Chapter 16

Plants, Fungi, and the Move onto Land

Biology and Society: The Diamond of the Kitchen

- Truffles are
  - subterranean reproductive bodies of a certain fungus and
  - highly prized by gourmets for their powerful earthy scent.

Figure 16.0

- Truffles, and many fungi, have an association with tree roots, a type of **symbiosis**, an interaction in which one species lives in or on another species.
- The symbiotic relationship between a truffle and a tree
  - helps the plant absorb water and inorganic nutrients and
  - helps the fungus by receiving sugars and other organic molecules from the plant.

COLONIZING LAND

- Plants are terrestrial organisms that include forms that have returned to water, such as water lilies.

Terrestrial Adaptations of Plants

- A **plant** is
  - a multicellular eukaryote and
  - a photoautotroph, making organic molecules by photosynthesis.

Structural Adaptations

- In terrestrial habitats, the resources that a photosynthetic organism needs are found in two very different places.
  - Light and carbon dioxide are mainly available in the air.
  - Water and mineral nutrients are found mainly in the soil.
- The complex bodies of plants are specialized to take advantage of these two environments by having
  - aerial leaf-bearing organs called **shoots** and
  - subterranean organs called **roots**.

Figure 16.1

- Most plants have **mycorrhizae**, symbiotic associations of fungi and roots, in which the fungi
  - absorb water and essential minerals from the soil,
  - provide these materials to the plant, and
  - are nourished by sugars produced by the plant.
- Mycorrhizae are key adaptations that made it possible for plants to live on land.

Figure 16.2

- Leaves are the main photosynthetic organs of most plants, utilizing
  - **stomata**, microscopic pores found on a leaf's surface, for the exchange of carbon dioxide and oxygen with the atmosphere,
  - **vascular tissue**, a system of tube-shaped cells that branch throughout the plant, for the transport of vital materials, and
  - a waxy layer coating the leaves and other aerial parts of most plants called the **cuticle**, for the retention of water.

Figure 16.3

Reproductive Adaptations

- Plants produce their gametes in protective structures called **gametangia**, which have a jacket of protective cells surrounding a moist chamber where gametes can develop without dehydrating.
- The zygote develops into an embryo while still contained within the female parent in plants but not in algae.

Figure 16.4
Figure 16.4a

The Origin of Plants from Green Algae

- The algal ancestors of plants
  - carpeted moist fringes of lakes or coastal salt marshes and
  - first evolved over 500 million years ago.
- **Charophytes**
  - are a modern-day lineage of green algae and
  - may resemble one of these early plant ancestors.
- Plants and present-day charophytes probably evolved from a

common ancestor.

Figure 16.5
Figure 16.5a
Figure 16.5b

PLANT DIVERSITY

- The history of the plant kingdom is a story of adaptation to diverse terrestrial habitats.
- The fossil record chronicles four major periods of plant evolution, which are also evident in the diversity of modern plants.

Figure 16.6
Figure 16.6a
Figure 16.7
Figure 16.7a
Figure 16.7b
Figure 16.7c
Figure 16.7d

Bryophytes

- Mosses
  - are bryophytes,
  - sprawl as low mats over acres of land, and
  - need water to reproduce because their sperm swim to reach eggs within the female gametangium.
- Mosses display two key terrestrial adaptations:
  - a waxy cuticle that helps prevent dehydration and
  - the retention of developing embryos within the mother plant's gametangium.

Figure 16.8

- Mosses have two distinct forms:
  - the **gametophyte**, which produces gametes, and
  - the **sporophyte**, which produces spores.

Figure 16.9

- The life cycle of a moss exhibits an **alternation of generations** shifting between the
  - gametophyte and
  - sporophyte forms.
- Among plants, mosses and other bryophytes are unique in having the gametophyte as the larger, more obvious plant.

Figure 16.10-1
Figure 16.10-2
Figure 16.10-3
Figure 16.10-4
Figure 16.10-5

Ferns

- Ferns are
  - by far the most diverse seedless vascular plants,
  - represented by more than 12,000 known species.
- The sperm of ferns, like those of mosses,
  - have flagella and
  - must swim through a film of water to fertilize eggs.

Figure 16.11
Figure 16.11a
Figure 16.11b
Figure 16.11c
Figure 16.11d

- During the Carboniferous period, from about 360 to 300 million years ago, ferns
  - were part of a great diversity of seedless plants and
  - formed swampy forests over much of what is now Eurasia and North America.
- As they died, these forests
  - fell into stagnant wetlands,
  - did not decay, and
  - eventually helped to form coal.
- **Fossil fuels**
  - formed from the remains of long-dead organisms and
  - include coal, oil, and natural gas.
- The burning of fossil fuels releases
  - carbon dioxide and

- other greenhouse gases into the atmosphere, contributing to global climate change.

Figure 16.12

Gymnosperms

- Near the end of the Carboniferous period, the climate turned drier and colder, favoring the evolution of gymnosperms, which can
  - complete their life cycles on dry land and
  - withstand long, harsh winters.
- The descendants of early gymnosperms include the conifers, or cone-bearing plants.

Conifers

- Conifers
  - cover much of northern Eurasia and North America,
  - are usually evergreens, which retain their leaves throughout the year, and
  - include the tallest, largest, and oldest organisms on Earth.

Figure 16.13

Terrestrial Adaptations of Seed Plants

- Conifers and most other gymnosperms have three additional terrestrial adaptations that make survival in diverse terrestrial habitats possible:
  - further reduction of the gametophyte,
  - pollen, and
  - seeds.
- Seed plants have a greater development of the diploid sporophyte compared to the haploid gametophyte generation.

Figure 16.14
Figure 16.14a
Figure 16.14b
Figure 16.14c

- A pine tree or other conifer is actually a sporophyte with tiny gametophytes living in cones.

Figure 16.15
Figure 16.15a
Figure 16.15b
Figure 16.15c

- A second adaptation of seed plants to dry land came with the evolution of pollen.
- A **pollen grain**
  - is actually the much-reduced male gametophyte and
  - houses cells that will develop into sperm.
- The third terrestrial adaptation was the development of the seed, consisting of a
  - plant embryo and
  - food supply packaged together within a protective coat.
- Seeds
  - develop from structures called **ovules**, located on the scales of female cones in conifers, and
  - can remain dormant for long periods before they **germinate**, when the embryo emerges through the seed coat as a seedling.

Figure 16.16-1
Figure 16.16-2
Figure 16.16-3
Figure 16.16a

Angiosperms

- Angiosperms
  - dominate the modern landscape,
  - are represented by about 250,000 species, and
  - supply nearly all of our food and much of our fiber for textiles.
- Their success is largely due to
  - refinements in vascular tissue that make water transport more efficient and
  - the evolution of the flower.

Flowers, Fruits, and the Angiosperm Life Cycle

- Flowers help to attract pollinators that transfer pollen
  - from the sperm-bearing organs of one flower
  - to the egg-bearing organs of another.
- A flower is a short stem bearing modified leaves that are attached in concentric circles at its base.

- **Sepals** form the outer layer and are usually green.
- Next inside are **petals**, which are often colorful and help to attract pollinators.
- **Stamens,** the male reproductive structures, are below the petals. Pollen grains develop in the **anther**, a sac at the top of each stamen.
- **Carpels** are the female reproductive structure at the center of the flower. The carpel includes
  - the ovary, a protective chamber containing one or more ovules in which the eggs develop, and
  - the sticky tip of the carpel, the **stigma**, which traps pollen.

Figure 16.17

- Flowers come in many forms.

Figure 16.18
Figure 16.18a
Figure 16.18b
Figure 16.18c
Figure 16.18d

- Flowers are an essential element of the angiosperm life cycle.

Figure 16.19
Figure 16.19a-1
Figure 16.19a-2
Figure 16.19a-3
Figure 16.19b-1
Figure 16.19b-2
Figure 16.19b-3

- Although both have seeds,
  - angiosperms enclose the seed within an ovary while
  - gymnosperms have naked seeds.
- **Fruit**
  - is a ripened ovary,
  - helps protect the seed,
  - increases seed dispersal, and
  - is a major food source for animals.

Figure 16.20
Figure 16.20a
Figure 16.20b
Figure 16.20c

Angiosperms and Agriculture

- Gymnosperms supply most of our lumber and paper.
- Angiosperms
  - provide nearly all our food and
  - supply fiber, medications, perfumes, and decoration.

Angiosperms and Agriculture

- Agriculture is a unique kind of evolutionary relationship between
  - plants and
  - animals.

Plant Diversity as a Nonrenewable Resource

- The exploding human population is
  - extinguishing plant species at an unprecedented rate and
  - destroying 50 million acres, an area the size of the state of Washington, *every year*!

Figure 16.21

- Humans depend on plants for thousands of products including
  - food,
  - building materials, and
  - medicines.

Table 16.1

- Preserving plant diversity is important to
  - many ecosystems and
  - humans.
- Scientists are now rallying to
  - slow the loss of plant diversity and
  - encourage management practices that use forests as resources without damaging them.

FUNGI

- Fungi
  - recycle vital chemical elements back to the environment in forms other organisms can

- assimilate and
- form mycorrhizae, fungus-root associations that help plants absorb mineral and water from the soil.

- Fungi are
  - eukaryotes,
  - typically multicellular, and
  - more closely related to animals than plants, arising from a common ancestor about 1.5 billion years ago.

- Fungi
  - come in many shapes and sizes and
  - represent more than 100,000 species.

Figure 16.22
Figure 16.22a
Figure 16.22b
Figure 16.22c
Figure 16.22d
Figure 16.22e
Figure 16.22f

Characteristics of Fungi

- Fungi have unique
  - structures and
  - forms of nutrition.

Fungal Nutrition

- Fungi
  - are chemoheterotrophs and
  - acquire their nutrients by **absorption**.
- A fungus
  - digests food outside its body by secreting powerful digestive enzymes to break down the food and
  - absorbs the simpler food compounds.

Fungal Structure

- The bodies of most fungi are constructed of threadlike filaments called **hyphae**.
- Hyphae are minute threads of cytoplasm surrounded by
  - a plasma membrane and
  - cell walls mainly composed of chitin.
- Hyphae branch repeatedly, forming an interwoven network called a **mycelium** (plural, *mycelia*), the feeding structure of the fungus.

Figure 16.23
Figure 16.23a
Figure 16.23b

- Mushrooms
  - arise from an underground mycelium and
  - mainly function in reproduction.
- Fungi reproduce by releasing haploid spores that are produced either
  - sexually or
  - asexually.

The Ecological Impact of Fungi

- Fungi have
  - an enormous ecological impact and
  - many interactions with humans.

Fungi as Decomposers

- Fungi and bacteria
  - are the principal decomposers of ecosystems and
  - keep ecosystems stocked with the inorganic nutrients necessary for plant growth.
- Without decomposers, carbon, nitrogen, and other elements would accumulate in nonliving organic matter.

- Molds can destroy
  - fruit,
  - grains,
  - wood, and
  - human-made material.

Parasitic Fungi

- Parasitic fungi absorb nutrients from the cells or body fluids of living hosts.

- Of the 100,000 known species of fungi, about 30% make their living as parasites, including
  - Dutch elm disease and
  - deadly ergot, which infests grain.

Figure 16.24a
Figure 16.24b

- About 50 species of fungi are known to be parasitic in humans and other animals, causing
  - lung and vaginal yeast infections and
  - athlete's foot.

The Process of Science: Did a Fungus Lead to the Salem Witch Hunt?

- **Observation**: In 1692, eight young girls were accused of being witches and had symptoms consistent with ergot poisoning.
- **Question**: Did an ergot outbreak cause the witch hunt?
- **Hypothesis**: The girls' symptoms were the result of ergot poisoning.
- **Prediction**: The historical facts would be consistent with this hypothesis.

Figure 16.25

- **Results**:
  - Agricultural records from 1691, before the symptoms appeared, indicated a particularly warm and wet year, in which ergot thrives.
  - Records from the following year, when accusations of witchcraft died down, indicate a dry year consistent with an ergot die-off.
  - This correlation is consistent with the hypothesis but not conclusive.

Commercial Uses of Fungi

- Fungi are commercially important. Humans eat them and use them to
  - produce medicines such as penicillin,
  - decompose wastes, and
  - produce bread, beer, wine, and cheeses.

Figure 16.26
Figure 16.26a
Figure 16.26b
Figure 16.26c
Figure 16.27

Evolution Connection: Mutually Beneficial Symbiosis

- Relationships between species are also an evolutionary product.
- Mutually beneficial symbiotic relationships benefit both species.
- Examples of mutually beneficial symbiotic relationships involving fungi include
  - mycorrhizae, the association of fungi and plant roots, and
  - **lichens**, the association of fungi and algae.

Figure 16.28
Figure 16.28a
Figure 16.28b
Figure 16.UN01
Figure 16.UN02
Figure 16.UN03
Figure 16.UN04
Figure 16.UN05
Figure 16.UN06
Figure 16.UN07
Figure 16.UN08
Figure 16.UN09
Figure 16.UN10
Figure 16.UN11
Figure 16.UN12
Figure 16.UN13