LABORATORY

# Diversity—Fungi and the Nontracheophytes

# 23

## OVERVIEW

Multicellularity allows for great increases in the size of organisms and for the specialization of their parts. The advantages of multicellularity have allowed organisms belonging to the kingdoms Fungi and Plantae to develop the specific structural modifications, life styles, and unique reproductive mechanisms required to adapt to and succeed in a variety of habitats.

During this laboratory period you will examine representatives of the **Fungi** and begin your study of the Plantae by examining the **nontracheophytes**—plants that lack special vascular tissues for the distribution of water, minerals, and photosynthetic products.

## STUDENT PREPARATION

Prepare for this laboratory by reading the text pages indicated by your instructor. Familiarizing yourself in advance with the information and procedures covered in this laboratory will give you a better understanding of the material and improve your efficiency.

Last week you were given three plastic bags and a slice of bread. You exposed the pieces of bread to different environmental conditions (heat, cold, light, or dark) for approximately 6 days. You should also have formulated a hypothesis stating how you expected the experimental conditions you chose to affect fungal growth.

In Exercise A, Extending Your Investigation (p. 23-4), state your hypothesis and summarize your method of treatment (experimentation), results (observations), and conclusions supporting or refuting your supposition. Bring your experiment on fungal growth to the laboratory and place your materials on the demonstration table for other students to observe.

On campus or in a nearby woods, you may be able to find examples of fungi, lichens, and mosses. Bring them to class for identification. If you find something you do not recognize, bring it too. You and your classmates can try to identify unknown plant organisms during this laboratory period.

## PART I KINGDOM FUNGI

Members of the kingdom Fungi were long classified among the plants, but they are so unlike any other plant group that taxonomists now assign them to a separate kingdom. Like other eukaryotes, fungi probably originated from an ancestral heterotrophic protist. Most fungi are multinucleate or multicellular, although some, including the yeasts, are uninucleate and unicellular. Unlike plants, the fungi lack chlorophyll. They have cell walls composed of cellulose or **chitin.**

Because fungi lack chlorophyll and therefore cannot manufacture their own food, they feed either on decomposing organic matter (**saprophytes**) or on living organisms (**parasites**). Fungi maximize their contact with sources of nutrients by making branched or unbranched threadlike filaments called **hyphae,** which form a spreading mass called a **mycelium.**

Both asexual and sexual reproduction are common among the fungi and result in the production of **spores.** Elaborate mechanisms of spore production, including formation of many different, and sometimes bizarre, types of **fruiting structures,** protect fungal spores and promote their dissemination to new habitats.

Fungi can be grouped into four phyla based on their basic structure and patterns of reproduction, particularly sexual reproduction. The four phyla include: the Zygomycota, zygospore fungi; the Ascomycota, sac fungi; the Basidiomycota, club fungi; and the Chytridiomycota, chytrids. Because the imperfect fungi (deuteromycetes) are probably polyphyletic (all other phyla of fungi are monophyletic), they are not assigned phylum status.

## EXERCISE A Phylum Zygomycota

If you leave a piece of bread or other bakery product covered and at room temperature for a while, a fuzzy gray or black mold will appear. This fungus, *Rhizopus stolonifer,* a common bread mold, is representative of the **zygomycetes,** members of the phylum Zygomycota. This group of fungi is characterized by the formation of **zygospores**—special resting structures composed of a zygote surrounded by a thick protective wall. The zygospores germinate to form a fruiting structure, the **sporangium,** which produces spores by meiosis. Accumulations of these dark-colored sporangia give *Rhizopus* its gray-black color.

### Objectives

- ☐ Identify the structural characteristics typical of zygomycetes, and distinguish between asexual and sexual reproductive structures.
- ☐ Explain the basis for the name "Zygomycota."

### Procedure

1. Locate the following structures in the life-cycle diagram of *Rhizopus stolonifer* (Figure 23A-1) and familiarize yourself with the function or importance of each structure.

   **Hypha** Strands (hyphae) composing the fungal body are multinucleate (**coenocytic,** containing many haploid nuclei) in most zygomycetes. Some hyphae arch upward and are called **stolons.** These form hyphal **rhizoids** wherever they touch the substrate (surface on which the fungi are growing).

   **Mycelium** The fungal body composed of a mass of hyphae.

   **Sporangium** The structure responsible for producing spores, either asexually by mitosis from hyphal cells (**sporangiospores**) or sexually by meiosis from the **zygospore** (meiospores). A long stalk raises the sporangium above the surface, where air can disperse the spores.

   **Gametangium** Haploid cell formed at the tip of a hypha. Gametangia fuse to produce the zygote (Figure 23A-2a).

   **Zygospore** Zygote formed by the fusion (**syngamy**) of two gametangia and covered by a thick protective wall. Since the zygote is not derived from the fusion of true gametes (egg and sperm) but from the fusion of gametangia, it is called a zygospore. The zygospore germinates to form a sporangium which produces spores by meiosis (Figure 23A-2b).

2. *Without opening the dishes,* use a dissecting microscope to identify as many structures as possible in the available living material. Note the black "dots" on older parts of the mycelium.

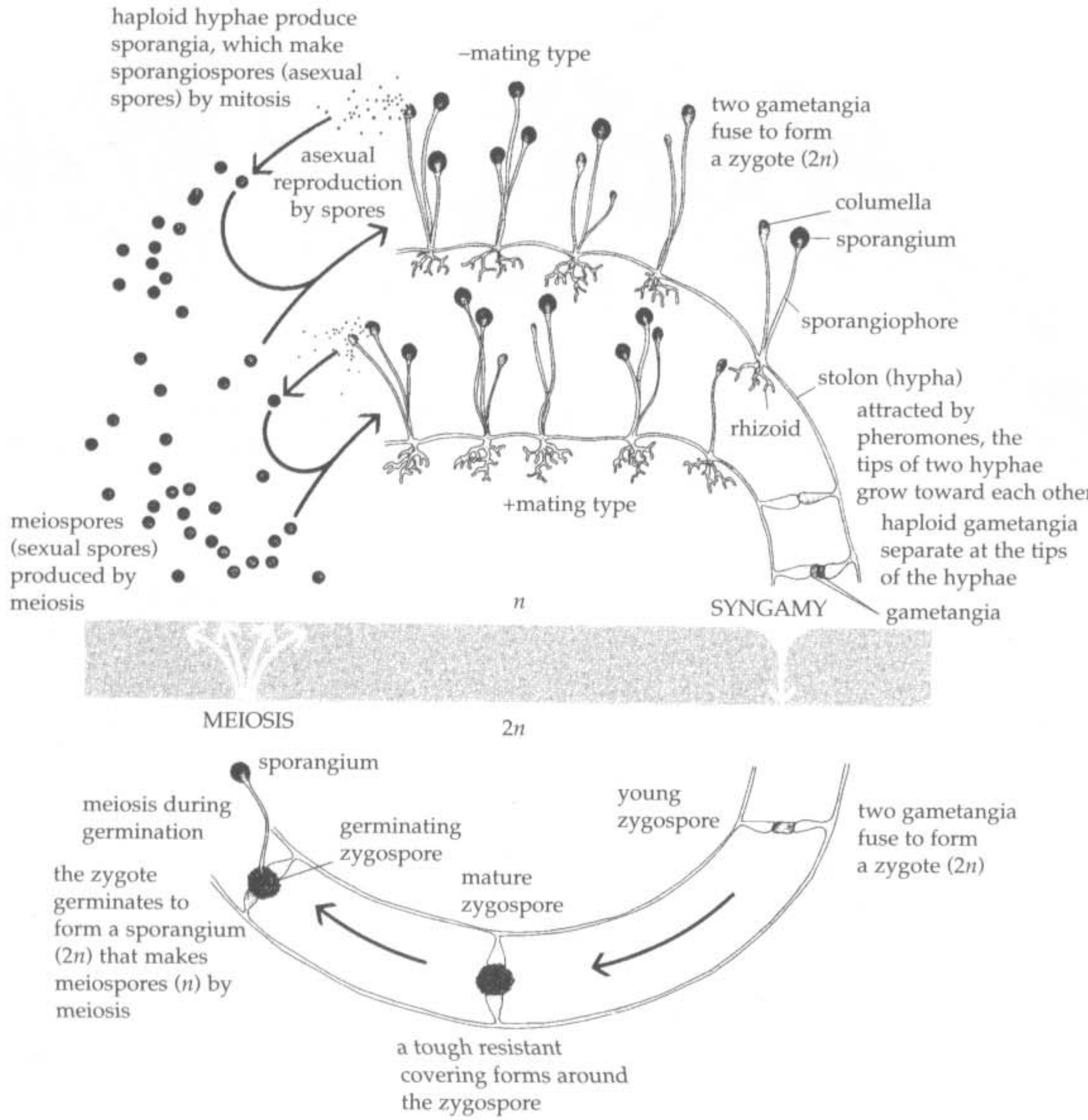
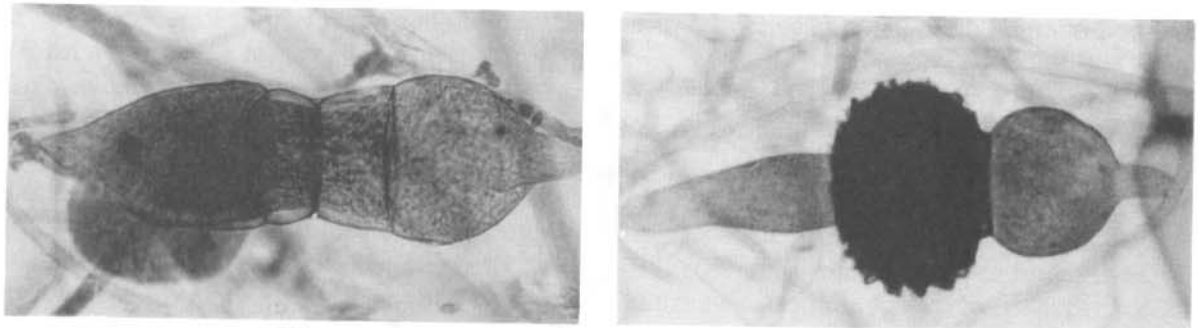



**Figure 23A-1** *Life cycle of the zygomycete* Rhizopus stolonifer. *Sexual reproduction occurs between different mating strains, traditionally referred to as the + and − mating strains, even though they are morphologically alike. Asexual reproduction occurs by the mitotic production of spores within haploid sporangia.*

These are sporangia. Observe the upright stalks (**sporangiophores**) bearing the sporangia. Locate the stolons and rhizoids. Draw and label these structures in the space below.



(a) (b)

**Figure 23A-2** *(a) Gametangia, the gamete-producing structures of* Rhizopus stolonifer. *(b) A zygospore, or sexual resting spore (the dark mass in the center).*

3. Examine a prepared slide of *Rhizopus* showing stages of sexual reproduction. Locate the gametangia and zygospores. Draw and label these structures in the space below.

   *a. Is the mycelium haploid* (n) *or diploid* (2n)? ______

   *b. What types of products* (n *or* 2n) *are produced by mitosis?* ______ *By meiosis?* ______

   *c. Are true gametes formed?* ______

   *d. By what process are gametangia formed?* ______________________

4. On Figure 23A-1, circle and label the portion of the life cycle involving sexual reproduction; now do the same for the portion of the life cycle involving asexual reproduction.

## EXTENDING YOUR INVESTIGATION: CONDITIONS FOR FUNGAL GROWTH

Last week you were asked to choose experimental conditions for growing fungus on bread and to formulate a hypothesis about how these conditions would affect fungal growth. What was your hypothesis?

HYPOTHESIS:

NULL HYPOTHESIS:

What did you **predict** would happen under the conditions that you chose?

What was the **independent variable?**

What was the **dependent variable?**

What experimental procedure did you use to conduct your investigation? Describe it in the space below.

PROCEDURE:

OBSERVATIONS AND RESULTS:

What type of mold did you find growing on the bread? Was *Rhizopus* present? Examine the slices of bread brought to the laboratory by your classmates. Each person treated the bread in a different experimental manner. In the chart that follows, indicate the conditions tested by your classmates and state the results, growth or no growth.

| Condition Tested | Growth or No Growth |
|---|---|
| | |
| | |
| | |
| | |

Based on these data, what conditions favor the growth of mold or fungi?

From your observations, why do you suppose that molds are so common?

Do your results and those of your classmates support your hypothesis?

Your null hypothesis?

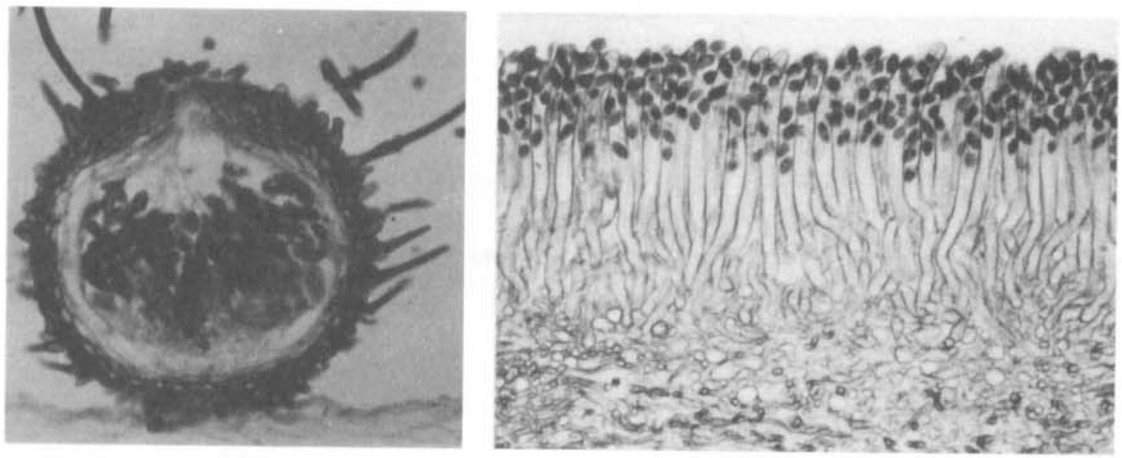
## ✓ EXERCISE B Phylum Ascomycota

**Ascomycetes,** or sac fungi, are often referred to (along with the basidiomycetes) as "higher fungi" because their hyphae are made up of uninucleate cells partitioned by cell walls (septate), whereas the hyphae of Zygomycota are coenocytic (multinucleate).

Ascomycetes include some familiar fungi such as morels, truffles, *Sordaria, Neurospora,* and yeasts. One member of this division, *Claviceps,* produces a mycelium known as ergot on grasses such as rye grass. Perhaps one of the most well known ergot-derived products is LSD. Yeasts produce ethyl alcohol by the process of fermentation and thus are important in the production of beer and wine. Chestnut blight, Dutch elm disease, apple scab, brown rot in fruit, and powdery mildew infections are serious plant diseases caused by the ascomycetes. There are approximately 30,000 known species of ascomycetes.

Asexual reproduction in the ascomycetes occurs by the mitotic production of haploid **conidiospores,** which are produced in long chains at the end of specialized hyphae called **conidophores.**

Sexual reproduction in most ascomycetes results in the development of an **ascus** (derived from the Latin word for "sac") containing four to eight **ascospores** (four are produced by meiosis; additional spores are the result of mitosis). A group of asci are usually found together in a fruiting body known as an **ascocarp** (Figure 23B-1). The ascocarp occurs in a variety of shapes, by which different ascomycetes can be identified. Species that have an ascocarp are collectively called *euascomycetes* (true ascomycetes); those without ascocarps are called *hemiascomycetes* (half ascomycetes).



(a) (b)

**Figure 23B-1** *(a) Ascocarp of* Chaetomium erraticum *showing enclosed asci and ascospores. Note the small pore at the top. (b) A section through a layer of asci on the inner surface of an ascocarp of* Morchella.

## Objectives

- ☐ Identify the structures typical of ascomycetes.
- ☐ Distinguish between mechanisms of asexual and sexual reproduction.
- ☐ Explain the basis for the name "Ascomycota."

## Procedure

1. Use a dissecting microscope to examine living material from *Sordaria,* or observe prepared slides using the 40× objective on your microscope. In the space below, sketch and label the fruiting bodies (ascocarps), asci, and ascospores of the ascomycete *Sordaria.*

2. Remove several of the small, black, round fruiting bodies from a culture of *Sordaria* and prepare a wet-mount slide. Press on the coverslip with a small cork to squash the ascocarps and release the asci (Figure 23B-2). Study the slide at high power (40× objective). In the space next to Figure 23B-2, draw and label your observations.

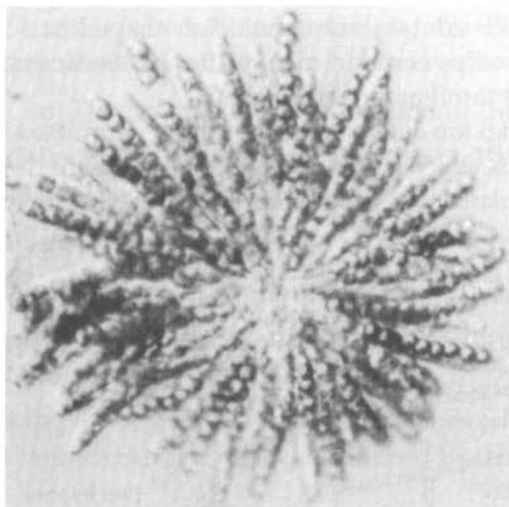


**Figure 23B-2** Sordaria *ascospores within asci.*

*a. How many ascospores are present in each ascus?* ______

*b. By what division process (or processes) were the ascospores produced?*

______________________________________________

3. Obtain a drop of yeast culture and make a wet-mount slide. Notice the buds on some of the cells. Instead of having a hyphal filament, yeasts are unicellular and can reproduce asexually by budding or sexually by the production of asci (Figure 23B-3a, b).

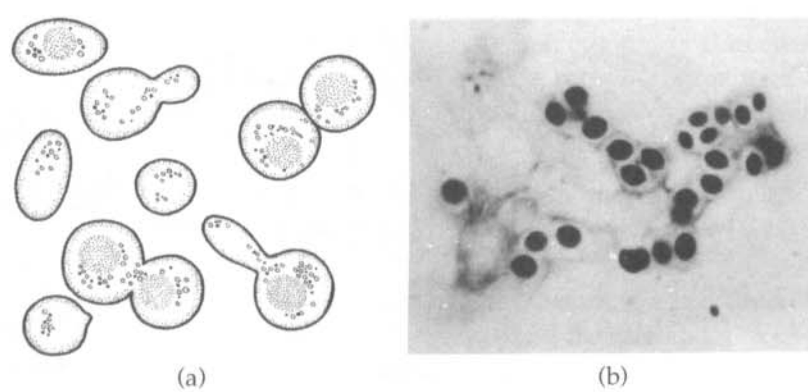



**Figure 23B-3** *Yeasts. (a) Budding cells of bread yeast,* Saccharomyces cerevisiae. *(b) Asci with ascospores of* Schizosaccharomyces octosporus.

4. Examine a prepared slide of *Schizosaccharomyces* on demonstration. Identify an ascus containing ascospores (Figure 23B-3b).

*c. How many ascospores are present in each ascus?* ______

✓ ## EXERCISE C Phylum Basidiomycota

The **basidiomycetes,** or club fungi, have a septate mycelium, as do the ascomycetes, but they differ from the ascomycetes in having sexual spores (**basidiospores**) borne *externally* on a club-shaped structure, the **basidium,** instead of within a sac.

The fruiting body of the basidiomycetes is the **basidiocarp.** The mature basidiocarp develops a large number of pores or gills on its underside. These gills contain numerous club-shaped basidia, single cells that produce basidiospores (Figure 23C-1). Basidiocarps come in many different sizes, shapes, and colors. Some, such as the mushrooms with which you are familiar, are edible.

Rusts, smuts, puffballs, toadstools, and shelf fungi are also members of the phylum Basidiomycota. Many species form **mycorrhizal** associations with plants, in which case a symbiotic relationship develops between fungal hyphae and plant roots, providing both the plants and fungi with important nutritional elements.

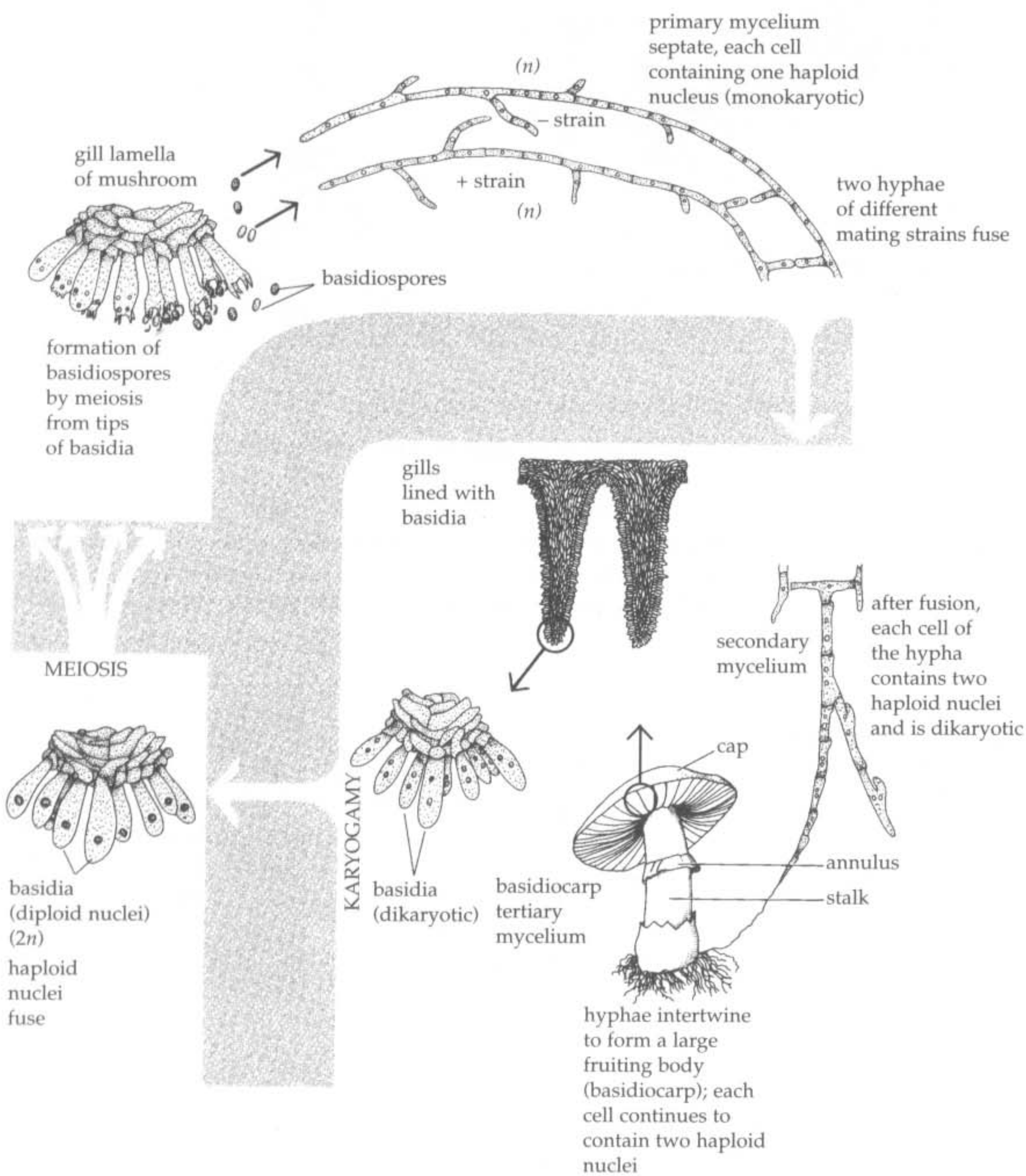



**Figure 23C-1** *Generalized life cycle of a basidiomycete.*

## Objectives

- ☐ Identify the structures typical of basidiomycetes.
- ☐ Describe how a "mushroom" is formed.

## Procedure

1. Obtain a fresh edible mushroom, *Agaricus,* and examine it carefully. Identify the parts described below and locate these on the life-cycle diagram (Figure 23C-1).

   **Cap** The umbrella-shaped portion of the fruiting body (basidiocarp).

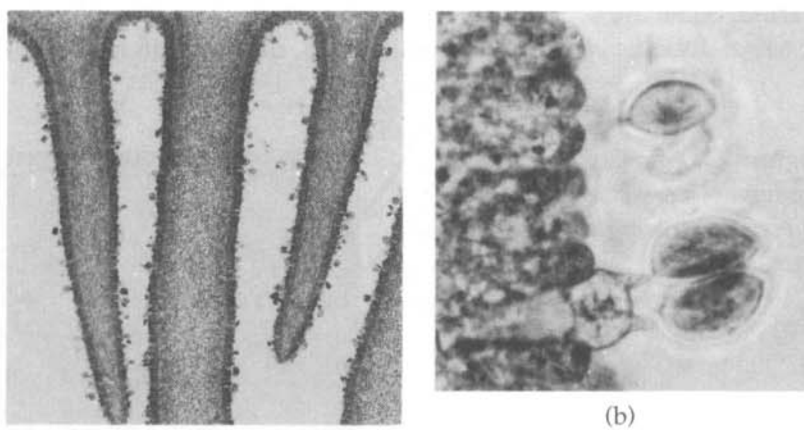
   **Gills** Radiating strips of tissue (**lamellae**) on the undersurface of the cap; basidia form on the surface of the gills.

   **Basidia** Club-shaped, spore-producing structures on the surface of the gills (Figure 23C-2a).

   **Basidiospore** A spore produced by meiosis on the outside of a basidium (Figure 23C-2b).

   **Stalk** The upright portion of the fruiting body that supports the cap—a mycelium composed of many intertwined hyphae.

   **Ring** (or **annulus**) A membrane surrounding the stalk of the fruiting body at the point where the unexpanded cap was attached to the stalk.



(a) (b)

**Figure 23C-2** *(a) Section through the gills of* Coprinus. *The dark margins constitute the layer of developing basidia. (b) Mature basidiospores attached to a basidium.*

2. Remove a small portion of several gills. While holding them together, cut a very thin cross section with a razor blade. Put sections in a drop of water on a slide and cover this with a coverslip. You should be able to see basidia on the surface of the gills. Study your slide at high power (40× objective).

   *a. Can you see the hyphae making up the thickness of the gills?* ______ *Are they septate?* ______

   *Are the basidia club-shaped?* ______

3. For a clearer view of the reproductive structures of basidiomycetes, examine a prepared slide of a cross section through the cap of the basidiomycete *Coprinus.* Find basidia and basidiospores (Figure 23C-2a, b). In the space below, draw and label your observations.

4. Note the diversity of structures in other examples of basidiomycete fruiting bodies on demonstration. Draw several of these in the space below.

## ✓ EXERCISE D Phylum Chytridiomycota

Chytridiomycota is the most ancient of the fungal phyla (Figure 23D-1). Chytrids are often classified among the protists, along with the Oomycetes and other water molds. This is because they have flagellated spores and gametes—the only flagella present in the kingdom Fungi. Molecular evidence indicates, however, that they are monophyletic with the fungi. They were probably the first to diverge from a common fungal ancestor. All fungi in the other branch lost their flagella.

Chytrids are either parasitic or saprobic. Most live in fresh water or in damp soil, but some are marine. Some are unicellular, while others take the form of branched chains. They can reproduce sexually or asexually. *Allomyces*, a common chytrid, displays alternation of generations. See Figure 23D-2.

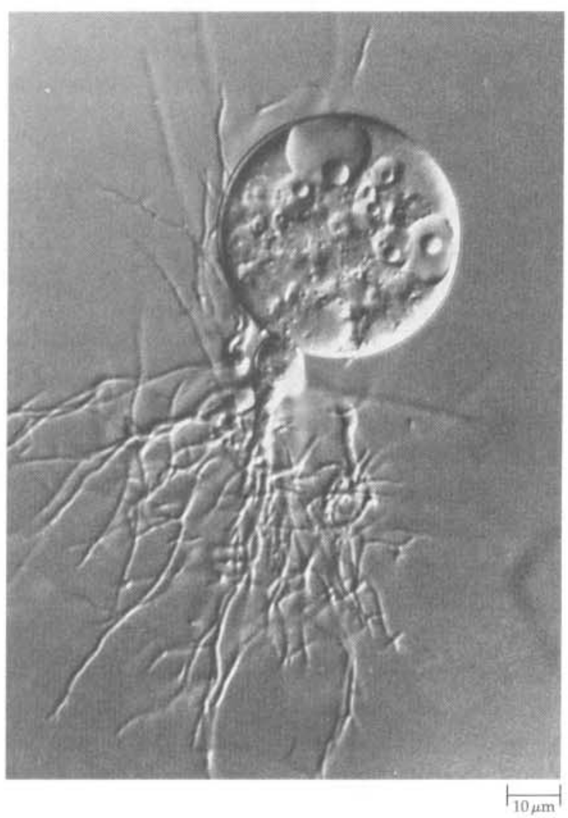



**Figure 23D-1** Chytridium confervae, *a common chytrid. You can see the slender rhizoids extending downward.*

### Objectives

- ☐ Observe life-cycle stages of chytrids.

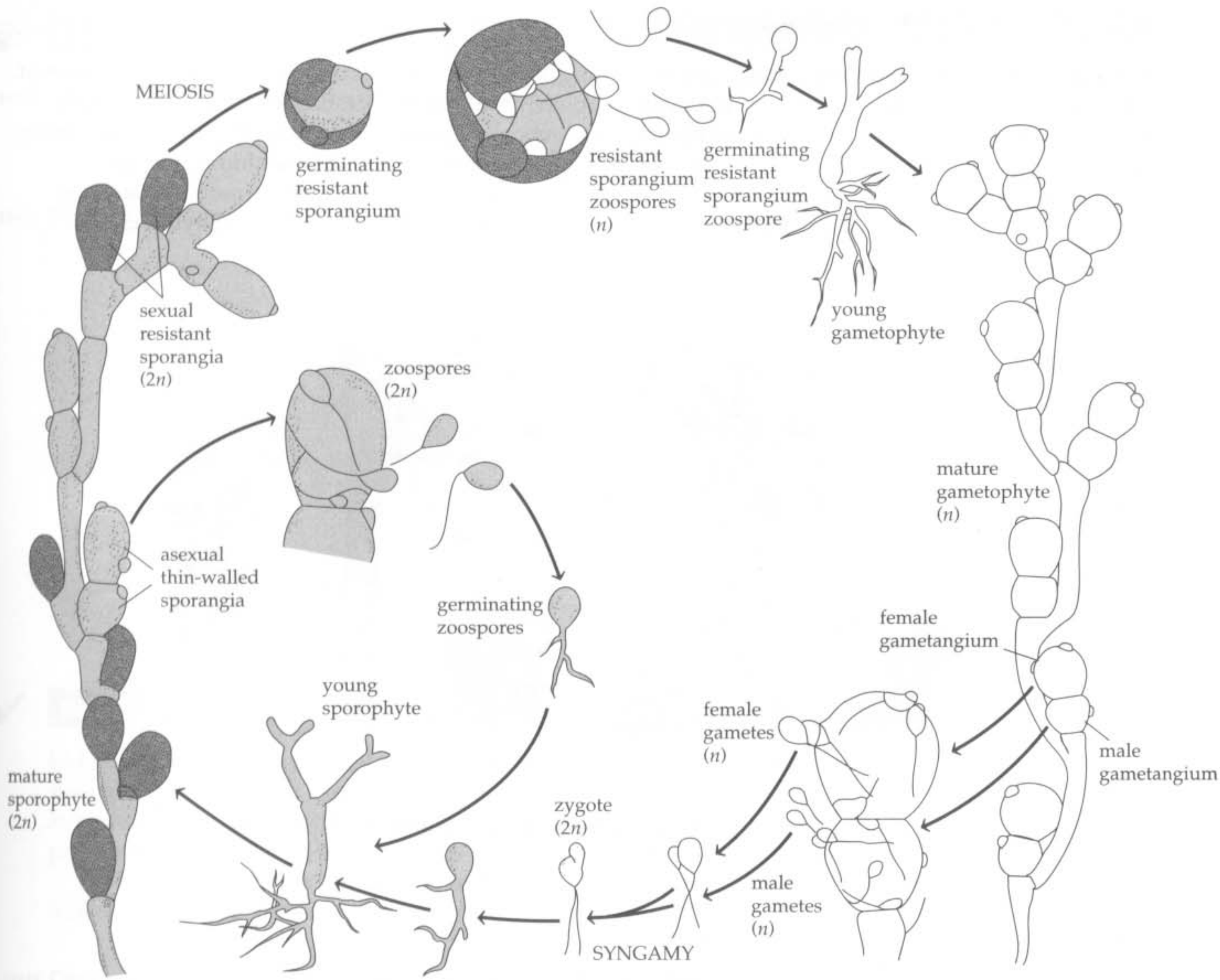


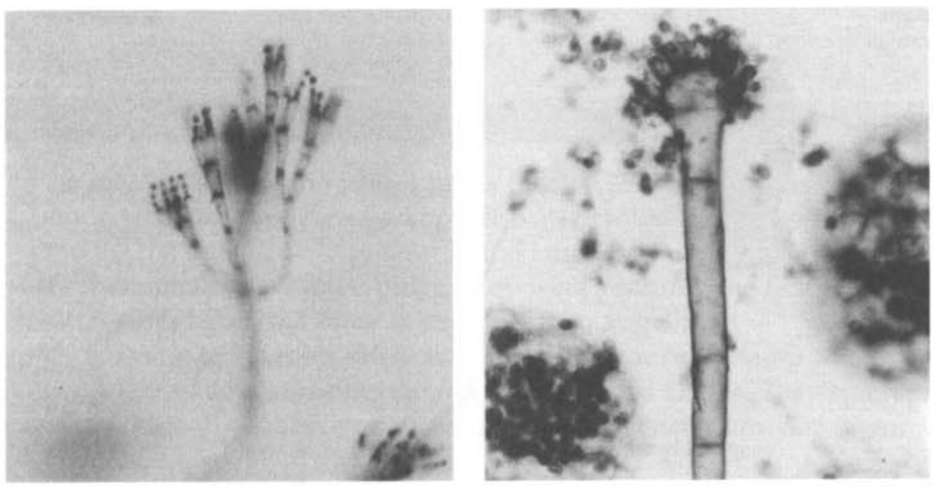

**Figure 23D-2** *Life cycle of the chytrid* Allomyces arbusculus. *In* Allomyces, *haploid zoospores germinate on the seeds or dead plant material available. They form male and female gametangia, which produce haploid gametes by mitosis. Both types of gametes have flagella. The female gametes produce a chemical that attracts the male gametes, and they fuse to form a diploid zygote. Cell divisions give rise to a small diploid organism that can then produce diploid flagellated zoospores, which germinate to form more diploid organisms. Eventually the diploid organisms form a thick wall around themselves and become resting zygospores. Meiosis within the resting zygospores produces haploid zoospores, and the cycle begins again.*

## Procedure

1. Examine living cultures of *Allomyces* on demonstration. Identify the resting spores.
2. Remove a sample of the lake water and examine it under the microscope (40×).
   *a. Do you see any flagellated zoospores?* ______

## ✓ EXERCISE E The Deuteromycetes

**Deuteromycetes,** the "imperfect" fungi, are those fungi in which the sexual stages are not known to exist. This may be because these fungi have not been completely studied, or because the sexual stages have truly been lost during the course of evolution. Reproduction is asexual by **conidia** (Figure 23E-1). Unlike spores, conidia are produced at the tips or sides of haploid hyphae rather than within sporangia. Examples in this group include blue molds and green molds, some of which are important sources of antibiotics; others are used to add flavor or odor to certain cheeses. The genus **Trichophyton** causes athlete's foot.



(a) (b)

**Figure 23E-1** *The conidiophores of (a)* Penicillium; *(b)* Aspergillus.

### Objectives

☐ Explain why the deuteromycetes are considered to be "imperfect" fungi.

### Procedure

Examine a prepared slide of *Aspergillus* or *Penicillium.* Study the slide using the compound microscope (40× objective) and identify conida. Notice that most of the conidia dispersed as the slide was made. Air currents perform this task in nature. In the space below, make a labeled sketch of your observations.

*a. Since the imperfect fungi are not known to have a sexual cycle, are conidiospores produced by mitosis or meiosis?*

______________

*b. Of what economic importance is the mold* Penicillium *to the medical industry?*

______________________________________________

*To the food industry?* ______________________________________

## EXERCISE F Identification of Collected Fungi

### Objectives

☐ Classify a variety of local fungal specimens by phylum or type.

### Procedure

1. Now that you have completed your study of the fungi, try to determine the type of fungus you collected. Give the reasons for your decision.
2. On a 3" × 5" card, write your name, the date, the type of fungus collected, and the place where it was found, and describe the substrate upon which the fungus was growing. Place the card and your material in the demonstration area. Examine the other specimens and decide whether or not you agree with your classmates' identifications. If you disagree with a particular identification, locate the "collector" and see if you can come to an agreement.

   *a. List several ways in which fungi are beneficial to humans.* ________________

   ________________

   *b. List several ways in which fungi are harmful to humans.* ________________

   ________________

## EXERCISE G Diversity Among the Lichens

**Lichens** are distinct organisms that are actually two organisms in one. The body is made up of certain genera of green algae or cyanobacteria that embed themselves in the mycelium of a fungus (usually an ascomycete or a basidiomycete) and live symbiotically with it. The fungus is the dominant (most prominent) of the two organisms. Thus lichens are usually studied with the kingdom Fungi.

Lichens are found on tree trunks, rocks, and arctic mountain tops, to name just a few locations. Often lichens are the first colonists on bare, rocky areas.

### Objectives

☐ Recognize lichens in nature and identify their growth forms.

### Procedure

1. Note the growth forms of lichens on demonstration. See if you can identify the following three types (Figure 23G-1a–c): **crustose,** closely encrusting bodies; **foliose,** leafy bodies; **fruticose,** shrubby, branching bodies.
2. Examine a prepared slide of lichen thallus showing algal cells surrounded by fungal hyphae (Figure 23G-1d). In the space below, draw and label your observations.
3. Did you or others in your class collect any lichens?

   *a. Do your lichen collections (or lack or them) reflect the air quality in your community or are they simply indicative of the habitats surveyed for the collections?* ________________

   ________________

   *b. In which Kingdom would you classify lichens: with the algae?* ________________ *with the fungi?*

   ________________

   *c. Which lichen characteristics would you use for classification?* ________________

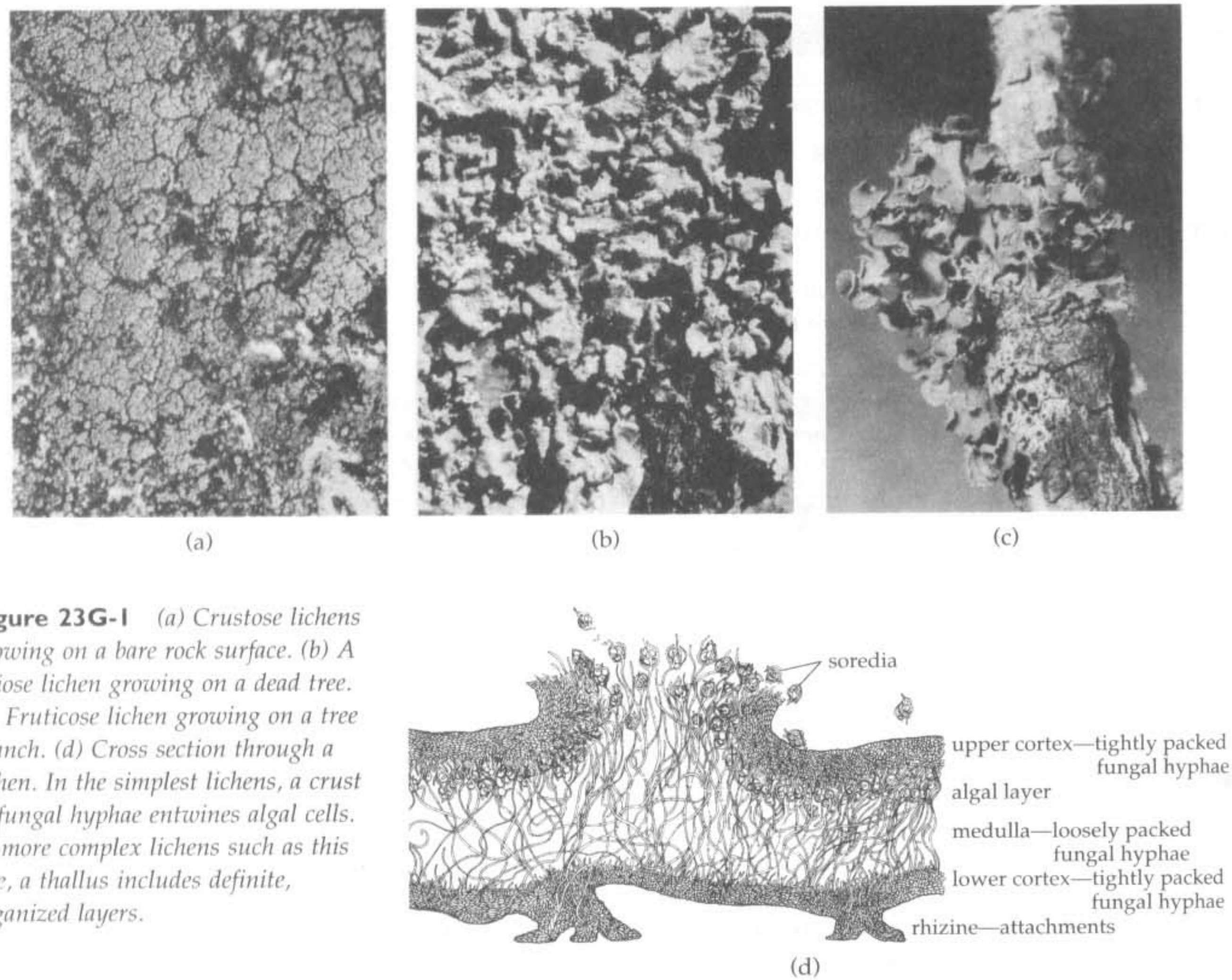



**Figure 23G-1** *(a) Crustose lichens growing on a bare rock surface. (b) A foliose lichen growing on a dead tree. (c) Fruticose lichen growing on a tree branch. (d) Cross section through a lichen. In the simplest lichens, a crust of fungal hyphae entwines algal cells. In more complex lichens such as this one, a thallus includes definite, organized layers.*

## PART II KINGDOM PLANTAE

### NONTRACHEOPHYTES

Members of the kingdom Plantae are photosynthetic autotrophs. Those in existence today can be grouped into 12 phyla. Most are land plants that developed the following adaptations to make the transition from an aquatic to a terrestrial environment:

- A waxy coating or cork layer that retards water loss on plant parts located above ground.
- Pores (called **stomata**) in the aboveground parts for gas exchange.
- Multicellular reproductive organs (**gametangia** and **sporangia**).
- Retention of the fertilized egg within the female gametangium so that the young sporophyte plant is protected.

Not long after the transition to land, plants diverged into two lines—one gave rise to the **nontracheophyte plants** (including mosses, hornworts, and liverworts) and the other to the **tracheophyte plants** (including ferns, gymnosperms, and angiosperms). (*Note:* The term "nonvascular plants" has long been used to describe the mosses, liverworts, and hornworts, but it is misleading because some mosses, unlike liverworts and hornworts, have limited amounts of vascular tissue. The term "bryophytes" has also been used to describe these three phyla of nontracheophytes, but this term is now used to refer to the mosses only.)

In general, tracheophytes (vascular plants) have specialized vascular tissues: **xylem** for the transport of water and minerals upward to the plant body and **phloem** for the distribution of photosynthetic products.

Nontracheophytes absorb moisture mainly through aboveground structures and depend on diffusion for transport.

All land plants have the same type of life cycle involving an alternation of generations. A haploid **gametophyte** plant produces haploid ($n$) gametes by mitosis. These gametes fuse to form a diploid ($2n$) **zygote,** which then grows into a diploid plant, the **sporophyte,** which produces spores ($n$) by meiosis. The haploid spores then develop into haploid gametophytes and the cycle begins again (Figure 23II-1).

Among the nonvascular plants, the gametophyte generation is the most conspicuous and occupies the dominant part of the life cycle.

Before you continue, make sure you understand the importance of the last two paragraphs. Check your understanding by answering the following questions.

*a. In plants, what process produces gametes?* ________________

*b. What is the process that produces gametes in animals such as humans?* ________________ *Is this the same process that produces gametes in plants?* ______

*c. Why is it beneficial to plants to produce spores in addition to gametes?*

________________________________________________

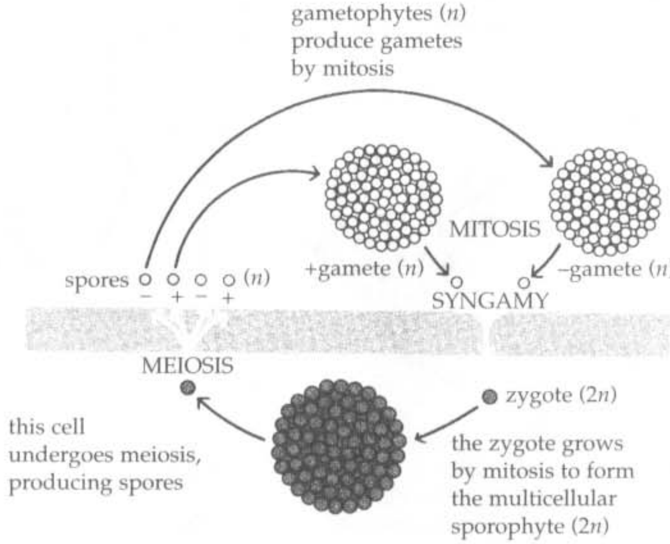
*d. What process produces spores?* ________________

*e. Why don't humans produce spores?* ________________________________

*f. What is the dominant part of the life cycle in the nontracheophytes?*

________________________________________________

**Figure 23II-1** *Generalized life cycle, known as alternation of generations, characteristic of land plants.*




## EXERCISE H Nontracheophytes—Mosses, Liverworts, and Hornworts

Although basically terrestrial, nontracheophyte plants are restricted to moist habitats such as creek banks and moist woods. Some are even aquatic, though none are marine. Members of this group are small plants that have structures resembling roots, stems, and leaves, but because most nontracheophytes lack the vascular tissues typical of most land plants (phloem and xylem), they do not, strictly speaking, have "true" roots, stems, or leaves.

A distinct alternation of generations occurs. Both gametophyte and sporophyte are multicellular and visible to the eye, with the gametophyte being more prominent.

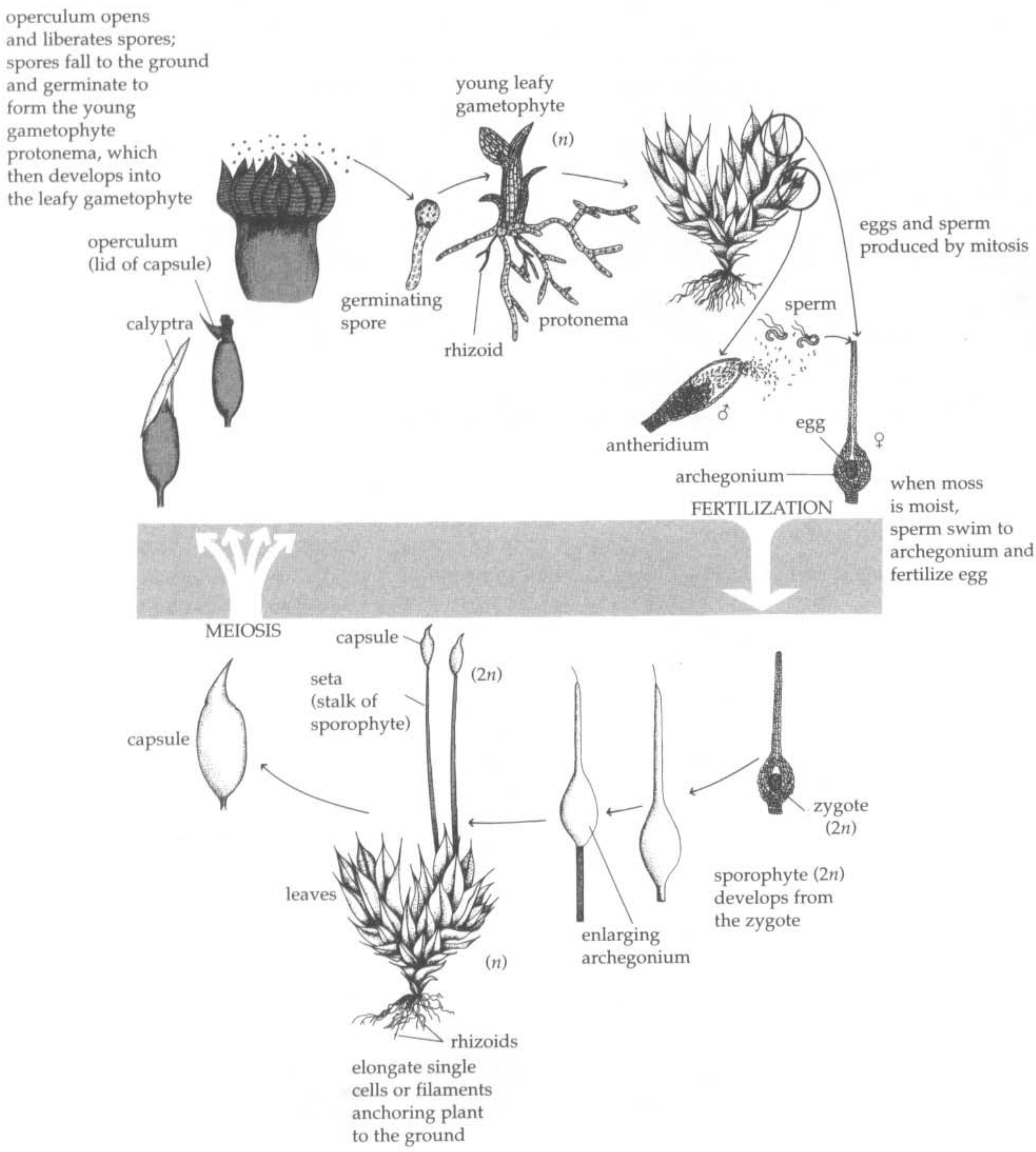



**Figure 23H-1** *Life cycle of the moss. The gametophyte generation is the soft, green carpet you walk on in the woods. Gametes are produced by mitosis within specialized gametophyte structures called archegonia (produce eggs) and antheridia (produce free-swimming biflagellated sperm).*

*If you examine moss closely at certain times of the year, you will see the sporophyte generation—small hairlike projections topped by capsules (sporangia)—rising above the green leaves of the gametophytes. Spores produced within the sporangia by meiosis fall to the ground and germinate, giving rise to a filamentous or platelike protonema—the new gametophyte generation.*

Mosses (phylum **Bryophyta**), liverworts (phylum **Hepatophyta**), and hornworts (phylum **Anthocerophyta**) are the three phyla of nontracheophyte plants.

## Objectives

- ☐ Name the major structures of a moss.
- ☐ Describe the life cycle of a typical bryophyte.

## Procedure

**1.** Examine fresh moss (phylum Bryophyta) sporophyte and gametophyte material and identify the following structures. Refer to the moss life-cycle diagram (Figure 23H-1) and be sure that you understand the relative importance and function of each structure.

**Gametophyte** The leafy green plant of the haploid generation.

**"Leaves"** Bladelike structures spirally or alternately arranged around the axis of the moss gametophyte.

**Rhizoids** Rootlike structures anchoring the gametophyte.

**Protonema** Haploid structure produced by the germinating spore, which gives rise to the gametophyte.

**Sporophyte** The body of the diploid generation, consisting of a foot, stalk (**seta**), and capsule (Figure 23H-2).

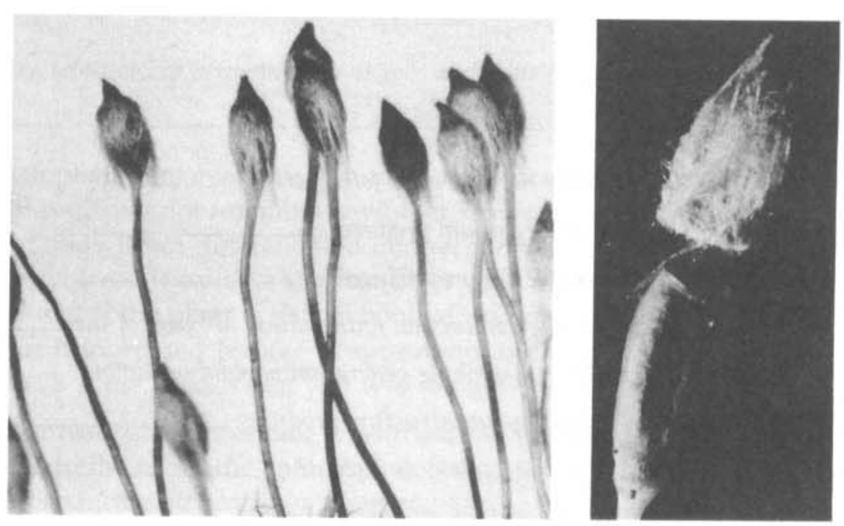
**Capsule (sporangium)** The top portion of the moss sporophyte within which spores are produced. Spores are released through the lid (**operculum**) of the capsule.

**Spores** Haploid reproductive structures responsible for the asexual portion of the moss life cycle.

*a. Why do mosses need a moist environment to reproduce sexually? (Refer to the moss life cycle, Figure 23H-1.)* ______________________________

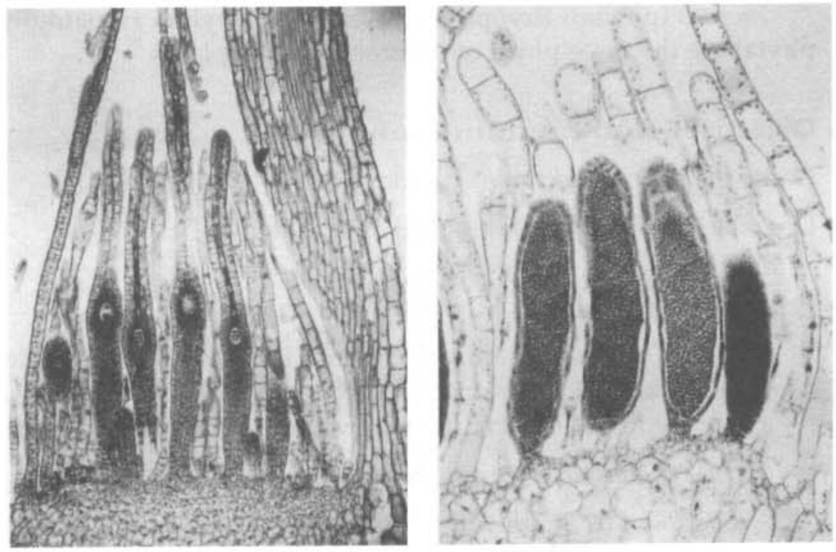
______________________________

**Figure 23H-2** *Spore-bearing setae of the hairy moss,* Pogonatum brachyphyllum. *(b) Capsule of the sporophyte of a moss, with the calyptra (the enlarged archegonium) totally removed, revealing the lid, or operculum, of the capsule.*



(a) (b)

**Figure 23H-3** *Gametangia of a moss,* Mnium. *(a) Longitudinal section through female gametangia (archegonia) with eggs. (b) Longitudinal section through male gametangia (antheridia) containing male gametes, sperm.*



(a) (b)

*b. How (or when) do mosses growing in dry environments reproduce?*

________________________________________

________________________________________

**2.** Examine prepared slides of moss antheridia and archegonia (Figure 23H-3) and identify the following structures. (Refer to the moss life-cycle diagram to be sure that you understand their relationship to other gametophyte and sporophyte structures.) Draw and label your observations in the space below.

**Antheridium** The male reproductive organ in which sperm develop.

**Sperm** The motile (flagellated) male gamete produced in an antheridium.

**Archegonium** Female gametangium in which the egg develops.

**Egg** Nonmotile female gamete produced in an archegonium.

*c. Is water necessary for fertilization?* ______

*d. The archegonium produces* ______________.

*e. The antheridium produces* ______________.

*f. The archegonium and antheridium are part of the* ______________ *generation.*

*g. Is the gametophyte generation haploid or diploid?* ______________

*h. The sporophyte structure produces* ______________.

*i. Are spores haploid or diploid?* ______________

*j. The process that produces spores is* ______________.

*k. What do you notice about the shapes of the antheridia and archegonia?*

________________________________________

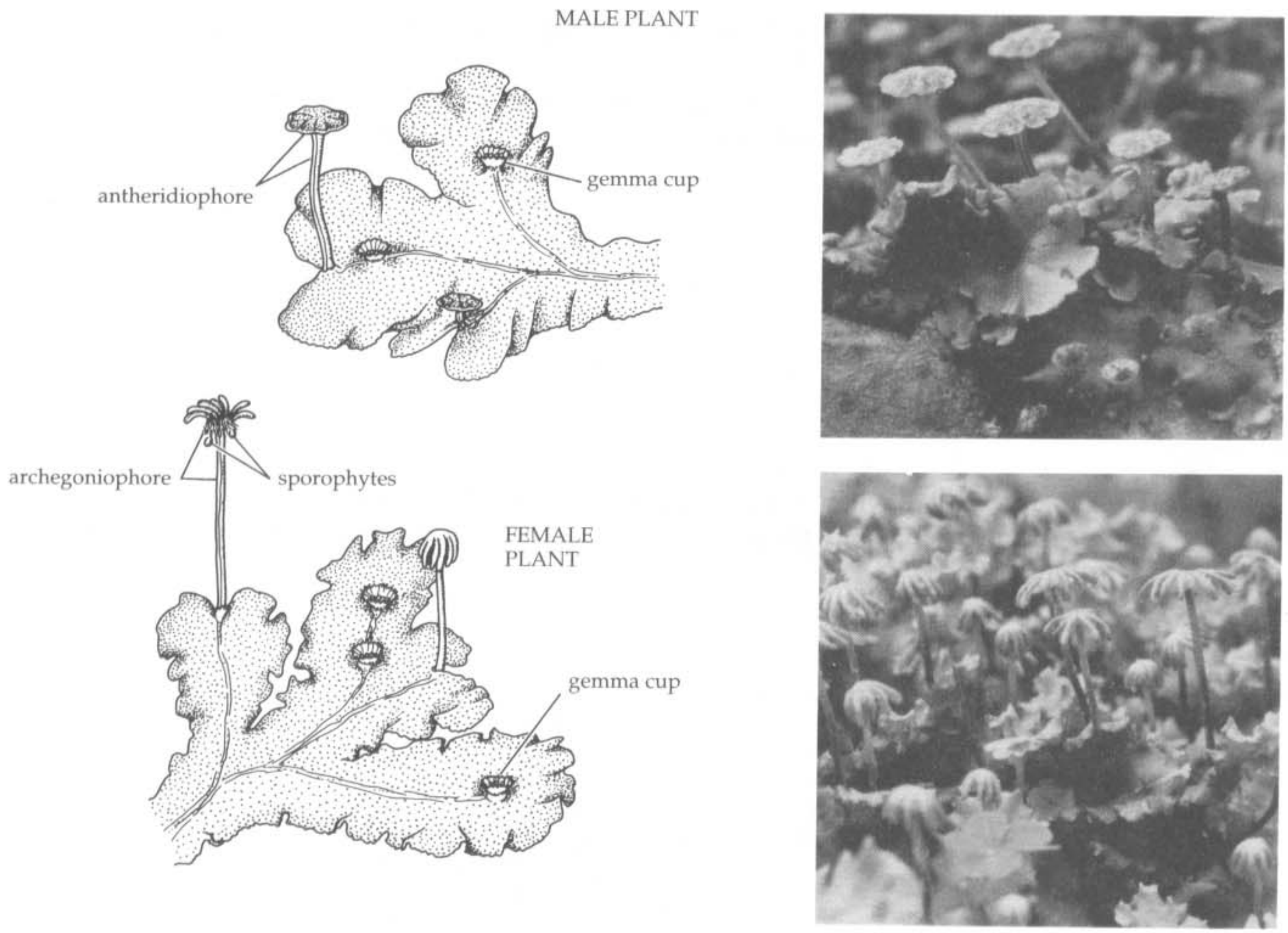



**Figure 23H-4** *Gametophyte and sporophyte of the leafy liverwort* Marchantia. *The male and female gametophyte plants bear raised gametangia. Antheridia, which produce sperm, appear on the male plant; archegonia, which produce eggs, appear on the female plant.*

*l. How would you describe the relationship between their shapes and their functions?*

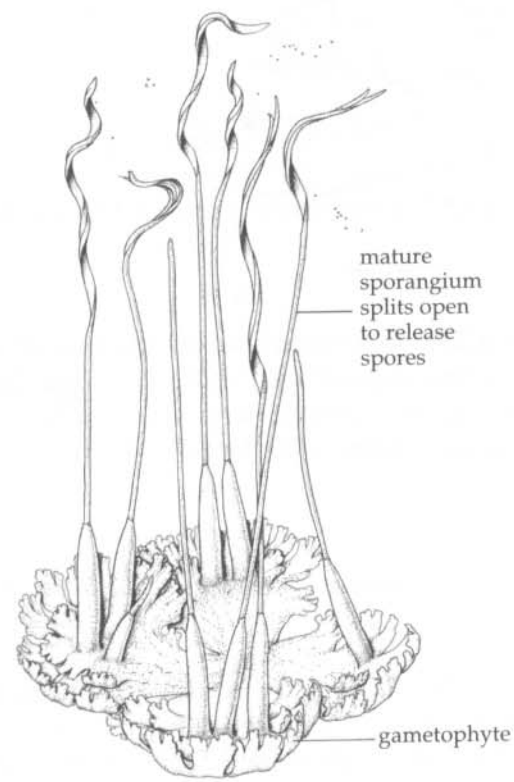
3. If liverworts (phylum Hepatophyta) are available, examine them carefully (Figure 23H-4). At first glance, a liverwort will probably not resemble any other kind of plant you have seen before. Notice that the plant body is not differentiated into recognizable roots, stems, or leaves. The type of structure you see is called a **thallus.** Liverworts assume one of two different forms: **thallose,** in which the plant is flat, ribbonlike, and dichotomously branched; or **leafy,** in which the thallus is lobed and leaflike in appearance (Figure 23H-4). More liverworts are leafy than thallose, but the species that you will see is a type of thallose liverwort.
4. Obtain a living liverwort, *Marchantia,* and examine it with a dissecting microscope. The plant body is the gametophyte—as in the moss, the gametophyte generation in the liverwort is the dominant one. The gamete-producing structures, archegonia and antheridia, appear as small palm-tree-like structures on the thallus of male and female plants. On the lower surface of the thallus, you will find rootlike structures (**rhizoids**) with which the liverwort adheres to its growth site and obtains nutrients. Also, look for **cupules** on the upper surface of the thallus.

These cups contain specialized reproductive structures called **gemmae** used for asexual reproduction (Figure 23H-4).

5. Using your knowledge of the typical life cycle of a moss and your observations of *Marchantia*, draw a typical life cycle for the liverwort in the space below.

6. If hornworts (phylum Anthocerophyta) are available in your laboratory, examine their structure and identify the parts belonging to the sporophyte and gametophyte generations (Figure 23H-5).

**Figure 23H-5** *Gametophyte of* Anthoceros, *a hornwort, showing attached sporophytes.*



## Laboratory Review Questions and Problems

1. Fill in the following table to summarize the differences among phyla in the kingdom Fungi.

| Phylum | Distinguishing Characteristics | Type of Hyphae | Type of Reproductive Structures |
|---|---|---|---|
| Zygomycota | | | |
| Ascomycota | | | |
| Basidiomycota | | | |
| Chytridiomycota | | | |

2. Why are the deuteromycetes ("fungi imperfecti") not included among the phyla of fungi?

3. Why are the chytrids (phylum Chytridiomycota) unusual among the fungi?

4. Lichens are usually studied with the kingdom Fungi. Is there another kingdom with which they might be studied? Explain.

5. Why can lichens be used as an example of symbiosis?

6. Why is it not correct to refer to mosses as "nonvascular plants"? How are the following terms related: bryophytes, nontracheophytes, nonvascular plants?

7. Draw a typical life cycle for a moss. Which generation is the conspicuous generation?

8. Define the following terms and indicate whether each term can be used to describe mosses, liverworts, or both.

Rhizoids

Sporangium

Thallus

Gemmae

Archegonium

Antheridium

Spores