Investigating Simple Plants: Mosses and Ferns Lab X-1

EQUIPMENT AND MATERIALS

You'll need the following items to complete this lab session. (The standard kit for this book, available from *www.thehomescientist.com*, includes the items listed in the first group.) If you are preparing your own live specimens, do so starting a week or so before you intend to do this lab session.

MATERIALS FROM KIT

- Goggles
- Coverslips
- Forceps
- Magnifier
- Pipettes
- Scalpel
- Slides, flat
- Stain: eosin Y
- Stain: methylene blue
- Teasing needles

MATERIALS YOU PROVIDE

- Gloves
- Microscope
- Microscope, stereo (optional)
- Slides, prepared (optional; see text)
- Specimen(s), fern (see text)
- Specimen(s), moss (see text)

BACKGROUND

This and the following lab session present an excellent opportunity for a field trip to your nearest botanical gardens. You can observe plant specimens in your own yard, a park, or a nearby woods, but identifying the plant species you find can be problematic. That is, of course, an educational opportunity in itself, but it's easy to get bogged down attempting to identify a few species and thereby miss out on observing the great diversity of plant life available.

> Know and follow all laws with respect to collecting plants. In particular, many federal, state, and municipal parks prohibit collecting specimens.

The advantages to visiting botanical gardens are that all of the species are set out and identified for you, allowing you to concentrate on observing the characteristics of specific known species, and that you will be able to observe many species that aren't found locally in the wild. Also, many botanical gardens have indoor facilities, where you will be able to observe specimens in leaf and in flower regardless of the time of year when you visit. Finally, you'll often find knowledgeable staff members who will be delighted by your interest and happy to help you make the most of your visit. Just let them know that you're interested in studying their collection seriously and you'll probably find they'll go out of their way to answer your questions.

Plan to spend at least half a day studying their collection. You'll probably find that you could easily spend an entire day or more without seeing everything there is to see. Take along your magnifier, camera, and lab notebook, and use them to study the collection in an organized manner. If you see something that you'd really like to have a specimen of, ask the staff. There are no guarantees, but sometimes they'll make an exception for you if they understand that you're doing a serious scientific study of plants.

> More than once, we've come away from such a visit with leaves, flowers, and other plant specimens that we'd not otherwise have had access to. Make sure to come prepared. Carry a supply of plastic zip bags and some plastic bottles or tubes to hold specimens. But always, always ask permission before you collect a specimen.

In the lab sessions, we focus on microscopic examination of plant structures, but that doesn't tell the whole story. The macroscopic structures of plants are also fascinating, and many of those will require getting away from your microscope and into the great outdoors, if only to collect specimens for later study. For example, you should familiarize yourself with the great variety in sizes, shapes, and venation patterns of leaves of the trees and herbaceous plants around you. Doing that makes it much more meaningful when you study the microscopic features of those same types of leaves.

Take every opportunity to study the plant life around you, not just while you're doing this group of lab sessions, but throughout the year. In fact, it's a useful project to choose one or a few plants in your yard or a nearby park and then examine them in detail as the seasons change through the course of year. Some of those changes are obvious, such as the changes in the foliage of a deciduous tree. Others are less obvious, such as the changes in your lawn's grass from spring though summer and autumn to winter.

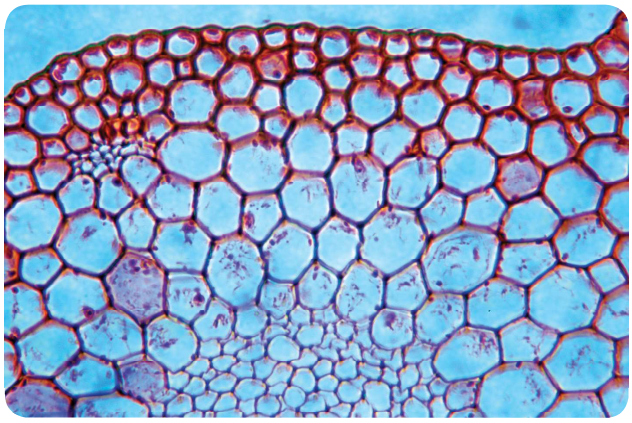
The earliest multicellular organisms evolved in water. Although they are now classified as protista, multicellular algae can be thought of as proto-plants. Some of these aquatic organisms gradually developed structures and mechanisms to transport, store, and manage water, allowing them to survive in drier environments. These were the ancestors of the first land plants.

The earliest land-dwelling plants were probably *mosses* (phylum *Bryophyta*), whose descendants now flourish in any environment where water is readily available. Like their close relatives, the *liverworts* and *hornworts* (also *Bryophytes*), mosses are structurally simple, lacking the vascular systems of more complex plants (*Tracheophytes*). The absence of a vascular system for water transport limits the physical size of mosses, which seldom grow taller than 10 or 15 cm, and usually much less. Figure X-1-1 shows a common moss, *Polytrichum formosum*, growing on a forest floor.

Figure X-1-1: *Polytrichum moss growing on a forest floor*

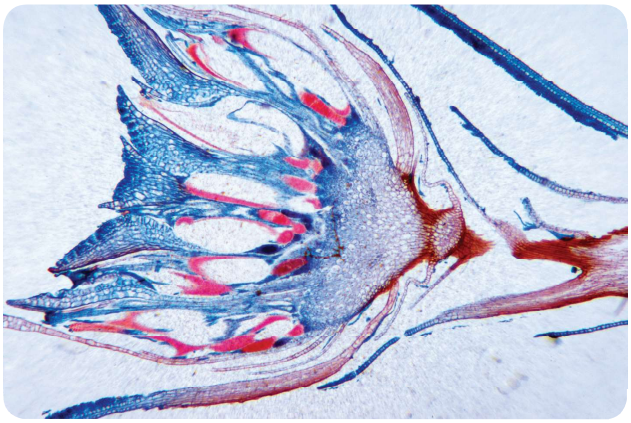
Structurally and reproductively, mosses in many respects more resemble fungi than other plants. Stems are simple herbaceous structures. (Figure X-1-2 shows a cross-section of a moss stem at 400X.) Rather than true roots, mosses employ rhyzoids as *holdfasts* to anchor themselves to their substrates. Rhyzoids do not absorb water or nutrients from the substrate, but are simple physical anchors. Water and nutrients are absorbed directly by leaf-like structures. Mosses lack flowers, and do not produce cones, fruits, or seeds, instead reproducing via spores. In contrast to *Spermatophytes* (seed plants), whose life cycles include a *haploid generation* (ovule and pollen) and a *diploid generation* (the flowering plant itself), mosses are haploid (unpaired chromosomes) for most of the life cycle, with only a short-lived *sporophyte* representing the diploid (paired chromosomes) phase.

Figure X-1-2: *Moss stem, cs (400X)*



When haploid spores germinate, they produce *protonemata* (singular *protonema*), a flat or filamentary mass from which the *gametophore* grows. The gametophore is the body of the plant, and is structurally differentiated into rhizomes ("roots"), stalks, and leaves. The lower part of the plant contains gametophyte structures, the female *archegonia* (singular *archegonium*) and the male *antheridia* (singular *antheridium*), shown in Figure X-1-3.

Figure X-1-3: *Moss (Polytricum commune) antheridia (40X)*



The archegonia are small bottle- or pouch-shaped structures at the "leafy" base of the structure, which gather sperm produced by the antheridia. The upper end of the archegonium is constricted like the neck of a bottle to contain captured sperm produced by the antheridia. *Sporophytes* (spore producing structures) consist of long modified stems called *setae* (singular *seta*) atop which sit spore-containing capsules called *calyptrae* (singular *calyptra*). Figure X-1-3 illustrates the life cycle of a typical moss.

Although they are in no sense hybrids, *ferns* (phylum *Pteridophyta*) can be thought of as intermediate between the simple mosses and other *Bryophytes* and the more complex *Spermatophytes* (seed plants). Structurally and in gross appearance (see Figure X-1-5), ferns resemble seed plants (angiosperms and gymnosperms). Unlike mosses, ferns are vascular (have *xylem* and *phloem*), and have true roots, true stems, and true leaves.

Figure X-1-4: *Life cycle of a typical moss*

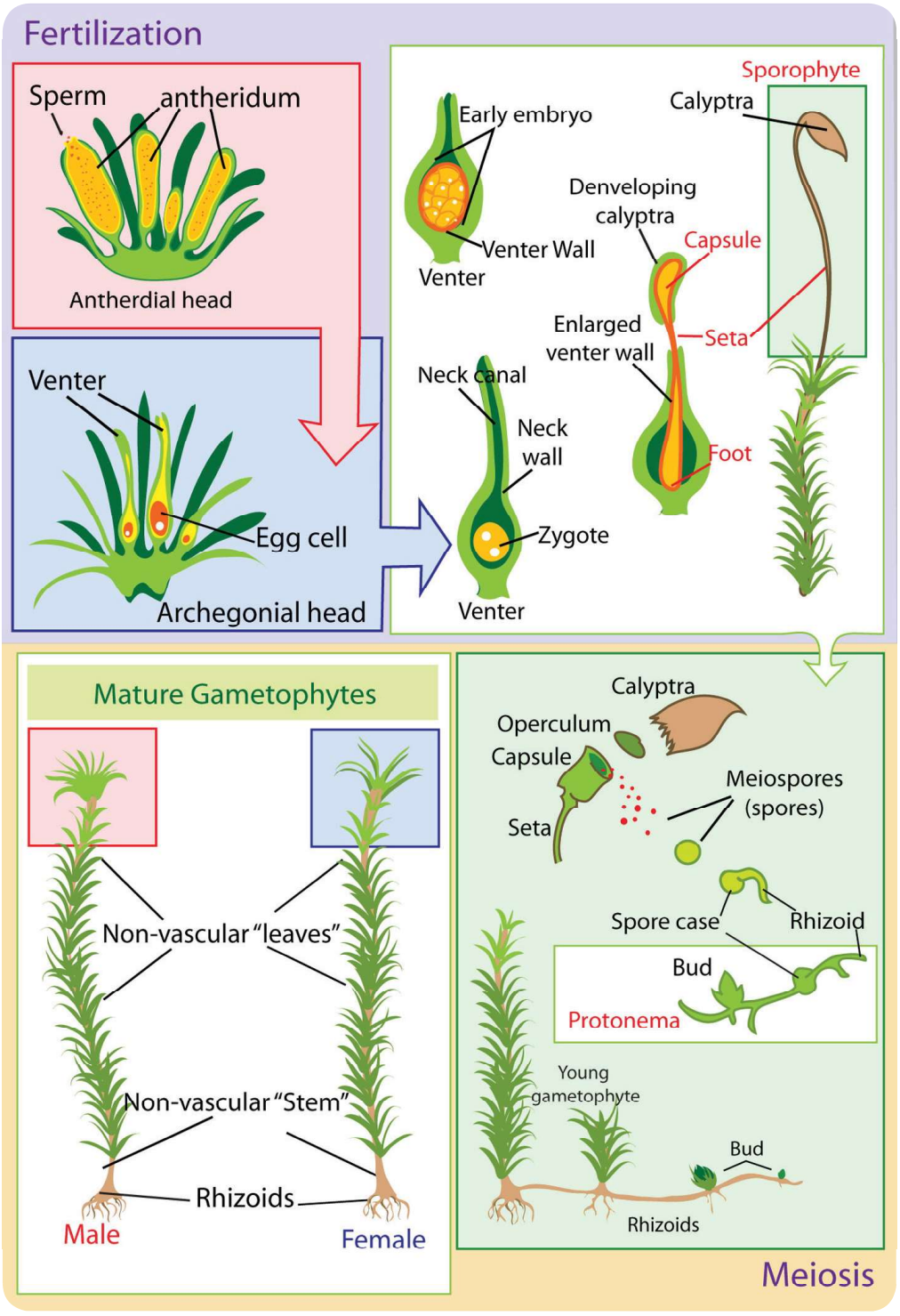
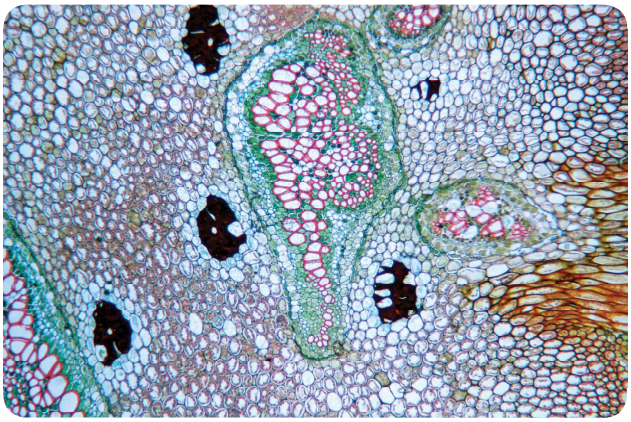


Figure X-1-5: *Cinnamon fern (Osmundastrum cinnamomeum), a typical fern*

Figure X-1-6: *Fern (Dryopteris championii) stem (rhizome), cs (40X)*



The major components of ferns are similar structurally and functionally to those of seed plants, including:

Roots

While mosses' root-like structures (rhizoids) provide only a physical anchor to the substrate, ferns possess true fibrous roots like those of seed plants, although those roots are actually unicellular rhizoids. Roots absorb water and nutrients from the soil, which the vascular system of the fern transfers to other parts of the plant.

Stems

Again unlike mosses, whose stem-like structures are simple undifferentiated groupings of cells, ferns possess true stems like those of seed plants with differentiated structures comprising specialized cells. (Compare the complex fern stem structure shown in Figure X-1-6 to the simple moss stem structure shown in Figure X-1-2.)

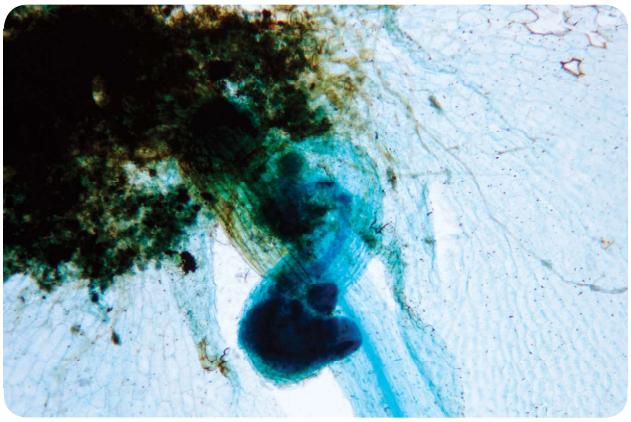
Leaves

Although mosses have leaf-like structures with chloroplasts, they are not true leaves. Ferns, conversely, possess not one but three types of true (vascular) leaves, which are referred to collectively as *megaphylls*. *Trophophylls* are similar in appearance and structure to the leaves on seed plants, and perform the same function: using photosynthesis to produce and store saccharides. *Sporophylls* appear similar to trophophylls, and also engage in photosynthesis, but also produce spores. In that respect, they are functionally similar to the cone scales of gymnosperms and the pistils and stamens of angiosperms. *Brophophylls* are similar in appearance to trophophylls, but also produce spores.

Reproductively, ferns more resemble mosses than seed plants. Ferns are not flowering plants, so they do not produce seeds. Instead, like mosses, ferns reproduce using spores, although their reproductive life cycle differs from that of mosses. As is true of all vascular plants, including the more complex seed plants, the life cycle of ferns is based upon alternation of generations, with a diploid (paired chromosomes) sporophyte phase and a haploid (unpaired chromosomes) gametophyte phase, as follows:

- Via meiosis, the diploid sporophyte (the fern plant) produces haploid spores
- Via mitosis, the haploid spore produces a haploid gametophyte (the *prothallium* or *prothallus*, shown in Figure X-1-7)
- Via mitosis, the haploid gametophyte produces haploid gametes (eggs and sperm)
- A motile sperm fertilizes a sessile egg (fixed to the prothallus) to produce a diploid zygote
- Via mitosis, the diploid zygote grows to become a diploid sporophyte (the fern plant)

Figure X-1-7: *Fern (Dryopteris-championii) prothallium with young sporophyte (40X)*



As with mosses, fern sperm are produced by antheridia and eggs by archegonia. A typical prothallus contains multiple antheridia and archegonia. Clusters of sporangia (spore-forming bodies) are called *sori* (singular *sorus*). Sori form on sporophyll or brophophyll leaves, usually as brown or yellow masses on the underside of the leaf. Although it is not present in all fern species, the *indusium* is a membrane that forms a protective cover for the spores contained within the sorus. Figure X-1-8 is a 100X cross-section of a fern sporophyll leaflet showing a sorus with the indusium and spores visible. Figure X-1-9 shows fern spores at 100X.

Figure X-1-8: *Fern sporophyll leaflet cs showing sorus with indusium and spores (100X)*

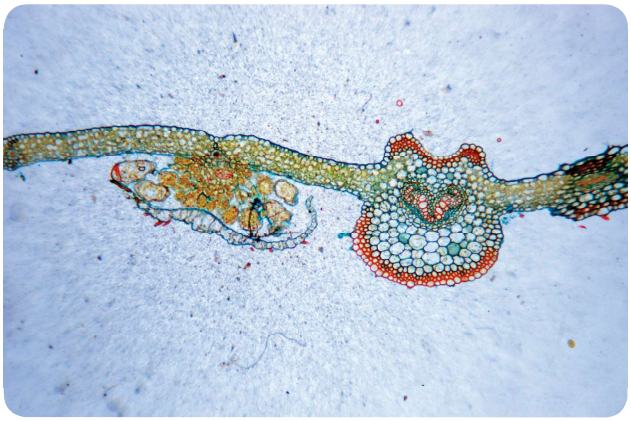
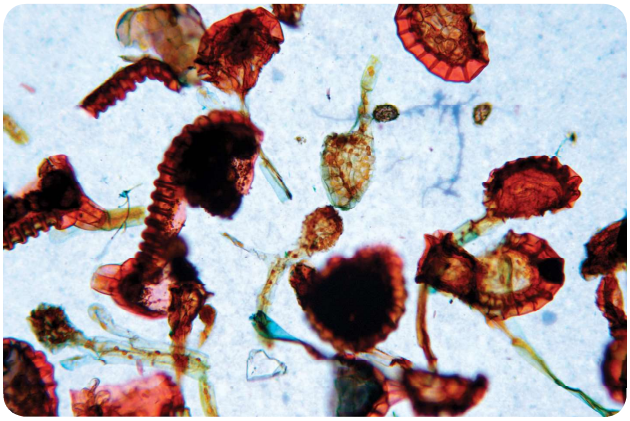


Figure X-1-9: *Fern spores, 100X*



Although you can purchase live specimens of various mosses and ferns from Carolina Biological Supply or another vendor, there's really no need to do so. Mosses are ubiquitous, can easily be gathered at any time of year, and can be dried to preserve them indefinitely. If for some reason you can't gather wild moss, you can purchase sphagnum moss inexpensively at a garden center or DIY store. (Make sure to get "sphagnum moss," which is dried live moss, rather than "peat moss" or "sphagnum peat moss," which is rotted sphagnum gathered from peat bogs.) You can also purchase sphagnum moss from pet stores, where it is sold for use in terrariums. Ferns can easily be gathered in the wild, or you may know someone who keeps them as house plants. You'll find the following prepared slides—which you can purchase or make yourself—useful for this session:

- Moss – stem; protonema; antheridium; and archegonium
- Fern – rhizome; prothallium; sporophyte; sori; and spores

If you prepare your own slides, you can experiment with different stains. We suggest starting with eosin Y and methylene blue, both of which are included in the standard kit.

PROCEDURE X-1-1: OBSERVING MOSS STRUCTURES

To begin, use the magnifier (or a stereo microscope, if you have one) to examine closely your moss specimen or specimens.

1. Note the color and gross morphology of each specimen. Compare any similarities and contrast any differences in your specimens, and record your observations in your lab notebook.

2. Using the Internet or printed reference material, attempt to identify each of the specimens to at least the genus level.

3. For each of your specimens, examine and identify any structures visible at low magnification, including gametophyte structures (rhizoids, stems, and leaves) and sporophyte structures (seta and calyptra). Note the differences between mature male and female gametophytes. If you have a camera with macro capability, record images of the various structures.

4. Using the forceps, carefully remove a leaflet, transfer it to a flat slide, add a drop of water, and observe the specimen at low and medium magnification. and make a wet mount

5. Using the teasing needle and forceps, carefully separate a sporophyte from its gametophyte. Use the scalpel to cut the seta just below the calyptra and transfer the calyptra to a flat slide.

6. Add a drop of water, and use the teasing needle gently to crush the calyptra and release the spores it contains. Position a coverslip and scan the slide at 40X to locate a cluster of spores. Switch to high-dry magnification to observe the spores. Make a sketch or shoot an image of the spores.

7. Using either purchased prepared slides or slides that you have prepared and stained yourself, observe the following structures at suitable magnifications: protonea, rhizoids, stems and leaves, antheridia, and archegonia. Sketch each of the structures or shoot an image of it.

PROCEDURE X-1-2: OBSERVING FERN STRUCTURES

To begin, examine closely your fern specimen or specimens with your naked eye, followed by examination with the magnifier or a stereo microscope.

1. Note the overall appearance and major structural features of each specimen. Compare any similarities and contrast any differences in your specimens, and record your observations in your lab notebook.

2. Using the Internet or printed reference material, attempt to identify each of the specimens to at least the genus level. (The presence or absence of sori, along with their positions, colors, shapes, sizes, and so on are important clues to identifying fern species.)

3. For each of your specimens, examine and identify any structures visible at low magnification, including gametophyte structures (rhizoids, stems, and leaves) and sporophyte structures (seta and calyptra). Note the differences between mature male and female gametophytes. If you have a camera compatible with your microscopes, record images of the various structures.

4. Using the teasing needle and forceps, carefully separate a sporophyte from its gametophyte. Use the scalpel to cut the seta just below the calyptra and transfer the calyptra to a flat slide.

5. Add a drop of water, and use the teasing needle gently to crush the calyptra and release the spores it contains. Position a coverslip and scan the slide on low magnification to locate a cluster of spores. Switch to high-dry magnification to observe the spores. Make a sketch or shoot an image of the spores.

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REVIEW QUESTIONS

Q1: Why might we group mosses and ferns together as "ancient plants"?

Q2: What similarities and differences, if any, did you observe between the moss leaf and the fern leaf?

Q3: What are the female and male reproductive structures in mosses and ferns called?

Q4: How do mosses differ from lichens?

Q5: Mosses seldom grow more than 10 to 15 cm tall. Ferns commonly reach heights of 10 meters or more. What structural feature explains this difference?