The Spore-Dispersing Vascular Plant Phyla
The Fern Allies

Introduction

The vascular plants are divided artificially into two major groups, the seedless (or spore-dispersing) vascular plants and the seed plants. There are four major Phyla of spore-dispersing vascular plants: Psilotales, Lycophyta, Equisetales, and Pterophyta. The first three Phyla, often referred to as the "fern allies" are not prevalent organisms in our ecosystems today although they are well represented in the fossil record. All of the vascular plants have a dominant sporophyte generation, and a reduced, often, dependent gametophyte stage.

Lycophyta: The Lycophytes

The living representatives of the Lycophyta are all relatively small plants, with true roots, true stems, and true leaves. The leaves are microphylls, having just one vascular connection or vein. The fossil members of this division, however, include many woody, treelike forms (the Lepidodendrids), which numbered among the dominant plants of the coal-forming forests of the Carboniferous period.

Examine the living specimens and herbarium specimens of *Lycopodium* and *Selaginella.* Identify the roots, stems, and leaves (microphylls) of these genera. *Selaginella* species are common in both temperate and tropical rain forests, although it is frequently confused with mosses. Some species of *Selaginella*, including the "Resurrection plant", are found in very dry habitats. *Lycopodium* species grow in many wooded areas throughout temperate ecosystems.

Examine the living, preserved, or herbarium specimens of *Isoetes*. Although the leaves of *Isoetes* are much larger than those of *Lycopodium* and *Selaginella*, they are still microphylls. In *Isoetes*, the leaves are attached to a corm-like structure (a fleshy stem). *Isoetes* is aquatic.

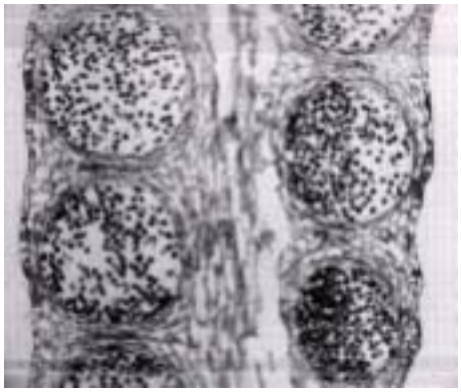
Lycopodium with Strobili

Selaginella sporophyte

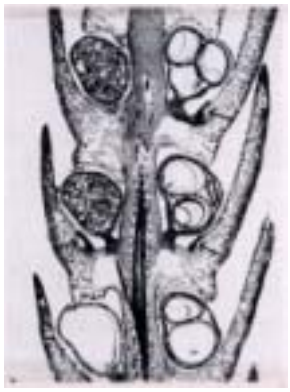
Isoetes

The sporangia of the Lycophyta are borne on leaves which are very similar to the sterile (non sporangia-bearing) leaves of the plant. The sporangium-bearing leaf is called a sporophyll. In *Selaginella* and in most species of *Lycopodium*, the sporophylls occur in compact aggregates called cones, or strobili. Examine the strobili on the specimens provided. In *Isoetes*, sporangia arise at the bases of the leaves, with a single sporangium per leaf.

Lycopodium is homosporous, producing one type of sporangium. Observe the prepared slide of *Lycopodium* strobilus and locate the sporangia. The gametophytes produce both archegonia and antheridia.



Lycopodium Strobilus

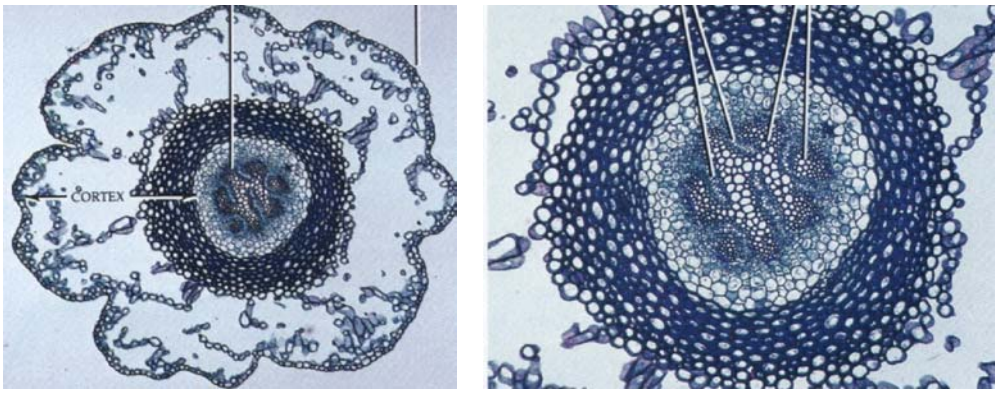


Selaginella Strobilus

Selaginella and *Isoetes* are heterosporous. They produce two types of sporangia: megasporangia (female) and microsporangia (male). Spores develop into either female gametophytes (which produce archegonia) or male gametophytes (which produce antheridia). Observe the prepared slide of the *Selaginella* strobilus. Locate the larger megasporangia and the smaller microsporangia. Compare the strobilus of *Selaginella* with the strobilus of *Lycopodium*.

It is exceedingly rare to find gametophytes of the Lycophyta. Most are subterranean and very tiny. However, sporophyte plants develop from the gametophyte structure so that whenever you find a sporophyte plant, you can be assured that a gametophyte was once there. (Once a sporophyte plant becomes established, the gametophyte degenerates.)

Before leaving the Lycophyata, example the prepared slides of *Lycopodium* stem. How does it compare to the stems of monocots and dicots observed earlier?



Lycopodium stem, xs

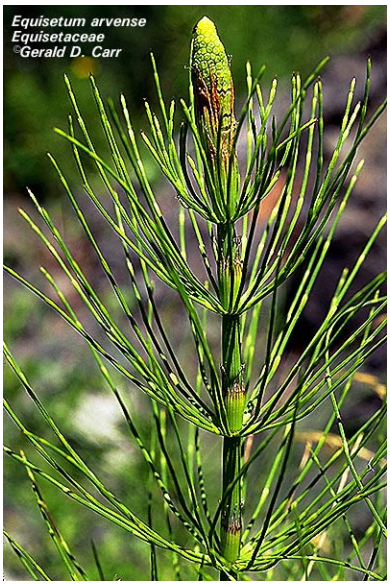
Pteridophyta – Ferns, *Equisetum* and Psilophytes
Equisetales: The Horsetails

Although once a very abundant and diverse group of plants, the Equisetales today are represented by a single herbaceous genus, *Equisetum*. This genus is widespread, however, and some species reach heights of 15 feet during the growing season. One reason for their success is the underground rhizome from which the above-ground shoots originate.

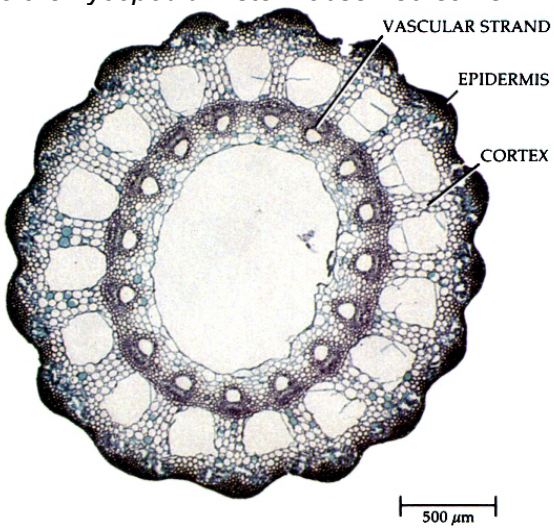
Examine the living and herbarium specimens of *Equisetum*. The sporophyte of *Equisetum* differs from that of the other fern allies in having jointed hollow and ribbed stems with the leaves (microphylls) arranged in whorls at nodes.

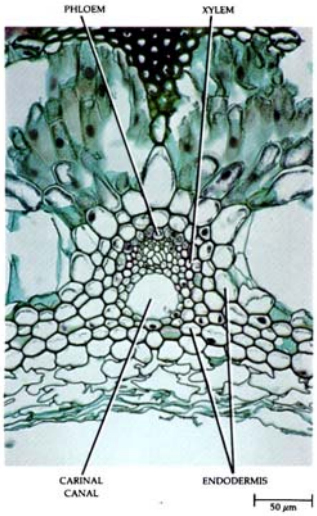
Feel the coarse texture of the stems. The stems of *Equisetum* contain silica. Note that the stems, rather than the leaves of *Equisetum* are photosynthetic.

Examine the cones or strobili on the specimens provided. The sporangia are borne on umbrella-like structures called sporangiophores, rather than on sporophylls.




Look at the cross section of *Equisetum* stem available to observe the structure of its hollow stem. Note the outer ring of cortex with large air spaces and the inner ring of vascular tissue surrounding the hollow center of the stem. Note the carinal canals within the vascular ring. How does the *Equisetum* stem compare to the *Lycopodium* stem observed earlier?

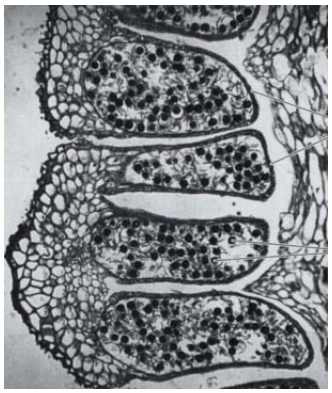




Equisetum stem, xs

Examine the prepared slide of the *Equisetum* strobilus. Is *Equisetum* homosporous or heterosporous?

Equisetum strobilus

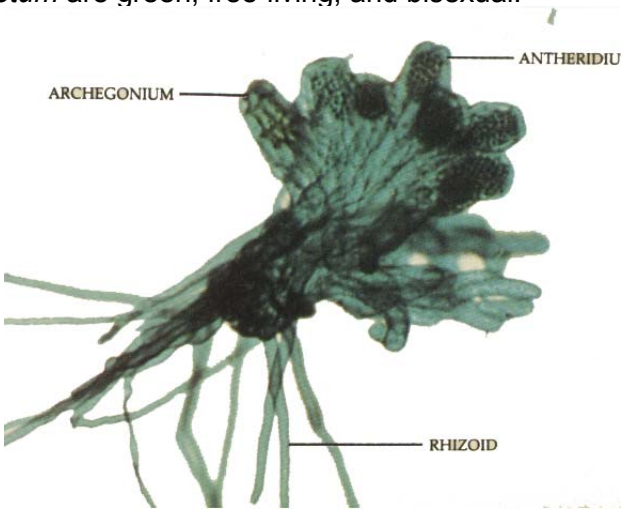


Sporangium

Spores

Now examine the prepared slide of *Equisetum* spores. Note that four threadlike structures, called elaters, surround each spore. The elaters, which are sensitive to humidity changes, are used to disperse the spores. When the sporangium breaks open, the sudden change in humidity causes the elaters to uncoil, which "whips" the spore out of the sporangium to be carried by air currents to a new location.

The gametophytes of *Equisetum* are green, free-living, and bisexual.



Equisetum gametophyte

Psilotales: The Whisk Ferns

The Psilotales are represented by two living genera, *Psilotum* and *Tmesipteris*. The sporophytes have vascular stems but lack leaves or vascular tissue in roots. Aerial shoots arise from underground rhizomes. Evolutionarily, the Psilotophytes are believed to be derived from other spore-dispersing vascular plants related to the ferns, rather than being very primitive vascular plants.

Examine the living specimens and herbarium specimens of *Psilotum*. *Psilotum* is unique among living vascular plants because it lacks both vascular roots and leaves. Only the stem is vascular. The scale like structures along the stem are called **enations**.

Note the dichotomous (forking) branching pattern of the aerial portion of the plant body. The below-ground portion of the plant axis is a rhizome (an underground stem) bearing rhizoids for the absorption of water.

Psilotum produces three-parted sporangia, which are borne on short side branches. *Psilotum* is homosporous; that is, it produces only one type of spore.

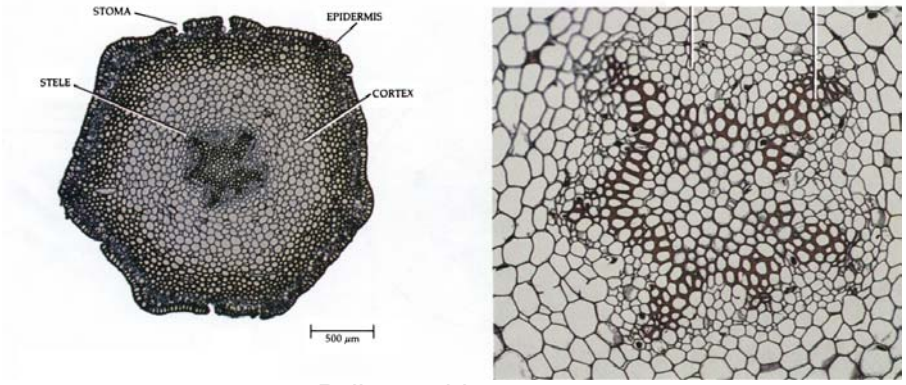
Psilotum Habit

Psilotum branch

Psilotum Sporangia

Examine the prepared slide of *Psilotum* sporangia. Living spores may be available. If so, make a wet-mount slide of the *Psilotum* spores. Although *Psilotum* gametophytes are bisexual; both archegonia and antheridia are produced on the same gametophyte. The gametophytes develop in association with mycorrhizae.

Examine the prepared slide of Psilotum rhizome. Compare its structure to stems of the other vascular plants.



Psilotum rhizome, xs

Tmesipteris, the second genus in the Psilotales, is an epiphyte that grows on tree ferns and other plants in the tropics and subtropics.

"Pterophyta": The Ferns

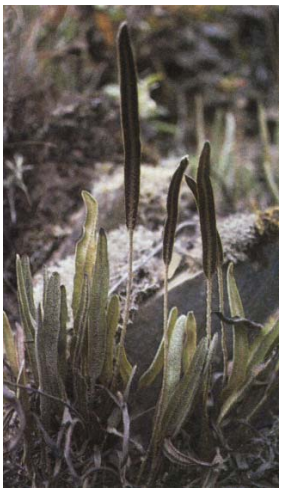
The ferns are the most conspicuous spore-dispersing vascular plants in the environment today. There are about 11,000 species of ferns, grouped into 5 orders, which vary from the filmy ferns, which are epiphytes on the leaves of tropical flowering plants, and the tiny aquatic *Azolla*, to large tree ferns whose roots and stems are among the toughest of woods known. Bracken fern, *Pteridium aquilinum*, may be the single most widespread vascular plant in the world. It occurs almost everywhere, including BCC parking lots. (Or at least it used to...)

Ferns are perennials that lack secondary growth. The sporophyte is the dominant photosynthetic generation. Ferns have either an underground rhizome, or a basal stem. In tree ferns the stem is columnar, with leaves forming much of the diameter of the stem.

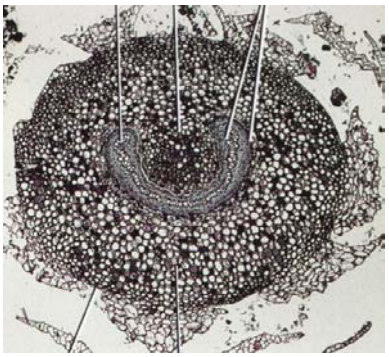
The fern leaf is called a frond. Fronds are megaphylls, with well developed vascular tissue. The "petiole" is a rachis. Many fern fronds are highly dissected and compound leaves are common. Separate fertile (sporangia producing) and sterile fronds are produced in many fern species. In colder habitats, the fronds die each year, and new growth is produced from the rhizome or basal stem. Fronds "emerge" by circinnate vernation, a nearly unique uncoiling process. The coiled young fern fronds are called fiddleheads.

Observe the many ferns on display, as well as those in our neighborhoods when you have the opportunity to do so.





Observe the prepared slides of fern rhizomes and compare their structure to those previously seen.



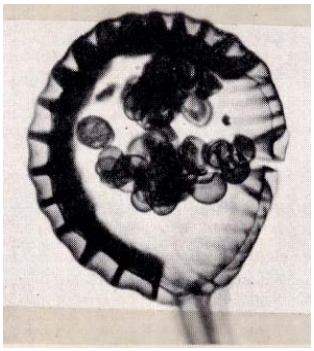

Fern stems, xs

Fern spores are produced in sporangia located in a Sorus that usually has a protective indusium. The sori (plural form of sorus) are located on the underside of fertile fronds Spores are released when a layer (called the annulus) of a sporangium responds to humidity; lip cells of the annulus break open and catapult the spores out of the sporangium.

Look at the sori on the display ferns. Can you discern the indusium that protects the sorus? Observe the prepared slide of fern sporangia. You might also make a wet mount of sporangia from one of the display fronds available in the classroom.


Fern sori on underside of frond


Fern sorus

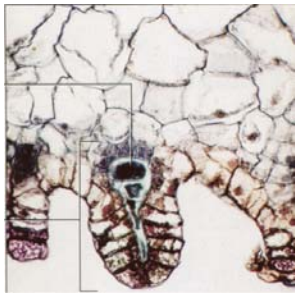

Fern sporangium

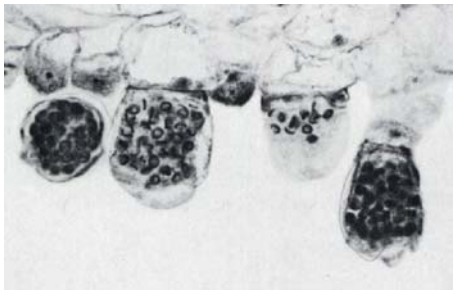
The fern gametophyte is called a prothallium, or prothallus. The gametophyte is independent of the sporophyte and photosynthetic. It is often heart shaped and tiny. The motile sperm require water for transport to eggs. Antheridia and archegonia may be on the same gametophyte or on separate gametophytes. After fertilization, the zygote and young sporophyte develop from within the archegonium.. The sporophyte rapidly becomes independent, however, and the gametophyte plant dies. Although inconspicuous in nature, fern gametophytes are common in greenhouses and can be found on the sides of moist clay pots and on the surface of the soil.

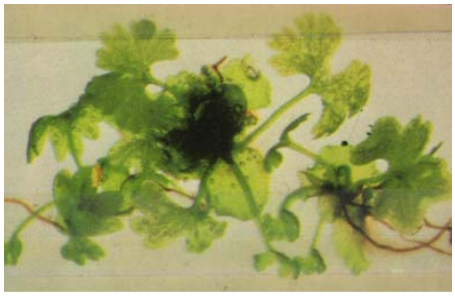
If a living gametophyte is available, look at it using the stereoscopic dissecting microscope. Now observe the prepared slides of fern prothallium. Look for antheridia and archegonia. They may be on the same gametophyte or not. Look at the slide of the young sporophyte developing from the archegonium of the gametophyte.


Living Fern Gametophyte


Fern Gametophyte, wm.


Fern Archegonium


Fern Antheridia


Young Sporophytes