2.15 Fungi

Fungi were once classified as members of the plant kingdom. However, fungi, unlike plants, do not photosynthesize, and enough other differences exist between plants and fungi to place them in separate kingdoms. **Figure 1** summarizes some of the similarities and differences.

The structure of fungi has been adapted for two main functions: absorption of nutrients and reproduction. Like some bacteria, fungi are saprophytes that feed on dead or decaying matter. Digestion is extracellular—nutrients are digested externally before being absorbed. In multicellular forms, nutrient absorption takes place in the **mycelium** (plural: mycelia), a mesh of microscopic branching filaments that are usually on or below the surface where the organism grows or is attached, called the substrate. Each of these filaments is called a hypha (plural: hyphae) (**Figure 2**). Often the only visible parts of a fungus are its reproductive structures, which display a wide variety of sizes, shapes, and colours (**Figure 3**).

mycelium a collective term for the branching filaments that make up the part of a fungus not involved in sexual reproduction

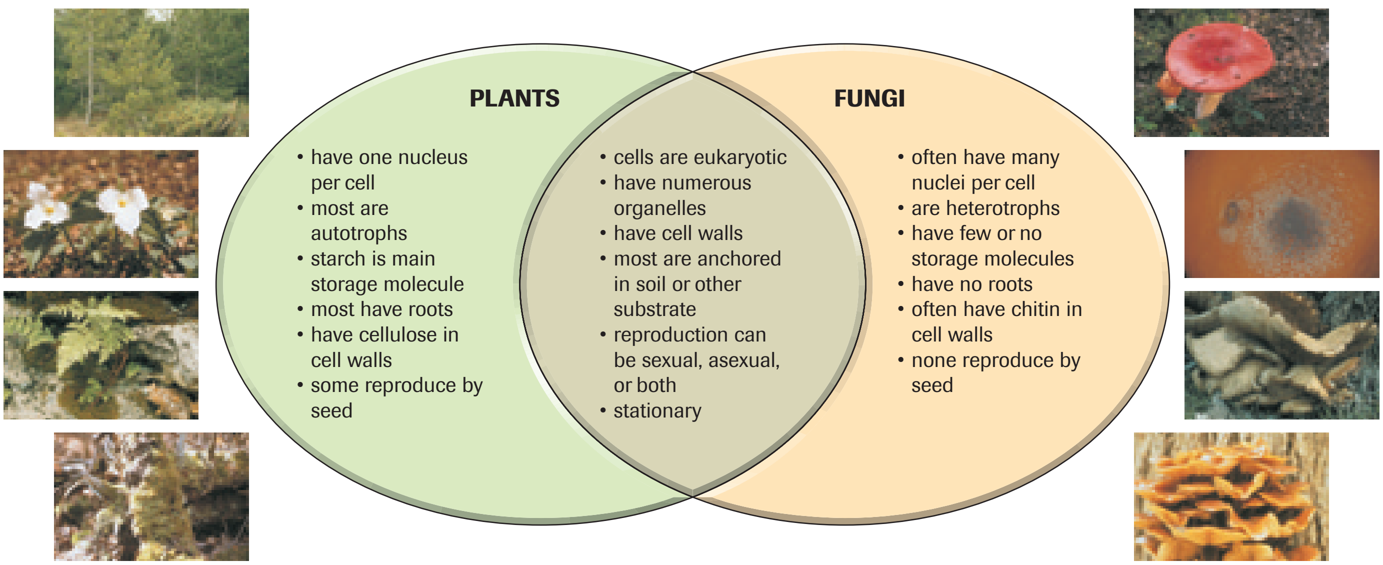
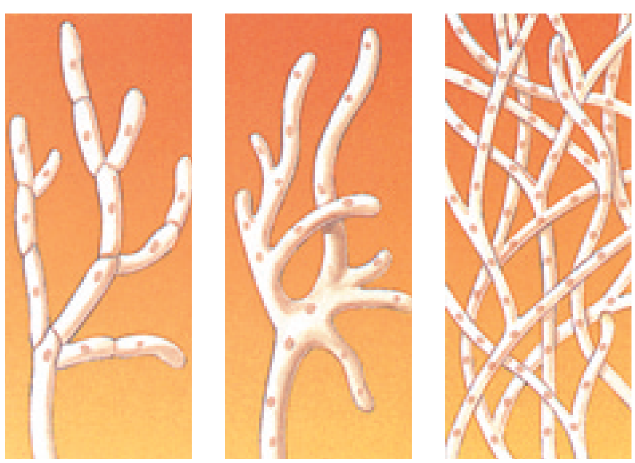
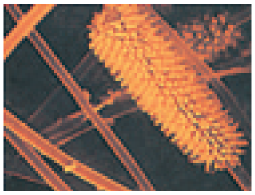


Figure 1
Similarities and differences between plants and fungi

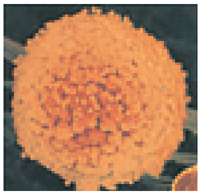


(a) **(b)** **(c)**

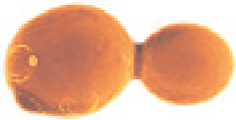
Figure 2
Some fungi have hyphae with cross-walls. Most hyphae have cell walls that are reinforced with chitin. It forms structures of considerable strength.
(a) Hyphae with cross-walls
(b) Hyphae without cross-walls
(c) Mycelium showing many interlocking hyphae



chytrids, water moulds
- mainly aquatic
- cross-walls in hyphae
- some saprophytes, some parasites
- asexual and sexual reproduction

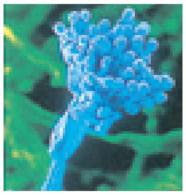


common moulds (bread, dung moulds)
- mainly terrestrial (soil, decaying plant matter)
- mainly multicellular
- no cross-walls in hyphae
- some saprophytes
- asexual and sexual reproduction



yeast, morels, truffles
- terrestrial and aquatic
- mainly multicellular
- cross-walls in hyphae
- many are pathogens
- asexual and sexual reproduction

mushrooms, shelf fungi
- mainly terrestrial
- mainly multicellular
- cross-walls in hyphae
- many are pathogens
- sexual reproduction



parasitic fungi
- mainly terrestrial
- some produce spores in sacs
- some produce spores in club-shaped structures
- asexual reproduction

Figure 3
Examples of fungi

Life Cycle of Fungi

A life cycle describes the development of an organism from a single cell to its reproductive stage. The cycle is complete when the organism produces the next generation. There is a wide variety of fungal life cycles. Fungi reproduce both asexually and sexually but always produce spores as reproductive cells. Spores have a haploid chromosome number and are produced in specialized reproductive structures called **sporangia** (singular: sporangium). Spores are usually dispersed by air currents, and when in a suitable environment, they sprout or **germinate**. Fungi may also produce asexually by fragmentation, in which portions of the mycelium break apart.

Field mushrooms grow wild in fields, lawns, and gardens (**Figure 4**). They are the type of mushroom most commonly cultivated for human consumption, and their life cycle is described in **Figure 5**, on the next page.

The mycelium is the nonreproductive or **vegetative** part of the mushroom. It consists of many hyphae and is usually just below the surface of the soil. When compatible haploid parent hyphae fuse, reproduction begins. These new hyphae develop enlargements that increase in size until they break through the soil's surface and can be seen as small white spheres called buttons. As the buttons grow and mature, they form a stalk and a cap that remains spherical. Within this cap, many changes occur. Thin membranous gills form and radiate out from the stalk. The gills consist of many tangled, modified hyphae. At first, the gills are pink, but they darken as they grow and mature. In specialized extensions from the gills, some of the cells that contain two haploid nuclei of different parents, called **dikaryotic**, fuse in a process considered to be a sexual union. The new diploid nucleus then undergoes meiosis to produce four haploid spores.

The underside of the cap detaches from the stalk and eventually looks like an opening umbrella. Spores are discharged from the mature gills over a period of several days. It is estimated that more than two billion spores may be produced from one average field mushroom. If a spore lands in a favourable environment, its protective coat will eventually split, and the haploid cell will divide by mitosis to produce a new hypha. It will continue to grow and branch into a complex mycelium.

sporangium a reproductive structure in which spores are produced

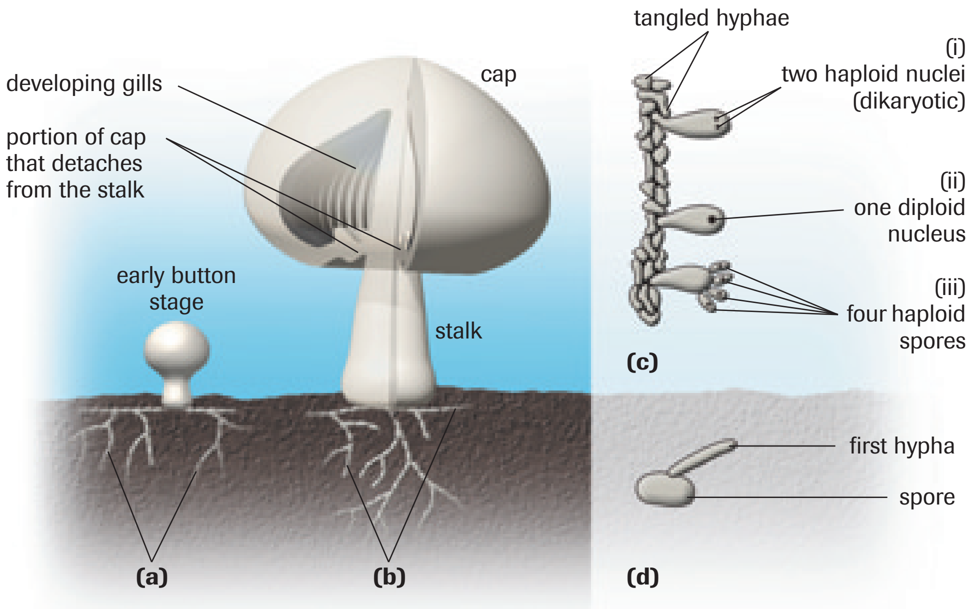
germinate to grow or sprout; refers specifically to the embryo inside a plant seed

vegetative any growth or development that does not involve sexual reproduction

Figure 4
Field mushrooms showing caps and stalks. Spore-producing cells line the dark, mature gills on the undersurface of the mushroom cap.

dikaryotic describes cells that contain two haploid nuclei, each of which came from a separate parent

Figure 5
General life cycle of a field mushroom
(a) An early button, consisting of dikaryotic tissue created by the fusion of the haploid hyphae, not the nuclei, of two separate parents
(b) A longitudinal section through an immature field mushroom. When the lower rim of the cap detaches from the stalk, the cap opens like an umbrella, exposing the maturing gills.
(c) A highly magnified view of a small section of one side of one gill consisting of tangled hyphae. Three extensions are shown at sequential stages of development.
(d) An enlarged view of a germinating haploid spore showing the first hypha protruding from the ruptured protective spore coat



Connection to Human Diseases

Several human diseases are caused by fungi. Most of these diseases are merely annoying, but some can be deadly.

Ringworm is a skin infection caused by *Microsporum*. This organism can cause severe itching in the groin, scalp, and beard. If left untreated, *Microsporum* can spread rapidly by spore and may be passed to others by direct or indirect contact. Sprays and powders containing fungicides can be used to help control its spread. Athlete's foot (**Figure 6**) is also caused by this genus of fungus, and is contracted from dirty shower floors or running shoes.

Figure 6
Epidermophyton floccosum is a fungus that causes athlete's foot.

Eating mushrooms picked in the wild can be a dangerous undertaking since many are poisonous. The most harmful and potentially fatal mushrooms belong to the genus *Amanita*. Ingesting only one or two of these so-called destroying angels can lead to abdominal pain and cramps, vomiting, and eventually death. These effects are caused by toxins in the mushroom that enter the bloodstream. Another type of *Amanita* produces poisons that can affect the nervous system and cause hallucinations and behaviour similar to drunkenness. Coma and death may result from these neurotoxins. The first step in effective treatment involves emptying the stomach and intestines before the poisons enter the bloodstream. Further treatment for mushroom poisoning depends on knowing which *Amanita* species was ingested. If *Amanita muscaris* was eaten, atropine is injected to counteract overstimulation of the nervous system. If *Amanita phalloides* (**Figure 7**) was ingested, an intravenous solution of sugar and salt is necessary to combat possible liver damage. If the species is not known, it is difficult for doctors to determine which treatment is needed. Eating only store-bought mushrooms removes this danger.

Figure 7
Amanita phalloides, or Death Cap, is the world's most dangerous mushroom.

Importance of Fungi

Humans often overlook the value of the lowly fungus and its role as a decomposer in nature's recycling system. Fungi, along with eubacteria, transform complex organic substances into raw materials that other fungi and plants use for growth and development.

Many fungi benefit humans. Yeast is used to make bread, wine, and beer. *Penicillium* produces an antibiotic; *Aspergillus* is used to flavour soft drinks. Certain mushrooms, morels, and truffles are sought-after food items. Some fungal species are potentially useful in decomposing harmful pollutants. Research is continuing into ways of using fungi to break down some complex hazardous chemicals in toxic dumpsites and wastewater treatment plants.

Many fungi are involved in a beneficial or **symbiotic relationship** with another organism. For example, in **mycorrhizae** (singular: mycorrhiza), an extensive network of fungal hyphae helps the roots of plants absorb nutrients such as phosphorus. In return, the fungi obtain sugars that the plant has made during photosynthesis. Some plant seeds will not germinate in the absence of the mycorrhizal fungi. For this reason, environmental biologists monitor mycorrhizal growth in contaminated soils to predict plant growth. It has even been suggested that the evolution of land plants has been dependent on the presence of mycorrhizae.

Lichen (**Figure 8**) is another example of symbiosis, in that two organisms function as one. The photosynthetic partner to the fungus is generally a green alga or cyanobacterium, and the fungus is usually a sac fungus. The fungal mycelium surrounds the photosynthetic cells and provides them with essential minerals, carbon dioxide, and water for photosynthesis. The mycelium also lends structural support to the entire organism. The algae share the carbohydrates they manufacture from carbon dioxide with the fungi. Lichens reproduce asexually by fragmentation. In the arctic tundra and boreal forests of northern Canada, lichens are an important source of food for caribou and other animals.

Lichens are important in plant succession. By being able to establish themselves on rocks and in barren areas, lichens help form basic soil material. Researchers have long recognized the value of lichens in detecting air pollutants. Unlike plants that absorb water that has been filtered through the ground, lichens absorb water directly from the air. In this way, they absorb more dissolved toxic substances than do plants. The presence or absence of different lichens in an area can be used to map concentrations of pollutants.

symbiotic relationship a relationship between two organisms in which both partners benefit from the interaction

mycorrhiza a symbiotic relationship between the hyphae of certain fungi and the roots of some plants

lichen a combination of a green alga or cyanobacterium and a fungus growing together in a symbiotic relationship

(a)

(b)

Figure 8
Examples of common Canadian lichens are **(a)** reindeer moss and **(b)** British soldiers.

TRY THIS activity — Collecting and Examining Lichens

Materials: ruler, small plastic bags, hand lens, prepared slide of lichen, compound light microscope

1. Use the edge of a ruler to carefully scrape lichens from various trees and rocks. Try to collect the scrapings from separate lichens in separate plastic bags.

2. Examine the lichen pieces under a hand lens.

(a) Classify the lichen according to **Table 1**, on the next page.

3. Examine a prepared slide of a lichen using a compound light microscope.

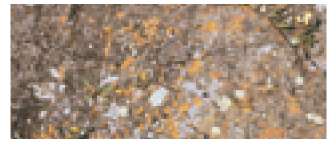
(b) How are you able to distinguish the photosynthetic partners from the fungi?

DID YOU KNOW?

Absorbent Lichens

Lichens are remarkably resistant to drought. A dry lichen can quickly absorb 3 to 35 times its weight in water!

Table 1 Appearance of Lichens

Lichen type	Description	
crustose	flat or crusty; forms a matlike structure on rocks or tree bark	
foliose	leaflike lobes; spreads outward; has a paperlike appearance	
fruticose	raised structure with stalks and multiple branching threads; may hang from trees	

Section 2.15 Questions

Understanding Concepts

1. What main feature is missing that prevents fungi from being included in the plant kingdom?
2. Study **Figure 1**, on page 136. Summarize the criteria used to classify fungi.
3. For each of the following, provide a definition and describe the function:
   (a) mycelium
   (b) spore
   (c) hypha
   (d) sporangia
4. When fungi reproduce asexually, where do the haploid spores form, and what steps lead up to spore formation?
5. List several harmful effects resulting from the ingestion of poisonous mushrooms such as those belonging to the genus *Amanita*. How can such harmful effects be avoided?
6. Describe the role of the fungus partner in each of the following:
   (a) mycorrhizae
   (b) lichens
7. Classify the lichens in **Figure 8**, on page 139, as crustose, foliose, or fruticose.

Applying Inquiry Skills

8. Hypothesize why a slice of store-bought bread might grow mould more slowly than a slice of homemade bread.
9. Obtain three varieties of edible mushrooms and prepare a visual record: sketch the mushrooms and describe their colour, odour, surface characteristics, and structure. Make spore prints for each type according to your teacher's directions. Use resources to identify these fungi.

Making Connections

10. One of Canada's largest breweries has an in-house brewer training program. Find out more about what it takes to become a brew master. What other programs are available in this field?

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11. If fungi were wiped out, how would this affect our lives? Consider the social, economic, environmental, and medical impacts.

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12. What steps could people who are allergic to fungal spores take to ensure that their living environment is relatively spore free?
13. Research one of the following topics:
    (a) the Irish potato blight of 1845–1847
    (b) the use of fungi in the production of antibiotics
    (c) the physiological effects of poisonous fungi on the human body

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