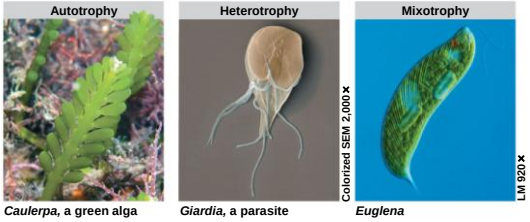
PROTISTS

16.12 Protists are an extremely diverse assortment of eukaryotes

- **Protists** are mostly unicellular eukaryotes that are found in a variety of aquatic or moist habitats. They may be
  - autotrophic, called **algae**,
  - heterotrophic, informally called protozoans, or
  - mixotrophic. **Mixotrophs** are capable of photosynthesis and heterotrophy.

Checkpoint question What is a general definition for "protist"?

Figure 16.12a



Caulerpa, a green alga | *Giardia*, a parasite | *Euglena*

Figure 16.12b

A protist from a termite gut covered by thousands of flagella, viewed with scanning electron microscope (left) and light microscope (below)

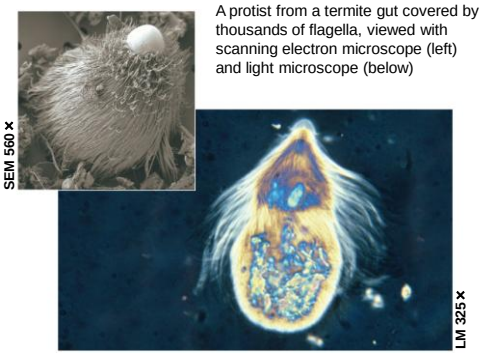
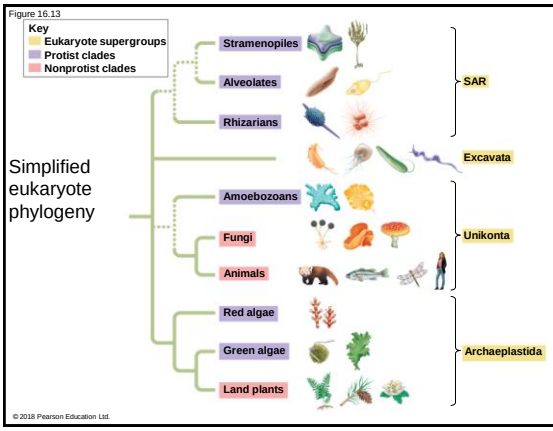


Figure 16.13



Simplified eukaryote phylogeny

Figure 16.14a

Diatom, a unicellular alga

Figure 16.14b

Brown algae: a kelp "forest"

Figure 16.14d

Figure 16.14e

A freshwater ciliate, *Paramecium*, showing cilia distributed over the cell surface (The photo also includes other unicellular organisms)

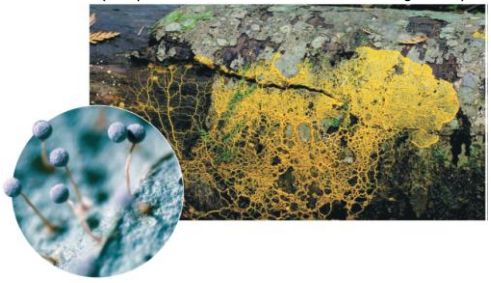
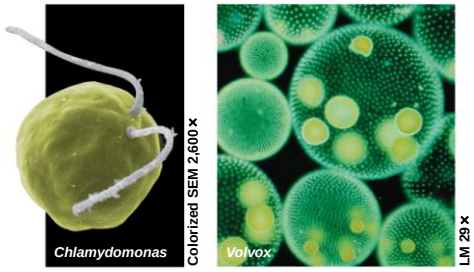


Figure 16.18b

Green algae, unicellular (left) and colonial (right)



Evolution of Plant and Fungal Diversity

Introduction

- Mutually beneficial symbioses between plants and fungi began 500 million years ago, when plants first occupied land.
  - These intimate associations allow plants to tap a vast underground network of fungal filaments into which water and mineral nutrients flow.
  - Plants supply mycorrhizae with sugars and other organic molecules.
  - At least 90% of all plants form such relationships.

17.1 Plants have adaptations for life on land

- More than 500 million years ago, the algal ancestors of plants may have carpeted moist fringes of lakes and coastal salt marshes.
- Plants and green algae called charophytes
  - are thought to have evolved from a common ancestor,
  - have complex multicellular bodies,
  - are photosynthetic eukaryotes.

17.1 Plants have adaptations for life on land

- Life on land offered many opportunities for plant adaptations that took advantage of
  - bright and abundant sunlight,
  - abundant atmospheric CO_2, and
  - initially, few pathogens or plant-eating animals.

17.1 Plants have adaptations for life on land

- But life on land had disadvantages, too. On land, plants must
  - maintain moisture inside their cells,
  - support the body in a nonbuoyant medium,
  - reproduce and disperse offspring without water,
  - anchor their bodies in soil, and
  - obtain resources from soil and air.
- Some species accumulated adaptations that made life on dry land possible.

Figure 17.1c

Comparing the aquatic adaptations of *Chara*, a multicellular green alga, with the terrestrial adaptations of moss, fern, and pine

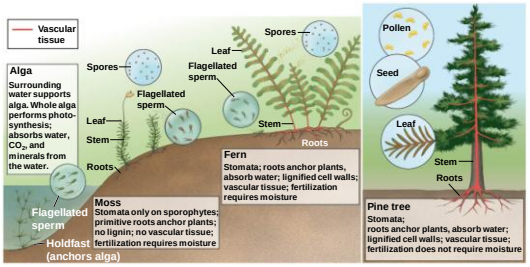
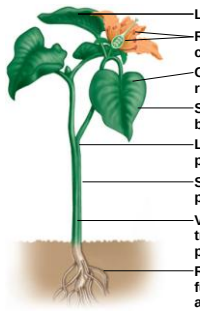


Figure 17.UN01



Leaves carry out photosynthesis
Reproductive structures, as in flowers, contain spores and gametes
Cuticle covering leaves and stems reduces water loss
Stomata in leaves allow gas exchange between plant and atmosphere
Lignin hardens cell walls of some plant tissues
Stem supports plant; may perform photosynthesis
Vascular tissues in shoots and roots transport water, minerals, and sugars; provide support
Roots anchor plant; mycorrhizae (root-fungus associations) help absorb water and minerals from the soil

17.1 Plants have adaptations for life on land

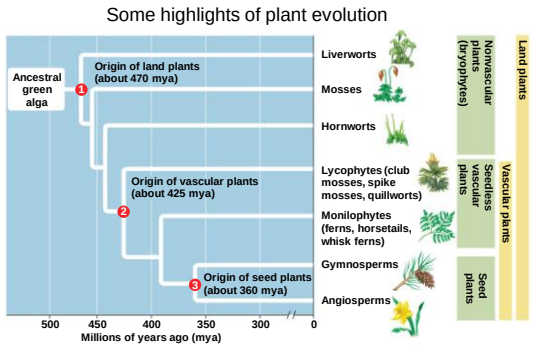
Checkpoint question What adaptations enable plants to grow tall?

The network of veins in a leaf

17.2 Plant diversity reflects the evolutionary history of the plant kingdom

- Three key events occurred in the history of the plant kingdom.
  1. Origin of land plants
  2. Origin of vascular plants
  3. Origin of seed plants

Figure 17.2a



17.4 Seedless vascular plants dominated vast "coal forests"

- Two groups of seedless plants formed vast ancient forests in low-lying wetlands during the Carboniferous period (359–299 million years ago).
- When these plants died, they formed peat deposits that eventually formed coal.
- Coal, oil, and natural gas are **fossil fuels**.
  - Pressure and heat gradually converted peat into coal.
  - Oil and natural gas formed from marine organisms.

17.4 Seedless vascular plants dominated vast "coal forests"

- Burning fossil fuels releases CO_2 and other greenhouse gases into the atmosphere, which are now causing a warming climate.
- As temperatures dropped during the late Carboniferous period,
  - glaciers formed and the climate turned drier and
  - wind-dispersed pollen and protective seeds gave seed plants a competitive advantage.

17.8 The structure of a fruit reflects its function in seed dispersal

- **Fruits** are
  - ripened ovaries of flowers and
  - adaptations that help disperse seeds.
- Seed dispersal mechanisms include
  - wind,
  - hitching a ride on animals, or
  - fleshy, edible fruits that attract animals, which then deposit the seed in a supply of natural fertilizer at some distance from the parent plant.

Figure 17.8a–c

Seed dispersal

17.9 CONNECTION: Angiosperms sustain us—and add spice to our diets

- We depend on the fruits and seeds for much of our food.
  - Corn, rice, wheat, and other grains are dry fruits.
  - Apples, cherries, oranges, tomatoes, squash, and cucumbers are fleshy fruits.
  - Spices such as nutmeg, cinnamon, cumin, cloves, ginger, and licorice are also angiosperm fruits.
  - Pepper fruits are harvested before ripening, then dried and ground into powder or sold whole as "peppercorns."

Checkpoint question Suppose you found a cluster of pepper berries like the ones in Figure 17.9. How would you know that they are fruits?

17.10 EVOLUTION CONNECTION: Pollination by animals has influenced angiosperm evolution

- Flowers attract pollinators by color and scent.
- Visiting pollinators are rewarded with nectar and pollen.

Figure 17.10a Flowers of red maple, whose pollen is carried by the wind

17.11 CONNECTION: Plant diversity is vital to the future of the world's food supply

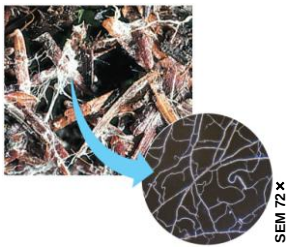
- Most of the world's population is now fed by varieties of rice, wheat, corn, and soybeans that require specific cultivation techniques.
- As plant biodiversity is lost through extinction and habitat destruction, potential crop species and valuable genes are lost.
- Some new crops may come from the hundreds of species of nutritious fruits, nuts, and grains that people gather and use locally.

DIVERSITY OF FUNGI

17.12 Fungi absorb food after digesting it outside their bodies

- **Fungi** are heterotrophic eukaryotes that acquire their nutrients by **absorption**.
- A fungus usually consists of a mass of threadlike filaments called **hyphae**, which branch repeatedly as they grow, forming a **mycelium**.
- The symbiosis between fungi and plant roots, called a **mycorrhiza** (plural, mycorrhizae), absorbs phosphorus and other essential minerals from the soil and makes them available to the plant.

Figure 17.12a

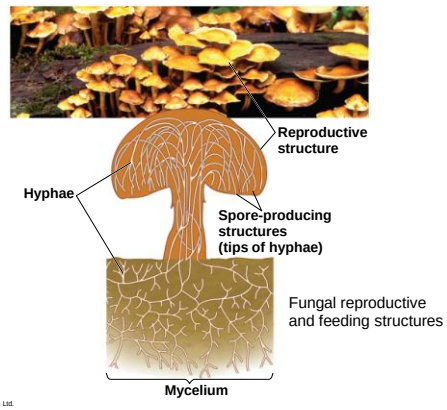


Mycelium on fallen conifer needles

Hidden Networks

- The mushrooms you see on the forest floor are just the aboveground parts of a vast network of underground filaments
- Fungal filaments absorb nutrients from the soil, transfer them to trees, and receive sugars in return
- Some even transfer sugars between trees of different species

Figure 17.12b



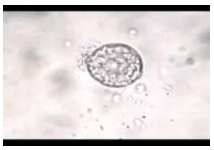
17.12 Fungi absorb food after digesting it outside their bodies

Checkpoint question Contrast how fungi digest and absorb their food with the way humans eat and digest their food.

17.13 Fungi produce spores in both asexual and sexual life cycles

- **Imperfect fungi** use only asexual reproduction for spore production. They include many species commonly called molds and yeasts.
  - A **mold** is any rapidly growing fungus that reproduces asexually by producing spores, often at the tips of specialized hyphae.
  - **Yeast** refers to any single-celled fungus.

Video: *Phlyctochytrium* Zoospore Release



17.14 Fungi are classified into five groups

- Biologists have described more than 100,000 species of fungi.
- But recent metagenomic studies suggest that this represents less than 10% of fungal diversity.
- Figure 17.14A shows a current hypothesis of fungal phylogeny based on molecular analyses.

Figure 17.14a

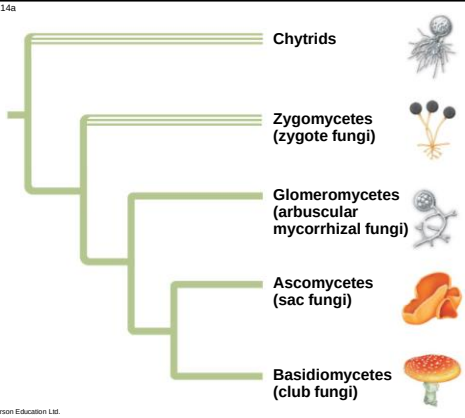


Figure 17.14b

Zygomycete: black bread mold

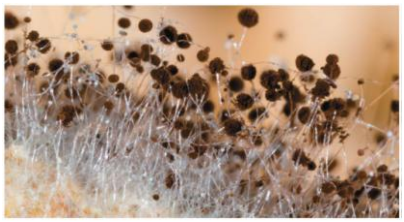


Figure 17.14c

Glomeromycete: a drawing of an arbuscule in a root cell

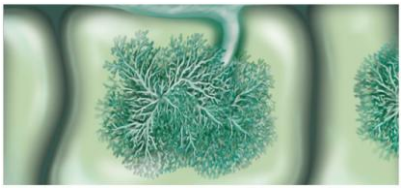
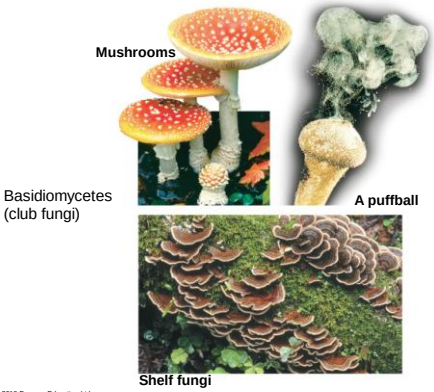


Figure 17.14d

Ascomycetes (sac fungi)

Edible morels **Cup fungus**

Figure 17.14e



Concept 31.2: Fungi produce spores through sexual or asexual life cycles

- Fungi propagate themselves by producing vast numbers of spores, either sexually or asexually
- Spores can be carried long distances by wind or water; they will germinate if they land in moist conditions with available food
- Fungi can produce spores from different types of life cycles

17.15 CONNECTION: Fungi have enormous ecological benefits

- Fungi
  - supply essential nutrients to plants through symbiotic mycorrhyizae,
  - along with prokaryotes are essential decomposers in ecosystems, breaking down organic matter and restocking the environment with vital nutrients essential for plant growth, and
  - may also be used to digest petroleum products to clean up oil spills and other chemical messes.

Figure 17.15

A fungal mycelium growing through gravel

17.16 CONNECTION: Fungi have many practical uses

- We eat mushrooms and cheeses modified by fungi.
- Yeasts produce alcohol and cause bread to rise.
- Some fungi provide antibiotics.
- Fungi figure prominently in molecular biology and in biotechnology. Yeasts, for example, are often used to study molecular genetics of eukaryotes.
- Fungi may play a major role in the future production of biofuels from plants.

Figure 17.16a

Blue cheese

17.16 CONNECTION: Fungi have many practical uses

Checkpoint question What do you think is the function of the antibiotics that fungi produce in their natural environments?

Figure 17.16b

A culture of *Penicillium* and bacteria

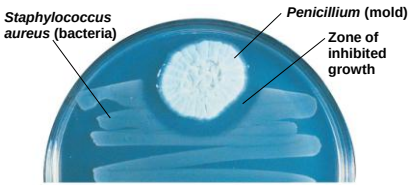


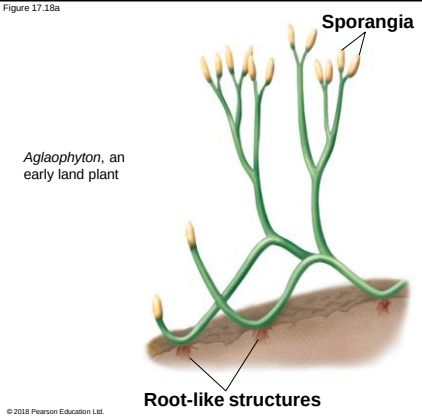
Figure 17.16c

White rot fungus

17.18 SCIENTIFIC THINKING: Mycorrhizae may have helped plants colonize land

- Scientists have proposed that symbioses with fungi were crucial to the colonization of land by plants.
- To test this hypothesis, researchers have pursued three lines of evidence:
  1. present-day mycorrhizal relationships,
  2. fossils of early land plants, and
  3. molecular genetics.

Figure 17.18a



17.19 CONNECTION: Parasitic fungi harm plants and animals

- Of the 100,000 known species of fungi, about 30% are either parasites or pathogens in or on plants.
- Many fungi are serious agricultural pests that cause tremendous economic losses.
- Some of the fungi that attack food crops are toxic to humans.

Figure 17.19a

Stately English elms in Australia, unaffected by Dutch elm disease

Figure 17.19b

Corn smut

17.19 CONNECTION: Parasitic fungi harm plants and animals

- About 500 species of fungi are known to be parasitic in humans and other animals.
- Fungal diseases in humans include
  - ringworm, named because it appears as circular red areas on the skin,
  - athlete's foot, also caused by the ringworm fungus, and
  - vaginal yeast infections.