The Kingdom Fungi includes some of the most important organisms, in terms of their ecological & economic roles.

- decompose & recycle organic matter-nutrients
- most vascular plants could not grow without symbiotic fungal mycorrhizae in/on roots
- provide bacterial antibiotics – penicillin, etc
- food: mushrooms, the bubbles in bread, alcohol in champagne & beer etc
- many plant & animal diseases; close phylogeny, genetics & biochemistry makes fungal diseases very difficult to treat.

Phylogenetic systematics suggests that fungi evolved from a flagellated ancestor. While the majority of fungi lack flagella, the chytrids do have flagella, and the protists that share a close common ancestor with animals also have flagella.

These three groups of eukaryotes - the fungi, animals, their protist relatives – are called opisthokonts: clade Opisthokonta. This name refers to the posterior (opistho) location of the flagellum in these organisms.

One fungus body constructed of tubular filaments (hyphae) was brought to our attention when molecular techniques were used to show that it was extensive (37 acres and an estimated blue whale size of 110 tons). The Michigan fungus clone (Armillaria bulbosa) grew in tree roots and soil.

In 2000, scientists discovered the mycelium of one giant individual of the fungus Armillaria ostoyae in Oregon that is 3.4 miles in diameter and spreads through 2,200 acres of forest, equivalent to over 1,600 football fields. This fungus is at least 2,400 years old and hundreds of tons in weight, qualifying it as one of Earth’s oldest and largest organisms.
Yeasts are unicellular.

The spheroid form of the yeast cells is only half their life story. The other half is more sinister. Yeast can transform themselves and grow hyphae (or very similar structures called pseudohyphae). At 37 degrees C, which happens to be 98.6 F, body temperature, the Candida grows hyphae that's not so deep: Doctor Fungus says 'The infection is restricted to the nonliving cornified layers of epidermis since the fungus lacks the ability to penetrate the viable tissues of the immunocompetent host'.

Fungus ... must eat other organisms ... live in damp environments so that the hyphae can absorb nutrients that are dissolved in water. They ... release extracellular enzymes into their environment to degrade complex nutrients like cellulose that they cannot absorb. In addition to simple enzymes, such as those that break down starches into sugar, many fungus produce toxins (called mycotoxins) that can disable, kill, and dissolve their food. Some toxins, such as gliotoxin produced by Candida and Aspergillus (among others), inactivates important enzymes, kills cells and disrupts the immune system.

The fungus is injecting its host (you) with toxins to dissolve and digest you. Even if the infection is localized, the toxic enzymes are transported throughout the body.

The basic cell construction of fungus is different from that of bacteria, plants and animals. Bacteria, plants, and fungus cells have a rigid cell wall. A major component of fungal cell walls is chitin (found in the exoskeleton of insects), whereas the major component of plant cell walls is cellulose. Chitin and cellulose are chemically similar, and the fungal cell wall also includes cellulose.

The plasma membrane (beneath the cell wall) of fungal cells contains ergosterol, a fungal cell-wall, structure not present in mammalian cells. Whereas there are dozens of prescription antibacterial drugs, there are very few oral drugs available for treatment of yeast and fungus. ... include itraconazole (Sporanox), ketoconazole (Nizoral), fluconazole (Difucan), fluconosine (also called 5-F), Amphotericin B, nystatin, caspofungin (Cancidas), terbinafine (Lamisil), plus voriconazole (Vfend).

Glucans in fungal cell walls are a new target of antifungal agents. In the fungal cytoplasmic membrane, is the target site of action of amphotericin B and the azoles.

The azole drugs inhibit synthesis of ergosterol (interfere with the enzyme) necessary for the conversion of lanosterol to ergosterol.

Terbinafine (Lamisil) inhibits ergosterol biosynthesis ... fluconosine, inhibits

Flucytosine ... is converted to 5-fluorouracil (5-FU) which inhibits thymidyate synthetase. Thymidine is required for DNA synthesis. Vertebrate cells have little of the enzyme cytosine deaminase required to convert the poison precursor flucytosine to the active poison fluorocil.

... more recently, the echinocandins disrupt the synthesis of glucan, a fungal cell-wall, structure not present in mammalian cells.
Editor's Summary
19 October 2006
The AFTOL (Assembling the Fungal Tree of Life) project ... reconstructed
the early evolution of fungi by tracking six gene regions through nearly 200 species.

Tom Bruns, Nature 443, 758-761 (19 October 2006)
Before now ... phylogenetic trees of the fungi were based on sequences of
a single gene - that encoding the small-subunit (18S) ribosomal RNA.
... different genes can give different views of evolutionary history.
AFTOL ... two additional rRNA genes, and three protein-coding loci.
The results of are similar to those from the earlier 18S data ...

Reconstructing the early evolution of Fungi using a six-gene phylogeny.
Fungi. Viridiplantae and Animalia
descended from unicellular, flagellated, aquatic forms
that radiated extensively on land.
Key adaptations to the terrestrial habit in the fungi include
the evolution of a filamentous growth form
and the development of aerially dispersed spores.
The sister kingdom to the Fungi (Animalia)
evolved diverse body plans
 capable of feeding by ingestion,
whereas the fungal branch developed
a myriad of unicellular and filamentous
forms optimized for absorptive nutrition.
Traditional fungal phylogenies indicate that
fungi with flagellated cells (Chytridiomycota)
are the sister group of the remaining
non-flagellated fungi.
Zygomycota,
Glomeromycota,
Ascomycota &
Basidiomycota ...

However ... continued

continuing James et al.
The combined gene phylogeny supported monophyly of
the Ascomycota, Basidiomycota & Glomeromycota.
The Ascomycota & Basidiomycota formed a clade 'dikarya'
... also supported a clade uniting dikarya & Glomeromycota
in agreement with previous 18S rRNA phylogenies.
The opisthokont clade
(Fungi, Metazoa and Choanoflagellida)
was ... continued

Two unexpected results were
the placements of the ... chytrids ... is polyphyletic
and (the "chytrid") R. allomycis grouped with the...
as the earliest diverging branch of the Fungi.
Microsporidiosis – unicellular parasites of animals & protists, characterized by the production of tiny resistant spores. Unlike most eukaryotes, they lack conventional mitochondria. Microsporidia are not primitive eukaryotes, but rather highly derived (obligate intracellular parasites). They are often used in the biological control of insect pests.


Microsporida – unicellular parasites of animals & protists, characterized by the production of tiny resistant spores. Unlike most eukaryotes, they lack conventional mitochondria. Microsporidia are not primitive eukaryotes, but rather highly derived (obligate intracellular parasites). They are often used in the biological control of insect pests.

Zygomycota – molds paraphyletic

Complementary mating types: different genotypes; signal with pheromones

A common zygomycete is black bread mold: asexual repro

'Safe Sex: the barrier method' mycelium is aseptate, except to wall off area where haploid nuclei are combining - keep 'parasitic' DNA out!

Chytrids are primitive, aquatic flagellated fungi. {Fig 31.11: Chytrids ar ‘paraphyletic’}

Origin of the amphibian chytrid fungus. Weldon et al. Emerg Infect Dis [serial on the Internet]. 2004 Dec. Available from http://www.cdc.gov/ncidod/EID/vol10no12/03-0804.htm. The sudden appearance of chytridiomycosis, the cause of amphibian deaths and population declines in several continents, suggests that its etiologic agent, the amphibian chytrid Batrachochytrium dendrobatidis, was introduced into the affected regions. However, the origin of this virulent pathogen is unknown. A survey was conducted of 697 archived specimens of 3 species of Xenopus collected from 1879 to 1999 in southern Africa ... We propose that Africa is the origin of the amphibian chytrid and that the international trade in X. laevis that began in the mid-1930s was the means of dissemination.

Glomeromycota - arbuscular, paraphyletic

... an ecologically significant group. All glomeromycetes form a distinct type of called arbuscular mycorrhizae. The tips of the hyphae that push into plant root cells branch into tiny treelike structures known as arbuscules.

About 90% of all plants have such symbiotic partnerships with glomeromycetes.

Mycorrhizal Root Dip Gel 13 different species of beneficial Endomycorrhizae & Ectomycorhizae. Increases Fruit/vegetable yields. Promotes Fast Growth.

Mycorrhizal symbioses: two types are recognized:

1. **Endomycorrhizae** enter into the root cells and are the most common type. Usually produce single spores in the soil for reproduction, not large fruiting bodies like mushrooms.

2. **Ectomycorrhizae** coat the tips of tree roots. Many large forest fungi form ectomycorrhizal partnerships, both truffles with underground fruiting bodies and fungi with the umbrella-shaped fruiting bodies: mushrooms.

About 95% of plants have mycorrhizal symbionts. The comparison of nucleic acid sequences has permitted the integration of asexual fungi such as the yeast *Candida albicans* into the Ascomycota.

**Ascomycota** - sac fungi
- Asexual 'naked' spores (= conidia) formed at ends of hyphae; produce sexual spores in saclike ascii.

**Saccharomyces cerevisiae**, an ascomycete is most important domestic fungus.
- Are different domestic strains: anaerobic fermentation of sugars to alcohol and CO2.

*Penicillium* (Penicillin)
- Club fungi with long-lived dikaryotic (n+n) mycelia and transient diploid (2n) stage = Basidium = mushroom.

**Vaginal yeast infections** are caused by *Candida albicans*, which, along with a few types of bacteria, are normally present in small numbers in your crotch. Sometimes the yeast multiply rapidly and take over, causing a full-fledged yeast infection. Antibiotics are probably the leading cause of vaginal yeast infections … the antibiotic kills the unwanted bacteria in your sinuses, but can also kill the "good" bacteria in your crotch, upsetting the balance of your vaginal ecosystem, allowing the yeast to take over. (we'll study ecosystems later)
Some of the fungi that attack food crops are toxic to humans. For example, some species of the mold Aspergillus contaminate improperly stored grain and peanuts by secreting compounds called **aflatoxins**, which are dangerous to humans.

LSD, an ergot derivative, strongly interferes with the neurotransmitter serotonin. It enhances another neurotransmitter, dopamine.

One type of ascomycete, Claviceps purpurea, forms purple structures called **ergots** on rye. If diseased rye is inadvertently milled into flour and consumed, poisons from the ergots cause gangrene, nervous spasms, burning sensations, hallucinations, and **temporary insanity**. One of the hallucinogens that has been isolated from ergots is **lysergic acid**, the raw material from which **LSD** is made.