UNIT 4: FERNS AND FERN ALLIES (Seedless Vascular Plants)

Botany: An introduction to plant biology, 5th ed. Mauseth. Chapter 21

OBJECTIVES

By the end of the lab, you should know which phyla comprise the seedless vascular plants, the characteristics of the phyla, and an example of each. You should also understand the life cycle of the ferns (Pteridophyta) and the fern ally *Selaginella* (a member of the Lycopodiophyta). You should also be able to discuss the difference between **homospory** and **heterospory,** and the structures associated with those conditions.

BACKGROUND

Seedless vascular plants include all of those plants with specialized conducting tissues for transporting substances but use spores as a dispersal unit rather than seeds. There are now considered to be only two extant phyla of seedless vascular plants: the **Pteridophyta** (including the whisk ferns, horsetails, and the true ferns) and the **Lycopodiophyta** (club mosses, quillworts, and spikemosses). The Phylum Pteridophyta is the largest of the phyla with around 9000-10,000 species; Lycopodiophyta has only around 1200 species.

Seedless vascular plants may be **homosporous** or **heterosporous**. Homosporous plants have one type of **sporangia** that produce one type of **spore**. When these spores germinate, they have the potential to develop into either male **gametophytes**, female gametophytes, or bisexual gametophytes depending upon the surrounding environment. In contrast, **heterosporous** plants have two types of sporangia which produce either small **microspores** or large **megaspores**. Microspores germinate and develop into male gametophytes (or **microgametophytes**). Megaspores produce female gametophytes (or **megagametophytes**). Most seedless vascular plants are homosporous, but members of Selaginellales, Isoetales, Marsileales, and Salviniales are heterosporous.

In many of the club mosses and horsetails the sporangia-bearing leaves (**sporophylls**) are located in a cluster at the end of a stem. This club-like structure of sporophylls is called a **strobilus** (**strobili**, plural). An exception is found in the genus *Isoetes*, a member of the Lycopodiophytes where the sporangia are found inside the base of the leaf, which is often underground.

THE HOMOSPOROUS LIFE CYCLE

In the ferns, the **sporophyte** is the dominant phase of the life cycle. The **sporophyte** is much larger in size and longer lived than its **gametophyte**. The leaves of the **sporophyte** are commonly referred to as **fronds**. The **fronds** attach to a horizontal stem, called a **rhizome**, which may grow above or below ground. Roots grow from the lower side of the **rhizome**. On the underside of some of the **fronds** are clusters of **sporangia** called **sori** (singular, **sorus**).

The fern **spores** germinate and grow into heart-shaped or rod-shaped **gametophytes** called **prothalli** (**prothallus**, singular). The **gametophytes** are much smaller than the **sporophytes** but are nutritionally independent. Most fern **gametophytes** are bisexual; that is, they have both **antheridium** and **archegonium** on the same **gametophyte prothalli**. Other ferns have unisexual **gametophytes** with **antheridia** and **archegonia** gametangia on separate **prothalli**. The presence of surface water is still required for the **sperm** to swim to the **egg** in the **archegonium**. After **fertilization**, the **zygote** is retained in the **archegonium** where the **embryo** begins its

development. Eventually the young **sporophyte** grows out of the parent **gametophyte**.

THE HETEROSPOROUS LIFE CYCLE (*SELAGINELLA*)

In many ways the life cycle of *Selaginella* is the same as that of the **homosporous** fern life cycle discussed above. However, it shows some differences relating to the development of **heterospory** and the retention of the female **gametophyte** by the **megaspore**.

The fertile leaves, or **sporophylls**, of *Selaginella* are arranged in **strobili** at the ends of some of its stems. Each **sporophyll** has a **sporangium**. Some of the **sporangia** will produce hundreds or thousands of small **microspores** while other **sporangia** will produce only 4 large **megaspores**. Each **microspore** that germinates will produce a male **gametophyte** with a single **antheridium**. The male **gametophyte** remains within and is nutritionally dependent upon the **microspore**. Each **megaspore** that germinates will produce a female **gametophyte** with **archegonia**. The female **gametophyte** also stays within and is nutritionally dependent upon the **megaspore**. When surface water is present, **sperm** will swim from the **antheridium** of the male **gametophyte**, some of which will arrive at nearby **megagametophytes** and swim down the **archegonium** to the **egg**. Fertilization occurs in the **archegonium** forming a **zygote** which will develop into the next generation of **sporophyte**. However, as the new **sporophyte** grows out of the female **gametophyte**, its **foot** remains attached to the **megaspore**. For a short time, the new **sporophyte** derives some of its nutrition from the **megaspore**. By the time the food reserves of the **megaspore** are depleted, the new **sporophyte** is photosynthetic and nutritionally dependent.

BEFORE YOU COME TO LAB ....

1. What are the major differences between the mosses (Phylum Bryophyta) and the ferns (Phylum **Pteridophyta**)?

2. What is the difference between protonemata and **prothalli**?

3. In what ways are ferns still not as well adapted to land environments as are the seed bearing plants?

4. Compare the size and complexity of the **gametophytes** of a green alga such as *Spirogyra*, a moss, a fern, and, *Selaginella*. Compare the size and complexity of the **sporophytes** of the same plants.

5. What is the difference between a **rhizome** and **root?**

6. What advantages does vascular tissue give the ferns over the nonvascular mosses?

7.

EXERCISE 1: THE FERN SPOROPHYTE
PART A: EXTERNAL STRUCTURE

On your lab bench or the front lab or side bench are a number of fern **sporophytes**. As you observe the mature **sporophytes**, answer the questions.

8. Draw a sporophyte and locate the following structures: **frond**, **rhizome**, **root, sori**, **sporangia**.

9. Are **sori** located on any (all) of the **fronds** ? Is there any type of tissue covering the **sorus**?

PART B. INTERNAL STRUCTURE

Obtain the slide of the **rhizome** cross-section (slide #1) and the root cross-section (slide #2). This is a section through the rhizome or horizontal stem of a fern. In it you will see a number of different types of cells. Some of these make up conducting tissues referred to previously. The tissue that transports water, called **xylem**, is the easiest to identify. The cells of the **xylem** are large and have very thick cell walls. They are located in round or elongate shaped clusters.

10. What differences do you see between the root structure and the rhizome structure?

11. Draw a rhizome and a root in the space provided.

PART C: STRUCTURE OF THE FROND AND SORI

Obtain the slide of the fern **frond** with **sori** (slide #3). First look at the overall leaf structure under low power. Find a **sorus** on the lower surface of the leaf. Center the **sorus** in your field of view and observe it with a higher power.

12. As you looked at the overall leaf structure, were you able to see any vascular tissue similar to that observed in the **rhizome**?

13. Approximately how many **sporangia** can you see in the **sorus** (one, two, or many)?

14. Around each **sporangium** you should be able to see an **annulus** (an incomplete ring of cells). What is the function of the **annulus**?

EXERCISE 2: FERN SPORANGIA AND SPORES

Obtain a small piece of a fern **frond** with **sori** from your instructor. Place a drop of water on a slide. Gently scrap off a few of the **sori** into the water drop. Place a cover slip on the slide and then observe the slide under the microscope.

15. Often the **sorus** is too thick to see through with a light microscope. What structure is present that is blocking the light?

16. What is the difference between **sorus**, **sporangium**, and **spore**?

17. Describe the external appearance of a **spore**.

EXERCISE 3: THE FERN GAMETOPHYTE

PART A. LIVING FERN GAMETOPHYTE

Obtain one or two living fern **prothalli** from you instructor. Make a wet mount of the **prothalli**, making sure that the ventral side (bottom side) of the **prothallus** is up. Locate the **archegonia** and **antheridia**. Keep the slides on your microscope for several minutes and observe it occasionally, looking for small swimming cells. When the exercise is complete, one person at the lab bench should keep her/his slide for exercise 4.

PART B. PREPARED SLIDE OF FERN GAMETOPHYTE

Obtain the slides labeled "Fern **Gametophyte Antheridia** and Fern **Gametophyte Archegonia** (slides #4 and #5)." See also slide #6 Fern prothallium embryo. Compare to living fern **gametophyte**.

18. Is the **gametophyte** independent or dependent on the **sporophyte**? What is your evidence?

19. Are there both **archegonia** and **antheridia** on each **gametophyte** or does each have only **archegonia** or **antheridia**?

20. What is the term for a **gametophyte** with both **archegonia** and **antheridia**?
    Hint: ____sexual

21. What is the term for a **gametophyte** with only **archegonia** or only **antheridia**?
    Hint: ____sexual

22. Where are the **archegonia** positioned compared to the **antheridia**?

23. Are there more **archegonia** or **antheridia**?

24. How does the structure of the fern **archegonium** differ from the structure of the moss **archegonium**?

25. What were the small cells swimming around on the slide? Would you have been able to see them if you had made a dry mount?

PART C. PREPARED SLIDE GAMETOPHYTE-SPOROPHYTE

Obtain the prepared slide of a fern **prothalli** with **sporophyte** attached (slide #7) and also Fern Prothallium embryo (slide #6).

26. What ploidy is the fern **gametophyte**? The young **sporophyte**?

27. Is the **sporophyte** dependent or independent of the **gametophyte** at this point of development? Why do you say that?

EXERCISE 4: THE FERN LIFE CYCLE

28. Is the **sporophyte** or **gametophyte** the dominant phase of the life cycle? Why?

29. Is the fern **sporophyte** dependent or independent of the fern **gametophyte**? Is there evidence to support your conclusion? What is it?

30. In what ways does the fern life cycle differ from the moss life cycle? In what ways is it the same?

31. How does the fern **sporophyte** differ from the moss **sporophyte**? How does the fern **gametophyte** differ from the moss **gametophyte**?

EXERCISE 5: THE WATER FERNS: Salviniaceae

On the side bench, there are three water ferns: *Marsilea, Salvinea,* and *Azolla* (which you may remember from the Algae Lab).

32. What class are these genera in?

33. Do these look like ferns? If you did not know, what would you assume that *Marsilea* was?

34. Are these specimens sporophytes or gametophytes? Haploid or diploid?

35. Can you find sporangia or spores on any of these specimens? Where do you think that you would expect to find them?

EXERCISE 6: The Pteridophyte "fern allies"

Remember that while we do still use the term "Fern Allies," that these species are now divided up and occur in both the Pteridophyta as well as the Lycopodiophyta. A representative of the genus *Equisetum* (Equisetopsida) is located in the lab. We have prepared slides of both the *Equisetum* stem as well as the *Psilotum* stem (slides #8 and #9 respectively). In addition, there is a slide (#10) of the *Psilotum* sporangia.

As you look at the representatives of the fern allies present in lab, answer the questions on the worksheet.

36. What class are these genera in?

37. Are **strobili** present on the *Equisetum*?

38. Is *Equisetum* a sporophytes or gametophytes? Haploid or diploid?

EXERCISE 7: The Lycopodiophyte "fern allies"

Representatives of the genera *Lycopodium* (Lycopodiopsida), and *Selaginella* (Isoetopsida) are also located in the lab. You should also have a slide of an *Lycopodium* stem (slide #11) as well as a slide of a *Selaginella* strobilus (slide #12). As you look at the representatives of the Lycopodiophyte fern allies present in lab, answer the questions on the worksheet.

39. What phyla are these genera in?

40. Some members of the "**Lycophyta**" are referred to as clubmosses. What structure on the plant might be coined the term "club"? "moss"? Why are these not true mosses?

41. Are **strobili** present on any of the specimens? Which ones?

42. Are the ferns and fern allies you are looking at **sporophytes** or **gametophytes**? **Haploid** or **diploid**?

EXERCISE 8: THE LIFE CYCLE OF *SELAGINELLA* (PHYLUM LYCOPODIOPHYTA)

In the room is a specimen of *Selaginella*. Examine it and look for **strobili**. Then secure a slide of a *Selaginella* **strobilus** (slide #12). This is a longitudinal section of a **strobilus** that will have both **microsporangia** and **megasporangi**a. As you observe this slide, answer the questions on the worksheet.

43. How can you tell the difference between the **microsporangia** and **megasporangi**a?

44. Other than size, what is the major (and more important) difference between **microspores** and **megaspores**?

45. What is the name of the structure on which the **megaspores** are produced?

46. What is the name of the structure on which the **microspores** are produced?

47. What is the advantage of the female **gametophyte** (or **megagametophyte**) developing and remaining attached to the **megaspore**?

48. What are the relationships between the following terms?
    megasporophyll
    megasporangium
    megaspore
    megagametophyte

EXERCISE 9: Summary of Information

Fill out the following table. You will probably need your textbook.

order	class	phylum	spore type	sporangium development	genera examined	other
Lycopodiales						
Isoetales						
Selaginellales						
Ophioglossales						
Psilotales						
Equisetales						
Marattiales						
Salviniales						
Polypodiales						

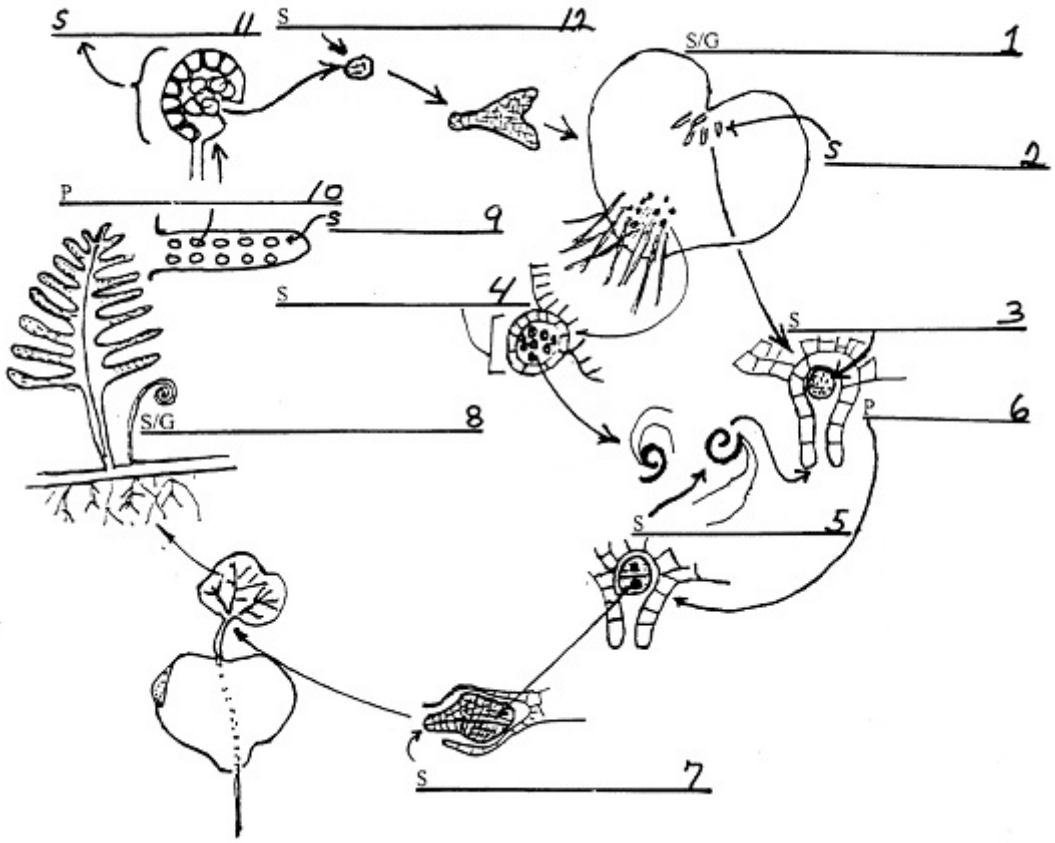
TERMINOLOGY TO BE FAMILIAR WITH

1. annulus
2. bisexual
3. fern ally
4. fertilization
5. fiddlehead
6. frond
7. foot
8. gametophyte
9. heterosporous
10. homosporous
11. indusium
12. lip cells
13. Lycophyta
14. megagametophyte
15. megaphylls
16. megaspore
17. megasporangium
18. megasporophyll
19. meiosis
20. microgametophyte
21. microphylls
22. microspore
23. microsporangium
24. microsporophyll
25. prothallus
26. Psilotophyta
27. Pterophyta
28. rhizome
29. sorus/sori
30. Sphenophyta
31. sporangia/sporangium
32. spore
33. sporophyll
34. sporophyte
35. stele
36. strobilus
37. unisexual
38. vascular tissue
39. xylem

60

Below are diagrams of the life cycles of ferns and *Selaginella*. Fill in the blanks on the diagrams. In the blanks labeled with a "**S**", place the name of the structure indicated and its ploidy. In blanks labeled "**P**" place the name of the process that has occurred. In blanks labeled "**S/G**" indicate whether that structure is part of the **gametophyte** or **sporophyte** generation.

40. LIFE CYCLE: FERNS
MEIOSIS TYPE: _____
GAMETE TYPE:_____



41. LIFE CYCLE: *SELAGINELLA*
MEIOSIS TYPE:_____
GAMETE TYPE:_____