

Plants, Fungi, and the Colonization of Land

Objectives

Introduction Explain the significance of mycorrhizae to plant health.

- 17.1 Compare the structure of multicellular algae and plants. Explain how plants are adapted to life on land.

Plant Evolution and Diversity

- 17.2 Explain how the first terrestrial plants evolved. Describe the structure of charophyceans and the plants called *Cooksonia*.
- 17.3 Distinguish between bryophytes, seedless vascular plants, gymnosperms, and angiosperms.
- 17.3 Describe the four key adaptations for life on land that evolved in plants.

Alternation of Generations and Plant Life Cycles

- 17.4 Describe the alternation of generations life cycle. Explain why this cycle appears to have evolved independently in different groups of plants.
- 17.5, 17.6 Describe the key events of the moss and fern life cycles.
- 17.7 Explain how coal formed.
- 17.7 Describe the conditions in which the gymnosperms became dominant.
- 17.8 Describe the stages of the pine tree life cycle.
- 17.9 Describe the parts of a flower and list their functions.
- 17.10 Describe the stages of the angiosperm tree life cycle.
- 17.11 Describe examples of adaptations that promote seed dispersal.
- 17.12 Describe the significance of angiosperms to humans.
- 17.13 Explain how flowers are adapted to attract pollinators.
- 17.14 Describe the human impact on plant diversity. Explain the significance of this loss for humanity.

Fungi

- 17.15 Describe the important roles of fungi in natural systems. Explain why the mutualistic relationship between plants and fungi was vital to the movement of both groups onto land.
- 17.16 Describe the main traits of fungi.
- 17.17 Describe the most common life cycle of fungi.
- 17.18 Describe the structure and characteristics of lichens.
- 17.19 Explain how parasitic fungi harm plants and animals.
- 17.20 Describe the positive ecological and practical roles of fungi.

Key Terms

mycorrhiza	seed	anther
kingdom Plantae	spore	carpel
cuticle	pollination	stigma
stoma	gymnosperm	ovary
vascular tissue	angiosperm	fruit
xylem	alternation of generations	kingdom Fungi
phloem	fossil fuel	absorption
gametangium	conifer	hypha
embryophyte	ovule	mycelium
charophycean	pollen grain	dikaryotic phase
sporangium	sepal	fruiting body
bryophyte	petal	mating type
vascular plant	stamen	lichen

Word Roots

bryo- = moss; **-phyte** = plant (*bryophytes*: the mosses, liverworts, and hornworts; a group of nonvascular plants that inhabit the land but lack many of the terrestrial adaptations of vascular plants)

di- = two; **-karyo** = nucleus (*dikaryotic*: a mycelium with two haploid nuclei per cell, one from each parent)

gymno- = naked; **-sperm** = seed (*gymnosperm*: a vascular plant that bears naked seeds not enclosed in any specialized chambers)

Lecture Outline

Introduction *Plants and Fungi—A Beneficial Partnership*

- A. The lives of modern plants and fungi are intertwined.
 1. We depend on plants and, indirectly, fungi for much of our food.
 2. Plants are often harmed by fungi.
 3. On the other hand, mycorrhizal fungi aid nearly all plants in the wild. **Mycorrhizae** are rootlike structures made of both fungi and plants. The fungi help plants obtain nutrients and water, and protect plant roots from parasites, in exchange for food the plants make by photosynthesis (Figure 17.0).
Preview: Mycorrhizae are also discussed in Module 32.11.
 4. Modern agricultural practices, such as killing the parasitic fungi with fungicides, may disrupt mycorrhizal fungi, forcing the need for fertilizer.
 5. *Preview:* This kind of dilemma often results when humans try to manipulate complex natural systems (Chapter 38).
- B. Plants and fungi evolved together as life moved onto land over 400 million years ago (mya). This observation is supported by the earliest plant fossils having mycorrhizae.

Module 17.1 What is a plant?

- A. *Review:* In the two-kingdom system, Linnaeus classified algae as plants. In the five-kingdom system, algae are protists (Modules 15.14 and 16.25).
- B. The definition of plants as multicellular, eukaryotic photosynthesizers also describes multicellular algae (Modules 16.23 and 16.24).
- C. Multicellular seaweeds, the most complex algae, are adapted for life in water, while plants are adapted for life on land (Figure 17.1A). For the former, the resources, including water, carbon dioxide, and minerals, are in direct contact with their tissues, and waste products can be washed away. Water supports and suspends the body of the alga. Holdfasts anchor the alga, and all other parts can be photosynthetic. Water provides a means of dispersal for gametes and offspring.
- D. Life on land imposes problems. Water and nutrients are concentrated in the ground, while carbon dioxide and light are most abundant above the ground. Air provides no support against the force of gravity and will dry out reproductive cells.
- E. Adaptations to a terrestrial environment in plants include the following:
 - 1. Discrete organs: roots, stems, leaves, and **gametangia** specialized for anchorage and absorption, support, photosynthesis, and reproduction, respectively.
 - 2. Mycorrhizal fungi to increase the efficiency of absorption of their roots.
 - 3. A vascular network to move food (**phloem**) and water (**xylem**) among the parts (Figure 17.1B).
 - 4. A **cuticle** on leaves and stems to help retain water.
 - 5. Dependency on wind or animal carriers to disperse male gametes (contained in pollen) and offspring.
 - 6. Offspring are kept moist by developing within the female gametangium.

I. Plant Evolution and Diversity**Module 17.2** Plants evolved from green algae called charophyceans.

- A. Plants and green algae have a number of homologous features, such as identical photosynthetic pigments, food storage molecules, cell walls, and mechanisms of cell division (Modules 16.23 and 16.24).
- B. Plants may have evolved from green algae about 500 mya. The ancestor is not known, but analysis of nucleic acid sequences, cell structure, and biochemistry indicate that a group of green algae, the **charophyceans** (Figure 17.2A, a simple charophycean), and plants shared a common ancestor (Figure 17.2B, a complex charophycean.)
- C. Early plants thrived on moist shorelines where space was essentially limitless, sunlight was abundant, and where there may not have been any herbivorous animals.
- D. Among the earliest plant fossils is *Cooksonia*, which have been found in strata dated to 408 mya. This plant had branched, upright, photosynthetic stems and spore sacs (**sporangia**) but lacked leaves (Figure 17.2C).
- E. Plants more complex than *Cooksonia* are known to have been abundant ≈400 mya. Like *Cooksonia* they lacked leaves, but they had more complex sporangia and were more firmly anchored to the soil.
- F. A large number and diversity of plants with well-developed leaves and roots were present by 375 mya.

Module 17.3 Plant diversity provides clues to the evolutionary history of the plant kingdom.

- A. Plant phylogeny shows branching of several plant lineages, reflecting major evolutionary steps. These are previewed here, and details are added in the modules that follow (Figure 17.3A).
- B. Two lineages of plants arose, most likely from charophyceans, ≈ 400 mya. One of these lineages gave rise to modern bryophytes. The other lineage gave rise to vascular plants.
- C. Like other plants, **bryophytes** have a cuticle and embryos that develop within gametangia. However, many bryophytes lack vascular tissue for water conduction and internal support. Like their algal ancestors, bryophytes have flagellated sperm and depend on water for reproduction (Figure 17.3B).
- D. **Vascular plants** have xylem and phloem that transport water and nutrients and provide support (Figure 17.3C). In addition, these plants have embryonic development within gametangia.
- E. About 360 mya, vascular plants split into two lineages. One of these lineages gave rise to seedless plants and the other gave rise to **seed** plants.
- F. Ferns are a modern example of a seedless vascular plant and use a haploid **spore** for reproduction. The leaves (fronds) develop from stems that grow along the ground (Figure 17.3C). Ferns are found in shady temperate forests and are most diverse in the tropics.
- G. Seed plants make up $\approx 90\%$ of all living plant species. Adaptations responsible for the success of this group include seeds that provide the embryonic plant with a protective coating and a food supply. These plants also produce pollen, vehicles that transfer non-flagellated sperm to the female parts of plants.
- H. The earliest seed plants to appear were the **gymnosperms** (naked seed). The name of these plants is based on their seeds not being contained within a fruit. Gymnosperms, along with seedless plants, were dominant for over 200 million years. The largest living group of gymnosperms are the conifers.
- I. Flowering plants (**angiosperms**) evolved from the seed plant line ≈ 130 mya. Flowers increase the efficiency of pollination and develop into fruits that protect seeds and increase the efficiency of seed dispersal. The majority of modern plant species are angiosperms.

Preview: Angiosperm structure is discussed in detail in Chapter 31.

II. Alternation of Generations and Plant Life Cycles**Module 17.4** Haploid and diploid generations alternate in plant life cycles.

- A. *Review:* *Ulva* life cycle (Figure 16.24C); human life cycle (Figure 8.13).
- B. Plant life cycles alternate between multicellular, diploid ($2n$) and haploid ($1n$) adults, unlike animals that are diploid as adults and produce single-celled haploid gametes (Figure 17.4).
- C. Sporophytes grow from diploid zygotes and produce spores by meiosis.
- D. Gametophytes grow from haploid spores and produce gametes by mitosis.
- E. **Alternation of generations** provides two chances to produce large numbers of offspring, zygotes, and spores.
- F. Major changes from the algal life cycle that occurred during the evolution of plants were the change in dominance from the gametophyte to the sporophyte, the change in dependency of sporophytes on gametophytes to the opposite dependency, and the loss of flagellated sperm except in mosses and ferns.

NOTE: Compare the mosses (dominant gametophytes, semiparasitic sporophytes, flagellated sperm) to the conifers or flowering plants (dominant sporophytes, semiparasitic, reduced gametophytes, pollen).

Module 17.5 Mosses have a dominant gametophyte.

- A. The green growth we see consists mostly of gametophytes (Figure 17.3B).
NOTE: Adult gametophytes consist of nonvascular stems and leaves and threadlike holdfasts. For water and minerals, they depend on rain or on water flowing along the stem from the ground surface.
- B. Gametophytes produce sperm and eggs in gametangia (Figure 17.5).
- C. Flagellated sperm require a film of water in which to swim from male gametangium to female gametangium.
- D. The zygote remains in the female gametangium and develops into the sporophyte.
- E. Meiosis occurs in the sporangium and produces spores.
- F. Spores are released and later develop into gametophytes by mitosis.
NOTE: Adult sporophytes lose their chlorophyll and become more dependent on the female gametophytes. The sporangia are adapted to dispersing spores by means of movable teeth around the sporangium opening, on wet/dry cycles.

Module 17.6 Ferns, like most plants, have a dominant sporophyte.

- A. The fern fronds we see are sporophytes.
NOTE: Ferns have underground stems with small roots, and all parts are vascularized. The fronds are the principal organs of photosynthesis.
- B. Gametophytes produce flagellated sperm and eggs (like mosses) (Figure 17.6).
- C. Like mosses, fern zygotes remain in the female gametangium and develop into adult sporophytes. Eventually the sporophytes take over.
- D. Sporangia in clusters on the frond's underside produce haploid spores by meiosis.
NOTE: Fern sporangia have a unique mechanism to release their spores. As the sporangia dry out, thick-walled cells along the "back" of the sporangium pull the thin-walled "front" cells into tension. In a fraction of a second, the front cells rupture, scattering the spores into the air.
- E. Spores are dispersed by wind and grow into small, heart-shaped gametophytes by mitosis.
- F. Today, about 95% of all plants have a dominant sporophyte generation.

Module 17.7 Seedless plants formed vast "coal forests."

- A. During the Carboniferous period ($\approx 285\text{--}360$ mya), vast forests grew in tropical, swampy areas over what is now Eurasia and North America.
- B. The forests included dominant lycopods, horsetails (both seedless plants more primitive than ferns), and tree ferns (Figure 17.7).
- C. The compressed remains of these forests survive as deposits of coal and other **fossil fuels**.
- D. At the end of the Carboniferous period, the climate turned colder and drier, providing the conditions for further plant evolution. The evolution of pollen was key to the adaptation of seed plants to dry land.

- E. The most successful of the early seed plants were the gymnosperms. They grew alongside seedless plants in Carboniferous swamps. Conifers survived the drying of these swamps and remain the dominant type of gymnosperm.
- F. Gymnosperms have had a wide distribution for ≈ 250 million years. **Conifers** are the most successful of several groups of gymnosperms because they are adapted to harsh winter climates. They readily shed snow, their needles resist drying, and since they do not shed their leaves they are able to start photosynthesizing as soon as the growing season begins.

Module 17.8 A pine tree is a sporophyte with tiny gametophytes in its cones.

- A. Cones are a significant adaptation to land, protecting all reproductive structures: sporangia, microscopic gametophytes, and zygotes.
- B. Female cones are larger. Scales bear a pair of **ovules** (sporangia with a covering, or integument). Within the ovule, one of the four products of meiosis develops into a tiny, multicellular, “female” gametophyte.
- C. Male cones are smaller, and scales bear many sporangia that make spores by meiosis. Spores develop into tiny male gametophytes (**pollen grains**), each consisting of a few cells. Pollen grains house the cells that will develop into sperm.
NOTE: The particular pollen grains in Figure 17.8 are typical of the pine family: The central cell and cells within it compose the gametophyte. The two lateral “cells” are outgrowths of the cell wall that function as floats.
- D. Pollen is dispersed by wind. Pollination occurs when a pollen grain lands near an ovule and grows into it.
- E. Meiosis occurs in the ovule where a haploid spore cell begins to develop into the female gametophyte. Months later, a few of the female gametophyte’s cells inside the ovule function as eggs. The pollen tube delivers a male gametophyte’s nucleus (functioning as a nonflagellated sperm) to fertilize an egg.
- F. The zygote develops into the embryonic sporophyte, and the remaining ovule develops into the other parts of the seed (the integument becomes the seed coat, and the female gametophyte becomes a food supply).
- G. Seed dispersal is by wind or animal.
- H. Under favorable conditions, the seed germinates and the embryo grows into a tree.

Module 17.9 The flower is the centerpiece of angiosperm reproduction.

Preview: The life cycle of the flowering plant (Modules 31.9–31.15).

- A. Flowers expose an angiosperm’s sexual parts and are the sites for pollination and fertilization (Figure 17.9A).
- B. Flowers are short stems with the following modified leaves: **sepals**, to protect flower buds; **petals**, to attract animal pollinators; **stamens**, the male parts (holding the anthers, in which pollen develops); **carpels**, the female parts (consisting of sticky **stigma** to trap pollen; and the **ovary**, which bears ovules and later develops into fruit) (Figure 17.9B).

Module 17.10 The angiosperm plant is a sporophyte with gametophytes in its flowers (Figure 17.10).

- A. *Review:* Gymnosperm life cycle (Figure 17.8).
- B. Flowers protect all microscopic reproductive structures: sporangia, male and female gametophytes, and zygotes.

- C. Meiosis in the anthers leads to haploid spores that undergo mitosis and develop into the male gametophytes (pollen grains).
- D. Meiosis in the ovules leads to haploid spores that undergo mitosis and develop into the female gametophytes, each of which produces an egg, inside the ovules.
- E. Pollen is dispersed by either wind or insects. Pollination occurs when a pollen grain lands on the stigma.
- F. The pollen grows into the ovary and delivers one nucleus (again functioning as a non-flagellated sperm) to the egg nucleus in the ovule. Fertilization usually occurs within 12 hours after pollination.
- G. Following fertilization, the zygote develops into the embryonic sporophyte in the seed, and the ovary develops into the fruit.
- H. Seed dispersal is also by wind or animal and is aided by the enveloping fruit.
- I. Under favorable conditions, the seed germinates and the embryo develops into a mature sporophyte.
- J. *Preview:* Further details about the flowering plant life cycle, including the unique adaptation of double fertilization, are covered in Modules 31.9–31.15.

Module 17.11 The structure of a fruit reflects its function in seed dispersal.

- A. **Fruits** develop from ovaries and ripen quickly, within one growing season.
- B. Some fruits are adapted for wind dispersal of seeds (Figure 17.11A).
- C. Others are adapted to hitch a ride on animals (Figure 17.11B).
- D. Fleshy, edible fruits are attractive to animals as food. Seeds of these fruits usually pass unharmed through the animal's digestive tract and are deposited, with fertilizer, far from the parent plant (Figure 17.11C).

Module 17.12 Connection: Agriculture is based almost entirely on angiosperms.

- A. Gymnosperms supply almost all our lumber and paper, but food comes from angiosperms.
- B. Angiosperms are also used for fiber, medication, perfumes, and as a source of fine hardwoods.
- C. Agriculture began when humans decided to cultivate grains in an effort to control food supplies. Selective breeding produced better plants and today genetic engineers are developing new and improved plants.

Module 17.13 Interactions with animals have profoundly influenced angiosperm evolution.

Preview: Coevolution (Module 36.3).

- A. Most flowering plants depend on insects, birds, or mammals for pollination and seed dispersal.
- B. Most land animals depend on flowering plants for food.
- C. Pollen and nectar provide food for pollinators. Bees are one of the most highly co-evolved groups of pollinators (Figure 17.13A).
- D. Flowers that are pollinated by birds are usually pink or red (Figure 17.13B).
- E. Flowers that are pollinated at night by bats or moths are usually large and light-colored (Figure 17.13C).
- F. These mutual dependencies have been favored by natural selection.

Module 17.14 Connection: Plant diversity is a nonrenewable resource.

- A. Plant biodiversity is being reduced at an unprecedented rate. The majority of plant genetic diversity is found in the rain forests of the world.
- B. The loss of plants is harmful in a variety of ways:
 - 1. Twenty-five percent of all prescription medicine comes from plants and only 5000 of the more than 320,000 plant species have been researched as possible medicines.
 - 2. Animals are perishing along with the plants.
 - 3. Plant loss reduces air and water quality.
- C. Approximately 50 million acres of forest are cleared every year. In an effort to reduce plant diversity loss, scientists have joined with the UN and an organization called the All Species Foundation in an effort to catalog all species in the next 25 years.
- D. Efforts are also under way to learn how to harvest timber in an environmentally sound manner.

III. Fungi

Module 17.15 Fungi and plants moved onto land together.

- A. *Review:* Mycorrhizae helped make colonization of land possible (*Opening Essay*, Figure 17.0).
- B. Fungi are heterotrophic and require external sources of food molecules. They likely evolved to terrestrial habitats from aquatic ancestors, joining their food supply, which were early plants on land.
- C. Fungi are found in both terrestrial and aquatic environments.
- D. Many fungi are parasites of plants (Figure 17.15A).
Preview: Some fungi and plants have a mutualistic relationship (Module 32.11).
- E. A few fungi have unique adaptations that enable them to trap animals for food (Figure 17.15B).
- F. A major role of fungi is the decomposition of dead organisms, particularly plants, and their organic molecular remains. Some fungi can break down other organic materials, including residues of pesticides and cancer-causing chemicals (Figure 17.15C).

Module 17.16 Fungi absorb food after digesting it outside their bodies.

- A. The **kingdom Fungi** includes heterotrophic eukaryotes that digest their food externally and absorb the resulting small molecules as nutrients. Other characteristics include: cell walls of chitin, spore production, and the absence of motile stages. Fungi are grouped in their own kingdom. They differ from plants, with which they were once classified, because they cannot make food by photosynthesis, and in the details of their cellular and molecular structure.
- B. Fungi are usually multicellular, but their bodies (mycelia) are composed of extensive networks of **hyphae** (filamentous cell-like units). Hyphae may be branched, may be a syncytium, or may be divided into cell-like compartments (Figure 17.16A, D).
- C. The hyphae of the **mycelium** extend rapidly into the food source, developing a huge surface area from which digestive enzymes are secreted and through which the digested food is absorbed. A large mycelium can add as much as a kilometer of hyphae each day (Figure 17.16B).
- D. Some fungi produce mushrooms, external reproductive bodies composed of packed hyphae (Figure 17.16C).

Module 17.17 Many fungi have three distinct phases in their life cycle.

- A. The phases of mushroom-producing fungi and their relatives are characterized by a **dikaryotic phase** (Figure 17.17).
- B. Fertilization of one nucleus in a dikaryotic pair with another in the mushroom (**fruiting body**) produces diploid zygotes. These are held in terminal cells of the hyphae in the mushroom. Meiosis of this zygote produces the haploid nuclei that form spores.
- C. Haploid spores are shed from the fruiting body, are wind-dispersed (or dispersed by water or animals), and develop into haploid mycelia. Two compatible, haploid mycelia can fuse to form a dikaryotic mycelium.
- D. The dikaryotic mycelium maintains the compatible (and genetically different) nuclei, paired but separate. This phase is dominant in the life of the fungus, often lasting for many years as it continues to grow into its food source. Dikaryotic hyphae also make up the tissues of the mushrooms produced by this mycelium periodically.

NOTE: The “humongous fungus” in Michigan, a species of *Armillaria*, is estimated to occupy 30 acres and be 1500 years old. However, the mycelium of *Armillaria* is a unique exception among mushroom-producing fungi. It is diploid for most of its life. An even larger fungus was recently found in Oregon that is spread out over 2200 acres.

- E. Some fungi are very simple. Yeasts are single-celled and mostly reproduce by mitotic cell division.
- NOTE:* The term *yeast* refers to a growth form and ecological habitat preference (plant saps), not to a taxonomic category. There are many types of yeasts, related by reduction in form to several not closely related fungi. Many yeasts exhibit sexual stages.

Module 17.18 Lichens consist of fungi living mutualistically with photosynthetic organisms.

- A. **Lichens** are associations of millions of green algae or cyanobacteria held in a tangled network of fungal hyphae (Figure 17.18B).
- B. The fungus receives food from the photosynthesis of its partner.
- C. The alga or cyanobacterium receives housing, water, and the minerals trapped by the hyphal network.
- D. All lichen fungi and most lichen algae and cyanobacteria cannot grow independently. The relationship is so complete that they are classified together as a single species.
- E. Asexual reproduction of the fungus and alga together is advantageous; dispersal of both partners occurs, and they can immediately reestablish the lichen.
- F. Lichens are able to survive in habitats where neither partner (nor any other multicellular organism) could grow alone (Figure 17.18A). However, they are highly susceptible to airborne pollutants.

- G. Lichens play important ecological roles in soil formation on rock surfaces and as food for animals (Figure 17.18C).

NOTE: Cyanobacterium-containing lichens fix nitrogen and play important roles in the nitrogen cycle (Module 36.16).

- H. Some lichens are thousands of years old.

Module 17.19 Connection: Parasitic fungi harm plants and animals.

- A. Of the 100,000 species of known fungi, about one-third are mutualistic in mycorrhizae and lichens, one-third are decomposers, and one-third are parasites.
- B. Parasitic fungi are the most serious plant pests. Particularly dangerous are nonnative parasites, such as the fungus that causes Dutch elm disease (Figure 17.19A).

- C. Some parasitic fungi attack developing seeds and fruits of grains (Figure 17.19B).
- D. Fungi cause a few diseases in humans. Flour made from grain infested with ergots can cause gangrene and nervous system disorders (17.19C). LSD is one of the toxins that has been isolated from ergots. Some infections of lung tissue can be fatal, particularly in people weakened by other diseases. Less serious are the fungal infections of the outer layers of the skin known as ringworm and athlete's foot. Fortunately, fungicidal ointments can control most of these fungal parasites.
- E. Yeast infections of the vagina are usually caused by some chemical, microbial, or immunologic change in the body and are classified as opportunistic infections. This type of infection is on the rise due to the emergence of AIDS, which suppresses the immune system.

Module 17.20 Connection: Fungi have enormous ecological and practical impact.

- A. Mushrooms and other fungi are eaten.
- B. Certain molds lend distinctive flavors and textures to foods such as Roquefort and blue cheese (Figure 17.20A), and underground truffles (which also are important mycorrhizal fungi).
- C. Different strains of one kind of yeast are used in baking, brewing, and winemaking.
- D. Some fungi are important commercial sources for antibiotics (Figure 17.20B).
- E. There is evidence that fungi evolved from the same protistan lineage that gave rise to animals.

Class Activities

1. Have your students collect and classify examples of the different plant and fungal species found in the area in which they live. (It's a classic, but it's still a good way of familiarizing your students with the diversity of life.)
2. A considerable number of wild, cultivated, and cultured fungi are now available in many markets in the United States, both in fresh and dried condition, depending on the season and local availability of mushroom farms or proper habitat. Bring in examples to stimulate discussion and interest in the topic of fungi. Point out that the mushroom you see is like the apple of an apple tree: the "plant" (mycelium) that produces the mushroom is invisible to the naked eye. The mycelium of the most commonly available mushroom, *Agaricus campestris*, is a litter decomposer of composted straw. Oyster mushrooms and the Japanese mushroom, shiitake, are quite common in better markets and are both litter decomposers of wood (but can be grown on artificial logs made of sawdust). In season, you may be able to find golden chanterelles (the mycelium of which forms mycorrhizae, so these are not domesticated), truffles (very expensive and also mycorrhizal), or morels (a recent, secret process allows these to be cultured). The moldy cheeses (Brie, Camembert, and blue); wine, beer, and soy sauce bottles; and a loaf of bread can also be used as props to stress the diversity of our dependency on fungi for food. In health-food stores you may also be able to find tempeh, a soybean product fermented with *Rhizopus* mold.
3. Almost every region of the United States has at least one serious plant-pathogenic fungus. Contact your local agricultural extension office to obtain details about the identity of these fungi, and their classification, hosts, and controls. Featuring a specific representative will help clarify the general characteristics of the kingdom as a whole, particularly the reproductive advantage of producing spores and the ease with which their hyphae enter plant tissues. In presenting special information on local parasitic fungi, be sure to remind your students that the majority of fungal species are beneficial to humans, either in their roles as recyclers or mycorrhiza formers.

Transparency Acetates

Figure 17.1A	Comparing a multicellular green alga and a plant
Figure 17.2C	<i>Cooksonia</i> , one of the earliest vascular land plants (fossil at left)
Figure 17.3A	Some highlights of plant evolution
Figure 17.4	Haploid and diploid generations (Layer 1)
Figure 17.4	Haploid and diploid generations (Layer 2)
Figure 17.4	Haploid and diploid generations (Layer 3)
Figure 17.5	Life cycle of a moss
Figure 17.6	Life cycle of a fern
Figure 17.8	Life cycle of a pine tree
Figure 17.9B	The parts of a flower
Figure 17.10	Life cycle of an angiosperm
Table 17.14	A sampling of medicines derived from plants
Figure 17.16A	A mycelium, made of numerous hyphae (in this case, consisting of chains of cells)
Figure 17.17	Life cycle of a mushroom

Media

See the beginning of this book for a complete description of all media available for instructors and students. Animations and videos are available in the Campbell Image Presentation Library. Media Activities and Thinking as a Scientist investigations are available on the student CD-ROM and web site.

Animations and Videos

File Name

Flowering Plant Life Cycle Time-Lapse Video	17-01-PlantTimeLapseVideo-B.mov
Flowering Plant Life Cycle Time-Lapse Video	17-01-PlantTimeLapseVideo-S.mov
Moss Life Cycle Animation	17-05-MossLifeCycleAnim.mov
Fern Life Cycle Animation	17-06-FernLifeCycleAnim.mov
Pine Life Cycle Animation	17-08-PineLifeCycleAnim.mov
Flower Blooming Time-Lapse Video	17-09-FlwrTimeLapseVideo-B.mov
Flower Blooming Time-Lapse Video	17-09-FlwrTimeLapseVideo-S.mov
Bee Pollinating Video	17-13A-BeePollinatorVideo-B.mov
Bee Pollinating Video	17-13A-BeePollinatorVideo-S.mov
Bat Pollinating Agave Plant Video	17-13C-BatPollinatorVideo-B.mov
Bat Pollinating Agave Plant Video	17-13C-BatPollinatorVideo-S.mov
<i>Allomyces</i> Zoospore Release Video	17-17-AllomyZoosporeVideo-S.mov
<i>Phlyctochytrium</i> Zoospore Release Video	17-17-PhlyctZoosporeVideo-B.mov
<i>Phlyctochytrium</i> Zoospore Release Video	17-17-PhlyctZoosporeVideo-S.mov
<i>Saprolegnia</i> Oogonium Video	17-17-SaproOogoniumVideo-B.mov
<i>Saprolegnia</i> Oogonium Video	17-17-SaproOogoniumVideo-S.mov

<i>Saprolegnia</i> Zoospore Release Video	17-17-SaproZoosporeVideo-B.mov
<i>Saprolegnia</i> Zoospore Release Video	17-17-SaproZoosporeVideo-S.mov
Fungus Life Cycle Animation	17-17-FungusLifeCycleAnim.mov

Activities and Thinking as a Scientist	Module Number
Web/CD Activity 17A: <i>Terrestrial Adaptations of Plants</i>	17.1
Web/CD Activity 17B: <i>Highlights of Plant Evolution</i>	17.3
Web/CD Activity 17C: <i>Moss Life Cycle</i>	17.5
Web/CD Activity 17D: <i>Fern Life Cycle</i>	17.6
Web/CD Thinking as a Scientist: <i>What Are the Different Stages of a Fern Life Cycle?</i>	17.6
Web/CD Activity 17E: <i>Pine Life Cycle</i>	17.8
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Web/CD Activity 17G: <i>Connection: Madagascar and the Biodiversity Crisis</i>	17.14
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