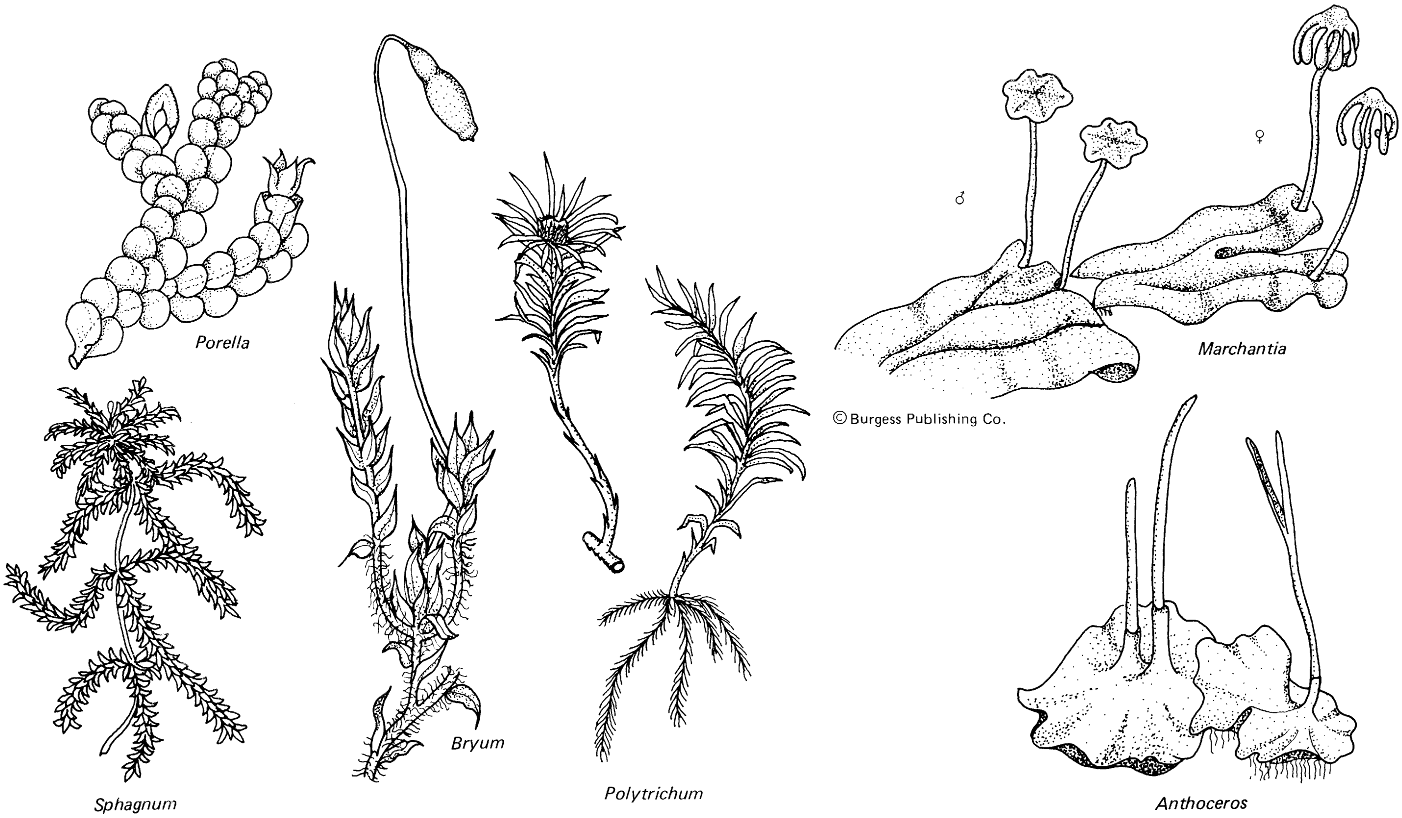


Fungi, Algae and Bryophytes



Things To Do Before Lab

1. Read this lab text BEFORE coming to lab.

2. Collect a small sample of a bryophyte somewhere on or near campus. Note the environmental conditions under which the organism was growing (moist, dry, sunny, etc.). Bring your sample to lab (you'll use it to complete a graded assignment).

3. There is a considerable amount of material in this lab. Your group must be prepared and work efficiently.

Things To Bring To Lab

Make sure you bring your textbook. The photos and figures will help in understanding the material in this lab.

Major Objectives of this Lab

1. Understand the distinguishing features of fungi, algae and plants.

2. Understand the concept of Alternation of Generations in plants.

3. Identify the gametophyte and sporophyte generations in plants.

4. Determine the features that facilitate or retard the movement of plants from water to a terrestrial environment.

The Biology of Fungi, Algae and Bryophytes

In this lab, we will introduce you to some of the diversity of the Fungi as well as the so-called "primitive" or "lower" plants, the algae and the bryophytes. Although fungi have been traditionally grouped with plants, they are as distinct from algae and plants as they are from animals. In fact, current molecular studies indicate that fungi and animals arose from a common ancestor. The fungi and plants have no direct evolutionary connection and were derived independently from different groups of unicellular organisms. The algae can be divided into red algae, brown algae and green algae based on differences in their morphology, pigments and biochemistry. However, it is believed that the land plants evolved from freshwater green algae. It is important to realize the relationships between these different groups of organisms. Once they were all grouped together but are now regarded as separate entities.

Fungi

More than 100,000 species of fungi are known. Fungi, are heterotrophs and obtain their food as saprophytes or parasites. Saprobes obtain their nutrition by breaking down and feeding on dead or decaying organic matter. Thus, fungi are extremely important as decomposers which recycle nutrients back into the biosphere. These organisms are not photosynthetic (why, then were they once classified with the plants?).

Fungi are primarily terrestrial, filamentous and possess a cell wall made of chitin which is similar to the polysaccharide found in the exoskeletons of arthropods. The majority of the fungi are usually composed of filaments known as hyphae (hypha = singular). Many hyphae, when joined together, form a mycelium (mycelia = plural). Mushrooms consist of densely packed hyphae. This filamentous form provides a high surface-to-volume ratio that greatly enhances its mode of nutrition.

> *Rhizopus*, or bread mold (Fig. 1.1) is a saprophytic fungus whose mycelium grows rapidly on bread and soft fruits. At certain times the hyphae form sporangia, containing numerous black spores which are easily spread by the wind. These sporangia are the result of either asexual or sexual reproduction. Fungi are classified into four divisions ("phyla" in the animal kingdom) based on their sexual structures. *Rhizopus* are Zygomycetes (about 600 species known) with reference to the zygospores which they produce as result of sexual reproduction.

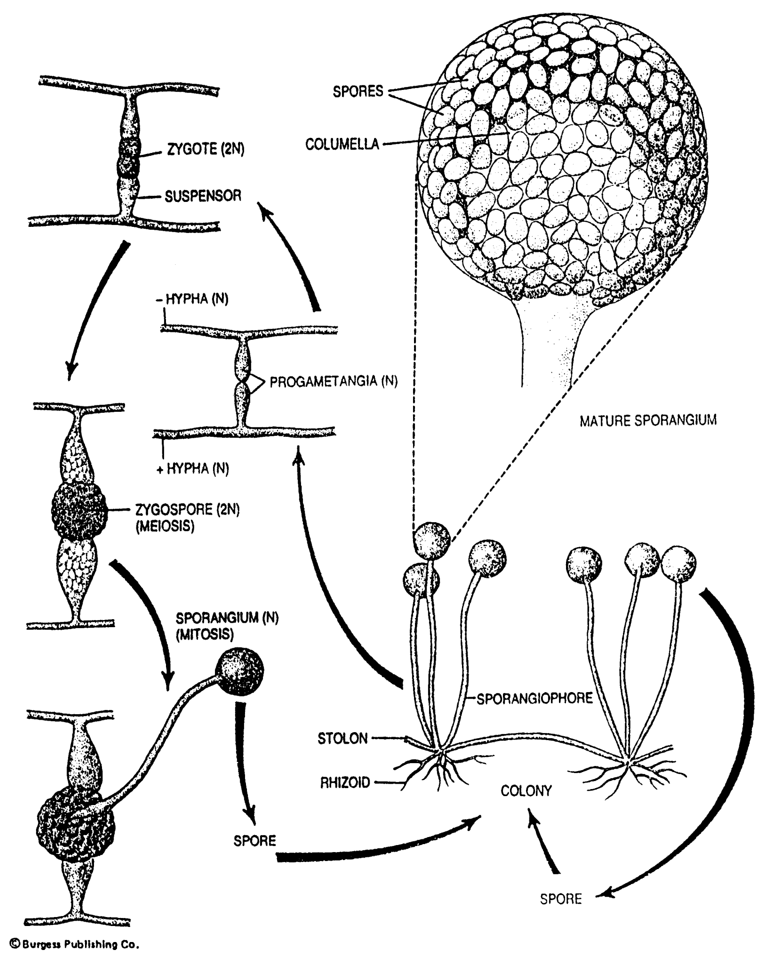


Fig. 1.1
Life history of the bread mold *Rhizopus.*

A beneficial species of terrestrial fungus is the common, store-bought edible mushroom *Agaricus bisporous*. The mushroom is the characteristic sexual reproductive structure of the Basidomycetes (about 25,000 species known). The hyphae making up the mushroom are dikaryotic (n+n) and form a diffuse mat hidden from view in substrates such as soil or rotting wood. In an open area the mycelium expands evenly in all directions and may grow as large as 100 feet in diameter. Mushrooms usually form at the outer edges of the mycelium because this is where the freshest nutritive material is located and hence the most active growth. As a consequence, mushrooms may be arranged in circular formation (the so-called "fairy rings" of legend). Mushrooms develop very quickly, sometimes overnight. This is possible because for a much longer period of time the hyphae were assimilating large amounts of food and producing new protoplasm underground.

So far we have considered fungi in their roles as decomposers, and to a lesser extent, as food. However, fungi also play a significant role as human pathogens. Many skin and lung (pulmonary) diseases are caused by fungi. A common disease affecting the mucous membranes and the skin and nails is caused by the fungus *Candida albicans*. This fungus is normally present in your environment and benign. However, in certain circumstances *C. albicans* can cause human disease. For example, vaginitis, involves infection of the mucous membrane of the female reproductive system by *C. albicans*. In the popular press, this disease is said to be caused by a "yeast", but in fact, what we commonly call yeast (involved in beer and bread making) belongs to an entirely different group *(Saccharomyces)*. Thus, popular advice that woman should avoid bread and other yeast-containing foods is in error. Note the cultures of *C. albicans* and as well photographs of other medically significant diseases caused by fungi. Both these "yeasts" are members of the Ascomycetes (over 60,000 species known).

The last major group of fungi are the Deuteromycetes or "Fungi Imperfecti" which form a miscellaneous assemblage of about 17,000 species of fungi in which the sexual reproductive features are not known. This division is artificial since most are clearly Ascomycetes, some are Basidiomycetes and Zygomycetes based on their asexual reproductive structures.

> *Penicillium* is a Deuteromycete which was found to produce an antibiotic which could significantly retard the growth of other living organisms such as bacteria. This accidental discovery by Sir Alexander Fleming in 1928 resulted in countless lives being saved. Many other Deuteromycetes are important as producers of antibiotics that are essential in the fight against disease pathogens.

Saprolegnia (the fly fungus) is a water mold Once also classifed with the fungi, they are now grouped with the Stramenopiles (see Campbell, 5th Ed). This organism consists of many fine thread-like hyphae which appear as a white fuzzy growth on the body of the fly. Water molds have flagellated reproductive cells and are the cause of several major crop diseases, such as the mildews. Water molds are now part of the group known as the Stramenopiles.

Slime molds - Once classified with fungi, the slime molds are now grouped with the Protista. Most slime molds live in cool, shady, moist places in the woods… on decaying logs, dead leaves and other damp organic matter. During its non-reproductive stage, a slime mold forms a large, multinucleate masses of streaming protoplasm known as a plasmodium (plural = plasmodia) which moves in an "amoeboid" fashion. As the plasmodium travels, it engulfs bacteria, yeast, fungal spores and small particles of decayed animal and plant matter. The ability to migrate exposes the plasmodium to new feeding areas. Depletion of the food supply stimulates movement. When food is in short supply, the plasmodium creeps to an exposed location and forms several masses of protoplasm, each of which develops into a sporangium consisting of a stalk and a sporangium in which spores are borne. Plasmodia come in a variety of colors and can be quite beautiful. It is probable that the pigments function as photoreceptors since only pigmented plasmodia require light for spore reproduction.

> *Physarum*, a typical slime mold, produces two macroscopic stages: 1) the vegetative plasmodium, and 2) the reproductive sporangium which contains numerous spores. Examine the rapid protoplasmic streaming within the "veins" of the plasmodium. Each vein is coated with a thick sheath of slime, hence the name slime mold.

Algae

The Algae are a diverse group of both unicellular and multicellular autotrophic organisms which have photosynthetic pigments. Algae are classified in part depending on the pigments they possess. We are concerned primarily with the green algae in this lab as they are the probable precursors to the land plants. Green algae (7,000 species) have chlorophyll pigments which are identical to the ones found in plants. Members of the green algae range from the microscopic to several hundred feet in length and are mostly aquatic, most are found in freshwater habitats but many are marine. A few are terrestrial. Some are symbiotic with lichens, protozoa and even various invertebrates. You can also find green algae growing on the surfaces of tree trunks or branches.

Spirogyra is a microscopic and filamentous green alga common in cool ponds where some movement of water occurs. It has a single spiral chloroplast in each cell. Pyrenoids, small round structures "decorate" the chloroplast. These store starch.

Volvox is a microscopic and colonial green alga. This group includes spectacular colonies composed of 512 to 50,000 cells. Each colony is motile. Within some of the mature colonies you may find daughter colonies which are eventually liberated to form new mature colonies.

Ulva, (known as sea lettuce), is a large green marine alga that is found along the Pacific coast. It has a sheetlike growth habit and is often found on rocks that are exposed at low tide. A holdfast anchors it to the substrate.

Other common macroscopic marine algae fall within the group known as the brown algae (1,500 species, mostly marine). Within this group are many of the familiar sea weeds, including the kelps. The brown algal body (thallus) takes on a range of forms and may be highly branched. Note that the thallus can often be subdivided into distinct regions: a holdfast, a stipe, a blade, and often a bladder. A bladder is an enlarged, hollow structure at the tip of a blade that allows it to float at or near the surface of the water. Examples of red algae (4,000 species, mostly marine) include the "sea weed" that is used for making sushi. Agar is an important commercial product made from red algae.

Blue-green algae (cyanobacteria). The so-called blue-green algae are not actually algae. They are cyanobacteria, which as the name implies, indicates that they are actually autotrophic bacteria which are prokaryotes. Prokaryotes have no nuclear membrane and thus lack a defined nucleus. They possess chlorophyll and evolve oxygen via photosynthesis although their pigments are not bounded by membranes into organelles like chloroplasts. These organisms, or closely related ancestors, are responsible for the formation of our oxygen atmosphere. Thus, they were very important in the evolution of organisms having aerobic respiration. A currently discussed theory of the origin of chloroplasts suggests that blue-green alga-like organisms became "incorporated" into cells of early plant progenitors and eventually evolved into chloroplasts. (Except for the blue-green algae the rest of the organisms we will study in today's lab, including the fungi, the remainder of the algae, bryophytes and ferns are all eukaryotes, which have a defined nucleus).

Lichens. Lichens are mutualistic symbiotic associations between fungi and certain green algae or cyanobacteria. The fungus is usually an Ascomycete. Because of this symbiotic relationship, lichens are able to inhabit some of the harshest environments on earth. However, they are particularly sensitive to toxic compounds in the atmosphere. Thus they are natural indicators of polluted air.

The Land Plants

It is estimated that there are 250,000 to 300,000 species of land plants on the earth at the present time. Although the plants most familiar to you have bodies composed of flowers, leaves, stems and roots, some plants may not have all these structures. Tremendous variation is to be noted in size as well… plants range from tiny fern gametophytes to gigantic forest trees over 350 feet tall. Plants also vary in the ways they reproduce and in the way they obtain their food. Throughout this exercise and subsequent ones you should ask yourself: "Why is this organism considered a plant? What characteristics does it show which includes this organism within the plants?"

> Besides having a waterproof waxy cuticle layer that protects against desiccation, a layer of sterile (non-reproductive) cells protects the gamete producing cells (and embryo) of plants from drying out. Plants also have stomata (absent in liverworts and some mosses) that control the loss of water that result from necessary gaseous exchange for photosynthesis and respiration. Plants also share some features with their progenitors, the green algae in having chloroplast, food storage as starch and cell walls of cellulose.

Botanists use many characteristics in order to arrange this great array of different organisms into an orderly system. Traits used include morphology, anatomy, cytology, biochemistry, physiology and life cycle pattern. Whenever possible, fossil evidence is also used. One characteristic used to classify plants is their life cycle. Shown in Fig. 1.2 is an imaginary, complete life cycle. All the plants will exhibit this Alternations of Generations life cycle where the sporophyte and gametophyte differ in morphology.

As you go through this and the next exercise, it will become apparent that there are major trends in life cycles as one moves from the "primitive" to the "advanced" plants. Make sure you know and understand what these major trends are. Knowing them will help tremendously in understanding themes unifying the plants (i.e., will make studying for exams much easier). Many of the trends involve the transition from life in an aquatic to a terrestrial environment. Examples of these trends include a waxy waterproof cuticle, the development of spores with their protective walls to tolerate dry conditions, conducting systems for the transport of water and food and the development of seeds to protect the embryo.

From this exercise and subsequent ones you should be able to distinguish between a spore and a gamete, the difference between a sporophyte and a gametophyte, and whether or not an embryo is different from a sporophyte. Most importantly, you should be able to relate their form and function to the respective plant groups.

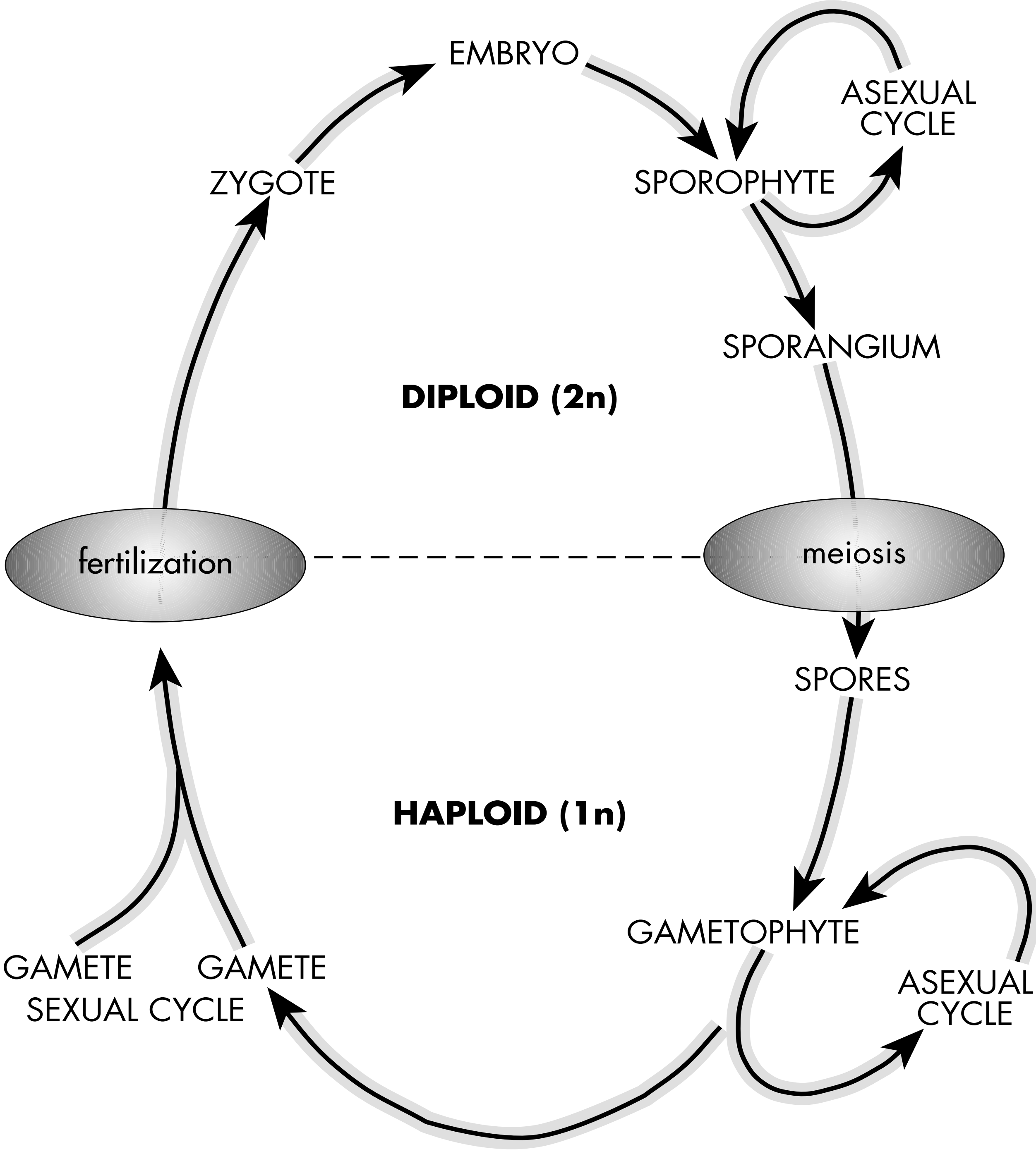


Fig. 1.2
Complete life cycle showing Alternation of Generations. All plants will exhibit these phases but the diploid and haploid phases may vary in duration in different plant groups.

Bryophytes

The next group of organisms, the Bryophytes, is considered to have retained many features of the first plants to move from the water onto the land. All these plants are small, and are usually found in an environment either periodically or permanently moist. The Bryophytes are usually divided into three divisions: the liverworts (6,500 species), the hornworts (100 species), and the mosses (12,000 species). In the Bryophytes, the sporophyte, or 2n generation, is borne on the gametophyte and is generally inconspicuous. Consult your textbook for further explanation. When you examine the representative Bryophytes, perhaps the most important question to keep in mind is, what is the gametophyte and what is the sporophyte, and which is dominant?

Within the Bryophytes, peat moss is probably the most important economically, forming vast peat bogs which are "harvested" and used for fuel. Some organisms are commonly called "mosses" - reindeer "mosses" are lichens, club "mosses" and Spanish "moss" are vascular plants, and sea "moss" and Irish "moss" are algae. Only genuine mosses are bryophytes.

Note the prominent midrib and the way the flat body (thallus) branches (known as dichotomous branching) in *Marchantia*. This is the gametophyte (n) generation. If we are lucky, and material is available, you will be able to distinguish the male and female thalli. The structures which allow you to "sex" the thalli look like umbrellas and are elevated above the surface of the thallus (Fig. 1.3). On top of each "umbrella" (antheridiophore) sperm are produced, and under the arms of the other "umbrella" (archegoniophore) an egg is formed. Water carries the sperm to the egg, and following fertilization, a new sporophyte develops (attached to the underside of the arm of the archegoniophore).

The green, leaf bearing structure of the moss *(Polytrichum* or *Funaria)* is the gametophyte, which is usually terminated by the partly green sporophyte (Fig. 1.4).

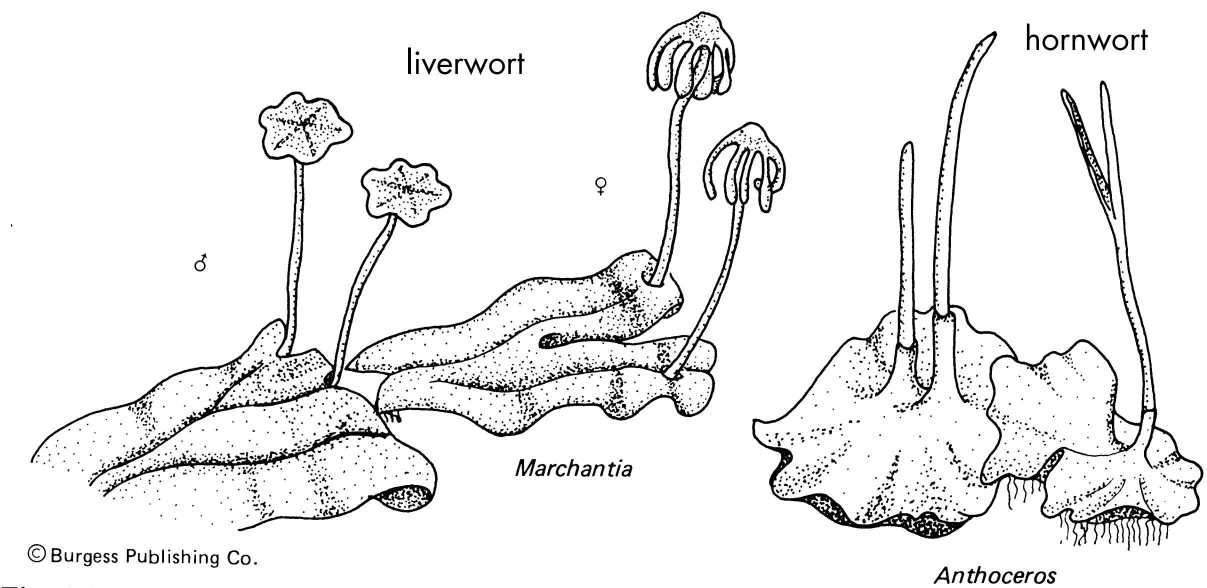
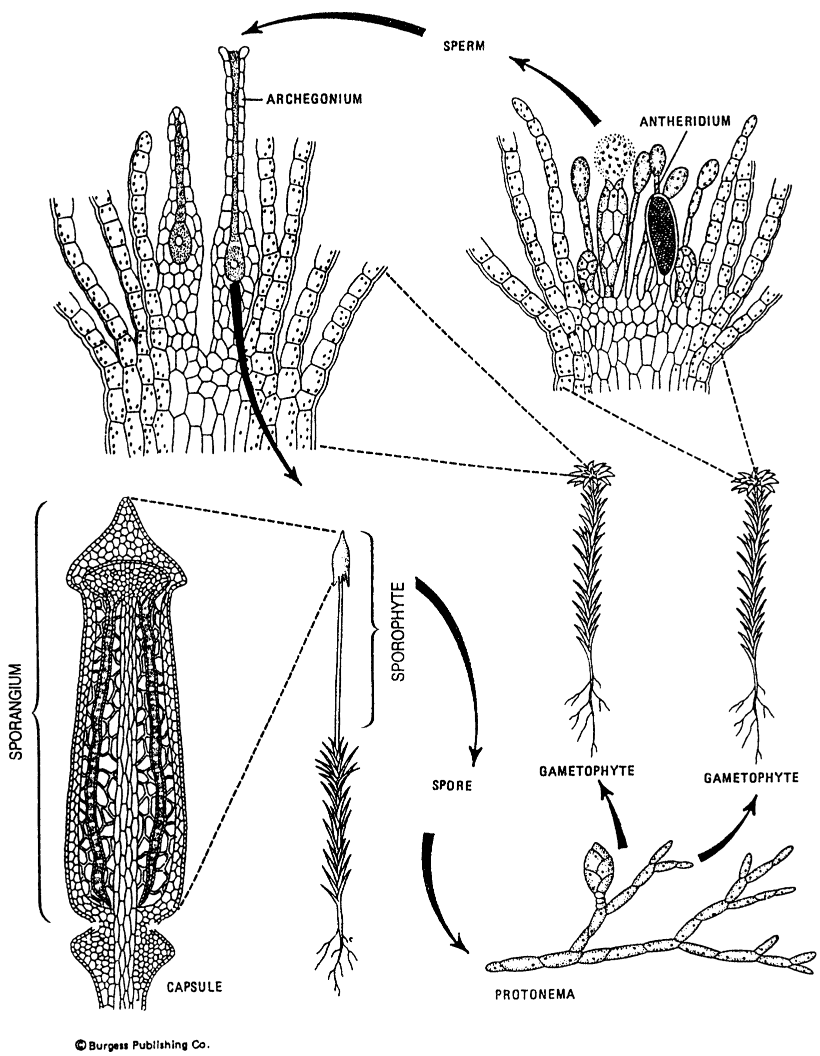


Fig. 1.3
The thallose liverwort *Marchantia*. The antheridia and archegonia are elevated on specialized stalks above the plant body. Male and female sex organs occur on different plants.

Fig. 1.4
In a representative moss life cycle *(below)*, spores are released from a capsule, which opens when a small lid (operculum) bursts. The spore germinates to form a branched, filamentous protonema, from which a leafy gametophyte develops. Sperm, which are expelled from the mature antheridium, are attracted into the archegonium, where one fuses with the egg cell to produce the zygote. The zygote divides mitotically to form the sporophyte. The sporophyte *(right)* consists of a capsule, which may be raised on a stalk, also part of the sporophyte, and a foot. Meiosis occurs within the capsule, resulting in the formation of haploid spores. **Additional representations of the life cycle will be given.**



Your Team's Assignments

Plant Biology Comes Alive!

This interactive portion of the lab consists of three activities (Mystery Identification, Tutorial, and Your Bryophyte Sample). Your GSI will base your grade for this part of the lab on the participation of all team members and demonstrated biological understanding. Each team member will receive the same grade.

Mystery Identification. Examine the *Mystery Organism* located on the front bench. As a team, decide whether this organism is a fungus, algae or bryophyte. Assuming you could analyze this material in any way, how could you obtain support for your identification? Write your identification and a one-sentence justification on the chalkboard. When discussing the *Mystery Organism* at the end of the lab period, your GSI may ask you to explain your response to the class.

Tutorial. During a future discussion section, your GSI will assign one of the seven tutorials listed below to your team. Prepare a five-minute presentation for delivery in front of the class.

<u>Tutorial #1</u>: Review the life cycle of a mushroom. Draw a simplified life cycle with sketches on the chalkboard. Explain each step. Tell where meiosis, mitosis, cytoplasmic fusion, and nuclear fusion occur. Tell what portions of the life cycle are haploid/dikaryotic/diploid.

<u>Tutorial #2</u>: Review the life cycle of a liverwort. Draw a simplified life cycle with sketches on the chalkboard. Explain each step. Where is the gametophyte located with respect to the sporophyte? Is the sporophyte or gametophyte the dominant vegetative phase in this species? Are both the gametophyte and sporophyte photosynthetic? Tell where meiosis, mitosis, and fertilization occur. Tell what portions of the life cycle are haploid/diploid.

<u>Tutorial #3</u>: Review the life cycle of a moss. Draw a simplified life cycle with sketches on the chalkboard. Explain each step. Where is the gametophyte located with respect to the sporophyte? Is the sporophyte or gametophyte the dominant vegetative phase in this species? Are both the gametophyte and sporophyte photosynthetic? Tell where meiosis, mitosis, and fertilization occur. Tell what portions of the life cycle are haploid/diploid.

<u>Tutorial #4</u>: Compare and contrast three ways of obtaining food: ingestion, absorption, and photosynthesis. Distinguish heterotrophic and autotrophic organisms. Explain how an organism's cellular characteristics provide clues about its mode of nutrition. Give examples.

<u>Tutorial #5</u>: The spores, but not the gametes, of mushrooms and bryophytes are dispersed over long distances. How are spores dispersed in these organisms? How are mushrooms, bryophytes, and ferns designed to facilitate spore dispersal? Why can't their gametes travel very far? How can these organisms complete their life cycles despite limited gamete dispersal?

Tutorial #6: Bryophytes have many structural attributes that are absent or rare in algae: embryos, wind dispersal of spores, parenchyma (three-dimensional tissue), and rhizoids/roots. Explain how each of these features represents an adaptation to life on land.

Tutorial #7: Compare the vegetative bodies of *Spirogyra*, *Volvox*, *Ulva*, a kelp, *Marchantia*, and a moss. Using chalkboard diagrams, explain how each is designed to maximize the interception of sunlight by photosynthetic cells.

Your Bryophyte Sample. When instructed by your GSI, show your bryophyte sample to the class. As a team, briefly explain why you feel that the material is a bryophyte. Indicate whether your sample consists of gametophyte tissue, sporophyte tissue, or both. Justify your conclusions.