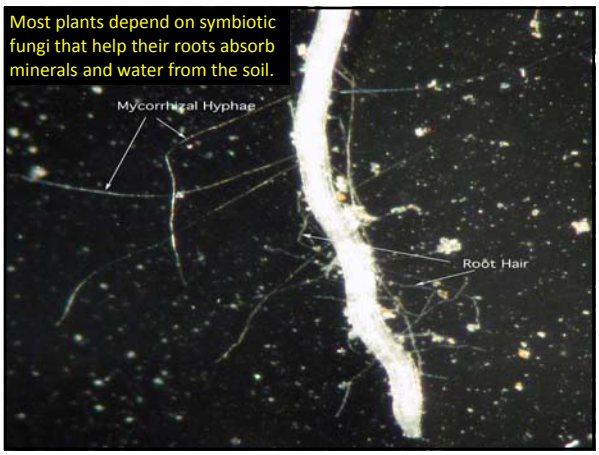
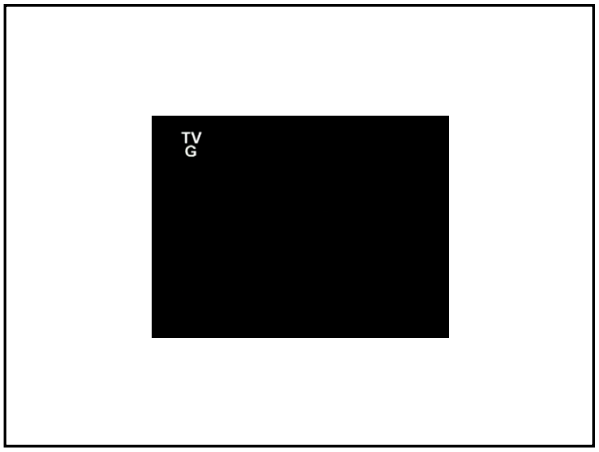
Ecosystems would be in trouble without fungi to decompose dead organisms, fallen leaves, feces and other organic wastes.

Decomposition recycles the chemical elements back to the environment in forms that other organisms can use.

Most plants depend on symbiotic fungi that help their roots absorb minerals and water from the soil.



Humans have grown fungi for: food, to produce antibiotics and other drugs, to make bread rise, and to ferment beer and wine.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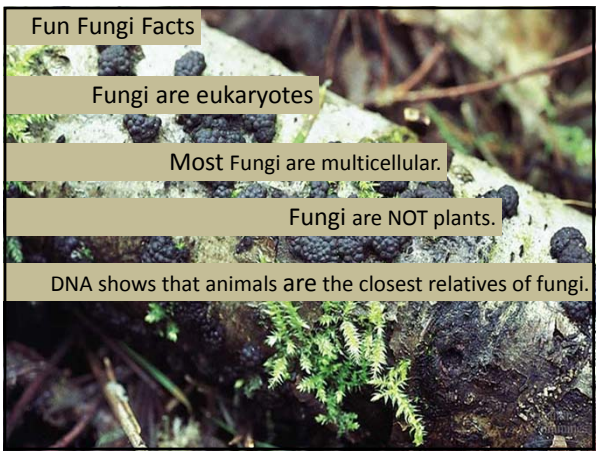
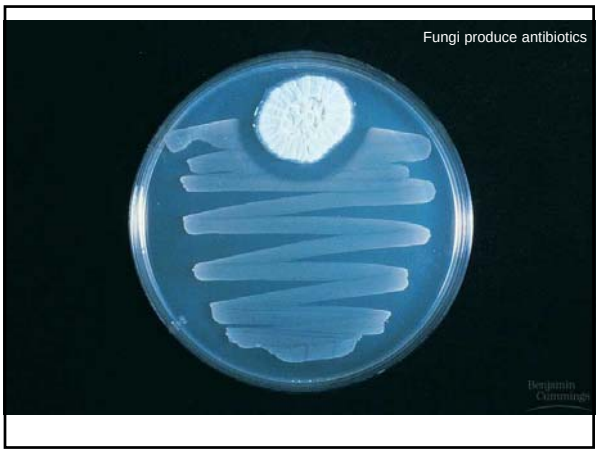
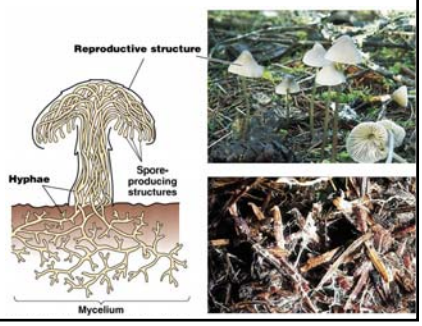

Fun Fungi Facts
Fungi are eukaryotes
Most Fungi are multicellular.
Fungi are NOT plants.
DNA shows that animals are the closest relatives of fungi.




## Extensive surface area and rapid growth adapt fungi for absorptive nutrition

- The vegetative bodies of most fungi are constructed of tiny filaments called **hyphae** that form an interwoven mat called a **mycelium**.




## Fungi are constructed of tiny filaments called hyphae

Fungal hyphae have cell walls made of chitin

Fungal chitin is identical to that found in arthropods.

Fungal mycelia can be huge, but because they live underground most people don't notice them.

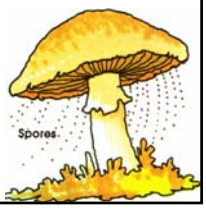
One giant individual of *Armillaria ostoyae* in Oregon is 3.4 miles in diameter and covers 2,200 acres of forest.

It is at least 2,400 years old, and weighs hundreds of tons.

How is it possible for a single fungus to get so big?

- the huge size may be a function of the dry climate in eastern Oregon. Spores have a hard time establishing new organisms, making room for the old-timers to spread.
- Without competition from other specimens this enormous Armillaria has been able to grow and spread unchecked.

- Fungi reproduce by releasing spores that are produced either sexually or asexually.
  - The number of spores from one reproductive structure is enormous, reaching into the trillions.
- Dispersed widely by wind or water, spores germinate to produce mycelia if they land in a moist place where there is food.

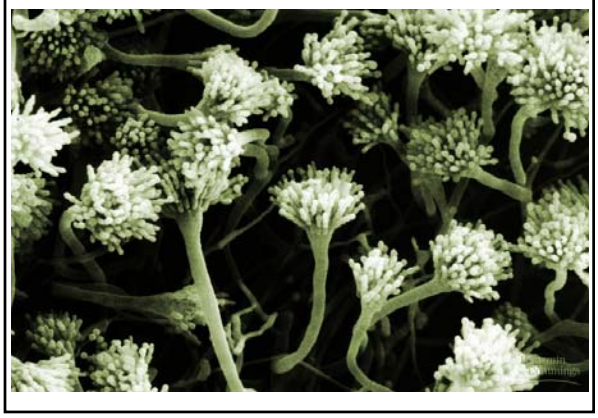


Some fungi such as Pilobolus, can aim their spores

## Phylum Ascomycota: Sac fungi produce sexual spores in saclike asci

- Mycologists have described over 60,000 species of ascomycetes, or **sac fungi**.
- They range in size and complexity from unicellular yeasts to elaborate cup fungi and morels.

*Aspergillus*

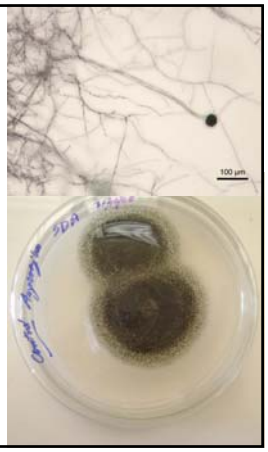


Species of Aspergillus are important medically and commercially.

For humans there are a range of diseases such as infection to the external ear, skin lesions, and ulcers classed as mycetomas.

Perhaps the largest application of *Aspergillus niger* is as the major source of citric acid; this organism accounts for over 99% of global citric acid production, or more than 1.4 million tons a year.

*Aspergillus niger* also causes a disease called black mold on certain fruits and vegetables such as grapes, onions, and peanuts, and is a common contaminant of food.




*Amanita (Death Cap mushroom)*

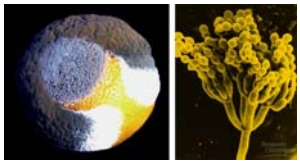
The genus Amanita contains about 600 species including some of the most toxic mushrooms in the world.

This genus is responsible for approximately 95% of the fatalities resulting from mushroom poisoning, with the death cap accounting for about 50% on its own.

The most potent toxin present in these mushrooms is α-amanitin.

- "Fairy Rings" are formed in areas where the mycelium has already consumed all the available nutrients in the center.
- As the mycelium radiates out, it decomposes the organic matter in the soil and mushrooms form just behind this advancing edge.

- A **mold** is a rapidly growing, asexually reproducing fungus.
  - The mycelia of these fungi grow as saprobes or parasites on a variety of substrates.
  - Early in life, a mold, a term that applies properly only to the asexual stage, produces asexual spores.
  - Later, the same fungus *may* reproduce sexually, producing zygosporangia, ascocarps, or basidiocarps.



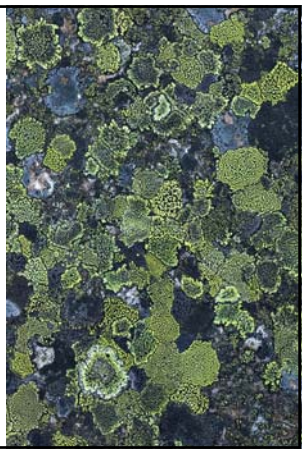
- **Yeasts** are unicellular fungi that inhabit liquid or moist habitats, including plant sap and animal tissues.
  - Yeasts reproduce asexually by simple cell division or budding off a parent cell.
  - Some yeast reproduce sexually but others have no known sexual stage.

- Humans have used yeasts to raise bread or ferment alcoholic beverages for thousands of years.
- Various strains of the yeast *Saccharomyces cerevisiae*, an ascomycete, have been developed as baker's yeast and brewer's yeast.
  - Baker's yeast releases small bubbles of $CO_2$ that leaven dough.
  - Brewer's yeast ferment sugars into alcohol.
- Researchers have used *Saccharomyces* to investigate the molecular genetics of eukaryotes because they are easy to culture and manipulate.

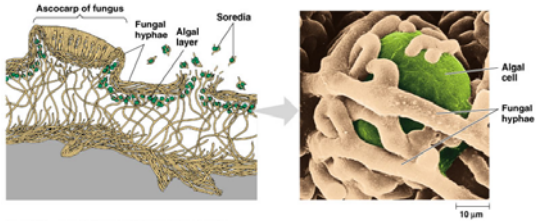
Lichens

While often mistaken for mosses or other simple plants when viewed at a distance, **lichens** are actually a symbiotic association of millions of photosynthetic microorganisms held in a mesh of fungal hyphae.

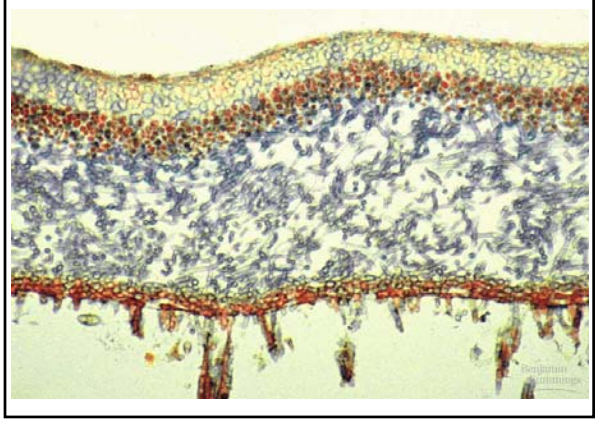
- The photosynthetic partners are usually unicellular or filamentous green algae or cyanobacteria.
- Over 25,000 species of Lichen have been described.



- The fungal hyphae provides most of the lichen's mass and gives it its overall shape and structure.
- The algal component usually occupies an inner layer below the lichen surface.




Anatomy of a lichen



- Mycorrhizae are mutualistic associations of plant roots and fungi.
  - The anatomy of this symbiosis depends on the type of fungus.
- The extensions of the fungal mycelium from the mycorrhizae greatly increases the absorptive surface of the plant roots.
- The fungus provides minerals from the soil for the plant, and the plant provides organic nutrients.

- Mycorrhizae are enormously important in natural ecosystems and in agriculture.
  - Almost all vascular plants have mycorrhizae and the Basidiomycota, Ascomycota, and Zygomycota all have members that form mycorrhizae.
  - The fungi in these permanent associations periodically form fruiting bodies for sexual reproduction.
  - Plant growth without mycorrhizae is often stunted.

- Fungi and bacteria are the principal decomposers that keep ecosystems stocked with the inorganic nutrients essential for plant growth.
  - Without decomposers, carbon, nitrogen, and other elements would become tied up in organic matter.
- In their role as decomposers, fungal hyphae invade the tissues and cells of dead organic matter.

Aggressive decomposition by fungi can be a problem.

- Fungi do not distinguish between wood debris and human structures built of wood.

## Some fungi are pathogens

- About 30% of the 100,000 known species of fungi are parasites, mostly on or in plants.
  - Fungi have had drastic effects on forest trees, such as American elms and American chestnut, in the northeastern United States.
  - Other fungi, such as rusts and ergots, infect grain crops, causing tremendous economic losses each year.

- Some fungi that attack food crops produce compounds that are harmful to humans.
  - For example, the mold *Aspergillus* can contaminate improperly stored grains and peanuts with aflatoxins, which are carcinogenic.
  - Poisons produced by the ascomycete *Claviceps purpurea* can cause gangrene, nervous spasms, burning sensations, hallucinations, and temporary insanity when infected rye is milled into flour and consumed.
  - On the other hand, some toxins extracted from fungi have medicinal uses when administered at weak doses.

- Animals are much less susceptible to parasitic fungi than are plants.
  - Only about 50 fungal species are known to parasitize humans and other animals, but their damage can be disproportionate to their taxonomic diversity.
- The general term for a fungal infection is **mycosis**.
  - Infections of ascomycetes produce the disease ringworm, known as athlete's foot when they grow on the feet.
  - Inhaled infections of other species can cause tuberculosis-like symptoms.
  - *Candida albicans* is a normal inhabitant of the human body, but it can become an opportunistic pathogen.

Ringworm

A skin infection by mold-like fungi known as dermatophytes

## Fungi are commercially important

- In addition to the benefits that we receive from fungi in their roles as decomposers and recyclers of organic matter, we use fungi in a number of ways.
  - Most people have eaten mushrooms, the fruiting bodies (basidiocarps) of subterranean fungi.
  - The fruiting bodies of certain mycorrhizal ascomycetes, truffles, are prized by gourmets for their complex flavors.
  - The distinctive flavors of certain cheeses come from the fungi used to ripen them.
  - The ascomycete mold *Aspergillus* is used to produce citric acid for colas.

- Yeast are even more important in food production.
  - Yeasts are used in baking, brewing, and winemaking.
- Contributing to medicine, some fungi produce antibiotics used to treat bacterial diseases.
  - In fact, the first antibiotic discovered was penicillin, made by the common mold *Penicillium*.