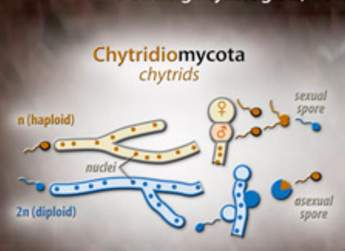
Introduction to Fungi

Fungi were traditionally considered plants, mainly because they looked plant-like and were obviously not animals. However, they've been and continue to be a taxonomist's nightmare. Fungi have cell walls like plants, but the walls are not cellulose but instead composed of chitin, found in the exoskeletons of lobsters, insects, and other animals. Fungi are heterotrophs—they must "eat" food like animals, rather than make it from sunlight and carbon dioxide like plants. Recent molecular evidence suggests that fungi are most closely related to animals, but nonetheless are so unique that they now have their own phyla in Kindom Fungi. Even these groups continue to be re-categorized as scientists investigate the often mysterious and confounding biology of fungi.

Fungi play an enormous role in decomposition of organic matter, nutrient cycling, and soil building. They form essential mycorrhizal root associations with at least 80% of all plants on Earth. Fungi are significant pathogens of animals and plants, but are also utilized by humans in almost all aspects of our lives: they ferment our beer, soy sauce, wine, and raise bread; they create bleu cheese, and are sources of pharmaceuticals and psychotropic ceremonial compounds; fungal enzymes are the active ingredients of detergents and dyes; yeasts and a filamentous zygomycete convert biomass waste into ethanol for the biofuel industry.

Alert: Of 70,000+ species of fungi that have been described, about 250 are edible and 250 are toxic. Many of these are look-alikes. Never eat wild-collected fungi that you can't abosolutely identify!

Fungi are classified on the basis of their reproductive strategies. Fungal taxonomy is awash with specific terminology which we will not introduce here; instead, 5 main groups of fungi are illustrated below, simplifying main differences. Budding mycologists, however, might familiarize themselves with the terms *mycota, mycete, mycellium, mycology:* all from *Mykēs,* Greek for "fungus." *Mycota* is used for the formal phylum name: Basidiomycota. *Mycete* is used as a common name: basidiomycete.



Chytridiomycota
chytrids

Once not considered true fungi due to their motile spores, this mainly aquatic, polyphyletic group is still being revised. Chytrids are often parasites on plankton. A few are plant pathogens, causing corn brown spot, alfalfa crown wart, and potato black wart.

Zygomycota
zygomycetes

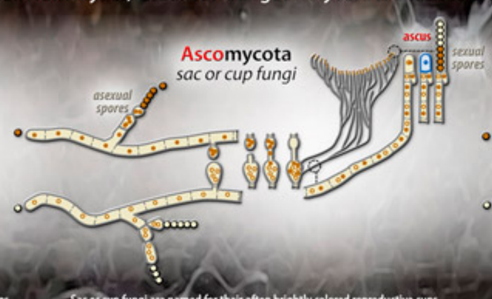
Another polyphyletic group currently under taxonomic scrutiny, Zygomycota is named for its resting zygospores that can remain dormant for long periods. Zygomycete hyphae have no wall divisions and the cytoplasm and nuclei can be seen streaming through the hyphal "tubes".

These fungi are mostly soil builders and decomposers, a process we often see via *Rhizopus stolonifer,* or black mold, on bread, fruits and vegetables. Some zygomycetes are parasitic on insects, and can act as crop pest controls.

Glomeromycota
glomeromycetes

"Glomero" refers to collecting or forming into a ball. This group develops large, multinucleate spores with layered walls, which persist a long time before conditions are right to release the spores. Glomeromycetes are obligate biotrophs, dependent on symbioses with land plants. They form a particular kind of mycorrhizae, called arbuscular mycorrhizas (AMs), with the roots of over 80% of all plant species.

Their importance to worldwide floral health is just beginning to be appreciated; however, glomeromycetes are difficult to culture independently from their host plants, and so are difficult to study.



Ascomycota
sac or cup fungi

Sac or cup fungi are named for their often brightly colored reproductive cups, funnels or pockets. Sexual production occurs in an ascus, the phylum's namesake. Cups are lined with these asci, wherein nuclei fuse, then undergo meiosis to create 8 spores per ascus. These fungi also regularly form microscopic conidia, in which asexual spores are produced via mitosis.

Ascomycete mycelia are well-known molds (many found in the neglected refrigerator), including powdery mildew and the devastating Chestnut and Dutch Elm blights. On the other hand, the delicious morels and truffles are ascomycetes, as are many yeasts involved in food fermentation processes.

Basidiomycota
club fungi

The club fungi are our most familiar mushrooms: umbrellas and parasols, toadstools, stinkhorns, bird's-nests, balls, and shelves on trees and logs. Sexual spores are produced in a club-shaped basidium. Basidia line the gills, pores, or "teeth" of mushrooms, which shed billions of spores—several trillion in the case of large puffballs.

Basidiomycetes include yeasts, plant pathogens, rusts and smuts, our most common and tastiest edible mushrooms, and also the most deadly. NEVER eat a mushroom you can't absolutely identify!

Fungi Imperfecti

This is an artifical group comprised of fungi awaiting taxonomic placement in one of the *bona fide* fungal phyla. These organisms have no known sexual cycle, traditionally required for identification. However, imperfect fungi are giving up their secrets via DNA testing, which usually identifies them as zygomycetes, basidiomycetes, or (usually) ascomycetes. *Penicillium,* for example, has been identified as an ascomycete.

The body of a fungus is made up of either single cells, in which case it is called yeast, or more commonly of microscopic filaments called hyphae, which form a mass or mycelium. The mycelium produces spores that create new individuals. Some fungal species (not all) exhibit two sexual strains, called + or – (rather than male, female). When such strains meet they form large fruiting bodies that we know as mushrooms, cups, shelf fungi, etc. These are not "fruits" like those of plants, but the role is the same: to disseminate the products of sexual reproduction.

The mushroom fades after a few days, but the body of the fungus, the mycelium, may grow for years. One individual fungus living three feet underground in the Malheur National Forest in eastern Oregon is estimated to cover 2,200 acres (1,665 football fields) and is at least 2,400 years old, but could be 7,200 years old.

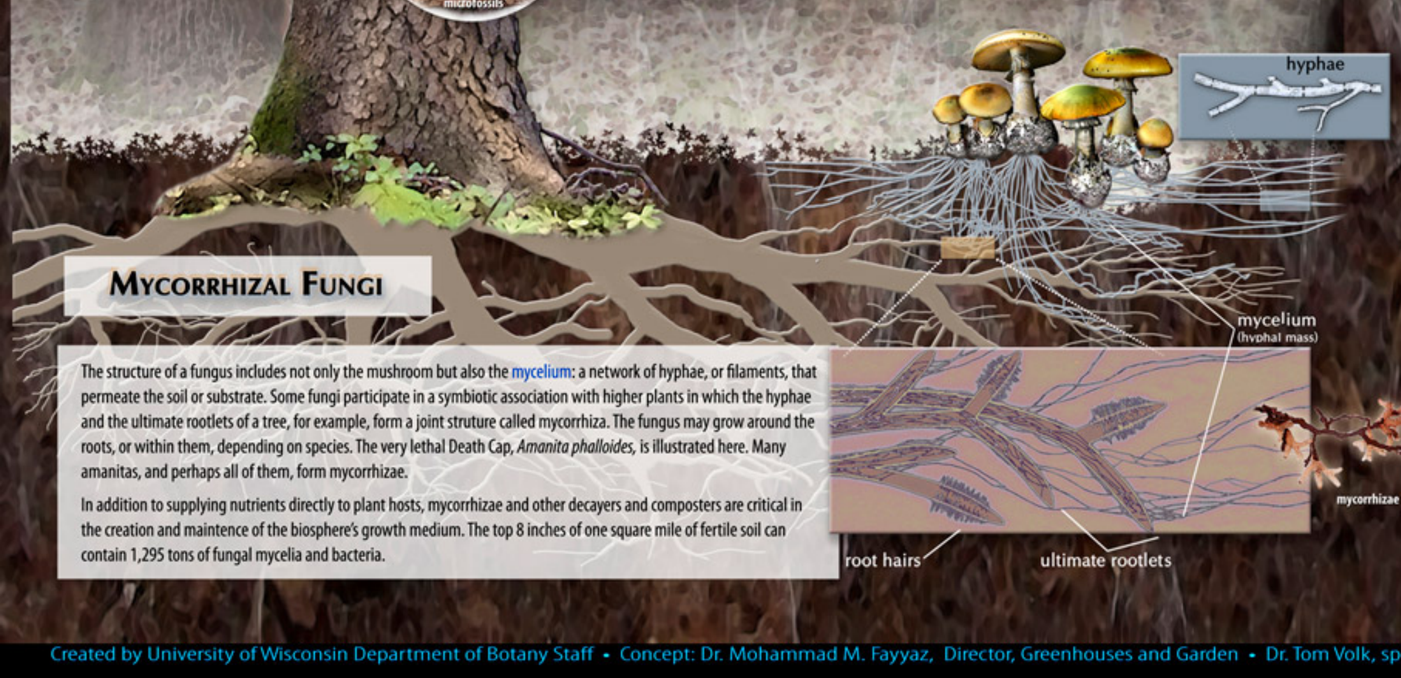
Lichens epitomize the evolution of a dual organism. They are composed of a fungus and either an alga or cyanobacterium, resulting in a mutualistic relationship between members of different phyla—in fact, different kingdoms!

Fungi are categorized by life style:
- **Saprophytes** feed on dead organic material.
- **Parasites** feed on living hosts, harming the host.
- **Mutualists** feed on living hosts, but also benefit the host.

Below left: The plant pathogen *Ustilago maydis,* corn smut, is a parasite. Right, this decomposer zygomycete, feeding on dung, is a saprophyte.

Fossil Fungi

Devonian and Carboniferous fossils of early land plants also show associations with microfossils: bacteria and fungi. In fact, all major fungal phyla are represented in these earliest fossils, showing that these associations were in place at least 400 million years ago and enforcing the long-held theory that fungi were instrumental in the colonization of land by plants.



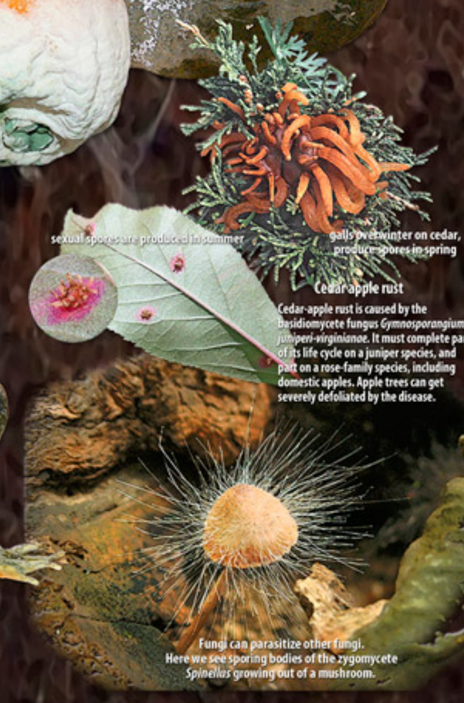
Mycorrhizal Fungi

The structure of a fungus includes not only the mushroom but also the mycelium: a network of hyphae, or filaments, that permeate the soil or substrate. Some fungi participate in a symbiotic association with higher plants in which the hyphae and the ultimate rootlets of a tree, for example, form a joint struture called mycorrhiza. The fungus may grow around the roots, or within them, depending on species. The very lethal Death Cap, *Amanita phalloides,* is illustrated here. Many amanitas, and perhaps all of them, form mycorrhizae.

In addition to supplying nutrients directly to plant hosts, mycorrhizae and other decayers and composters are critical in the creation and maintence of the biosphere's growth medium. The top 8 inches of one square mile of fertile soil can contain 1,295 tons of fungal mycelia and bacteria.

Geomyces destructans causes bat white-nose syndrome (WNS), associated with the death of hundreds of thousands of cave-hibernating bats in the northeastern United States. This ascomycete species, new to science, was finally identified in 2008.

Batrachochytrium dendrobatidis (Bd) is a chytrid fungus that causes the amphibian disease chytridiomycosis. It has devastated frog, toad, and salamander populations worldwide.



Created by University of Wisconsin Department of Botany Staff • Concept: Dr. Mohammad M. Fayyaz, Director, Greenhouses and Garden • Dr. Tom Volk, special consultant • Design, Illustration, Layout: Kandis Elliot, Senior Artist •