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Chapter 1

Finding the Fungus Among Us

Kingdom Fungi includes everything from the mushrooms you see in the forest or the grocery store, to the yeast that's used to make bread and wine, to the fuzzy green mold that grows on old oranges, and many more you may not even notice. Fungi can be mysterious, suddenly appearing as a "fairy circle" in the forest. Some fungi are a little spooky, like the ones that turn ants into zombies or those that glow in the dark. Fungi can be beautiful too, like the fly agaric with its bright red cap and white spots (*Amanita muscaria*) or the veiled lady (*Phallus indusiatus*) shown on the cover of this book.

These weird and wonderful fungi lead secret lives beneath the surface of the soil or within the bodies of other organisms. They are essential to the cycle of life on Earth, and many can directly harm or benefit human health. This chapter introduces you to fungi and gives you a peek into what is happening below the surface of the fungal structures you can see.



REMEMBER

Mycology is the study of fungi, including their structure, role in nature, life cycles, and chemistry (*myco*=fungus, *logy*=study of).

Appreciating the Power of Fungi in Nature

Organisms interact with each other and their environment in complicated webs called *ecosystems*. For example, you're probably familiar with the way organisms interact in food chains. A *food chain* represents the movement of energy and nutrients through a series of organisms. For example, a mouse eats seeds, and then a snake eats the mouse.

When one organism eats another, it takes in the large molecules like carbohydrates, proteins, and fats that form the bodies of living things. It digests these large molecules into smaller components, taking the energy and nutrients it needs for its own growth. The molecules that make up one living thing get broken down and reformed into the molecules of another. If you eat a slice of pizza, you will essentially recycle some of the pizza molecules to build or repair your own body. (Yes, in some ways, you are what you eat.)

While all organisms pass nutrients through food chains, fungi are nature's ultimate recyclers. They make enzymes that can digest the really tough stuff like wood that few other organisms can touch (for details on how fungi break down wood, see Chapter 2). And they're not squeamish. They don't need their food to be alive or even freshly killed. In fact, they're specialists in digesting the dead.



REMEMBER

Decomposers digest dead organisms, breaking down their large molecules into smaller components. In the process, they release nutrients like minerals and carbon dioxide (CO_2) back into the environment where they can be picked up and reused by other living things (see Chapter 2 for more details on how carbon moves through ecosystems).

The molecules that make up living things are a type of matter. *Matter* is anything that has mass (can be weighed) and takes up space. It's the stuff that makes up everything around you, from the metal atoms in your cell phone to the cellulose that forms the paper in this book. Except for the occasional meteorite that hits the surface of the planet, no new matter enters our environment. (Light from the sun is energy, not matter.) All of the matter that makes up our planet and living things must be recycled if life is to continue.



REMEMBER

Without decomposers like fungi and bacteria, there wouldn't be enough matter available for the growth of new life.

Exploring How Fungi Form Partnerships with Other Organisms

Many fungi form intimate relationships that facilitate the growth of other organisms.



REMEMBER

Mycorrhizal fungi attach to plant roots and grow outward through the soil in vast networks. In exchange for food, the mycorrhizae increase the access of plants to water and minerals (Chapter 3). Experiments suggest mycorrhizae can even enable communication between plants over their mycelial network. Almost all plants, including those we grow for food, have mycorrhizal partners that support their growth.

Fungi also form partnerships with other photosynthetic organisms, like algae and blue-green bacteria, becoming lichens that grow on the surfaces of rocks, plants, and soil.



REMEMBER

Lichens are plant-like growths that form from the symbiosis of at least two organisms, a fungus and a photosynthetic partner (Chapter 3).

The fungal mycelium provides a protective covering for its partner, storing water and blocking intense light. In return, the alga or bacterium shares some of the food it makes through photosynthesis.

Taking a Close Look at Fungal Structures

The parts of fungi that you can see are just a tiny fraction of the entire organism. When you see a mushroom, for example, you may think you're looking at a single individual, but what you're actually seeing is the reproductive structure of a massive organism that's growing beneath the mushroom.



REMEMBER

Fungi grow as barely visible threads called *hyphae* that weave through soil and decaying organisms (Chapter 4).

Hyphae are long chains of fungal cells that grow and weave themselves throughout their environment, forming mats called *mycelia*. Sometimes, fungi shape their mycelia into large reproductive structures like mushrooms, bracket fungi, or puffballs. Examining the details of structures like these can help you identify wild fungi.

The reproductive structures of fungi produce *spores*, which are special cells that protect the genetic information of a new individual (Chapter 4). Fungi can clone themselves by producing spores asexually, or they can produce spores after a sexual process that combines genetic information from two individuals. The spores found among the gills on the bottom of a mushroom or in the pores of a bracket fungus are examples of sexually produced spores.

Unlocking the History of Fungi

Fungi have an interesting life cycle, which makes them useful organisms for the study of genetics (Chapter 6). The cells that form fungal hyphae are *haploid*, meaning they only have one copy of each gene. This makes it easier to study the effects of mutations on genes in fungi than it is in other organisms, like plants and animals, which typically have two copies of each gene.

Scientists think the first fungi lived in the water, then made their way onto land around the same time as plants, although they're still debating the exact order of events (Chapter 7). Scientists haven't studied many fossils of fungi, but some fossils that resemble modern aquatic chytrids (Chapter 8) can be dated to the late Precambrian period (650 to 543 million years ago). Fossils from the Devonian period (417 to 354 million years ago) show land plants and fungi forming symbiotic associations similar to today's mycorrhizal associations. In fact, some scientists believe that plants wouldn't have been able to move from the water to the land without the help of fungal partners.

Discovering the Many Groups of Fungi

The ability to read and compare the DNA of organisms caused many changes to the way scientists see the relationships between life on Earth. Prior to the development of DNA science, scientists classified organisms based on their physical characteristics, how they got their nutrition, and how they reproduced. These methods worked well for many larger species, but microscopic organisms with few visible characteristics were harder to sort out.

As a result, scientists have made many recent changes to the organization of the fungi. Some organisms that we thought were closely related to fungi, because of the way they look and grow, were kicked out of the kingdom. Relationships within the kingdom changed, and some fungi were moved from one group to another. And some fungi that never did scientists the courtesy of showing their sexual stages so that they could be sorted were finally put in their place on the basis of their DNA. Finally, the vast majority of fungi that grow in nature haven't been identified at all, so more changes to our understanding of the relationships of fungi to each other and other organisms will no doubt occur in the future.

Whether they are true fungi or not, these groups of organisms are commonly included in the science of mycology:

- » **Stramenopiles** include the water molds (oomycetes) and slime nets (labyrinthulomycetes). Both of these groups were originally included in Kingdom Fungi because of their fungal-like lifestyles.
- » **Amoebozoa** are the slime molds, amoebae that can often be found along with fungi growing on rotten logs. Also like fungi, they reproduce by spores and are important decomposers.
- » **Opisthosporidia** are intracellular parasites that don't have much surface resemblance to fungi, but whose DNA reveals a very close relationship (Chapter 8).
- » **Chytridiomycota**, also known as chytrids, are swimming single-celled organisms that decompose organic matter and have chitin in their cell walls. These characteristics, along with their DNA, put them in the fungal kingdom (Chapter 8).

- » The **zygomycetous fungi** include many of the familiar molds you've seen growing on your cheese, bread, and spoiled fruit (Chapter 9).
- » The **Ascomycota** is important to human food production because this group contains yeast, morels, and truffles, as well as some plant pathogens known as mildews (Chapter 10).
- » The **Basidiomycota** is the home for most of the familiar mushrooms as well as plant pathogens known as rusts and smuts (Chapter 11).

Making Connections Between Fungi and People

In addition to their importance to the health of the planet, fungi have many direct impacts on the lives of people:

- » **Food:** Fungi are not only delicious, but they're also packed with beneficial nutrients such as dietary fiber (Chapter 12). Plus, research shows they have a positive impact on your brain and immune system and contain compounds with many potential health benefits (Chapter 14).
- » **Spiritual uses:** Some cultures past and present use psychedelic mushrooms in their spiritual practices (Chapter 13). Doctors today are exploring the use of these mushrooms to benefit mental health.
- » **Medicine:** The first antibiotic used to fight human infections was called penicillin after the *Penicillium* mold that makes it (Chapter 14). Today, scientists are testing fungi like turkey tail (*Trametes versicolor*) for their ability to fight cancer and using fungi to produce cholesterol-lowering statin drugs.