PBIO 111: Winter, 2002

Lab 7: Tracheophyta I - Seedless Vascular Plants (Ferns & Fern Allies): *Pteropsida*, *Psilotopsida*, *Lycopsida*, *Sphenopsida*

INTRODUCTION

Vascular plants are the largest and most conspicuous plants. They all have sporic life cycles in which the sporophyte is the dominant phase, but the details of the life cycle vary among the different groups of vascular plants. For example, the sporophytes of some vascular plants shed spores that are all of one size and develop into a single kind of gametophyte; these plants are said to be **homosporous**. Others shed spores that differ in size and develop into separate male and female gametophytes; these plants are **heterosporous**. The most complex vascular plants reproduce by means of seeds, a specialized form of heterospory.

In this laboratory, we will introduce you to the groups of vascular plants that do not reproduce by seed. As you examine them and learn their distinctive features, be sure to remain aware of which ones are homosporous and which are heterosporous.

EXERCISE A: PTEROPSIDA, THE FERNS (pp. 449-463 in text)

There are over 10,000 species of living ferns, making Pteropsida the second largest group of land plants. Only the angiosperms (flowering plants) have more species. Most ferns are homosporous, but some aquatic ferns are heterosporous.

Part 1. The Sporophyte

Fern sporophytes possess roots, stems, and leaves. Their leaves, called **fronds**, usually arise from a **rhizome** (horizontal stem). The fronds may be divided into many leaflets or **pinnae**.

! Examine the living ferns on display. Identify the fronds, pinnae, **croziers** (young, coiled leaves; also called fiddleheads) and rhizomes.

We are concentrating primarily on the ferns of the order **Filicales**. Sporangia of many filicalean ferns contain a layer of unevenly thickened cells called the **annulus**, which is involved in discharge of the spores from the sporangium. As the sporangium dries out, the annulus breaks in a zone of weakness composed of thin-walled cells. After breaking, the annulus recurves, carrying spores with it, then suddenly snaps back into its original position, throwing the spores with a catapult-like motion.

! Examine the living ferns again, and look at the undersides of the fronds. You should see round or elongated dark spots called **sori** (singular: **sorus**). Each sorus is a collection of sporangia.

In some ferns (e.g., the staghorn fern), the sporangia cover a large area on the lower surface of the leaf instead of being restricted to distinct sori.

- ! Where are the sporangia in *Ophioglossum*?

- ! Tear off a small piece of a *Polypodium* pinnule with a sorus. Look at the sorus under the dissecting scope.

- ! Use a dissecting needle to scrape the sporangia from the sorus onto a drop of water on a slide. Apply a cover slip.

- ! Identify the sporangia, annulus, and spores. What is the ploidy level of each? Are the spores produced by meiosis or mitosis?

- ! Examine a living specimen of *Cyrtomium*. Each sorus of *Cyrtomium* is covered by a specialized protective outgrowth called an **indusium** (plural: **indusia**).

- ! Identify the sori, indusia, and sporangia.

You may be able to watch spore discharge in living material of *Cyrtomium* or *Pteris* . Tear off a small piece of leaf containing sori, and place it under the light on your dissecting scope. The heat from your lamp may be sufficient to dry out the sporangium and cause spore discharge.

- ! Examine a prepared slide of a *Cyrtomium* sorus (see also Fig. 19-36 on p.459). Identify the indusium, sorus, sporangium, annulus, and spores.

- ! Examine *Adiantum*. Notice that the edges of some pinnules fold under, covering the sori in a **false indusium**.

Most ferns are homosporous, but a few are heterosporous.

- ! Examine the living water ferns that are on display, including *Marsilea*, *Azolla*, and others if available.

Do you recall what kind of relationship *Azolla* has with *Anabaena*?.
These water ferns have heterosporous life cycles. Later in this laboratory, you will examine more closely some other plants with a heterosporous life cycle.

Part 2. The Gametophyte.

Homosporous ferns produce a bisexual gametophyte called a **prothallus**, which is small and often somewhat heart-shaped.

! Examine a prepared slide of a fern prothallus with antheridia and archegonia (see also p. 461).

! Identify the **rhizoids**, the **archegonia** near the notch of the heart, and the **antheridia** near the bottom of the heart.

What is the ploidy of these structures? What is produced inside archegonia, and by what cell division process? What is produced in the antheridia?

! Examine the prepared slide of a fern prothallus with an emergent sporophyte.

Look at the fern developmental series (demo) consisting of a tiny gametophyte, a gametophyte with a sporophyte growing out of it, a young sporophyte, and a mature sporophyte with sporangia.

EXERCISE B: "Fern Allies" (Psilotopsida, Lycopsida, Sphenopsida).

In addition to ferns (Pteropsida), there are three other groups of seedless vascular plants alive today: Psilotopsida (whisk ferns), Lycopsida (club-mosses and their relatives), and Sphenopsida (horsetails).

Part 1. Psilotopsida. Whisk Ferns (pp. 443-447 in text).

The class Psilotopsida includes two living genera with **homosporous** life cycles: *Psilotum* and *Tmesipteris. Psilotum* is a vascular plant, but the sporophyte body is not differentiated into roots, stems and leaves. Rather, it consists of a system of leafless axes that branch **dichotomously** (i.e., at each branching point, the two branches are similar in size). The aerial axes bear scale-like outgrowths called **enations** (which are not true leaves because they don't contain vascular tissue), and the underground axes bear **rhizoids**.

Three-lobed **synangia** (singular: **synangium**), each consisting of three fused sporangia, are attached to the axes at the base of some enations. Spores are produced in the synangia. After they are dispersed, the spores germinate to produce bisexual gametophytes, i.e., each gametophyte produces both **antheridia** and **archegonia**.

! Examine a living plant of *Psilotum* and identify the enations, aerial axes, and synangia.

! Examine a prepared slide of a *Psilotum* synangium (see also p. 447-448).

! Identify the scale-like outgrowths subtending the synangium, the **spore mother cells** (which give rise to spores), and **sterile jacket cells** (protective layer).

Are the spores produced from the spore mother cells by meiosis or mitosis?

Part 2. Lycopsida. Club-mosses, Spike-mosses, and Quillworts (pp. 435-443 in text).

The sporophytes of lycophytes have true roots, stems, and leaves. The leaves of most lycophytes contain only a single vein. Sporangia are borne on the upper surfaces of certain leaves, which are called **sporophylls**. In some taxa (e.g., *Diphasiastrum*), sporophylls are aggregated into a cone, or **strobilus**, at the end of a branch. In others (e.g., Huperzia), sporphylls are simply inserted among the vegetative leaves. The gametophytes that develop from the spores are often very small and may require 6-15 years to begin producing gametangia.

! Examine fresh or dried specimens of Huperzia andDiphasiastrumsporophytes. Note the **strobili** in *Diphasiastrum. Huperzia* lacks strobili. Can you see its sporangia?

You may find gemmae present near the tips of some branches in *Huperzia*. Do you know what their function is?

! Examine the prepared slide of a *Diphasiastrum* strobilus (the slide is labeled as "Lycopodium"). Like *Psilotum, Diphasiastrumis* homosporous.

! Identify the spores, sporangium, and sporophyll.

! Examine the prepared slide (demo) of a *Lycopodium* gametophyte. Note the antheridia. What is inside them? Archegonia are also present but are more difficult to make out.

Two other lycophytes, *Isoetes* and *Selaginella*, are **heterosporous**. Two kinds of spores are produced: **microspores**, which give rise to **microgametophytes**, which produce sperm; and **megaspores**, which give rise to**megagametophytes**, which produce eggs.

! Examine the live specimens of *Selaginella*. Do you see any strobili?

! Examine a prepared slide of a *Selaginella* strobilus.

! Identify the **microsporophyll**, **microsporangium**,**microspores**,**megasporophyll**,**megasporangium**, and **megaspores**. Which structures are diploid and which are haploid?

! Examine the living plant of *Isoetes*.

! Examine the prepared slide of *Isoetes*. The sporangia are located at the base of the sporophylls.

! Identify the **microsporophyll**, **microsporangium**, **microspores**, **megasporophyll**, **megasporangium**, and **megaspores**.

Living lycophytes are rather small, **herbaceous** (non-woody) plants, but during the Carboniferous period (286-360 million years ago) most were trees and comprised much of the coal-forming biomass of the peat swamps.

! Examine the sections of fossil stem casts on display, and compare them with the living material.

Notice the diamond-shaped scars on the surface. These mark the positions of the leaves that once covered the stem.

Part 3. Sphenopsida. Horsetails (pp. 445-451 in text).

The class Sphenopsida is an ancient and formerly diverse group, but only one genus exists today: *Equisetum*. *Equisetum* sporophytes have leaves arranged in whorls on the stems. As in Lycophyta, each leaf contains only a single vein.

At the tip of the stems are **strobili**. The strobili are composed of clusters of **sporangiophores**, umbrella-like structures that bear sporangia (see text p. 450). The spores produced by the sporangia germinate to form tiny gametophytes. Each gametophyte may produce both eggs and sperm. (Is *Equisetum* homosporous or heterosporous?)

! Examine preserved specimens of *Equisetum* arvense and fresh specimens of *Equisetum hyemale*.

! Identify the whorled leaves, **nodes** (places where leaves arise), **internodes** (areas between the nodes), and strobili.

! Dissect a strobilus of *Equisetum hyemale* under the dissecting scope. Identify the sporangiophores, sporangia, and spores. What is the ploidy level of the spores?

The spores have **elaters** coiled around them. Elaters, which are derived from the spore wall, are sensitive to moisture; they coil in response to moisture and uncoil as they dry out (see pictures on p. 449 & 451). In doing so, the elaters help discharge the spores from the sporangium.
If the sporangia are fresh and the elaters therefore moist, the heat from your dissecting scope lamp will make the elaters uncoil and the spores will jump around. If the sporangia are on a dried specimen, the elaters should already be uncoiled; in this case, gently breathing on them may provide enough moisture to make the elaters curl up again.

! Examine the prepared slide of an *Equisetum* strobilus. Identify the sporangiophore, sporangium, and spores.