Topic 23. The Ferns and Their Relatives

Domain: Eukarya
Kingdom: Plantae

Ferns
Leptosporangiate Ferns
Psilophytes
Genus: *Psilotum*
Horsetails
Genus: *Equisetum*

In this treatment we lump the **Psilophytes** and **Sphenophytes** with the ferns. Historically, Psilophytes, Lycophytes and Sphenophytes, together, have been called **the fern allies**. Molecular evidence,however, shows that the Psilophytes and Sphenophytes sprang from the same group as the ferns, while the lycophytes are more distantly related.

I. **Ferns** (= Leptosporangiate Ferns)

Ferns are a major phylogenetic group of plants consisting of several different orders. They are widespread and ecologically important. Fern sporophytes are structurally complex and typically have true **stems**, **roots** and **leaves**. Fern leaves are **megaphylls**. They have numerous veins, and are associated with a leaf gap (an area of parenchyma in the stem where the vascular trace diverges from the stem's vasculature). While some ferns have non-photosynthetic gametophytes, and some are heterosporous, the gametophytes we will see in lab are photosynthetic and are of homosporous species (hence, these gametophytes are bisexual).

Ia. The Sporophyte.

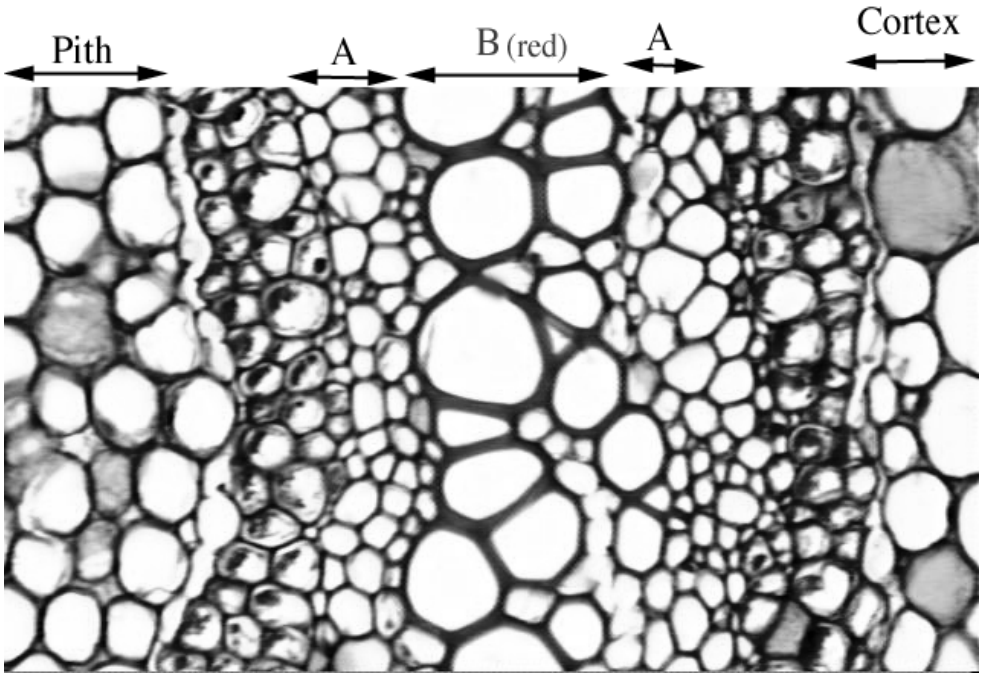
Take a pressed specimen from the front bench to your seat.

Make a drawing and label the following parts: frond, petiole, blade, sori, rhizome (stem), roots.

Observe the living sporophytes in the room. Identify the stem and the leaves.

Ia1. The Stem.

Take a prepared slide of the rhizome of *Dicksonia* and hold it up to the light. Note, this is a cross section through a stem of this fern. Place the slide on your microscope and observe the cylinder of red stained cells. This tissue is xylem and the stain binds with lignin. Note the dense tissue in the very center of the stem is not xylem. On either side of the xylem is a layer of phloem. Label the figure below.



A = _____ B = _____

Ia2. The Leaf.

Look at the demonstration of a leaf gap. This is definitive of megaphylls which is the type of leaf ferns have. Take the prepared slide labelled sorus of *Cyrtomium* and place it on your microscope. This is a cross section through the blade of *Cyrtomium* (holly Fern). Note the numerous veins throughout the leaf, this is also characteristic of megaphylls. Now carefully study a **sorus** with **sporangia**.

Are the spores all one size?

What nuclear process resulted in the production of the nuclei in these spores?

Based on your observation here, will these spores produce a unisexual or bisexual gametophyte?

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Ib. The Gametophyte.

Take a living fern gametophyte (available at the side bench) and place it on a microscope slide in a drop of water. Do not add a cover slip yet. Study the plant with a dissecting microscope. The plant is thin and translucent. Note the complete absence of vascular tissue. Add a cover slip and observe with your compound microscope at 100x and 400x. Note the rhizoids that anchor the plant to its substrate. Also note the distinctive disk-shaped chloroplasts of the photosynthetic cells.

Does the growth form of the gametophyte remind you of any other group of plants studied previously? Which one/ones?

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Now take the prepared slide of a whole-mounted gametophyte and look for gametangia. **Archegonia** can be found near the notch and **antheridia** will be found scattered across the whole thallus. The archegonium is embedded in the tissue of the gametophyte. To observe the egg in the venter you must carefully through focus.

Make two drawings of an archegonium (400x). One with the focus on the neck, the second with the focus on the venter. Label the neck and the venter.

What type of nuclear division resulted in the formation of the egg nucleus?

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Make a drawing of an antheridium (400x).

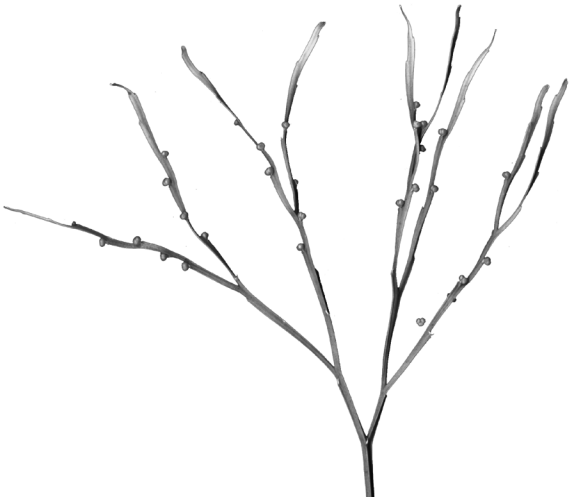
Draw the entire gametophyte at 40x. Label archegonia and antheridia.

Ic. Gametophytes with attached Young Sporophytes

Take a petri dish containing a gametophyte with attached young sporophyte.

Draw these two generations: Label gametophyte and sporophyte.

II. Psilophytes - *Psilotum*.



The sporophyte of *Psilotum* has no true roots or leaves and has only one plant organ, the stem. For decades this was thought to have been a primitive characteristic passed down from the earliest vascular species (Rhyniophytes) seen in Devonian aged fossils. Recent molecular evidence, however, firmly anchors these plants in the same phylogenetic grouping as certain ferns that have

both leaves and roots.

On the side bench we have living material of sporophytes of *Psilotum nudum* commonly called the whisk fern. Observe the plant and answer the following questions.

How does branching occur in the sporophyte of *Psilotum*?

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You have seen this pattern with three other organisms previously studied. Which are they?

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Are any of the other examples homologous to the branching pattern of *Psilotum*?

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Note: That while the shoot consists of only a stem there are small leaf-like structures coming off the stem (enations). These are not vascularized and, hence, are not considered to be leaves. While it now seems unlikely that *Psilotum* is truly a direct descendent of the Rhyniophytes, preserving their primitive structure, the structure of *Psilotum* is much like that of these earlier plants.

If you have not already identified the sporangia on *Psilotum,* do so now. Observe the demonstration slide of the sporangium.

What nuclear division process resulted in the production of the spore nuclei?

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III. Horsetails.

Equisetum giganteum

While molecular evidence anchors the horsetails within the Pteridiophytes, horsetails are an ancient group and have been separate from the ferns since the Devonian. *Equisetum* is structurally identical to fossil materials over a hundred million years old. Observe the living and pressed specimens of *Equisetum* on the side bench. These sporophytes have well defined nodes and internodes. At the internodes whorls of leaves are attached. The leaves are small and non-photosynthetic. Like higher plants, the nodes are the site of lateral bud formation. In this case, however, the buds do not reside in the axils of the leaves, but below the leaves. Some species form whorls of lateral shoots from these buds so observe the diversity of form available. Of the three taxa of fern allies, the sphenophytes in the form of the genus *Equisetum*, is the most common. *Equisetum* is found in sour pastures. In Wisconsin, *Equisetum arvense* is considered a weed in that it destroys B vitamins if eaten by livestock. Other species of *Equisetum* are found along railroad tracks and in marshes.

Note the demonstration of the strobili of *Equisetum* on the side bench. These strobili are considerably different from those of the Lycopods. It consists of a central stem to which modified stems (sporangiophores) bearing sporangia are attached

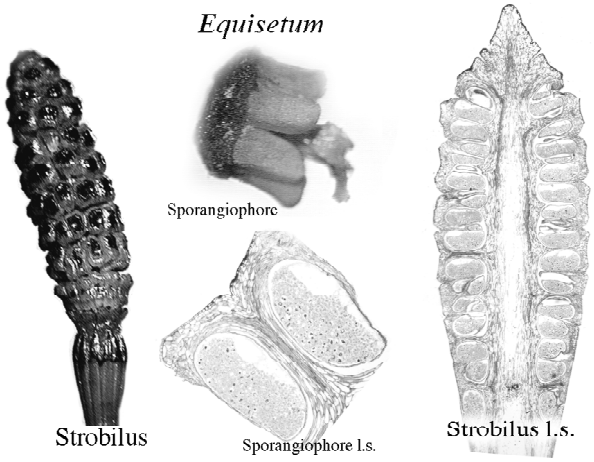
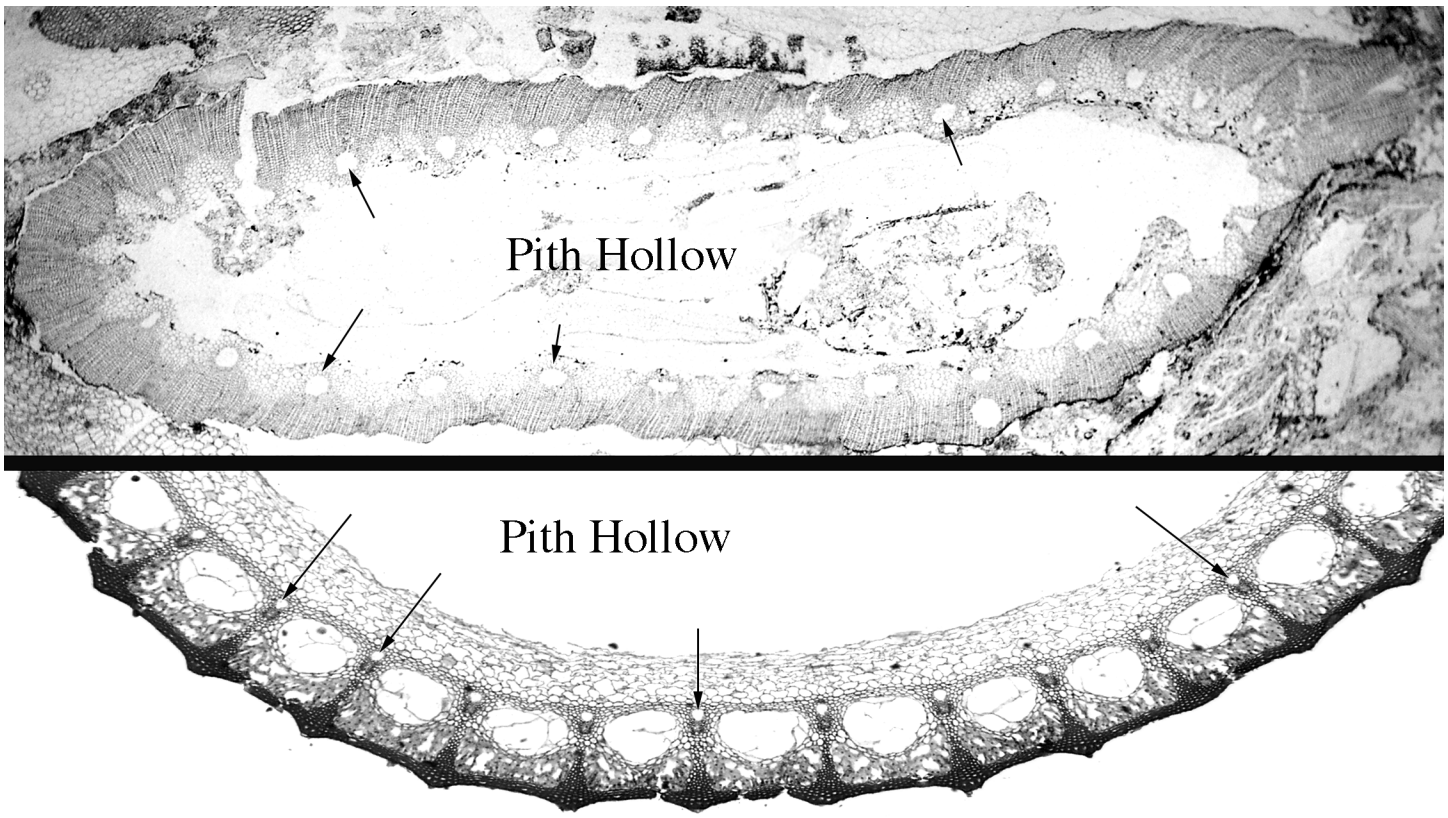


Illustration of *Equisetum* Strobilus

Extinct tree-sized species of horsetail from the Carboniferous, Calamites.

Observe the demonstrations of *Calamites*. Recognize the reconstruction of the plant and the fossils of the plant as an example of an extinct member of the horsetails, and that these trees were a significant part of the vegetation that gave rise to much of the coal in North America. Below is a stem section of *Calamites* with one of *Equisetum*. Note the similarities even though these are separated by hundreds of thousands of years.

Stem Cross Sections: The extinct tree-like horsetail, *Calamites*, on top. *Equisetum* below. Arrows point to the carinal canals in each.



Discussion Questions:

On volcanic islands, ferns are often the first vascular plants to appear. How can you explain this.

Bracken ferns are important on many dry sites here in Wisconsin. How can they persist if they are dependent on liquid water for fertilization?

Researchers have successfully produced diploid gametophytes. Surprisingly they do not possess vascular tissue. They produce gametes that result in tetraploid sporophytes. If the number of sets of chromosomes is not the deciding factor in the morphogenesis of these pants, can you think of other factors that influence the proper development of the sporophyte?

In the Appalachians there are species of fern that do not have a sporophytic stage. The gametophytes reproduce vegetatively only. In terms of survival, how could this possibly be beneficial to these species?

Based on the structure of the gametophyte, and on molecular studies, botanists think that *Psilotum* is a type of fern. This would mean that its morphology is secondarily derived. Its structure is simple but is its structure primitive? What is the difference between simple and primitive?