

Kingdom Plantae

Objectives

- Be able to recognize and name the plant phyla studied
- Understand the life cycle of these phyla
- Know what alternation of generations means
- Be able to distinguish between sporophyte and gametophyte
- Be able to identify and name important reproductive structures in the phyla studied

Introduction

The Kingdom Plantae is composed of multicellular, photosynthetic organisms which differ from the animal kingdom not only in their ability to manufacture their own food, but also in the number of phases they pass through in their life cycle.

When diploid animals reproduce, specialized cells undergo meiosis and produce haploid cells that mature into gametes (sperm or eggs). These gametes join at fertilization, producing a new diploid animal and completing the life cycle. When diploid plants (called sporophytes) reproduce, specialized cells undergo meiosis and produce haploid cells called spores. These do not become gametes but germinate and grow into multicellular haploid plants called gametophytes. Specialized cells in the gametophyte then produce gametes by mitosis.

These gametes will join at fertilization and produce a new sporophyte plant, completing the life cycle.

Because a plant's life cycle has these two distinct multicellular phases, this life cycle is referred to as Alternation of Generations. A generalized plant's life cycle is shown in the diagram.

Plant groups differ largely by the appearance of structures associated with their life cycle, the relative amount of time the sporophyte and gametophyte persist, and the ability of the sporophyte and gametophyte to survive independently. To begin examining these, go to the Diversity section of the BiologyOne DVD and select 'Kingdom Plantae'. The four phyla covered in this lab are introduced. Click on the forward arrow in the lower right to begin your investigation of the Phylum Bryophyta.

Activity 22.1 Division Bryophyta

The Bryophyta include the mosses, hornworts, and liverworts. These are relatively small plants found in habitats that are wet at least once during the year but most Bryophytes can withstand drought periods by becoming dormant. The gametophyte generation is dominant in this group.

In the Kingdom Plantae simulation of the BiologyOne DVD, examine the gametophyte plant of bryophytes. Note the relatively small size. Usually these grow no taller than 20 cm. Along the axis of the plant are flat, leaflike structures called microphylls. If you examine the anatomy of the gametophyte, you would find an absence of tissue to conduct water or nutrients. Answer the questions in the Results Section.

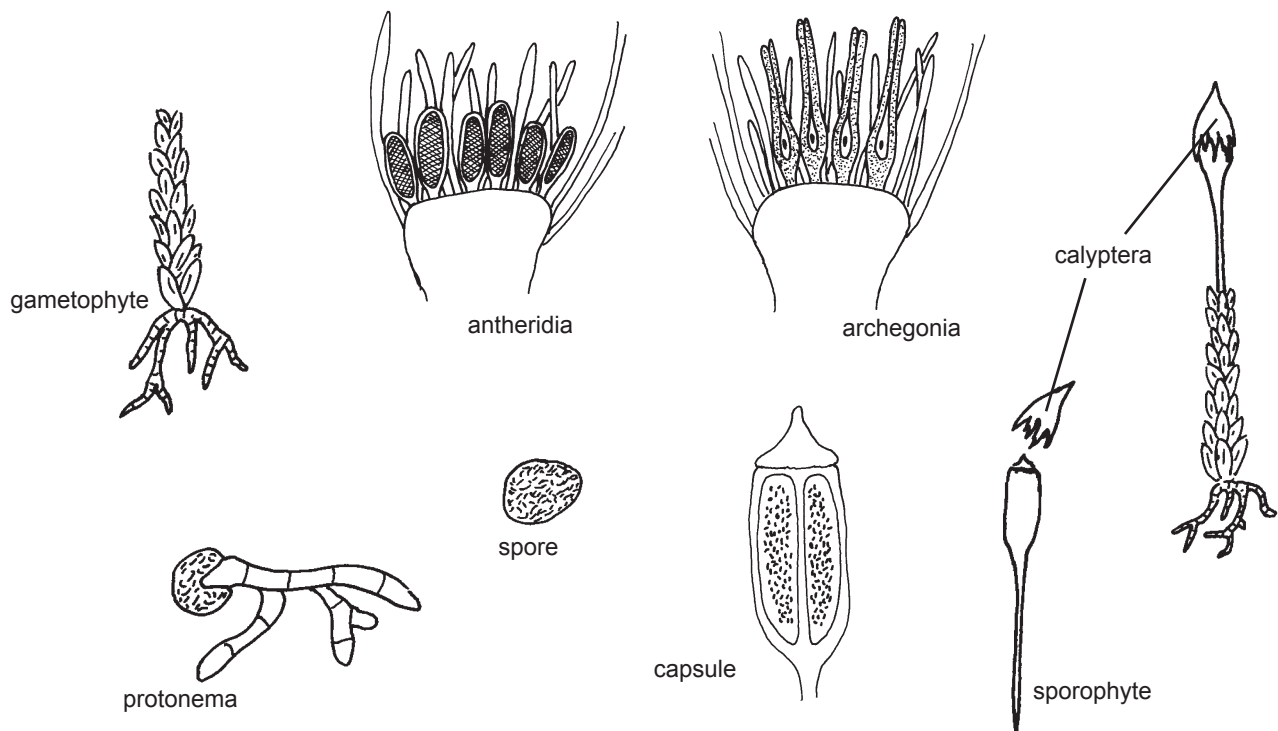
The structures which produce gametes are located at the top of the gametophyte plant among the top microphylls. The structure that produces sperm cells is termed an antheridium (pl. antheridia) and the structure that produces an egg cell is termed an archegonium (pl. archegonia). The flagellated sperm swim through a film of water to

reach the archegonia and then swim down the central canal to fertilize the egg.

After fertilization, the newly formed zygote grows into the sporophyte plant. However, the sporophyte is never released from the gametophyte; it just grows from the top of the gametophyte. The part of the sporophyte called the foot anchors the sporophyte in the gametophyte and absorbs food and water from the gametophyte. At the top of the sporophyte, a capsule is formed, within which meiosis occurs and the spores are produced. When the spores are mature, the top of the capsule, the operculum, pops off and the spores are then dispersed by the wind. Frequently, an immature capsule is covered by a thin tissue layer called the calyptra. This is actually derived from the top of the archegonium and consequently is haploid tissue.

After the spores are released they will begin to grow when environmental conditions are favorable. The first structure that grows from a spore is an alga-like filament of cells. This is called the protonema and will eventually develop into the mature gametophyte.

Structures of Moss Life Cycle



Activity 22.2 Division Pterophyta

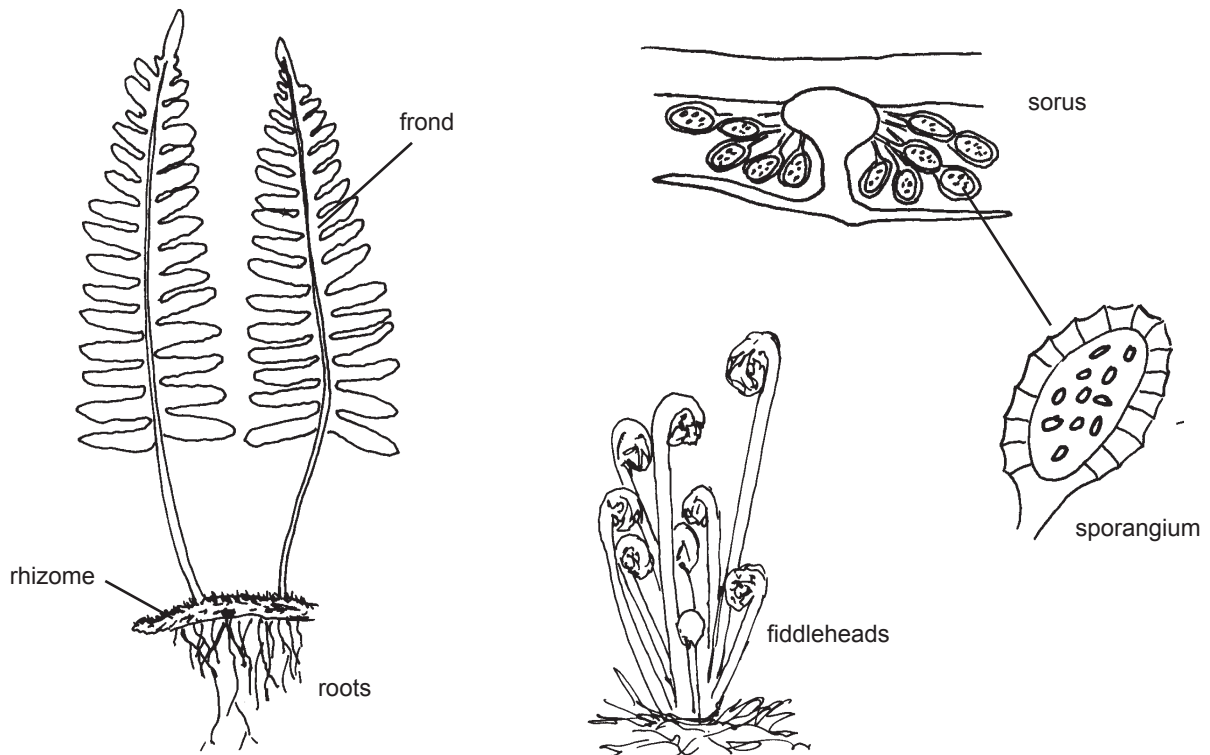
Other members of the Phylum Bryophyta include the liverworts and the hornworts (some place these in separate phyla).

After studying the structures of moss, label the illustration of the moss life cycle in the Results Section.

The Pterophyta are the ferns. This is a very diverse group with members found growing from the tropical forests to above the Arctic Circle. The majority are found in warm, moist habitats. Like the Bryophytes, for completion of the life cycle, the ferns require a wet period in the growing season. Unlike the Bryophytes, the sporophytic phase is the dominant generation.

Examine the pictures of the fern sporophyte. Usually, all one is able to observe above the ground are the leaves, referred to as fronds. Frequently, the fronds are highly dissected, giving the incorrect impression that there are many small leaves on each frond. These small blade structures on the frond are called the pinnules. When the leaves emerge, they unroll in a characteristic pattern. These immature leaves are referred to as fiddle heads because of their appearance. Below ground, one will find the horizontally growing stem called a rhizome. From the rhizome grow roots down into the soil. The development of a system to transport water and nutrients allows the sporophyte to grow to a large size. This transport system

Fern Sporophyte



is referred to as the vascular system and is composed of two principle tissues: xylem to transport water and minerals from the roots and phloem to transport sugar nutrients from the leaves. Vascular tissues also provide structural support to the plant.

On the under side of the fronds, you frequently find structures that appear as dark spots or, in some species, as rows or mats. These are the locations where spore-producing structures are located. These structures are called the sori (singular = sorus). These are clusters of spore producing sacs called sporangia. Around the outside of each sporangium is a layer of cells with thick walls called the annulus. These cells help to open the sporangium and disperse the mature spores. The sporangia are connected to the center of the sorus by stalks. In many species, a flap of tissue covers the sporangia of a sorus. This flap is called the indusium and helps protect the sporangia as they mature.

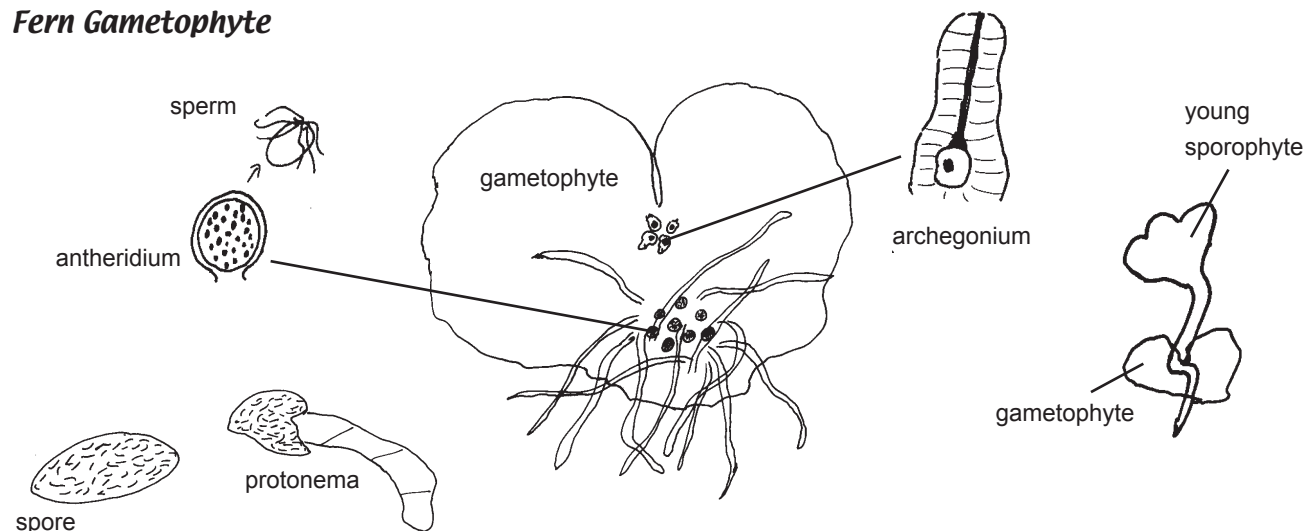
After the spores are released, when favorable conditions occur they will germinate and grow into the gametophyte plant. Initially the gametophyte is filamentous but soon grows into a somewhat heart shaped plant, but remains only a few cell layers thick. The gametophyte is green and photosynthetic. On the bottom side of the gametophyte are hairlike cells called rhizoids which extend down into the substrate to anchor the gametophyte and help absorb water and nutrients. Examine the pictures of fern gametophytes and answer the questions in the Results Section.

On the lower surface of the gametophyte, specialized structures are formed to produce the sperm and the eggs. The sperm-producing structure is called the antheridium; the egg producing structure is called the archegonium. Depending on the species, the gametophyte may produce both antheridia and archegonia or may only produce one type. When both are produced on a single gametophyte, the archegonia are usually found near the notch of the 'heart'. The antheridia are usually found among the rhizoids, closer to the bottom of the heart shape .

When the flagellated sperm are mature, they are released and swim through a film of water to an archegonium. There they will swim down the central canal to fertilize the egg. The newly formed zygote will grow to form a new sporophyte. Initially, the sporophyte remains attached to the gametophyte, using it for nutrition. However, very shortly, the sporophyte develops roots and grows independently of the gametophyte. The gametophyte will eventually wither and die. Examine the micrographs of young sporophytes. Any young sporophytes will grow out from the underside of the gametophyte, usually emerging somewhere around its 'notch.'

Divisions with similar life cycles include the Lycopphyta and Equisetophyta.

Fern Gametophyte



Activity 22.3

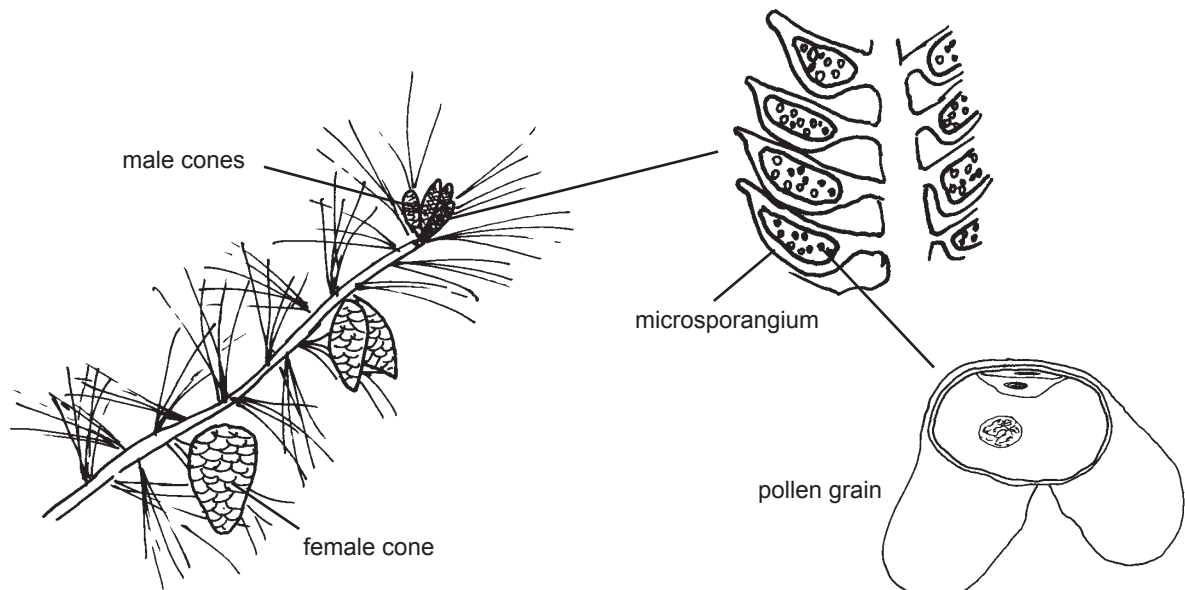
Division Coniferophyta

The Coniferophyta includes the pines, firs, and spruces. These plants are found throughout the world, but are especially abundant in cooler climates. The sporophyte phase is dominant in the life cycle, producing plants which are the largest in the world (the California Redwoods, *Sequoia sempervirens*, reach heights of 340 feet).

Look at the diagram of the stem cross section shown here. This is part of the sporophyte generation. The axis of the branch and stem is mostly vascular tissue (secondary xylem and secondary phloem). These tissues have been produced by a layer of dividing cells called the vascular cambium, located between the bark and the wood. Secondary xylem is produced toward the center, creating the wood, while secondary phloem is produced toward the outside, creating part of the bark. Seasonal variations in growth create the annual rings seen in wood.

Examine one of the pictures that shows a branch with needles. At the base of the needles is a small scale called the scale leaf. From the axis of this scale leaf is the structure called the spur shoot which actually produces the needles. Most conifer needles are evergreen (retain their leaves year round) rather than deciduous (lose their leaves annually). Can you think of advantages of an evergreen habit? Disadvantages? Place your thoughts in the Results Section.

Pine Male Structures



The reproductive structures of conifers are produced in specialized structures called cones. One type of cone produces spores which produce gametophytes which only produce eggs. This cone is correctly referred to as a megastrobilus but sometimes (inaccurately) called a female cone. Another type of cone produces spores which produce gametophytes which only produce sperm. This second type of cone is correctly referred to as the microstrobilus but sometimes (also inaccurately) called a male cone. Examine the micrographs of the microstrobilus and pollen grains.

The microstrobilus is composed of a number of scales called microsporophylls. On the lower surface of each microsporophyll is a sac called the microsporangium. Inside this sac, meiosis occurs, producing microspores. At this point, the development pattern differs from Bryophyta and Pterophyta. The spore does give rise to the gametophyte, however, the spores are not released from the microsporangium nor does the gametophyte plant grow outside the spore wall. Instead, cell divisions inside the microspore usually gives rise to a four-celled gametophyte, one of which is the sperm cell. A microspore containing the gametophyte portion of the life cycle inside is referred to as a pollen grain. When the pollen grains are mature, the microsporangium will break open and the pollen is dispersed

by wind. Make your own drawing of these structures in the Results Section.

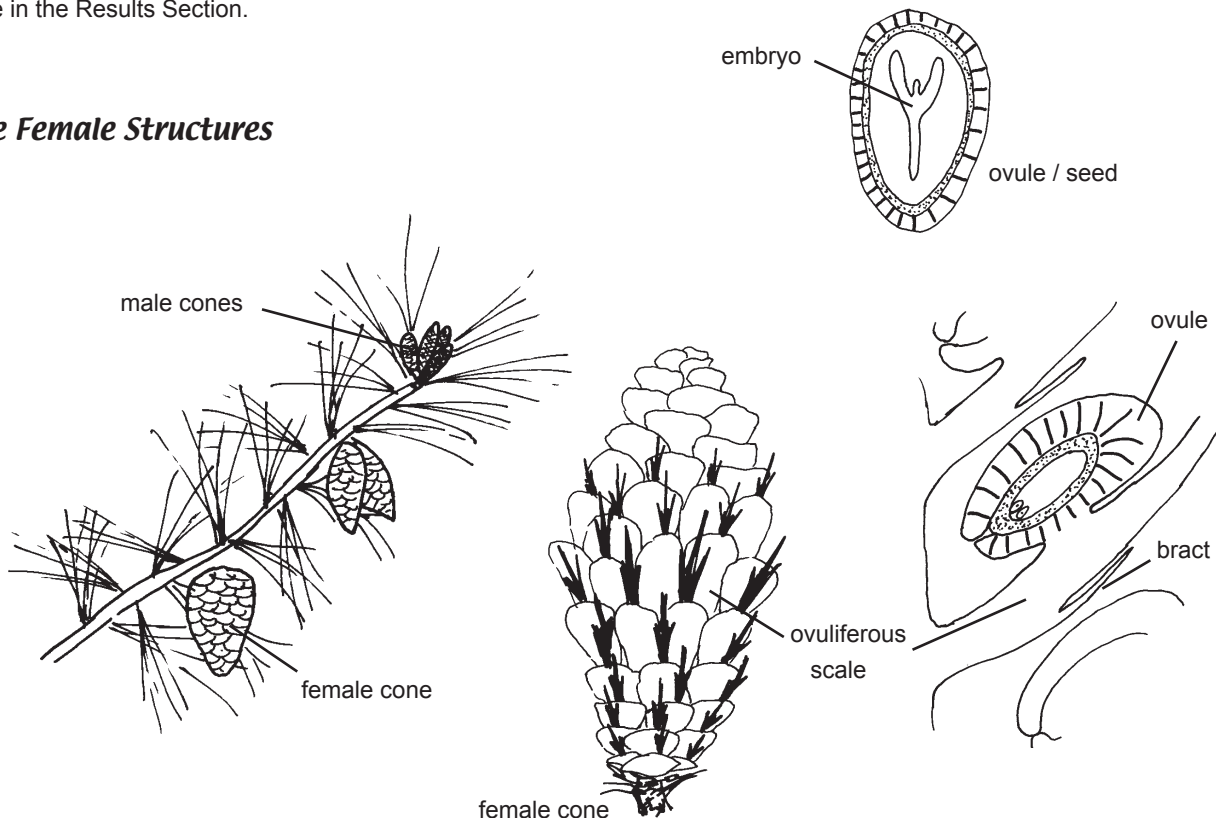
Next examine the pictures and the whole specimen of the megastrobilus. Like the microstrobilus, the megastrobilus is composed of a number of scales. Here they are referred to as ovuliferous scales. On the upper surface of each ovuliferous scale is a sac, which at its center, will produce a single megaspore by meiosis. Surrounding and protecting this spore are several layers of tissue; the outermost layers make up the integument. This structure, a megaspore surrounded by tissue layers including the integument, is called an ovule. When an ovule matures, it is referred to as a seed.

Inside the spore, the gametophyte portion of the life cycle will develop. As with the microspores, the gametophyte will not be released from inside the spore wall. The gametophyte will grow and eventually produce two egg containing structures, the archegonia. Generally, only one of these archegonia will be fertilized to produce a new sporophyte generation. Make your own diagram of an ovule in the Results Section.

When pollen, dispersed by the wind, is deposited near an ovule, a specialized cell of the pollen's gametophyte will grow out of the pollen grain and produce a pollen tube which will eventually reach the gametophyte inside the ovule. Here, the sperm nucleus, which is located near the end of the pollen tube, will be released and fuse with the egg cell. In conifers, the maturation of a fertilized ovule, now the seed, is a prolonged process taking as long as two years. Examine the megastrobilus cones available and try to determine its stage of development using the diagram of a conifer's life cycle.

Other divisions with a life cycles similar to the pines are the Cycadophyta, Ginkgophyta and Gnetales.

Pine Female Structures



Activity 22.4

Division Magnoliophyta

The Magnoliophyta include all the flowering plants. This group is the most recently evolved group of plants as well as the most successful. Flowering plants are found throughout the world. The flower of flowering plants is a reproductive structure which is much more efficient than the cone structures of conifers however the basic structures are very similar.

The sporophyte is the dominant phase of the flowering plant's life cycle. All of these sporophytes will produce xylem and phloem but only some will produce secondary xylem (wood) and secondary phloem (part of the bark). Those plants which do not produce wood are referred to as herbaceous. The leaves of flowering plants are usually flattened and blade-like, unlike the needles of conifers. Frequently these leaves are deciduous, shed each year. The reproductive structures of these plants are located within the flower. The flower also contains some non-reproductive structures, the sepals and petals.

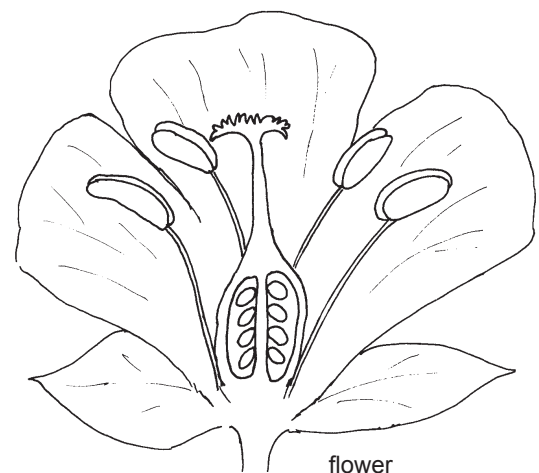
In flowering plants, the development of pollen from microspores is much the same as in the conifers. This occurs in sacs called anthers. Just as with conifers, ovules are

produced but here in the flowering plants, the ovules are enclosed within another structure called the ovary. After fertilization, the ovules mature into the seeds and the ovary matures into the fruit.

A unique characteristic of the flowering plants is that when fertilization occurs, two sperm are actually delivered by the pollen tube. One of these sperm will fertilize the egg cell in the megagametophyte, the other will fuse with two other cells in the gametophyte to produce a tissue with three sets of chromosomes, said to be triploid or $3N$. This $3N$ tissue is called the endosperm and will initially serve as a nutrient source for the developing embryo. This process is referred to as double fertilization.

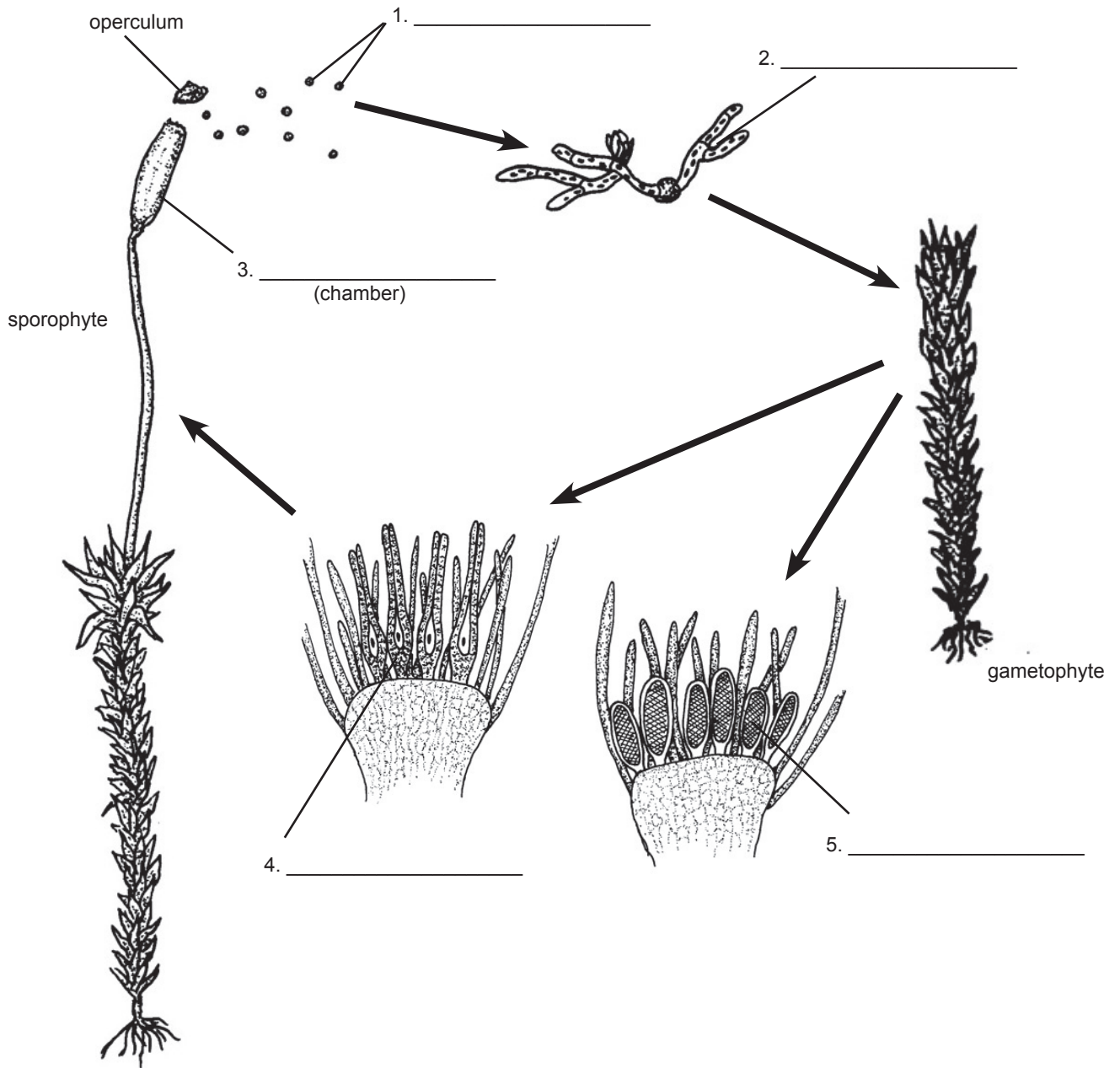
A more detailed examination of reproduction in flowering plants is found in other lab modules.

Sporophyte of Flowering Plants

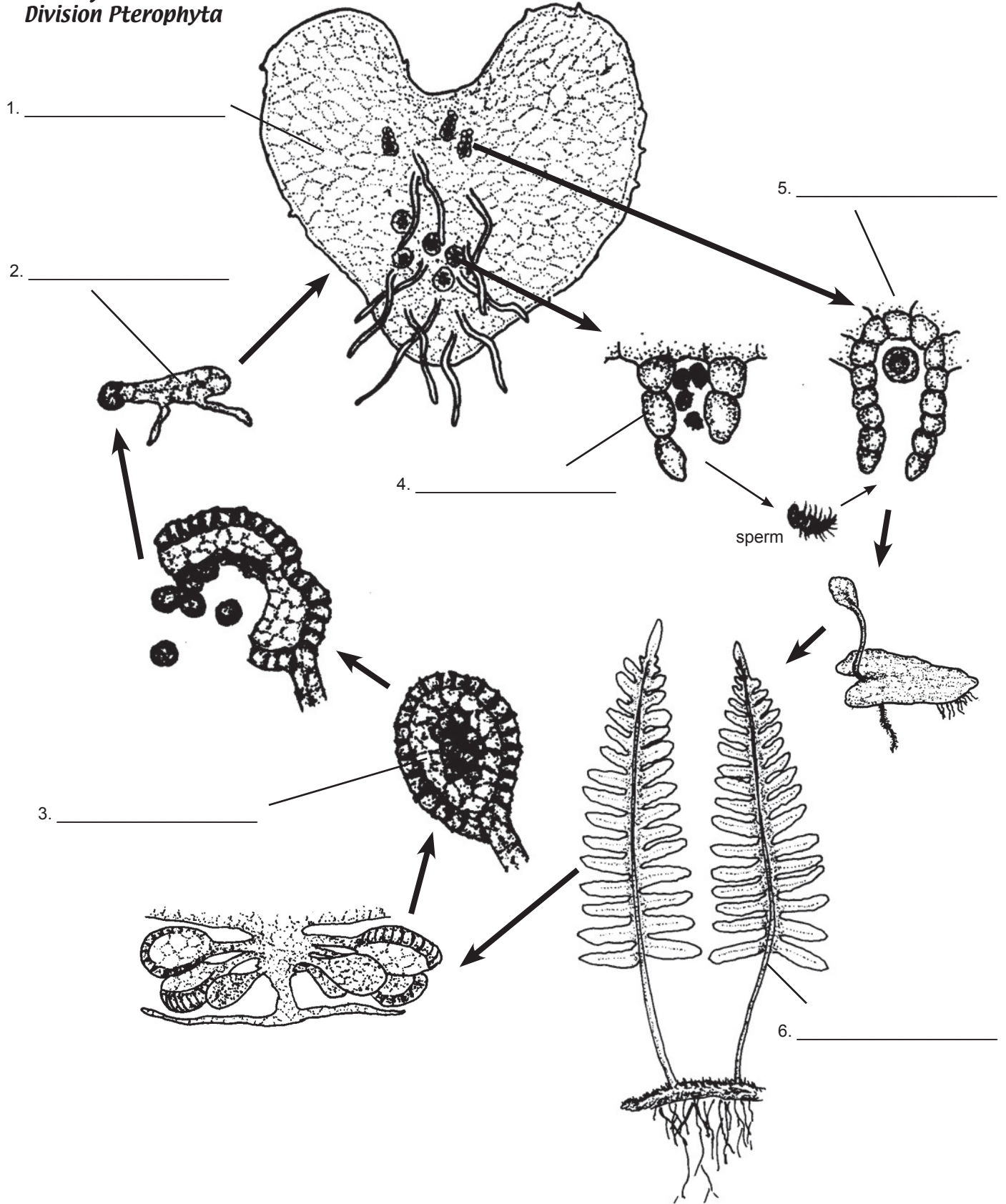


Results Section

Activity 22.1 Division Bryophyta



Activity 22.2
Division Pterophyta



Activity 22.3
 Division Coniferophyta

