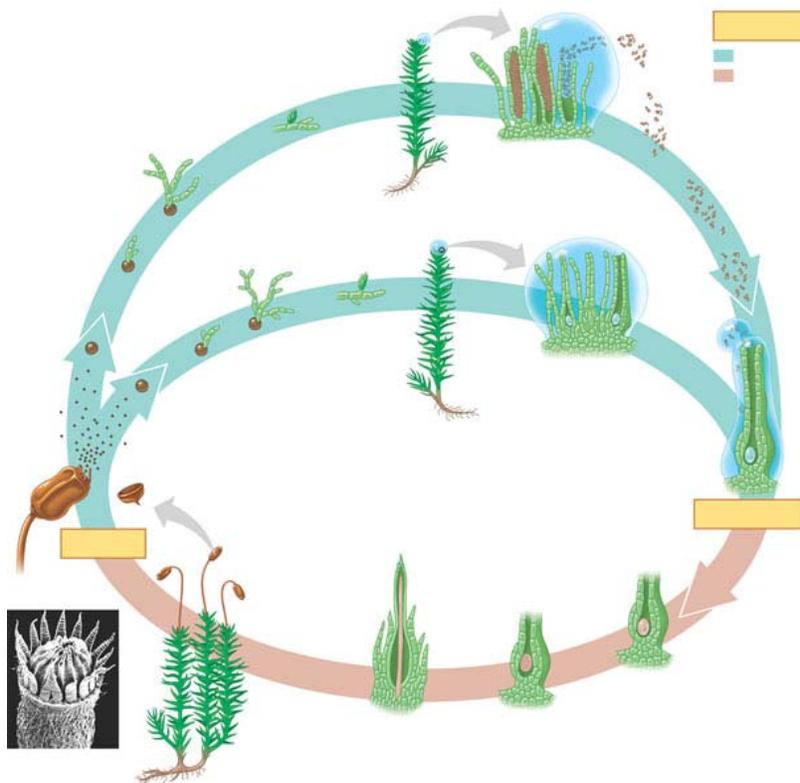
## Phylum Bryophyta: Mosses

All bryophytes begin life as a haploid **spore**. As the spore germinates, it develops into a thin, filamentous stage called a **protonema**. As the protonema grows, it develops into a mature **gametophyte** with root-like **rhizoids** that anchor the plant and an erect, stem-like structure with whorls of leaf-like photosynthetic tissues.

At the tops of the gametophytes are haploid reproductive structures surrounded by protective tissues called sterile jackets. Some of these apical structures develop into male **antheridia**, elongated pod-like structures that produce sperm. Other apical ends develop into clusters of female **archegonia**, each containing an egg. Dependent upon water for fertilization, **flagellated sperm** are transported to the archegonia by raindrops or a film of dew. The sperm cell swims into the archegonium and fertilizes the egg, resulting in a diploid zygote within the haploid archegonium.

The zygote grows by mitosis into a multicellular, mature moss **sporophyte**. As the sporophyte develops from the female gametophyte, it remains attached and is nutritionally dependent upon the gametophyte during its existence. The base of the sporophyte is anchored inside the archegonium by the **foot** with the **seta**, or stalk, terminating in a **capsule** containing diploid spore mother cells. Once spore mother cells have undergone meiosis, the capsule pops open scattering the haploid spores. Spores landing in an appropriate environment will germinate and grow into new protonema and eventually into leafy green gametophytes.

- A. Using the laminated keys provided, label the life cycle of the moss: spores, protonema, gametophyte, rhizoids, antheridia, archegonia, sporophyte (foot, seta, capsule), meiosis, fertilization, haploid, diploid

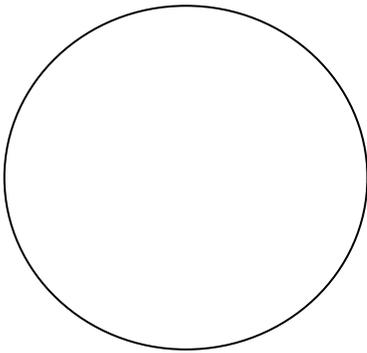


**B. Observe the moss specimens provided.**

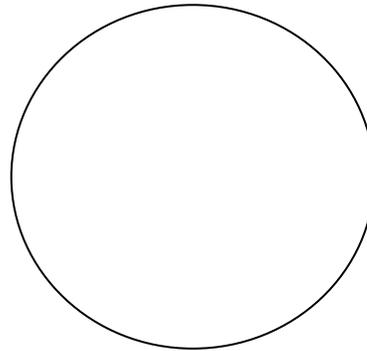
- 1) Examine a moss gametophyte. Note the whorls of leaf-like photosynthetic tissue.
- 2) Examine a moss sporophyte. Identify the foot, seta and capsule.

**C. Examine prepared slide of moss archegonia. Note the location of the egg and the upright orientation of the vase-shaped archegonia. Sketch your observations below.**

**D. Examine prepared slide of moss antheridia. Note the numerous, sac-like antheridia. Sketch your observations below.**



**Moss archegonia**  
(high power)



**Moss antheridia**  
(high power)

**Questions:**

1. What is the dominant generation of a moss? Is this generation haploid or diploid?
2. What process occurs inside the capsule to produce spores?
3. What role does water play in the reproductive life cycles of nonvascular plants?
4. Is the moss sporophyte photosynthetic?

## STATION 1B: Phylum Hepatophyta

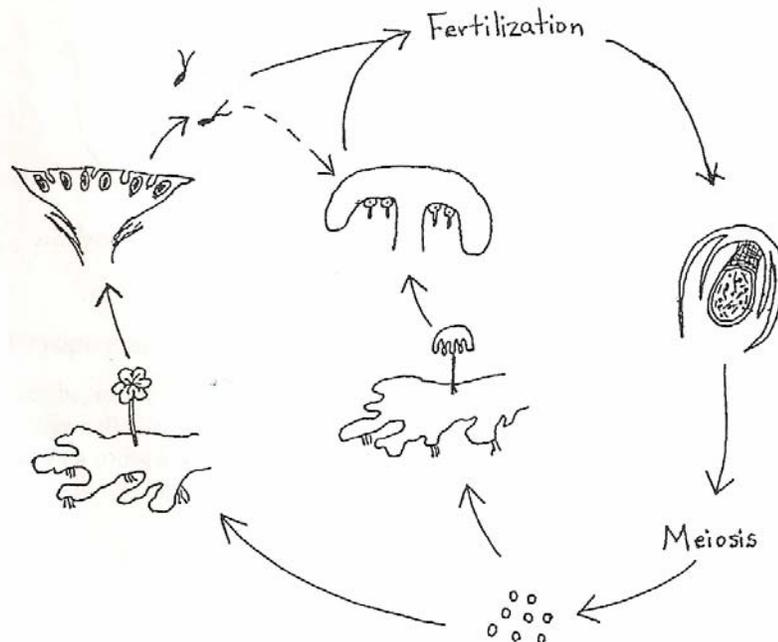
### Phylum Hepatophyta: Liverworts

Like the moss, liverworts begin as a haploid spore. As a liverwort spore germinates, it develops into a flat, lobed, leaf-like structure called a **thallus**. The thallus grows prostrate with the ground's surface, forming **rhizoids** that anchor it in place.

Liverworts reproduce asexually primarily by **fragmentation**; however, some liverworts may also reproduce asexually by bundles of tissue called **gemmae**. In many liverworts, gemmae develop in small cup-like structures called **gemmae cups**. Splashed from the cups by rain, gemmae landing in a suitable environment will germinate and grow into new thalli.

In sexual reproduction, vertical reproductive structures sprout from the gametophyte. The female reproductive structure, resembling a tiny palm tree, consists of an **archegonial head** borne at the end of a stalk-like **archegoniophore** with egg-containing archegonia hanging down. The male reproductive structure consists of sperm-producing **antheridia** located within an **antheridial head** borne on the end of an **antheridiophore**. Like mosses, liverworts require water as a medium for the motile sperm to reach the egg. Within the archegonium, the zygote develops into an embryo, or young sporophyte. The sporophyte consists of a **foot**, a short **seta** (stalk) and a **capsule** containing diploid spore mother cells. Following meiosis of the spore mother cells, a mature capsule contains both haploid **spores** and elongate, narrow cells called **elaters**. As the capsule splits open, the elaters are exposed to air. As the elaters dry, their coiling and twisting action aids in spore dispersal from the capsule. These spores germinate into new thalli and the cycle of alternation of generations continues.

- A. Using the laminated keys provided, label the life cycle of the liverwort: spores, thallus, gametophyte, rhizoids, antheridia, archegonia, sporophyte (foot, seta, capsule), haploid, diploid



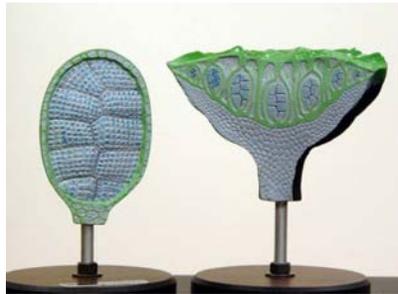
**B. Observe the liverwort specimens provided. Look for the presence of gemmae cups on the thallus.**

**C. Observe liverwort models.**

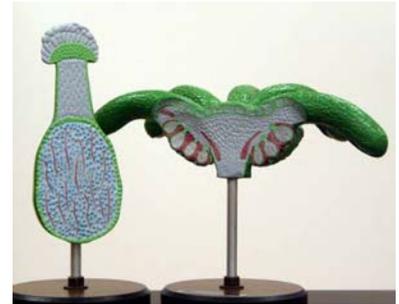
- 1) Identify the archegonial head, archegonia, egg, antheridial head, antheridia and sperm.
- 2) Examine the sporophyte, identifying the foot, seta, capsule, spores and elaters.



Archegonial head  
w/ archegonium



Antheridial head  
w/ antheridium



Mature archegonial  
head w/ sporophyte

### Questions:

1. How does the orientation of the liverwort archegonium compare with that of the moss archegonium?
2. List the two means by which liverworts reproduce asexually.
3. What is the function of the rhizoids?
4. Is the liverwort thallus haploid or diploid?
5. What is the function of elaters in a liverwort?

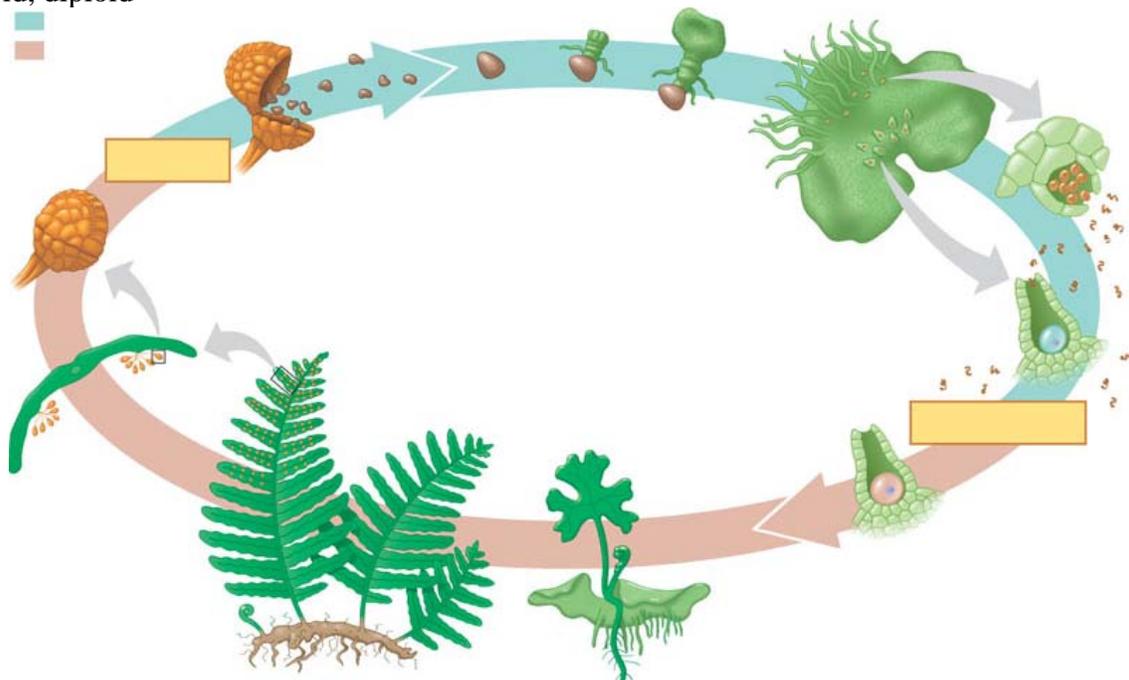
## STATION 2A: Phylum Pterophyta

### Phylum Pterophyta: Ferns

The diploid fern **sporophyte** has true roots, stems and leaves. The **roots** and a modified stem called a **rhizome** are located underground with only the compound leaves, or **fronds**, rising above the soil level. Clusters of **sporangia** known as **sori** (**sorus**, singular) form on the underside of fronds. The sporangia may be protected by a shield-shaped **indusium**, a specialized outgrowth of the frond. Along the back of each helmet-shaped sporangium is a row of thick-walled cells termed the **annulus**. The annulus readily responds to moisture changes, bringing about the dispersal of **haploid spores** produced within the sporangia.

As a spore germinates, it develops into a tiny, heart-shaped **gametophyte** called the **prothallus** (or **prothallium**). The prothallus lacks vascular tissues and is anchored to the soil by hair-like **rhizoids** extending from the ventral surface. Located near and between the rhizoids are several sperm-producing antheridia; near the notch or indentation of the prothallus are several egg-producing archegonia. The biflagellate **sperm** swim through water to reach an **egg** in the archegonia. Fertilization results in a diploid **zygote** that develops into a mature sporophyte with vascular tissue. The sporophyte is initially dependent on the gametophyte, but as the sporophyte matures, the prothallus withers and dies. Young leaves emerging from the rhizome begin as tightly coiled **fiddleheads** that eventually unfurl into the mature fronds characteristic of ferns.

A. Using the laminated keys provided, label the life cycle of the fern: spores, gametophyte, rhizome, frond, sori, prothallus, rhizoids, sperm, egg, zygote, fiddleheads, meiosis, fertilization, haploid, diploid



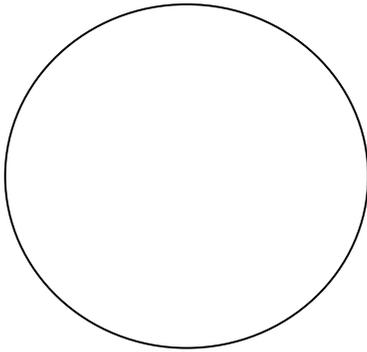
**B. Observe the fern specimens provided.**

**Questions:**

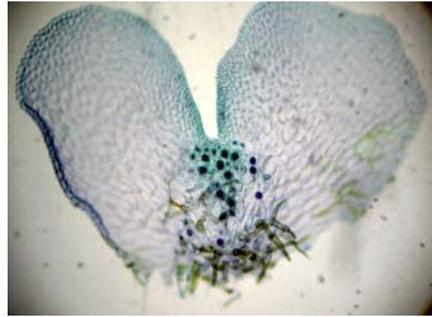
1. Which is the dominant generation in all vascular plants?
2. What is an immature fern leaf called?
3. Is the prothallus haploid or diploid? Does it produce gametes or spores?
4. What type of environmental conditions are required for the prothallus to survive. Why??
5. What is the function of an indusium?
6. Draw and label a sorus.

## STATION 2B: Phylum Pterophyta

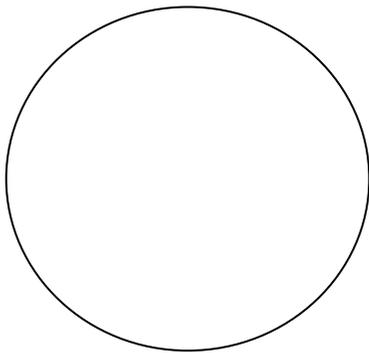
- A. **Observe fern specimens. Examine the fronds, fiddleheads and sori.**
- B. **Observe fern models.**
- 1) Identify prothallus, rhizoids, archegonia, antheridia, egg, sperm and embryo.
  - 2) Differentiate between sporophyte and gametophyte structures.
- C. **View prepared slide of fern sorus. Identify and sketch indusium, sporangia and annulus.**
- D. **View prepared slide of fern prothallus.**  
Sketch the gametophyte structure and label rhizoids, archegonia and antheridia.



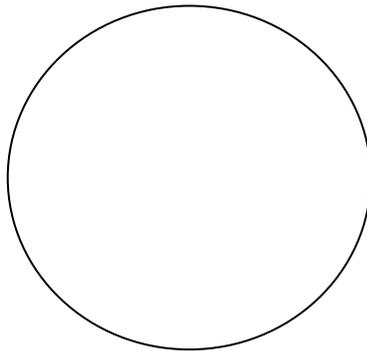
**Fern Prothallus**  
(scanning power)



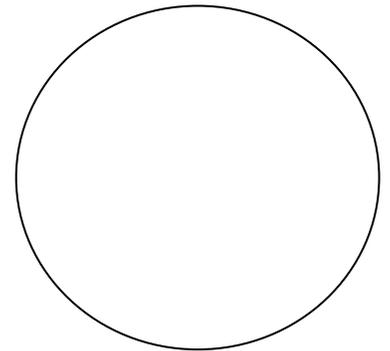
**Fern Prothallus**



**Fern sorus**  
(scanning power)



**Fern archegonium**  
(high power)



**Fern antheridium**  
(high power)

## STATION 3A: Fern Allies

The plants referred to as the “fern allies” include those plants that are also seedless, vascular plants and are related (some distantly) to the ferns. They include the following:

### Whisk Ferns

There are only two surviving genera of this phylum, one of which is *Psilotum*, the whisk ferns. Whisk ferns are so named because their stems exhibit a dichotomous branching pattern resembling a whisk broom. While the sporophyte possesses true stems, it has no roots or leaves. Both a horizontal, underground rhizome as well as a vertical aerial stem may be present. In the absence of leaves, aerial stems are the main organs of photosynthesis. The stems bear small, lobed **sporangia** in which spores are produced. After dispersal, a spore germinates into a non-photosynthetic, underground prothallus that receives nutrients from a symbiotic relationship with fungi.



*Psilotum*

Observe the *Psilotum* specimen.

### Horsetails

The only extant member of this phylum is the genus *Equisetum*, commonly called horsetails or scouring rushes. The sporophyte plant has true roots, stems (both rhizomes and aerial), and leaves. However, the leaves are greatly reduced, leaving the aerial stems as the main organs of photosynthesis. The hollow, jointed stems contain silica and bear cone-like clusters of sporangia known as **strobili** (**strobilus**, singular). Spores produced within the sporangia possess **elators**, small ribbon-like strands that uncoil rapidly to hurl each spore into the air for dispersal when the sporangium ruptures. Spores released from the strobili germinate into small, photosynthetic gametophytes.



*Equisetum*

Observe the *Equisetum* specimens noting the hollow stem with reduced, scale-like leaves.

### Club Mosses

The sporophyte of a club moss possesses true roots, stems (both rhizomes and aerial), and leaves. Sporangia are borne on small, specialized leaves termed **sporophylls** typically clustered in cone-shaped **strobili** at the tips of stems. Given their appearance, club mosses are often mistaken for true mosses or immature pines. Representatives of this group include *Lycopodium* and *Selaginella*.



Observe the *Lycopodium* and *Selaginella* specimens.

**Questions:**

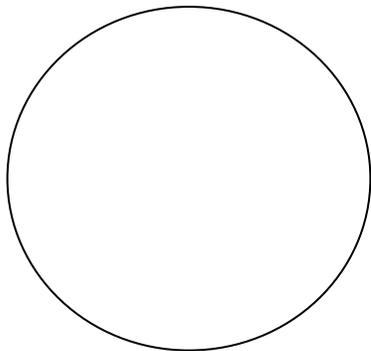
1. Which of the fern allies is known for its dichotomous branching?
2. Name the cone-like structures observed in horsetails and club mosses that produce spores.
3. What substance is responsible for the abrasive texture of the horsetail?
4. What is the function of elaters in a horsetail?
5. Why are horsetails normally found growing along streams, rivers or irrigation ditches?

## STATION 3B: Homospory vs. Heterospory

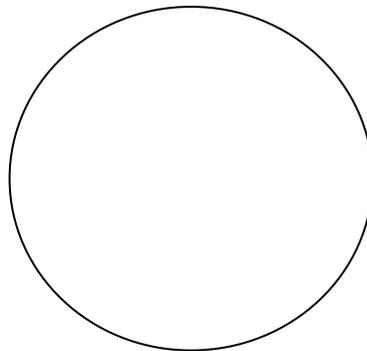
Most seedless vascular plant species are **homosporous**, meaning that they produce one type of spore. Ferns, whiskferns, horsetails and the club moss *Lycopodium* all fall into this category. However, the club moss *Selaginella* is **heterosporous**, generating two different types of spores: megaspores and microspores. **Megaspores (produced in a megasporangium)** can develop into female gametophytes that produce eggs within archegonia. **Microspores (produced in a microsporangium)** can develop into male gametophytes that produce sperm within antheridia. Because the gametophytes develop within the spores, they are not free-living as the gametophytes of other seedless vascular plants. Heterospory is important as an evolutionary precursor in the development of seeds.

**View prepared slides of *Lycopodium* and *Selaginella* strobili.**

- 1) Note the difference between homospory and heterospory.
- 2) Sketch and label the spores and sporangia of *Lycopodium*.
- 3) Sketch and label the megaspores, megasporangia, microspores & microsporangia of *Selaginella*.



*Lycopodiums strobilus*  
(scanning power)



*Selaginella strobilus*  
(scanning power)

### Questions:

1. Compare homospory and heterospory. What is the evolutionary significance of heterospory, how might heterospory lead to plants depending less on water to complete their life cycle?

2. Name the other plants observed in today's lab that are considered homosporous.