EXERCISE 9

Plantae: Bryophytes & Vascular Plants

The Kingdom Plantae represents an extremely large group of mostly terrestrial organisms that are photosynthetic. Hence they provide the base of the food chain for most terrestrial ecosystems. Members of this group have ancestral ties to the Chlorophyta (Green Algae), and like them, plants have chlorophylls a and b, carotenoids, store food as starch, and have cellulose cell walls. Many features of plants are the result of adaptations to life on land, such as: 1) a protective jacket of cells surrounding egg- and sperm-producing structures (the **archegonia** and **antheridia**, respectively), a protective layer of cells covering the spore-producing structures (sporangia), 3) a protected embryo, and 4) specialized cells for water conduction. However, members of many plant groups have secondarily readapted to living in aquatic habitats.

Objectives:

Upon completing this week's laboratory, you should be able to:

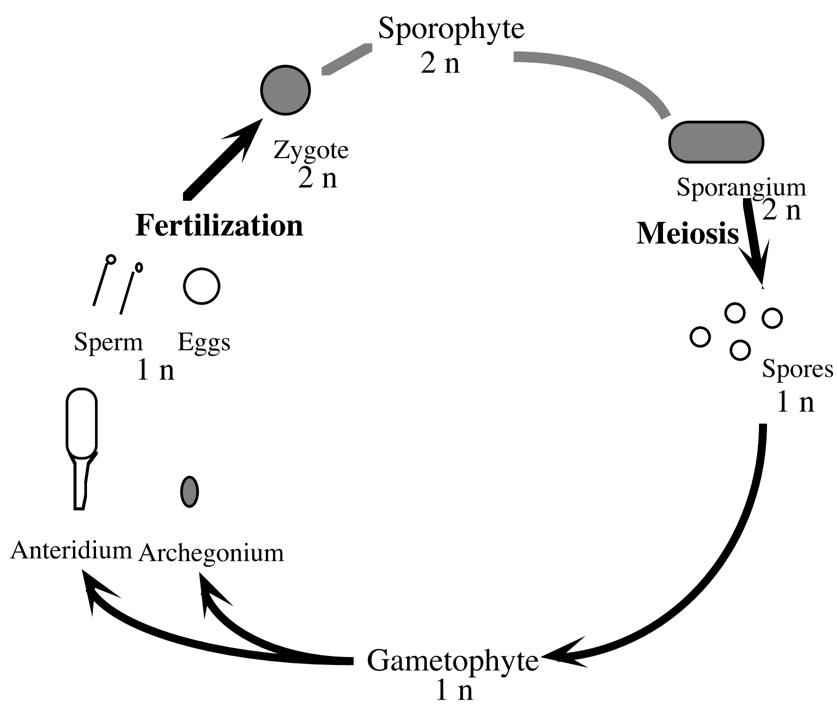
1. Identify members of the following divisions: Bryophyta, Psilophyta, Lycophyta, Sphenophyta, Pterophyta, Conifera, Cycadophyta, and Anthophyta.
2. Discuss the typical life cycle of the following divisions: Bryophyta, Psilophyta, Lycophyta, Sphenophyta, Pterophyta, Conifera, Cycadophyta, and Anthophyta.
3. Distinguish between gametophyte and sporophyte generations in each of the above divisions.
4. Identify members of the Class Hepaticae and Musci and their general life cycles. Also be able to tell a leafy liverwort from a moss.
5. Be able to identify the genus *Sphagnum*.
6. Discuss the difference in life cycles between homosporous and heterosporous ferns (and related divisions).
7. List major differences between monocots and dicots, and recognize an unknown angiosperm to its class.
8. Identify the following mitotic stages of root meristem tissue: interphase, prophase, metaphase, anaphase, and telophase.
9. Identify the epidermis, cortex, endodermis, xylem, and phloem of an herbaceous dicot root.
10. Identify the epidermis, phloem, xylem, cortex, and vascular bundles of a corn stem.
11. Identify the epidermis, phloem, xylem, cambium, cortex, vascular bundles, and pith of an herbaceous dicot stem.
12. Identify the epidermis, bulliform cells, mesophyll, vascular bundles, and stoma of a corn leaf.
13. Identify the epidermis, palisade mesophyll, spongy mesophyll, vascular bundle, guard cell, and stoma of a typical dicot leaf.

Division Bryophyta

Liverworts, hornworts, and mosses comprise the bryophytes, which are thought to be among the first plants to dominate the ancient terrestrial environment approximately 400 million years ago. Bryophytes are found in almost all terrestrial habitats (even in deserts!) but have their greatest diversity in moist habitats. Most bryophytes are small, usually less than 2 cm. Two important characteristics distinguishes bryophytes from vascular plants (Tracheophyta): 1) bryophytes lack specialized vascular tissue, xylem and phloem, used to transport water and food throughout the plant, and 2) the sporophyte generation is nutritionally dependent upon the gametophyte.

The basic bryophyte life cycle begins with a haploid (1 n) spore that germinates on moist soils and grows into a haploid gametophyte, the dominant life cycle stage. The gametophytes of typical bryophytes are diecious—that is, they are either male or female. Mature gametophytes produce antheridia or archegonia, depending on sex. During rains or snowmelt, sperm emerge from antheridia and swim to the archegonium, where one sperm cell fertilizes the egg to form a diploid (2 n) zygote. A diploid sporophyte develops within the archegonium and as it matures produces a sporangium. Meiosis occurs within the sporangium resulting in the production of haploid spores.

FIGURE 39. Typical bryophyte lifecycle showing gametophyte and sporophyte generations and where fertilization and meiosis occur.



Class Hepaticae – The Liverworts

Liverworts have one of two body plans: a thallus or a leafy structure. Thallus-type liverworts have a dichotomously-branched and dorso-ventrally flattened body that spreads out along moist riverbanks, on the surface of marshes, or on rotting forest logs. *Marchantia polymorpha* is most commonly used in introductory biology courses because of the unique shape of its antheridiophores and archegoniophores. However, a very similar-looking thallose liverwort, *Conocephalum* *conicum*, is extremely abundant around seeps, springs, and cold-water streams in calcareous soils throughout Michigan. The most obvious feature of *Conocephalum* is its large cells giving it an alligator-skin appearance. It is the one you are likely to encounter in this state.

The most-studied thallus liverwort is *Marchantia*. Its ribbon-like, dichotomously-branched gametophyte germinates from haploid spores. When male gametophytes mature, they produce small, umbrella-like structures called **antheridiophores** (means 'antheridia-bearing'), which have numerous antheridia embedded along their dorsal surface. Female gametophytes produce **archegoniophores** (means 'archegonia-bearing') that resemble miniature palm trees. Archegonia are formed on the ventral surface of the archegoniphore head (where the coconuts would be). Rain stimulates the antheridia to release sperm that make their way to a female gametophyte, up the archegoniophore stalk, and to the egg contained within the archegonium, where fertilization takes place and the zygote formed. Diploid sporophytes develop within swollen archegonia and sporangia are formed. Mature sporangia contain both spores (via meiosis) and **elaters**. As the elaters dry, they twist and disperse spores. *Marchantia* can also form new gametophytes asexually by means of **gemmae**, small multicellular bodies produced within **gemma cups**.

Leafy liverworts do not look anything like the thallus types; instead, they resemble diminutive mosses. However, they differ from mosses in several important ways, liverworts: 1) lack a protonema, 2) have single-celled rhizoids, and 3) have a 2-ranked leaf arrangement. In mosses, spores germinate to form protonema, they have multiple-celled rhizoids, and their leaves are usually 3- or 5-ranked.

FIGURE 40. ***Frullania eboracensis*, a leafy liverwort, from Steere 1940.**

Class Musci – The Mosses

Mosses can be easily separated into two groups: **brown mosses** and **peat mosses**. There is a large diversity of brown mosses throughout the world, but in North America, only one genus of peat moss—***Sphagnum***. *Sphagnum* has two features that allow it to dominate bog habitats worldwide: 1) large, open cells to soak up and transport rainwater and 2) an ion-exchange mechanism to obtain minerals that are in short supply in bogs.

FIGURE 41. *Sphagnum centrale*, **a peat moss, from Crum 1988.**

The gametophytes of brown mosses have two basic growth forms: 1) acrocarps—erect leafy stems, with terminal archegonia and 2) pleurocarps—prostrate leafy stems with lateral archegonia. Acrocarps of the genus *Mnium* are most often studied in introductory biology courses and we'll use it to describe the general moss lifecycle.

Antheridia or archegonia, depending on sex, are produced on the tips of mature acrocarpus gametophytes. As in liverworts, rain stimulates antheridia to release sperm which travel to the female gametophyte and into the archegonia, where fertilization takes place. Diploid sporophytes sprout from the archegonia, but carry with them a loose-fitting hood called the **calyptera**, which is actually part of the gametophyte. The sporophyte is composed of a long, slender seta and a capsule. The capsule is a modified sporangium and is composed of a **spore sack**; with an apical opening surrounded by a ring of small teeth, the **peristome**; and covered by a small cap, the **operculum**. When fully mature, the operculum falls away and the peristome teeth curl outward as they dry, which disperses the spores. Spores are produced are the result of meiosis thus they are haploid. Spores germinate into a filamentous protomena with root-like rhizoids. Leafy gametophytes develop from the protonema and, as they mature, produce specialized sex structures: antheridia and archegonia. Mosses reproduce asexually via fragmentation of the gametophyte.

Subkingdom Tracheophyta – The Vascular Plants

Several anatomical characters are associated with plant adaptation to life on land. Some of the more important features are: 1) protective walls surrounding spores to prevent desiccation, 2) a waxy cuticle to reduce evaporation, 3) stomata for gas exchange, 4) xylem and phloem to conduct water and food throughout the plant, 5) incorporation of lignin in cells for support, and 6) roots for anchorage and absorption of water and minerals from the soil.

The general life cycle of vascular plants has all the elements of the bryophytes, but as we look at higher evolved plants, the sporophyte generation becomes more dominant and the gametophyte becomes more dependent upon the sporophyte. Many primitive vascular plants (e.g., the whisk ferns, horsetails, some club mosses, and almost all ferns) produce only one type of spore—they are **homosporous**. When homosporous spores germinate, they develop into bisexual gametophytes that produce antheridia and archegonia. In this case, the gametophyte and sporophyte plants are completely independent. More advanced vascular plants are **heterosporous**; they produce **microspores** and **megaspores** (megaspores are not always larger than microspores). Microspores produce male gametopytes, whereas megaspores give rise to female gametophytes. For both types of heterospores, the gametophyte develops inside the spore wall, and mature gametophytes are released when the spore ruptures.

The Seedless Vascular Plants

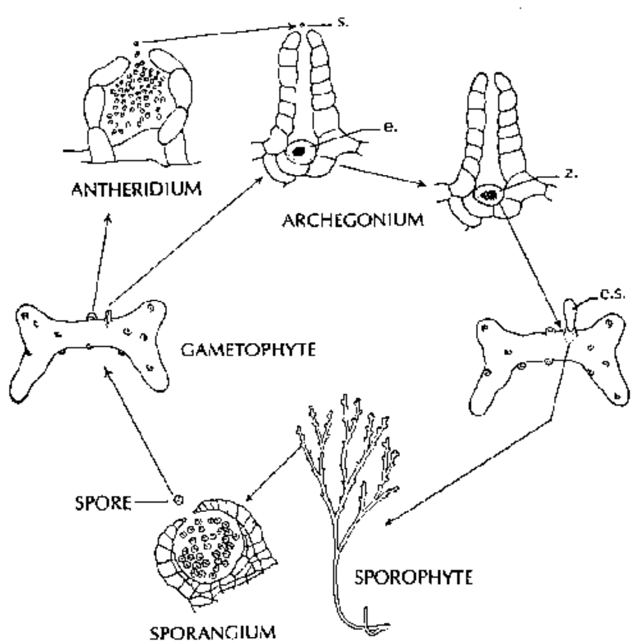
Seedless vascular plants were dominant terrestrial flora from the Devonian through Carboniferous periods (approx. 400–300 million years ago). Most plants of that time are now extinct, but the ferns and fern-allies are representatives still extent today.

Division Psilophyta – The Whisk Ferns

Only two genera of whisk ferns are living today: *Psilotum* and *Tmesipteris*. *Psilotum* is a tropical and subtropical plants that occurs in the extreme southern parts of the United States, whereas *Tmesipteris* is found in many South Pacific islands. *Psilotum* has no leaves or roots, just dichotomously divided branches and with sporangia produced at the ends of short, lateral branches.

Psilophytes are homosporous and have a nutritionally independent, gametophyte **prothallus** that produces antheridia and archegonia. Sperm from the antheridia are released in wet habitats and make their way to the eggs, which are inside the archegonia. The diploid zygote develops into the sporophyte.

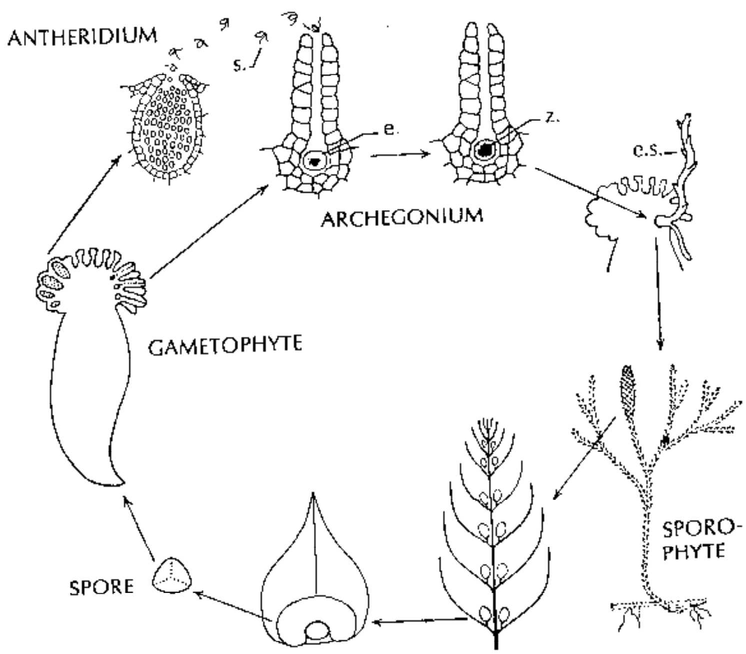
FIGURE 42. **Life cycle of *Psilotum*, after Cronquist 1971.**



Division Lycopoda – The Club Mosses and Quillworts

There are only five genera of lycopods, three of which are common in Michigan: *Lycopodium* and *Seliginella* (both are club mosses), and *Isoetes* (a quillwort). Club mosses resemble over-sized mosses with an elongated cone at its apex. *Lycopodium* is homosporous and has a bisexual, prothallic gametophyte.*Selaginella* is heterosporous in which the haploid microspores have male gametophytes developing inside them, and the haploid megaspores contain the female gametophyte. *Isoetes* is a small aquatic plant whose leaves resemble porcupine quills and is commonly found on lake bottoms.

FIGURE 43. Life cycle of *Lycopodium*, after Cronquist 1971.

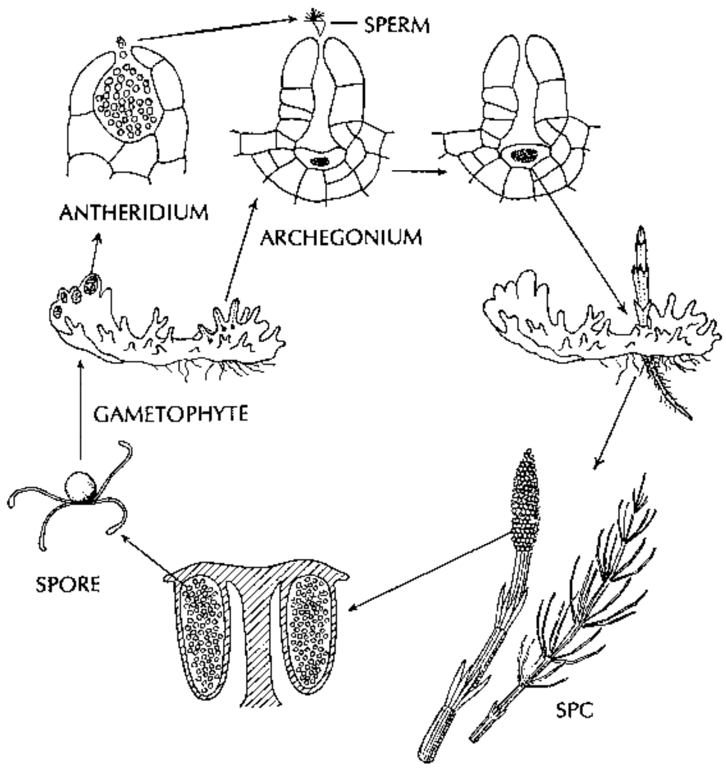


Division Sphenophyta – The Horsetails and Scouring Rushes

The sphenophytes reached their maximum abundance approximately 300 million years ago, but today are all extinct except for the single genus, *Equisetum*. Some of the fossil forms were tree-like, reaching heights of nearly 15 meters. Equisetum has two sporophyte types: both **fertile** and **sterile shoots**. Each shoot is comprised of sections joined at nodes. Sterile shoots have whorls of long, narrow leaves at each node, whereas fertile shoots lack leaves and chlorophyll. However, fertile shoots terminate with a sporangia-containing structure called a **strobilus**. *Equisetum* shoots have silica deposits in their outer tissue for strength. Early American pioneers often used *Equisetum* to their clean pots and pans, thereby earning the common name, scouring rush.

Equisetum is homosporous and produces independent, prothallic gametophytes (either male or bisexual), about the size of a pinhead, on recently flooded soils. Bisexual gametophytes produce eggs and multiflagellated sperm from their respective archegonia and antheridia. *Equisetum* also reproduces asexually as shoots along an underground rhizome.

FIGURE 44. ***Equisetum*** **life cycle, after Cronquist 1971.**



Division Pterophyta – The Ferns

Ferns are the largest group of seedless plants living today. Again, the sporophyte is the most conspicuous portion of the plant. Most of the fern stem is an underground rhizome that has aerial, **pinnately compound leaves**. The typical fern leaf has sporangia-containing **sori** along its underside, but some species have separate **fertile** and **sterile leaves**.

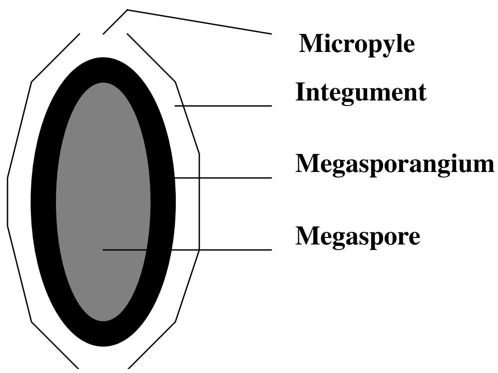
Most ferns are homosporous and germinate **heart-shaped**, bisexual gametophytes, called **prothalli**. Many ferns have prothalli that are photosynthetic. **Archegonia** appear as small, raised bumps on the underside of the prothallus's notched end; a single egg is produced with each archegonium. **Antheridia** are also found on the underside of the prothallus, but they are scattered among the many hair-like **rhizoids** towards the gametophyte's apex end. Antheridia are distinguished by the cluster of sperm nuclei they contain. Sperm swim through moist soils to the archegonia, and upon fertilization, a new sporophyte develops.

The aquatic fern, ***Marsilea***, is heterosporous. Its sporophyte leaves have a long petiole attached to four floating leaflets, suggesting a floating four-leaf clover. Sporangia are enclosed within a modified leaf structure called a **sporocarp**. Sporocarps are filled with a thick **gelatinous material** and a mass of **microspores** and **megaspores**. As the sporocarp decays, it breaks open from pressure produced by the expanding gelatin. *Marsilea* is excellent for observing a fern life cycle, because the male and female gametophytes have rapid development. While still in the gelatinous mass, microspores break open, the male gametophyte germinates and matures, and within 24 h, sperm are released. *Marsilea* sperm are cork-screw-shaped with multiple flagellae. Megaspores contain the female gametophyte, which is composed of a single, large cell and a small, multicellular archegonium. The female gametophyte matures within 14 h, produces a chemical attractant for the sperm, and fertilization normally occurs within 24 h. The embryonic sporophyte is also fast developing and can usually be seen in approximately 2–3 d.

Vascular Seed Plants

Evolution of seeds gave plants an important advantage in the ability to survive severe environmental conditions. Seed development begins with a highly reduced female gametophyte contained within a **megaspore**, which is contained within a **megasporangium**. In addition, megasporangia are enclosed, except for a small opening called the **micropyle**, by tissue layers, the **integuments**, that become a protective **seed coat** after fertilization. The unfertilized megasorangium plus its integuments is called an **ovule**.

FIGURE 45. **Schematic of an ovule showing the megaspore, megasporangium, and integument.**



Rather than using water as medium for bringing gametes together for fertilization, as with algae and seedless plants, seed plants use **pollination** to bring the sperm to the egg. Pollination employs wind, insects, birds, mammals, or sometimes water to carry pollen grains, which contain the male gametophyte, to the female gametophyte.

There are two major groups of seed plants: 1) the **gymnosperms**, those that have seeds, and ovules, exposed on the sporophyll (most often a cone), and 2) the **angiosperms**, which have their seeds enclosed within a fruit.

The Gymnosperms

Gymnosperms include the conifers, cycads, and ginkgoes. The name, gymnosperm, means ‘naked seed’ in reference to the fact that the seeds are exposed on the sporophyll. Pollination is usually accomplished via the wind, and afterwards, the pollen grain germinates a hypha-like pollen tube that grows through the ovule tissues to the female gametophyte. The pollen tube carries with it sperm nuclei and upon reaching archegonia, the tube bursts, releasing sperm to fertilize the egg.

Division Conifera

Conifers are today’s most numerous and widespread gymnosperms and they extend back into the fossil record almost 300 million years. Pines, firs, redwoods, junipers, cedars, hemlocks, cypresses, and yews are the most familiar conifers in North America and the tallest living plants on earth are the *Sequoia*, a redwood of northern California and Oregon. Modern conifers have highly modified, drought resistant leaves that are needle-like or flattened scales.

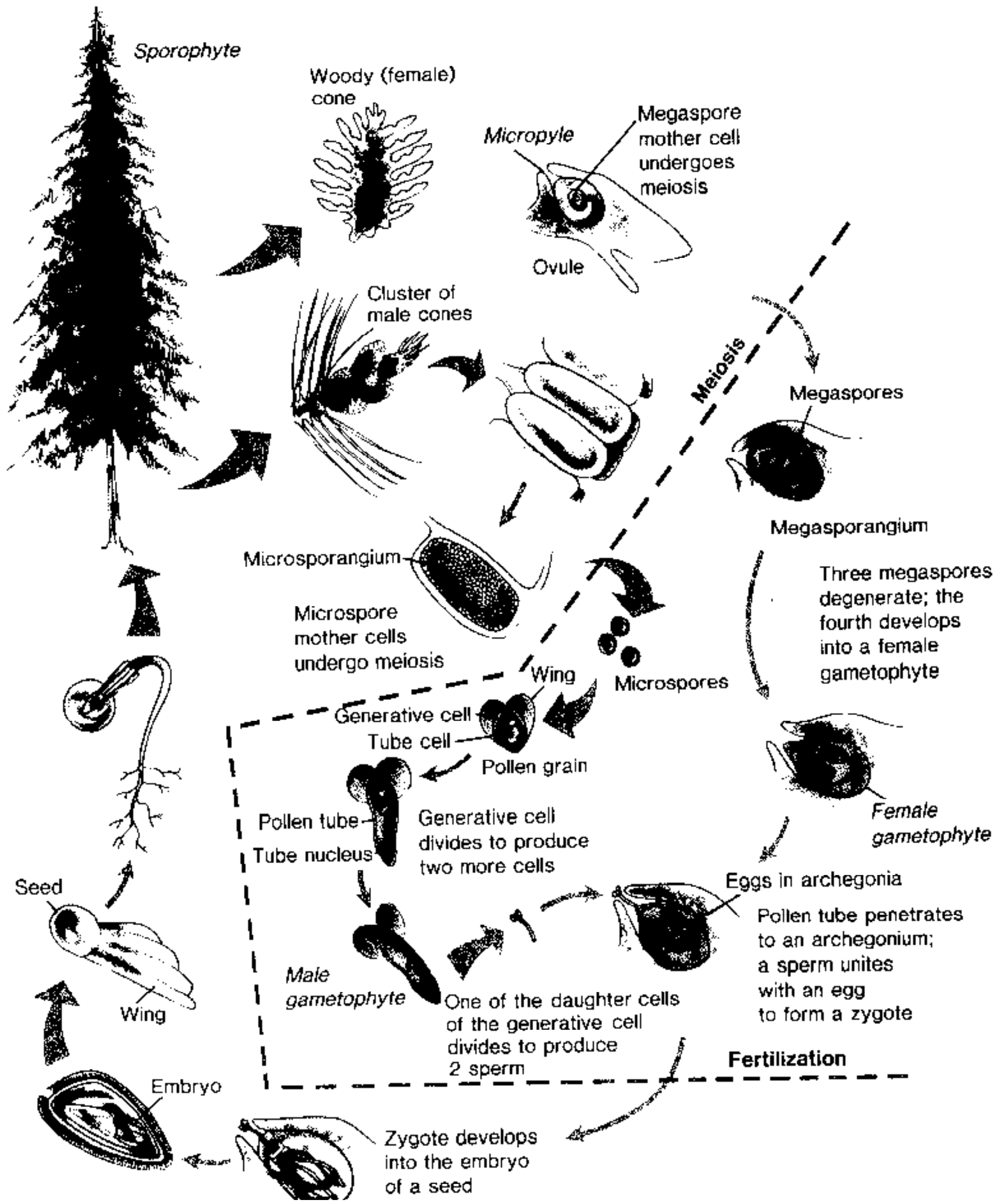
Pine Life Cycle

Microsporangia are borne on **male cones** while megasporangia are on **female cones**; both are in the same tree. Male cones are small, fleshy, and ephemeral; while female cones are woody and may remain attached for several years. Young microsporangia have numerous diploid, microspore mother cells and each undergoes meiosis to form haploid microspores. Each microspore develops into a pollen grain with two nuclei: a **generative nucleus** that gives rise to the sperm cells, and a **tube nucleus** that controls the pollen tube. Pine pollen has a unique, 'Mickey Mouse hat' appearance, where the mouse ears aid in being dispersed by the wind.

Each scale of the female come has two ovules, which are composed of a megasporangium surrounded by a thick integument. Inside the megasporangium, a diploid megaspore mother cell undergoes meiosis to form four haploid megaspores, of which only one survives. This remaining megaspore develops into the female gametophyte that bears two or three archegonia.

Once the pollen grain has reached a female cone's ovule, it takes approximately $1^1/_2$ years for its pollen tube to each the egg. Inside the tube, the generative nucleus divides to form two **sperm nuclei**, only one of which fertilizes the egg, the other degenerates. The fertilized ovule develops into two winged seeds, each of which is composed of an embryo, two embryonic leaves called **cotyledons**, an embyonic root, female gametophyte tissue that serves as reserve food, and a hard seed coat.

FIGURE 46. **Pine life cycle., after Johnson 1983.**



Division Cycadophyta

Cycads are palm-like, tropical and subtropical plants that dominated the landscape when dinosaurs roamed the earth. Today, about 100 species survive and only one species, *Zamia pumila*, is native to the United States; it's found in Florida. Cycads differ from palms in producing cones.

Division Ginkgophyta

Ginkgo biloba is the only surviving member of the Ginkgophyta. It is easily recognized by its fan-shaped, deciduous leaves that are deeply lobed. Ginkgo trees are diecious, male trees having small cones while female trees have fleshy-coated seeds that have a rancid odor. Ginkgoes were once native to Japan and China but today there are no wild populations. They are, however, a common ornamental plant. There is strong selection of male trees over female trees in horticulture to avoid the odoriferous fruit.

The Angiosperms

A single division, Anthophyta, comprises the angiosperms, which are the most complex and diverse group of living plants. In the strict sense, only plants of this group have true flowers and, as mentioned above, their seeds are usually enclosed in a fruit.

Division Anthophyta – The Flowering Plants

Flowering plants can be divided into two prominent classes: **Monocotyledones** (monocots) and **Dicotyledones** (dicots), based on a number of easily observed characteristics.

TABLE 56. **Comparison of monocot and dicot characters, after Raven et al. 1986.**

Characteristic	Monocots	Dicots
Flower Parts	in 3's or multiples of 3.	in 4's or 5's or multiples.
Cotyledons	one	two
Leaf Venation	parallel	net
Vascular Bundles	scattered or complex arrangement	in a ring
True Secondary Growth (with vascular cambium)	absent	can be present

Flowers

Flowers may be arranged on a plant in many different patterns; some are borne singularly, while others are in various clusters or **inflorescences**. Solitary flowers are raised on a stalk called a **peduncle**, whereas infloresecnes are on a **pedicle**. Two sets of floral appendages are often modified to attract pollinators. The inner appendages and often brightly colored are the **petals**, collectively called the **corolla**. The outer appendages are often green; they are **sepals** and called collectively the **calyx**. In some cases, both the corolla and calyx are brightly colored, while in others, both are reduced and inconspicuous.

The male part of flowers is the stamen. It is composed of an anther, which contains the microsporangia and pollen, and is held up by a slender filament. The pistil is the female part of the flower. In the typical case, it is comprised of a **stigma**, a slender **style**, and an **ovary**, which contains the ovules and female gametophyte.

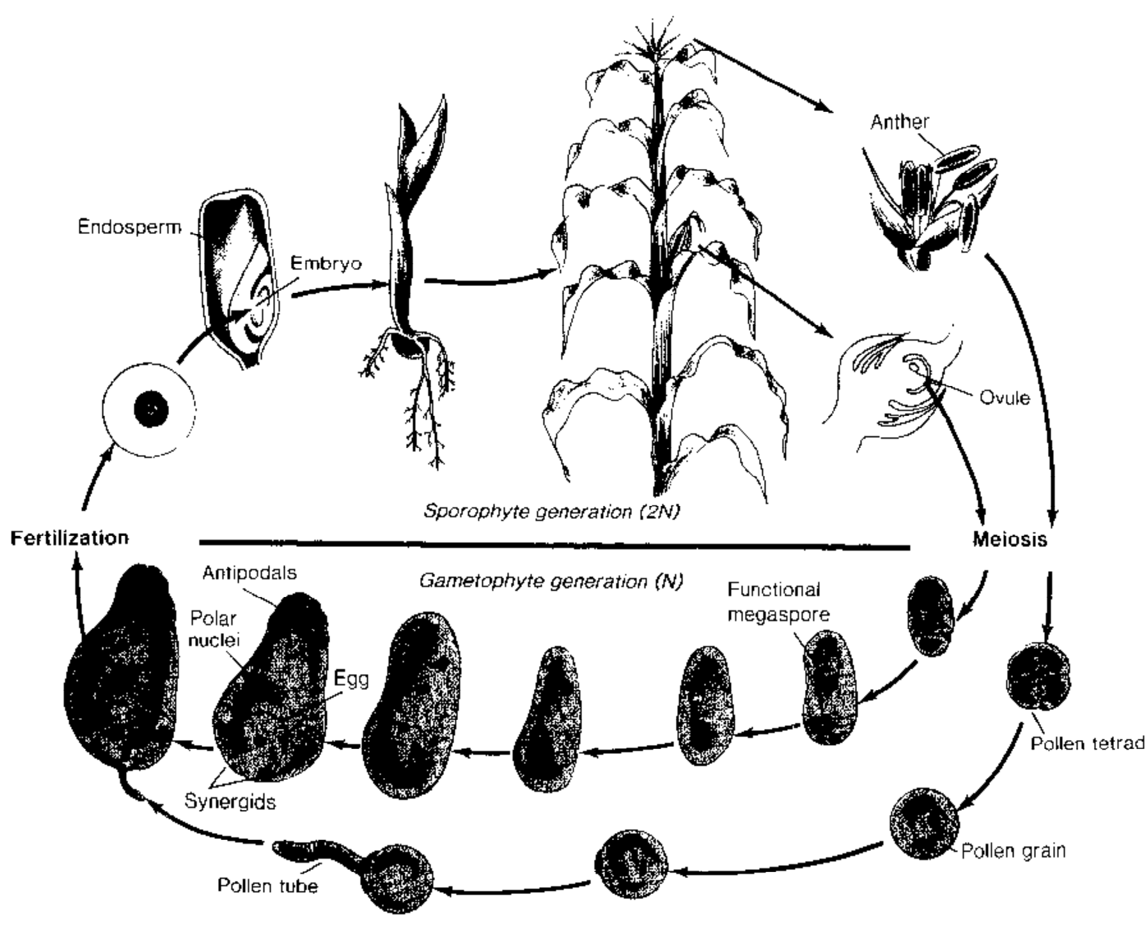
Life Cycle

The anthers contain the **microspore mother cell**, which undergoes meiosis to form haploid **microspores**. These microspores undergo further development to become **pollen grains**. Within the pollen grain, two nuclei are formed: the **tube nucleus**, which controls the pollen tube, and the **generative nucleus**, which further divides to form two **sperm nuclei**.

A diploid **megaspore mother cell** inside the ovule undergoes meiosis to form four haploid **megaspore nuclei**, three of which degenerate. The remaining megaspore divides mitotically to form two, haploid nuclei and each of these migrate to opposite ends of the ovule where they divide twice so there are four haploid nuclei at each end. One nucleus from each end migrates to the center to form the **polar nuclei**. One of the three nuclei closest to the micropyle becomes the **egg** and the other two become the **synergid nuclei**. The three remaining nuclei at the ovules opposite end have no known function.

The transfer of pollen from the anthers to the stigma is **pollination**. There is a wide variety of methods that pollination is accomplished in angiosperms, some of the most complex methods involve the **coevolution** of flowers and insects to insure cross pollination among flowers of the same species. After reaching the stigma, the pollen germinates a tube that grows down through style and ovary tissues until it penetrates the ovule. Inside the ovule, the tube discharges the two sperm. One nucleus fuses with the egg nucleus to form the zygote and subsequent embryo, while the second sperm fuses with both polar nuclei to form a triploid **endosperm** nucleus. The endosperm in many plants is a food-storage tissue.

FIGURE 47. Corn life cycle, from Johnson 1983.



Root Tissue

Roots function in anchoring the plant and absorbing water and minerals from the soil. Often roots also serve in food storage. Various root tissues assist in these duties. The tip of growing roots have a root cap made large cells which are sloughed off as the roots moves through the soil. The root cap protects rapidly growing **apical meristem**. Meristem cells will later differentiate into cells and tissues specialized for food storage, or for conducting water or food. Above the apical meristem is a **region of elongation**, where cells elongate and continue differentiating. You will look at cells apical meristem cells to observe chromosomes in various stages of mitosis.

Some tissues can be best seen in a root cross-section. The **epidermis**, the outer most tissue, protects from soil abrasion. Much of the root is taken up with **cortex**, which is comprised of large cells specialized for starch storage. Towards the root's center there is usually a prominent **vascular cylinder**. **Endodermis** cells make up the vascular cylinder's outside boundary. Just inside the endodermis are one or more layers of the **pericycle**, which can give rise to lateral roots. The bulk of the vascular cylinder is comprised of two tissues: **xylem** and **phloem**. Xylem is made of large, thick-walled, empty cells for transporting water; whereas phloem is made up of bundles of smaller, thinner-walled sieve cells and sieve-tube members. You should be able to find these tissues in a root cross-section.

Stems

Monocot stems typically have xylem and phloem in vascular bundles that are scattered through out the stem cross-section. You should also me able to find the epidermis and cortex. The vascular tissue of dicots is arranged so that the phloem is outside the xylem. Between these tissues is a few layers of a highly mitotic, **fascicular cambium** that adds cells to both xylem and phloem. Cortex is found outside and between dicot vascular bundles. The innermost ground tissue of an herbaceous dicot stem is made of large-celled **pith** tissue.

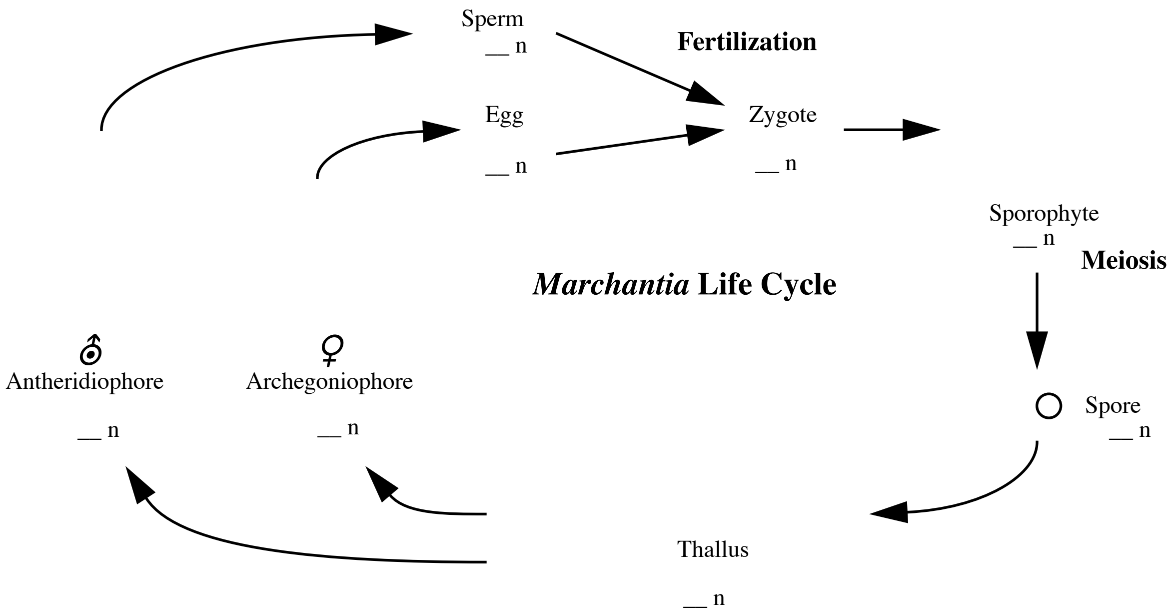
Leaves

Several specialized tissues for photosynthesis can be observed in a leaf cross-section. Corn leaf cross-sections show an upper layer of clear cells (devoid of chloroplasts) which make up the upper **epidermis**. Scattered along the epidermis are openings for gas exchange called **stomata**. Each stoma is surrounded by a pair of small, choroplast-filled cells, called **guard cells** that control the opening's size. Other specialized cells on the epidermis are **bulliform cells**. These large, empty cells allow the leaves to fold. The vascular bundles of corn leaves are surrounded by **bundle sheath cells**, which are important for a high-efficient form of photosynthesis (C_4-photosynthesis) of which corn is capable. Chloroplast-filled **mesophyll** cells surround each vascular bundle. This arrangement is called **Kranz anatomy**.

A typical dicot cross-section has an upper and lower epidermis, **palisade mesophyll** in columns, loosely-arranged **spongy meophyll**, vascular bundles, stoma, and guard cells.

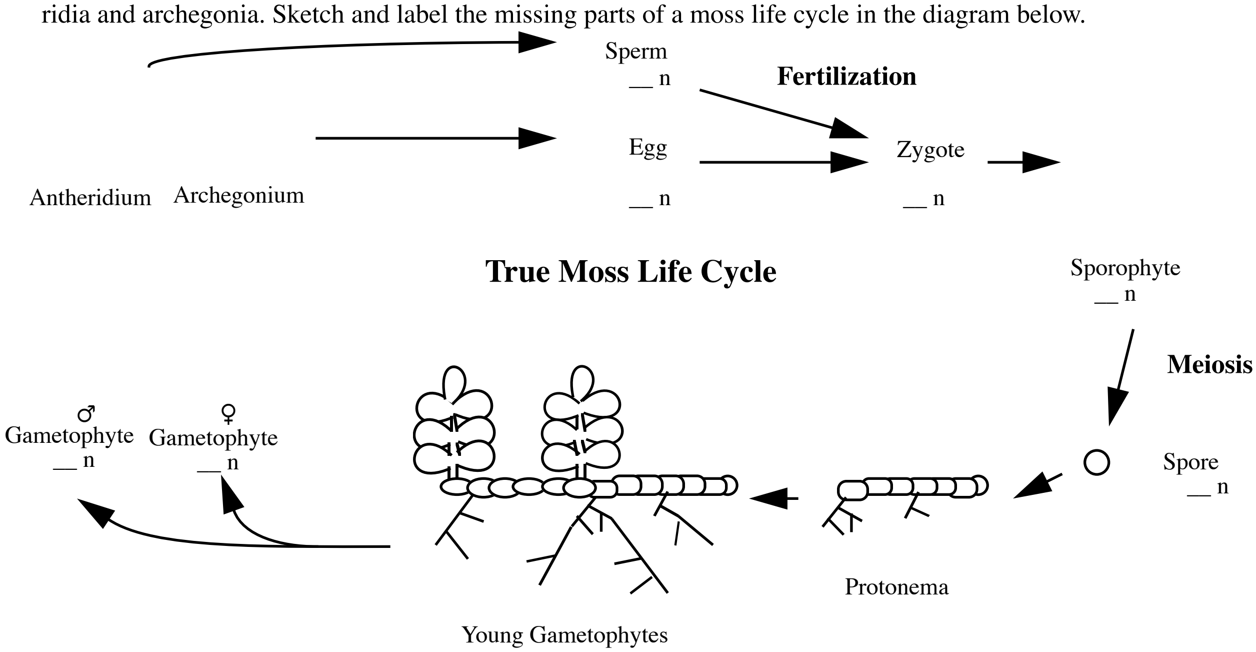
Exercises:

1. Observe the thallose liverwort, *Marchantia*, on display. Sketch the missing parts to complete the diagram of its life cycle. Label the antheridia, archegonia, sporophyte, and gemmae cups. Look at *Conocephalum conicum* also on display and note the difference between *Marchantia* and *Conocephalum*.



2. Observe the leafy liverworts on display. Note two differences between them and mosses?

3. Observe the acrocarpus and pleurocarpus mosses on display. Also, obtain a prepared microscope slide of moss antheridia and archegonia. Sketch and label the missing parts of a moss life cycle in the diagram below.

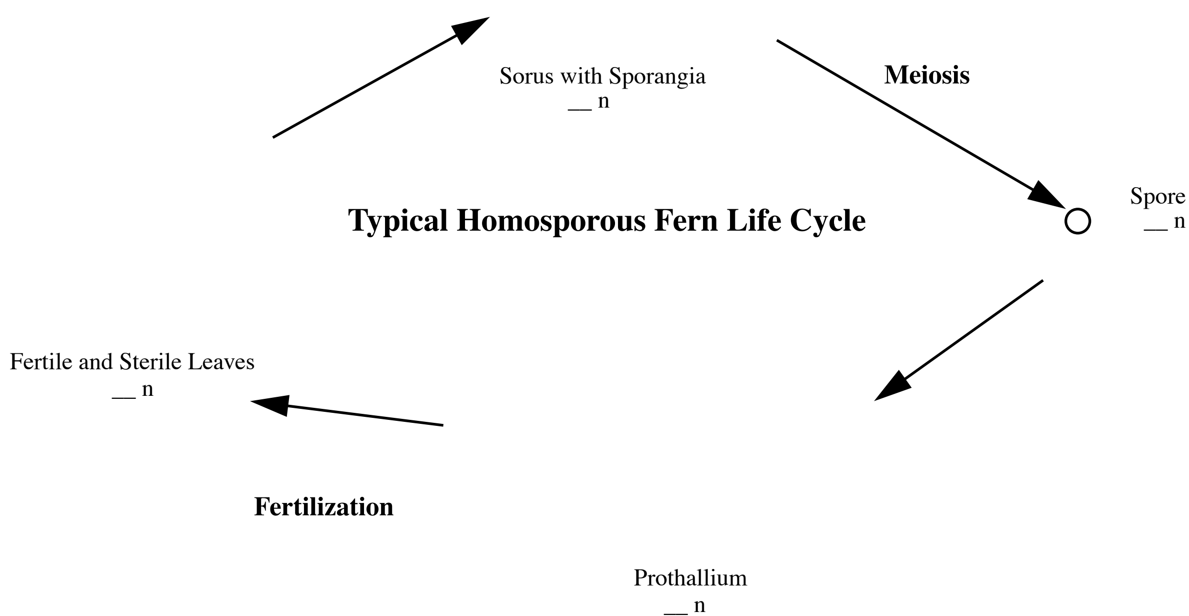


4. Observe the *Sphagnum* on display.
5. Observe the *Psilotum* on display. Sketch and label the sporophye, showing its branches and sporangia.

6. Observe the *Lycopodium* and/or *Selaginella* on display. Sketch and label the sporophyte the these plants.

7. Observe the *Equisetum* on display. Sketch and label its fertile and sterile shoots, noting the nodes, leaves, and strobilus.

8. Observe the ferns on display, note which have fertile leaves and sterile leaves. Obtain a prepare microscope slide of Fern Prothallia. Sketch and label the missing parts of a typical fern life cycle in the diagram below.



9. Follow the developmental stages of the aquatic fern, *Marsilea*, on demonstration (by the window). These can be found in various petri dishes in the lab that are labeled as to the date and time germination began. You should try to find, sketch, and label the following:

- Stage 1: Gelatinous ring bearing sori. This is directly after (30–90 m) nicking the sporocarp.

- Stage 2: Maturation of microspores and megaspores (7–14 h) Separate mega- and microspores by pulling apart the sori with a dissecting needle. The microspores will float while the megaspores generally sink. Make a detailed sketch of the microspores and megaspores. Label your drawings.

- Stage 3: Fertilization. The archegonium will appear green when fertilization takes place. On your drawing, indicate the path of sperm entry.

- Stage 4: Young Sporophtye.

- Stage 5: Mature Sporophyte.

10. Observe various examples of conifer branches and cones on display. Note differences between male and female cones, pine and spruce needles, pine and spruce cones, etc.

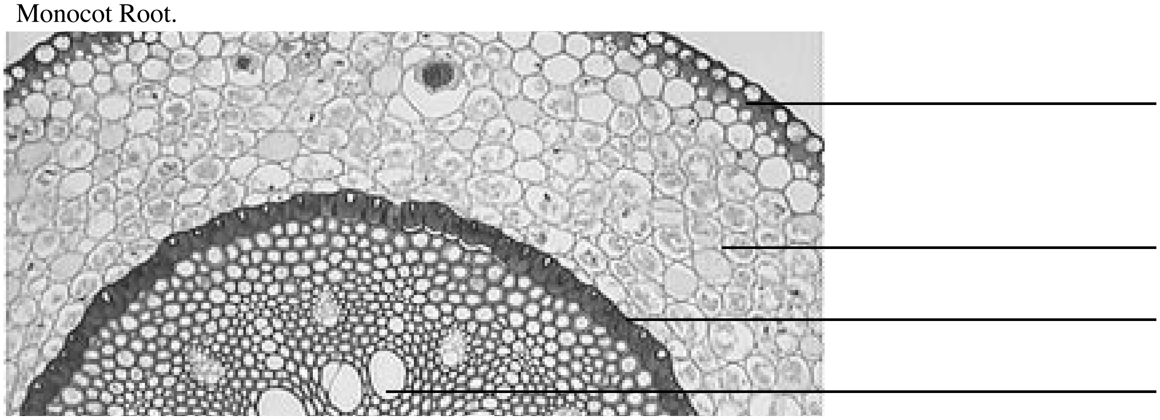
11. Observe the *Ginkgo biloba* tree near Holmes Hall just outside the exit doors closest to the lab. Note its distinctive leaf shape.

12. Observe the various angiosperms on display. Can you tell which are monocots and which are dicots? If available, dissect a *Gladiola* flower. Sketch and label its flower parts in the space below.

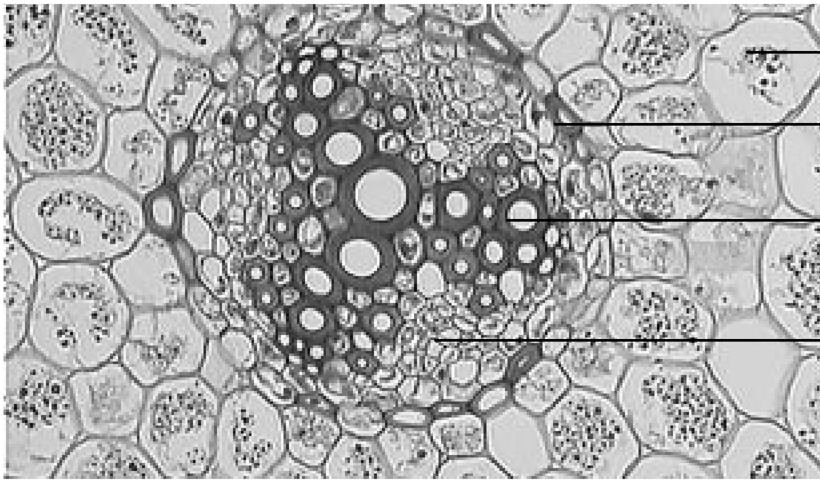
13. Prepare a root tip for observing mitotic stages. Stain, squash, and prepare a wet mount of the root tip material as described on the instruction sheet in lab. Draw and label chromosomes in the following mitotic phases: interphase, prophase, metaphase, anaphase, and telophase.

14. Obtain a microscope slide of Typical Monocot and Dicot Roots. Label the structures in.

- Monocot Root.

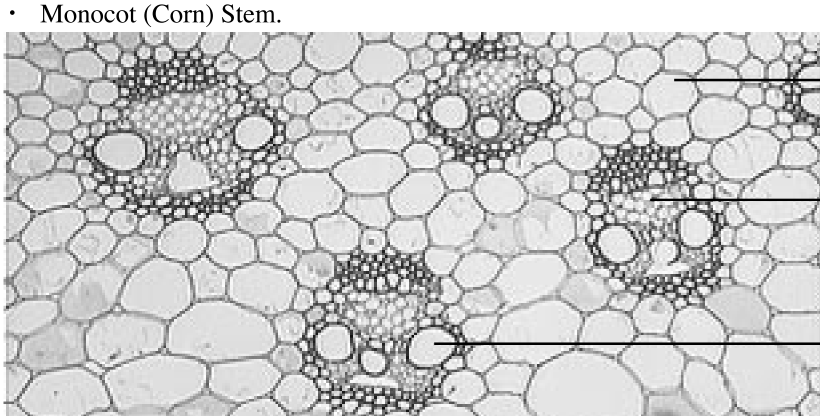


- Dicot Root.

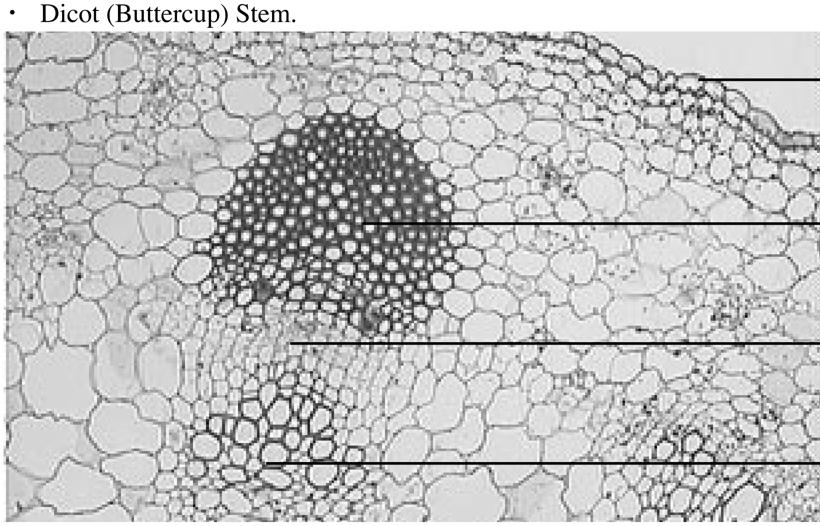


15. Obtain a microscope slide of Typical Monocot and Dicot Stems. Label parts of the monocot and dicot stems on the diagram below.

- Monocot (Corn) Stem.

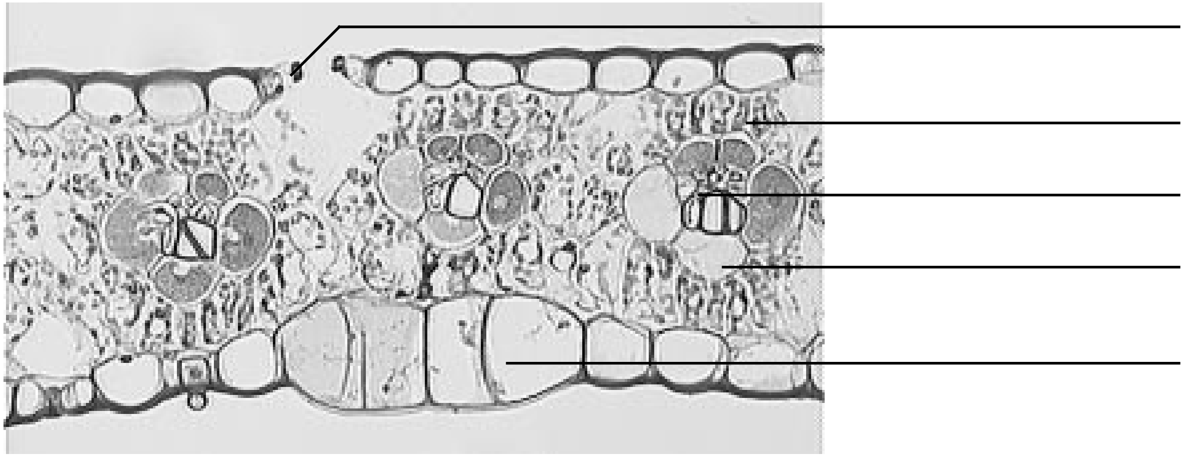


- Dicot (Buttercup) Stem.

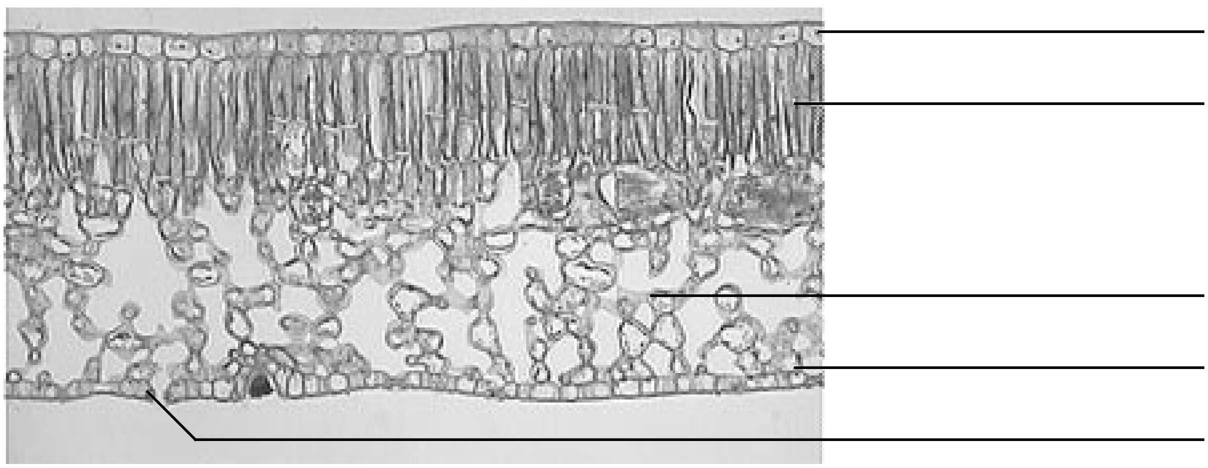


16. Obtain a microscope slide of Typical Monocot and Dicot Leaves. Label the parts of each on the diagrams below.

- Monocot (Corn) Leaf Showing Kranz Anatomy.



- Dicot Leaf.



17. Ask the TA on duty for an exit quiz.