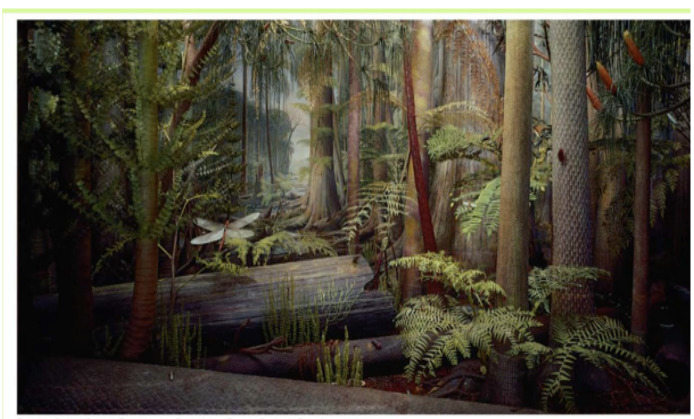
Lab 9: Spore-Dispersed Vascular Plants:
The lycophytes and monilophytes

Please bring your textbook to lab!

This week we'll continue our tour of the plant kingdom by looking at **lycophytes** and **monilophytes**. Keep the life cycles of mosses and liverworts from last week's lab in mind as you look at these groups so you can notice how they are the same and how they are different. Remember, any change in structure is the result of evolution. As you detect differences between the **spore-dispersed non-vascular plants** (i.e., mosses and liverworts) and this week's specimens, the **spore-dispersed vascular plants**, consider how each is an adaptation to addressing the various challenges of surviving and reproducing on land over 400 million years ago!

With ferns, horsetails, whisk ferns, and club mosses, you begin the study of **vascular plants** (i.e., plants with vascular tissues - xylem and phloem).

- **Lycophyta** – club mosses (e.g. *Lycopodium)* and spikemosses (*Selaginella)*
- **Monilophyta** – ferns, whisk ferns (*Psilotum*), and horsetails (*Equisetum*)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"Coal forests" consisted of early vascular plants and non-vascular plants. "Fossil" fuels, like coal and oil, are extracted from the fossils of these early vascular plants.

Some early spore-dispersed vascular plants date back ca. 350 million years to the Carboniferous Era. At that time, lycophytes were as big as trees and formed great "coal forests" and swamps that covered much of the earth! Small herbaceous ferns existed side by side with the tree forms. It is likely that most of these plants were out-competed when conditions grew colder and drier. Today we have only a few living types, all of which are small.

All **spore-dispersed vascular plants** have vascular tissue (xylem and phloem), which is a feature absent in the nonvascular plants you studied last week. This character gives them evolutionary selective advantages for survival on land. Within certain habitats, monilophytes and lycophytes are quite successful, and, in some instances, they even out-compete the now dominant plants, the flowering plants. Their **vascular system** allows them to attain a much larger body size than that of the nonvascular plants. This allows them to live in areas that nonvascular plants cannot. However, they retain some features in their life history that are a holdover from their aquatic algal ancestry (i.e., recall the green algae are the common ancestors of the land plants). The most notable of these is the necessity of water for sperm cells to reach the eggs. Because of this, both the nonvascular and vascular spore-dispersed plants require water for reproduction.

KEY TERMS

Gametophyte (haploid; n): the plant life cycle phase that produces gametes via mitosis.

Sporophyte (diploid; 2n): the plant life cycle phase that produces spores via meiosis.

Sporangium (diploid; 2n): located on the sporophyte; produces haploid spores by **meiosis** within the sporangium.

Antheridium (haploid; n): located on the gametophyte; male gamete-producing organ, produces flagellated sperm through **mitosis**.

Archegonium (haploid; n): located on the gametophyte; female gamete-producing organ; produces eggs through **mitosis**.

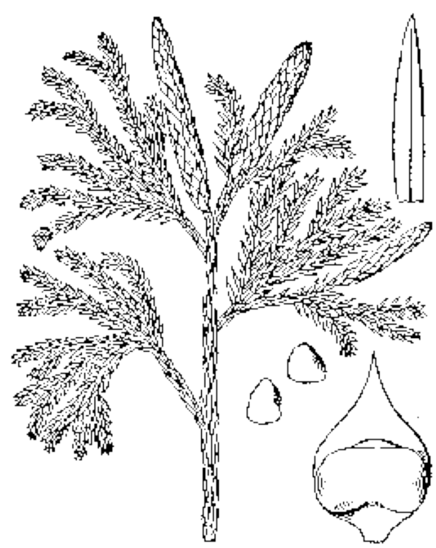
Microphyll: minute leaves with a single vein. Present in lycophytes, but not mosses.

In spore-dispersed vascular plants (and the seed plants) the **sporophyte stage in the life cycle is the dominant phase**, not the gametophyte stage as in nonvascular plants. By elaborating the sporophyte stage into the dominant life cycle phase, these plants found a winning combination of functions—the functions of photosynthesis and spore production. Both functions are sustained by the same environmental conditions and structural design - namely, a sturdy, erect plant making use of sun and air for photosynthesis and spore dispersal. This direction toward dominance of the sporophyte stage was a great innovation in the evolution of land plants.

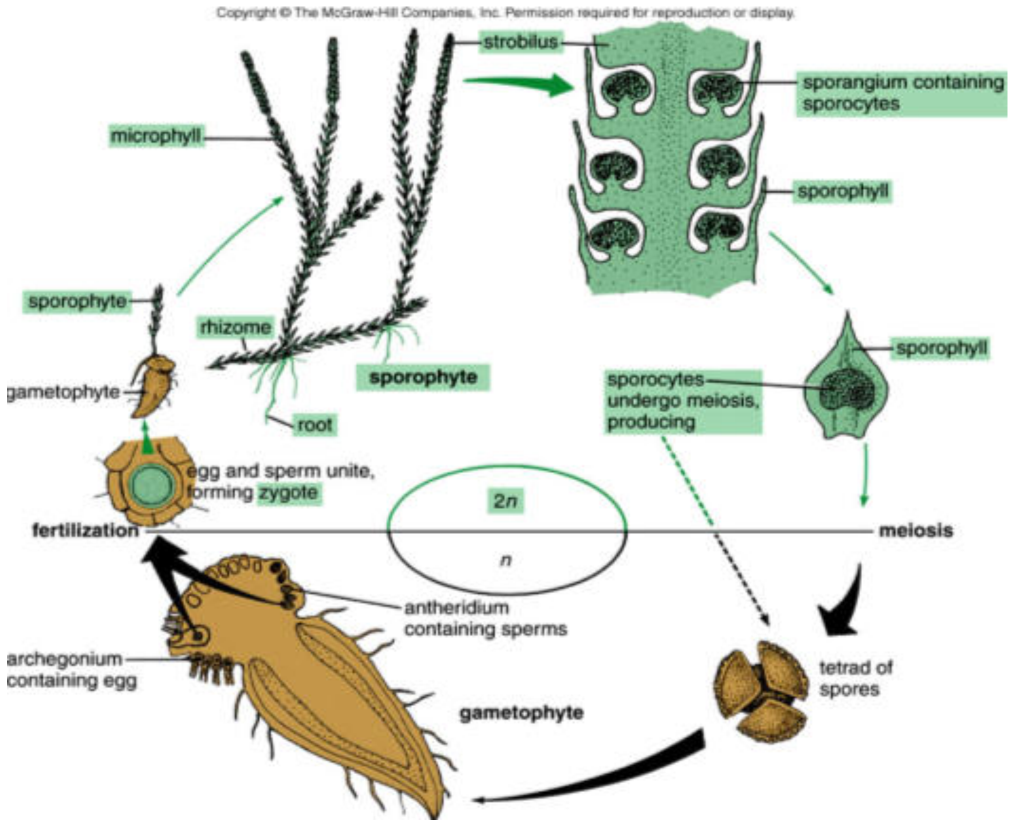
<u>Part I: Lycophyta</u>

Lycopodium, Huperzia,* and *Selaginella

Lycopodium* and *Huperzia: The simple leaves of these plants have a single vascular bundle and no petiole - they are called **microphylls**. Functionally they are like flowering plant leaves - they even have stomata. But their anatomy is simpler than that of true leaves. Look in your book to compare microphylls and true leaves.



The club mosses have only one kind of spore, which are produced via meiosis in a capsule of cells called a **sporangium**. Several species have sporangia clustered into terminal “cones” (**strobili**; see life cycle diagram and slide of strobilus); on others the sporangia are solitary and occur in the axils of leaves (called sporophylls) along the stem.



1. **Study the life cycle of a lycophyte illustrated above.**

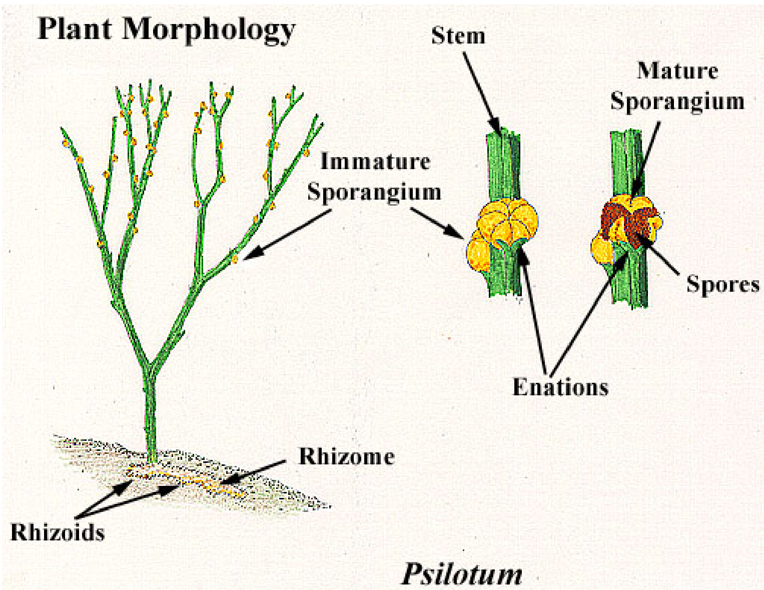
   A) Circle the parts that you can see on the living lycophytes in lab, either with your bare eyes or under a scope. Then list the function of each below.

   B) Are these leafy plants gametophytes or sporophytes? How can you tell by looking at them?

Part 2: Whisk ferns, horsetails, and ferns (Monilophyta)

Psilotum

Examine the living specimen of *Psilotum nudum.* It grows wild in Florida and Hawaii and other parts of the subtropics and tropics. *Psilotum* has features seen in some early diverging vascular plants. The simple plant you see is the sporophyte. The aerial **stem** is a slender axis that has an equal forking type of branching known as **dichotomous branching**.



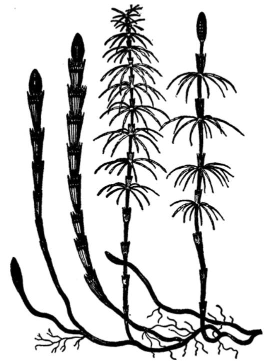
Psilotum is unique among living vascular plants in having neither leaves nor roots. Photosynthesis takes place in the outer cells of the stem (epidermis and cortex), which contains a central cylinder of xylem surrounded by phloem. The aerial stem originates from an underground stem, the rhizome. The rhizomes, which have short rhizoids over their surfaces, perform the functions of roots with the aid of mycorrhizal fungi.

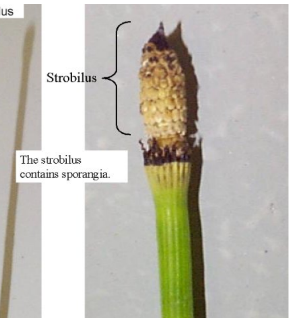
If possible, find the small, tri-lobed, globelike sporangia in the living specimen. Each sporangium occurs in the **axil** (upper angle) of a scale.

The gametophytes of *Psilotum* that arise from the spores are often overlooked: they are found beneath the surface of the soil, they are colorless, about 2 mm in diameter and seldom more than 6 mm long!

2. **Based on your observations of the living *Psilotum*, what features does it share with the non-vascular plants that you looked at during last week's lab? What is different? List at least <u>two</u> similarities and <u>two</u> differences.**

Horsetails (*Equisetum*)





About 25 species of horsetails (also called scouring rushes because of the high silica content of the stems) are scattered throughout all continents. They usually grow less than 4 feet tall, but some in the tropics and coastal redwood forests of California exceed 15 feet in height! Many fossil horsetails were tree-sized!

Note that there are whorls of leaves at the nodes, but that these are tiny microphylls that are not important in photosynthesis. They are green when they first appear, but they soon wither and bleach, and virtually all photosynthesis occurs in the stems. When the stem is viewed in cross section, it can be seen that the pith in the center breaks down at maturity, leaving a hollow central canal. The stems arise from horizontal rhizomes.

Sporangia are always clustered together on special stalked sporangiophores in cones located at the tips of shoots. When sporangia are young, the young cone has a tight, smooth surface. When sporangia and spores are mature, the cone surface becomes more loose and open, exposing the sporangia to the air.

Shedding and dispersal of the spores are aided by the movement of tiny appendages called **elaters** that are attached to the spore and that coil and uncoil in response to changes in humidity. While spores are being carried aloft by a breeze, the elaters are extended like wings. If a humid air pocket is encountered above a damp area below, the elaters coil around the spore, causing it to drop in an area where the probability of moisture being available for germination is increased. Cool adaptation, huh?

3. **Create a microscope slide of the living *Equisetum* stem in cross-section. Ask your TA for help with preparing your cross-section. Where do you think the vascular tissue is? Draw and label what you see.**

4. **Look at the fresh shoots of *Equisetum*. Draw the general structure of the plant and label the major plant organs (roots, stems, and leaves).**

Ferns

The ferns are the most diverse group of spore-dispersed vascular plants. There are about 12,000 species of ferns in the world.

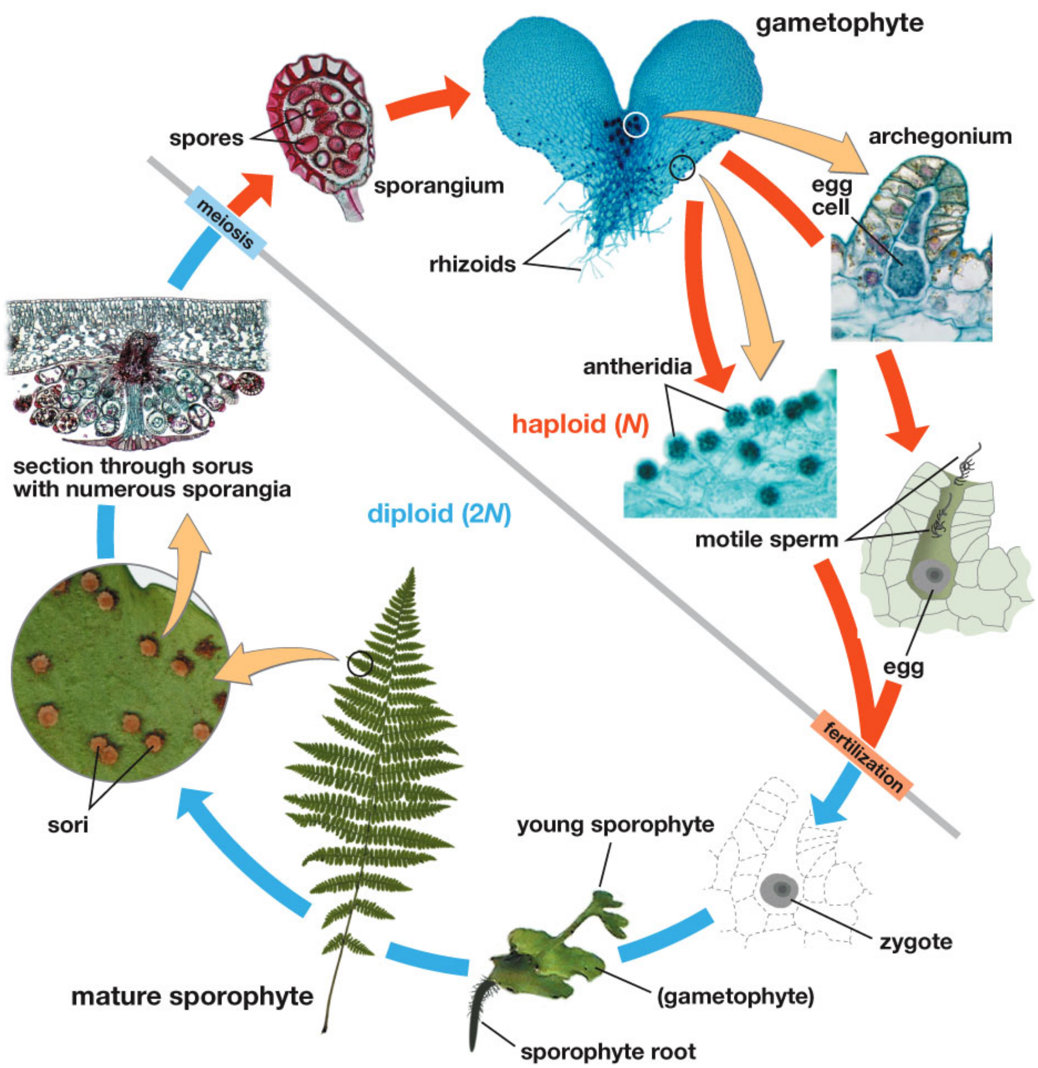


Figure 21.25 Plant Biology, 2/e © 2006 Pearson Education

The fern life cycle. Continually refer back to this figure throughout today's lab to help you answer questions about fern structures and functions.

Examine the fern specimens around the lab room. For each, note the shape of the **frond**, the arrangement of **pinnae** (and pinnules, if the pinna is divided), and the arrangement of **sori** (clusters of sporangia; singular = **sorus**).

5. Describe the fern life cycle in your own words, using these terms: sporophyte, gametophyte, annulus, spore, gamete, haploid, diploid, rhizoid, sorus, antheridium, archegonium, meiosis, and fertilization.

6. Which is the dominant phase in the fern life cycle, sporophyte or gametophyte?

7. What are <u>two</u> similarities between the life cycle of ferns and that of mosses?

Ferns are large-leaved plants, and the leaves have many veins, just like flowering-plant leaves. Look at the leaves of the living ferns in the laboratory. Look for the networks of veins in the leaf tissue. Notice that these leaves also have petioles (leaf stalks), another feature of these more advanced leaves. This larger leaf type with the many veins and the petiole is called a **megaphyll**, in contrast to the rudimentary leaves, or **microphylls**, you saw on *Lycopodium*.

8. **Choose one fern specimen available in lab and look at its sori (they look like fuzzy brown dots or stripes on the underside of a leaf, or they look like a brown shriveled leaf, depending on the species). Feel free to draw what they look like, in addition to describing them with words. *Note that each sorus has numerous sporangia, which in turn have numerous spores.* Then, answer the following multi-part question:**

   A. **Are the sori on all fronds of the plant, or only on specialized ones?**

   B. **Are they randomly placed on the frond, around the edges, or in lines?**

   C. **What is the shape of the sorus (e.g., round, elongate, etc.)?**

   D. **Gently knock some spores out of the sorus. Look at these under the dissecting 'scope. Draw what you see. (Note: Some changes may occur as the spores dry out under the light of the scope).**

9. **Look at a fern gametophyte microscope slide and answer the following questions:**

A. **What is the function of the gametophyte in the fern life cycle? Is it haploid or diploid? Draw and label what you see in the slide. (As always, record the magnification. You don't need to draw a bunch of circles to represent cells, just the general structure.)**

Now, observe the antheridia on the slide. The sperm are visible in the antheridia. *Note the different distributional patterns of antheridia and archegonia, either in the slide or in your textbook.* Recall that the spore-dispersed vascular plants require water for fertilization to occur. The prostrate growth habit of the gametophyte with the sex organs on its lower side facilitates the swimming of the sperm to the vicinity of the archegonia.

B. **What is the function of the antheridium in the fern life cycle? Is it haploid or diploid?**

The dispersed spores of ferns germinate and grow into separate gametophyte plants, just as in all the other spore-dispersed plants. However, this time we can show you. **Look at the living gametophytes of ferns on display in the lab and under the dissecting scope.** They are only a few cells thick, the cells are almost all virtually the same (there is very little specialization), and as you can see they do not have shoots. The archegonium consists of a venter and a neck. An egg occupies the venter. Usually only the neck is visible because the venter is embedded in the tissue of the prothallus.

Compare the living gametophytes in the petri dishes with the images on the microscope slides when answering the following questions:

10. Look at an archegonium cross-section microscope slide. What is the function of the archegonium in the fern life cycle? Is it part of the sporophyte or gametophyte generation? Is it haploid or diploid?

While inside the archegonium, the zygote develops into an embryo. The embryo produces the rhizome, roots, and leaves. The first young leaf grows upward through the apical notch. With continued growth, the rhizome produces more leaves.

11. Look at a microscope slide of a gametophyte with a developing sporophyte (embryo). What is the function of the gametophyte in the fern life cycle?

Observe the functioning of a sporangium. Using a dissecting needle, scrape the surface of one or two sori from one of the ferns we have in lab (please be gentle!) so that the sporangia fall into a drop of water on a slide. Cover with a cover slip and examine under the compound microscope. Look for golden-brown spheres. These are the sporangia. The cells comprising the walls of the sporangium are large and transparent, so you should be able to see the spores within. These are formed by the meiotic division of diploid spore mother cells.

Release of the spores is an important function. It is accomplished by a special band of cells, called the **annulus**. The annulus partly or completely encircles the sporangium. It forcibly hurls the spores for some distance. **Find the annulus**. You can recognize it by the thick inner walls and sidewalls of its cells. Note that the outer cell walls are thin. Near the stalk of the sporangium there are a few cells of the annulus with thin walls all around. This is the **stomium**.

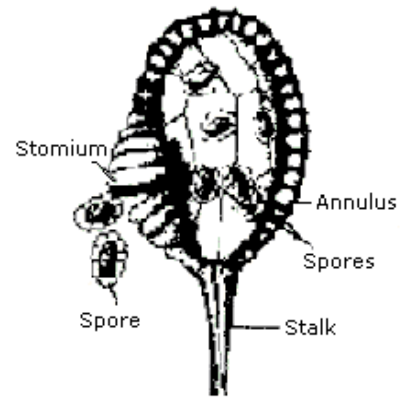


Fig. Single sporangium of ***Dryopteris***

When the spores are mature, the sporangium loses water and dries. As the annulus cells lose water, the thin outer walls shrink and the thick side walls are pulled towards one other. The annulus pulls back, tearing the sporangium at its weakest point, the stomium. As more water is lost, the tensile strength of water is overcome and gas comes out of solution, forming a bubble within each cell of the annulus. This results in a violent snapping back of the annulus, dislodging spores and catapulting them into the air! You can see this action by letting the sporangia dry out as you examine them under the dissecting scope.

12. What are sporangia for? In other words, what do they do, in terms of reproduction?

Review: Fill in at least one key physiological and at least one reproductive feature that differentiates each group of plants from the others in the table below.

Plant	Key physiological feature(s)	Key reproductive feature(s)
Nonvascular plants (mosses and liverworts, from last week)		
Psilotum		
Lycophytes		
Horsetails		
Ferns		

Before leaving lab...

Turn in your complete lab assignment (all questions answered) to your TA. Points will be docked if you do not turn in your assignment before leaving lab. Your graded assignment will be returned to you next week.

TOTAL: ____/10