19–2 Fungi in Nature

As you have learned, fungi live by feeding on living organisms or on the remains of dead ones. Although this may paint a grim picture of fungi—linking them with death and decay—they are actually some of the most beautiful organisms on Earth. In this section we will take a very human-centered view of the kingdom Fungi as we examine what effects these organisms have on us and the rest of the living world.

Guide For Reading

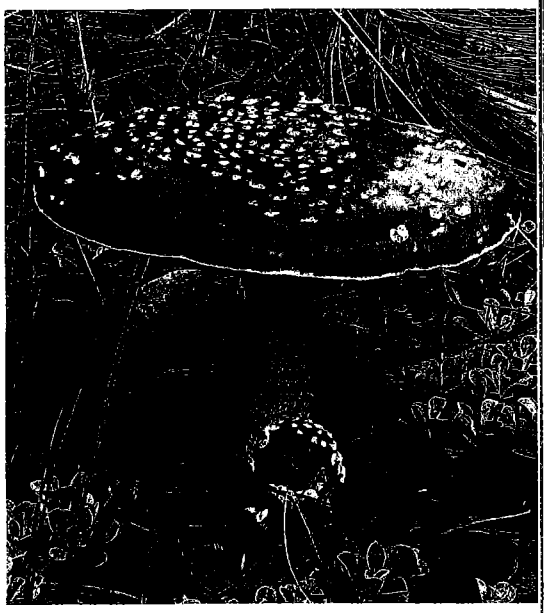
- What is the principal role fungi play in the environment?
- How do fungi form symbiotic relationships with other organisms?
- In what ways are humans affected by fungi?

Ecological Significance

The principal role fungi play in the environment is to decompose and recycle living material. Imagine a world in which fungi do not exist: The ground would be littered with leaves, fallen wood, and the bodies of dead animals. What impact would this have on organisms living in this world?

First, you may recall that the material of which a living organism is composed is rich in chemical energy. Because this energy exists, we can make a crackling fire out of wood or a good snack out of an apple. If such material does not undergo decay, the energy it contains will be lost. Second, many organisms, particularly green plants, require small amounts of trace elements and nutrients in order to survive. During their development, green plants remove these materials from the soil. If the materials are not eventually returned, the soil will soon be depleted and the destruction of plants, as well as animals whose lives depend on the plants, will result.

Figure 19–14 Together with bacteria, fungi—such as this mushroom—are the major decomposers and recyclers of living material on Earth.



WHERE ARE FUNGI FOUND? There are remarkably few places on Earth where one species of fungus or another does not make its home. Even more amazing is the fact that fungal spores are found in almost every environment. Indeed, this is why molds seem to spring up in any location that has the right combination of moisture and food.

In many places, large mycelia occupy a nearly permanent place in the environment and last for many years. A mushroom develops from a mycelium located just below the ground. As the mycelium grows, new mushrooms pop up from the mycelium wherever nutrients are available. This is why strands of mushrooms are often part of the same organism.

As time goes by, the available nutrients near the center of the mycelium become depleted, causing new mushrooms to sprout only at the edges of the mycelium. This produces a ring of mushrooms called a fairy ring. People once thought fairies dancing in circles during warm nights produced these rings, so they called them fairy rings. Over many years, fairy rings can become enormous, forming rings 10 to 20 meters in diameter.

SPORE DISPERSAL Many fungi, including most common mushrooms, produce dry, almost weightless, spores that are

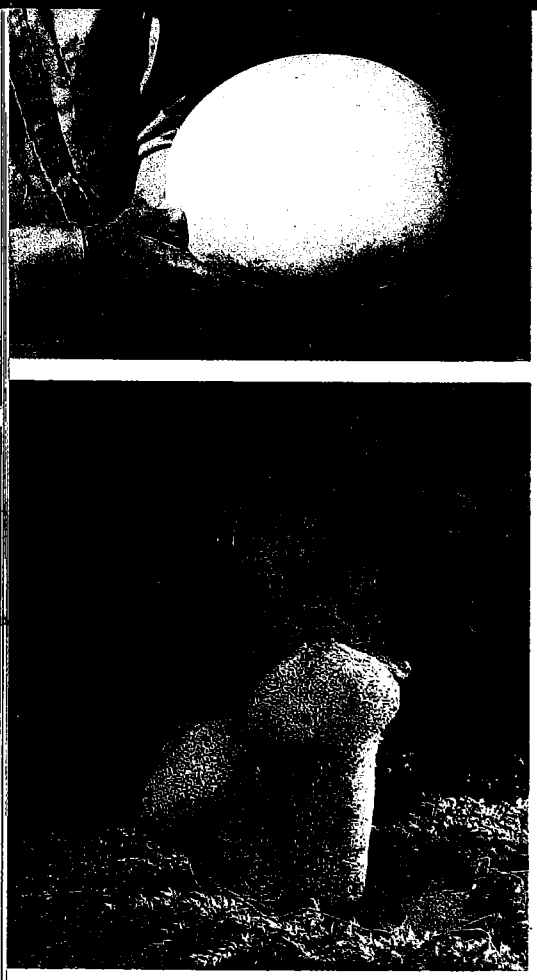


Figure 19–15 *The giant puffball contains as many as 7 trillion spores. In the common puffball, the dispersal of spores can be triggered by the slightest touch, even by a raindrop.*

easily scattered by the wind. On a clear day, a few liters of fresh air may contain hundreds of spores from many species of fungi. Some of these species have remarkable ways of getting their spores into places where they are likely to grow.

For fungi, spore placement is crucial. A single spore has a slim chance of finding the proper combination of temperature, moisture, and food so that it can germinate. Even under the best of circumstances, the odds of a spore producing a mature organism can be more than one in a billion. So you can see why anything that might help reduce those odds is considered a selective advantage to that species.

The puffballs (basidiomycetes) go to extremes to produce their spores. A mature puffball is virtually a warehouse of spores. The simple action of a raindrop falling on a puffball can release thousands of spores in a small cloud of dust.

Other species of fungi trick animals into dispersing their spores for them. The stinkhorns (*Phallus*) go so far as to mimic rotting meat. The surface of a stinkhorn is covered with a fluid that has the odor of rotting flesh. Flies are drawn to the stinkhorn. Then they land on the stinkhorn to taste the sticky fluid. Once ingested, the spore-containing fluid will pass unharmed out of the flies' digestive systems, depositing spores over great distances.

Symbiotic Relationships

Many fungi associate with members of other species in symbiotic relationships. In some of these relationships, such as early tomato blight, fungi are harmful. But in other cases, fungi form relationships in which both partners benefit. Such is the situation with the **lichens** (LIGH-kuhnz) and **mycorrhizae** (migh-koh-RIGH-zee).

Lichens are symbiotic partnerships between a fungus and a photosynthetic organism. The fungus in the relationship is usually an ascomycete, although it can be a basidiomycete. The photosynthetic organism is either a cyanobacterium (blue-green bacterium) or a green alga.

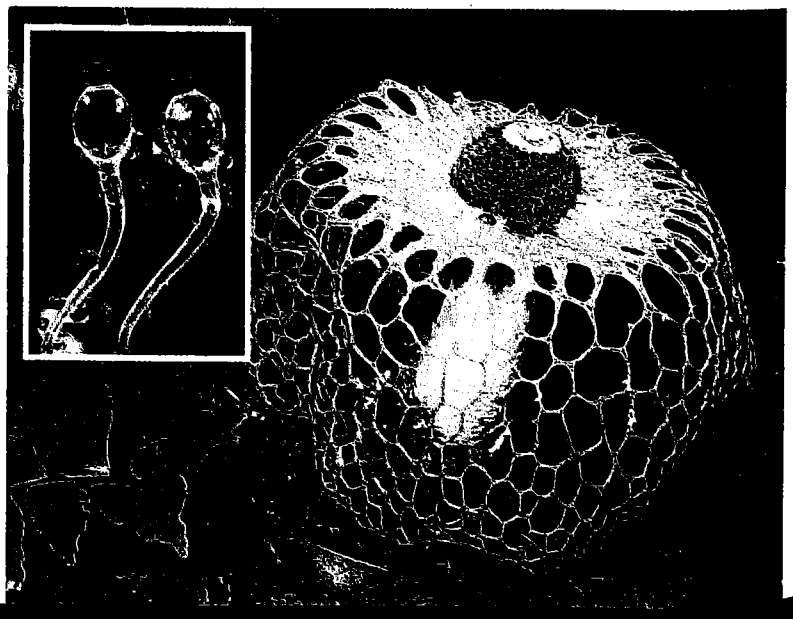


Figure 19–16 *Fungi have remarkable ways of dispersing their spores. The lacy stinkhorn attracts flies by producing a spore-containing fluid that has the odor of rotting flesh. The spores pass unharmed through the flies' digestive system and are deposited over great distances.* Pilobolus *(inset) fires its sporangia at an initial speed of 50 kilometers per hour—as far as 1 meter.*

Because they are extremely resistant to drought and cold, lichens grow in places where few other organisms can survive —on dry, bare rock in deserts and on the tops of mountains. Lichens are able to survive in these harsh environments because of the relationship between the two partner organisms. The alga carries out photosynthesis, providing the fungus with a source of organic nutrients. The fungus, in turn, provides the alga with water and minerals that it has collected from the surfaces on which it grows.

Lichens are often the first organisms to enter barren environments, gradually breaking down the rocks upon which they grow. In this way, lichens help in the early stages of soil formation and eventually form an environment that is hospitable to other organisms.

Another symbiotic relationship, called mycorrhizae, forms between fungi and green plants (mycorrhiza means fungus root in Greek). The tiny hyphae of the fungi aid plants in absorbing water, minerals, and nutrients. They do this by producing a network that covers the roots of the plants and increases the effective surface area of the root system. The plants, in turn, provide the fungi with the products of photosynthesis.

An example of mycorrhizae involves orchids, which are considered by many as the most beautiful of the flowering plants. The seeds of orchids germinate in nature only in the presence of a certain species of fungi. These fungi penetrate the seed, providing it with moisture and food during the early stages of the orchid's growth.

The symbiotic relationships between green plants and fungi have existed for millions of years. Some of the earliest fossils of land plants contain evidence of fungi. This suggests that fungi may have played a crucial role in the colonization of the land by green plants.

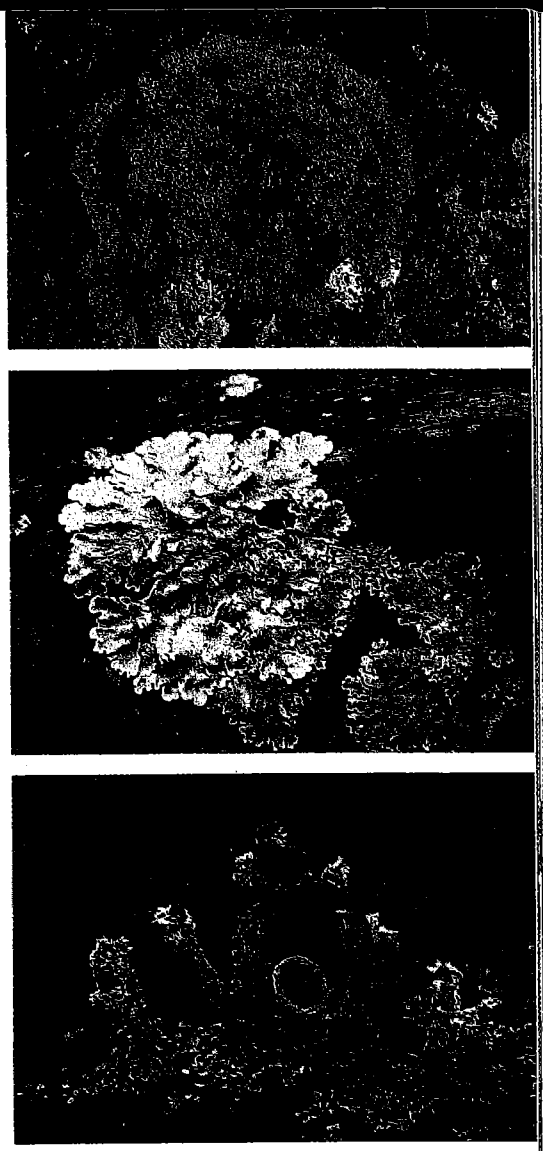


Figure 19–17 *Lichens generally grow in three forms. Crustose lichens are flat (top), foliose lichens resemble leaves (center), and fruticose lichens grow upright (bottom).*

Fungi and Human Life

Two of the oldest discoveries of civilization are the techniques for making bread and alcohol. Interestingly enough, both techniques rely on a cooperative effort between humans and fungi and provide an important example of the many ways in which humans have made use of this living kingdom.

Because of the role yeasts play in baking and brewing, one might argue that they are the most important fungi to humans. The common yeasts used for baking and brewing are members of the genus *Saccharomyces* (sak-uh-roh-MIGH-seez). To grow these yeasts, a rich nutrient mixture containing very little oxygen is prepared. In brewing, it is a vat of grape juice or barley malt. In baking, it is a mound of thick dough. The yeasts within the mixture quickly begin the process of alcoholic fermentation in order to obtain enough energy to survive. The byproducts of alcoholic fermentation are carbon dioxide and alcohol. The carbon dioxide gas makes bread rise (by producing bubbles

Figure 19–18 *In France, pigs are used in the search for truffles. Truffles (left) are considered by many people to be a rare and delicious treat.*

within the dough) and beverages bubble. The alcohol is used in alcoholic beverages or as a fuel.

As you may recall from Chapter 12, yeasts are now used for genetic engineering. Because they are eukaryotes, yeasts often process the protein products of genes cloned from other eukaryotes more efficiently than bacteria (prokaryotes) do. It is not impossible to imagine that sometime in the near future, genetically engineered yeasts may be used to produce a wide variety of biologically important compounds.

Some types of fungi have long been considered a delicacy by humans. One example are the mushrooms (basidiomycetes). There are approximately 10,000 different species of mushrooms found throughout the world. Many of these mushrooms are cultivated and prepared by people and then sold in supermarkets and specialty food shops. These species of mushrooms are easy to grow, taste good when properly cooked, and do not pose a danger to anyone who eats them.

Figure 19–19 *Although the death cap mushroom looks harmless, eating only one cap of it can prove fatal.*

Wild mushrooms are a different story: Although some are edible, many are poisonous. You may have heard someone say that only toadstools are poisonous, whereas mushrooms are safe to eat. Unfortunately, this is not true. For toadstools are mushrooms. Furthermore, poisonous mushrooms do not belong to just one order or family of basidiomycetes.

Because many species of poisonous mushrooms look almost identical to edible mushrooms, it is best not to pick or eat any mushrooms found in the wild. Instead, mushroom gathering should be left to experts who can positively identify each mushroom they collect. The result of eating a poisonous mushroom is severe illness and sometimes death.

History records that the Roman Emperor Claudius was given a plate of mushrooms, known as death caps *(Amanita phalloides),* by his wife and stepson Nero in a plot to remove him from the throne. He ate heartily. Although the death caps were delicious, the meal served its purpose and the throne was empty the next day.

Diseases Caused by Fungi

Not all fungi are suited to human needs. Some species of fungi cause tremendous losses of food and crops every year, and some cause disease in humans.

POTATO BLIGHT In their own way, the plant diseases caused by fungi have influenced history. In 1845, the potato crops of Ireland and Europe were devastated by a fungus that destroyed the foliage of the plant and infected the potatoes themselves. The culprit was the oomycete *Phytophthora infestans,* which causes the disease known as late potato blight.

Potatoes that are infected with the blight may appear normal at harvest time. But within a few weeks, the fungus makes its way into the potato, reducing it to a spongy sac of spores and dust. During the years that followed the potato blight infection, more than one million people in Ireland died of starvation as the result of the destruction of their main food source. Many others left Ireland and emigrated to the United States rather than face a similar fate.

WHEAT RUST Another fungal disease, called rust, affects wheat, one of the most important crops grown in North America. During the early part of this century, farmers in the Midwest watched helplessly as their plants developed tiny rustlike spots on their leaves. These spots gradually expanded and killed the plants before they could be used to produce grain. A similar incident occurred in the 1930s, when great plagues of rust disease added to the economic misery of the Great Depression. During this time, farmers not only lost their crops but their farms as well.

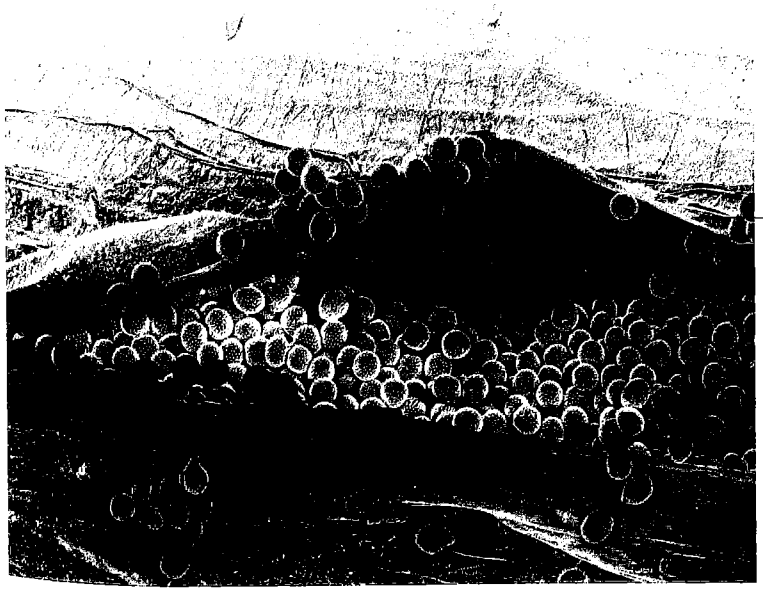


Figure 19–20 *This electron micrograph shows a cluster of spores of the wheat rust fungus bursting through the plant's epidermis, or outer covering.*

Rusts are caused by a type of basidiomycete that needs two different plants in order to complete its life cycle. Spores produced by the rust in the barberry plant are carried by the wind into wheat fields. There the spores germinate and infect wheat plants. The patches of rust produce a second type of spore that infects other plants, allowing the disease to spread through a field of wheat at an alarming rate.

Later in the year, often after the wheat crop has been ruined, new kinds of spores are produced by the rust. These black-colored spores are tough enough to survive through the winter. In the spring, they go through a sexual phase and produce spores that infect the barberry plant. Once on the barberry leaves, the rust produces the spores that infect the wheat plant, and the cycle continues. Fortunately, the life cycle of the rust can be broken and the disease brought under control by destroying the barberry plant.

OTHER PLANT DISEASES Fungi that attack crop plants cause other diseases such as corn smut, which destroys the corn kernels, and mildews, which infect a wide variety of fruits. It is estimated that fungal diseases are responsible for the loss of approximately 15 percent of the crops grown in temperate regions of the world. In tropical areas, where high humidity favors fungal growth, the loss of crops is sometimes as high as 50 percent. As you can see, these organisms are in direct competition with us for our own food supply.

HUMAN DISEASES Although most fungal diseases are associated with plants rather than animals, there are several fungi that cause disease in humans. These pathogenic (disease-causing) organisms are deuteromycetes (imperfect fungi). One type can infect the areas between the toes, causing athlete's foot. The fungus forms a mycelium directly within the outer layers of skin. This produces a red, inflamed sore from which the spores can easily spread from person to person.

When the same fungus infects the skin of the scalp, it produces a red scaling sore known as ringworm. Contrary to popular belief, ringworm is not caused by a worm; it is caused by a fungus. Ringworm can be passed from person to person by the exchange of hats, combs, and athletic headgear. The fungi that cause athlete's foot and ringworm can be destroyed by the application of fungicides, or chemicals that kill fungi.

Another type of fungal disease that infects humans is caused by the yeast *Candida albicans.* This fungus grows in moist regions of the body, such as the mouth and the urinary tract. Usually its growth is kept in check by competition from bacteria and by the body's immune system. This normal balance can be upset by many factors, including the use of antibiotics, which kill bacteria, or by damage to the immune system. When this happens, *Candida* may produce thrush, a serious and painful mouth infection, or infections of the urinary tract.

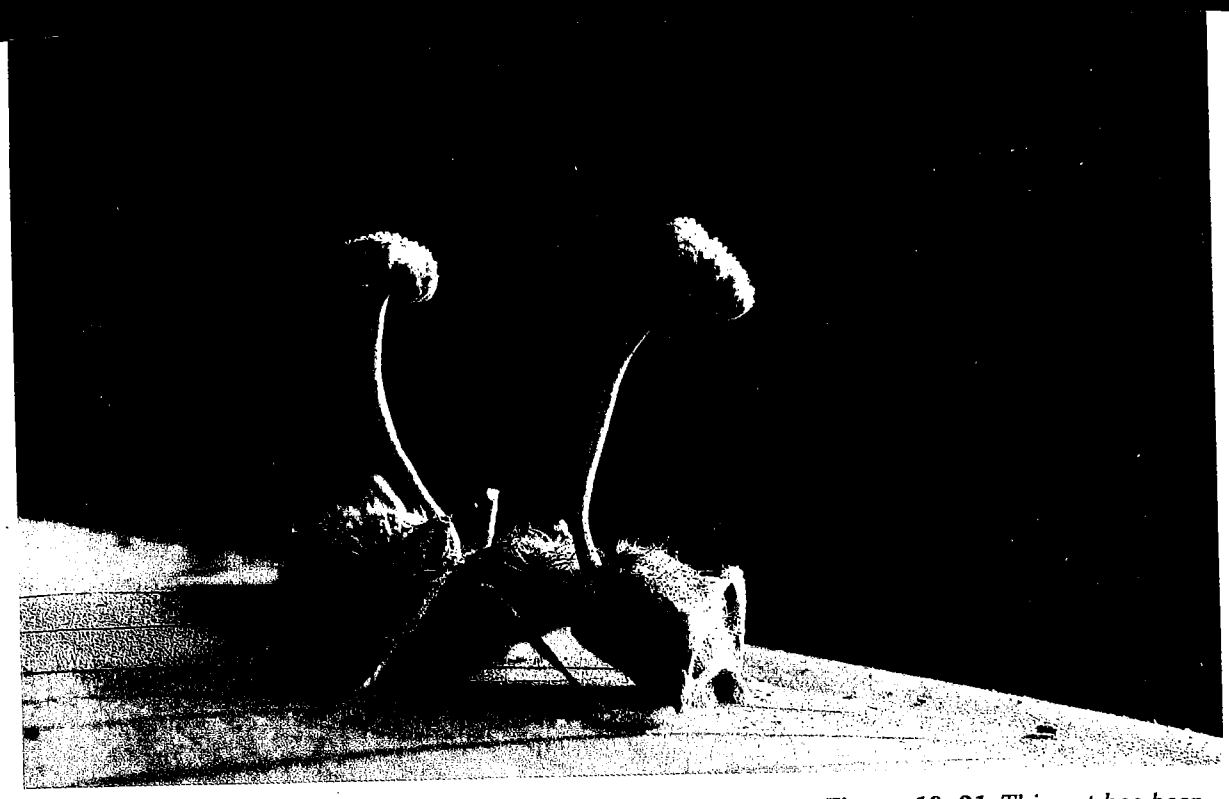


Figure 19–21 *This ant has been killed by a fungus called* Cordyceps lloydii. *Once the fungus's tiny spore enters the insect's body, it begins to multiply. Within days, the fungus digests all but the ant's outer covering. The umbrellalike structures growing out of the ant's body are the fungus's fruiting bodies.*

ANIMAL DISEASES As serious as human fungal diseases can be, few approach the deadliness of *Cordyceps lloydii.* This fungus infects ants in forests near the basin of the Amazon River in Venezuela. Microscopic spores become lodged in the ant, where they germinate and produce enzymes that slowly penetrate the insect's tough exoskeleton (external skeleton). Once the spores have gained entry, they multiply in the insect's blood, digesting all its cells and tissues until the insect dies. To complete the process of digestion, hyphae develop, cloaking the decaying exoskeleton in a web of fungal material. Reproductive structures, which will produce more spores that will spread the infection, then emerge from the ant's remains.

19–2 SECTION REVIEW

1. What is the major role of fungi in the environment?
2. What are some methods by which fungi disperse their spores?
3. Describe the role of fungi in two important symbiotic relationships.
4. What are some beneficial effects of fungi? Some harmful effects?
5. **Critical Thinking—Relating Concepts** Why are fungi a more serious problem in tropical regions of the world than they are in temperate regions?