I. Origin and Diversification
Fungi diverged from a Protistan ancestor.
Fungi and animals share a recent common ancestry.

55.1 Types of Ecological Interactions

<table>
<thead>
<tr>
<th>EFFECT ON ORGANISM 1</th>
<th>HARM</th>
<th>BENEFIT</th>
<th>NO EFFECT</th>
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<td>Competition (−/−)</td>
<td>Predation or parasitism (−/+ )</td>
<td>Amensalism (−/0)</td>
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<td>EFFECT ON ORGANISM 2</td>
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<tr>
<td></td>
<td>HARM</td>
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<td>Predation or parasitism (+/−)</td>
<td>Mutualism (+/+ )</td>
<td>Commensalism (+/0)</td>
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<td>NO EFFECT</td>
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<td>Amensalism (0/−)</td>
<td>Commensalism (0/+ )</td>
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unicellular and syncytial/multicellular forms; parasitic or saprobic; unique fungal traits; mainly aquatic, flagellate gametes, and chitin

most are soil-inhabiting plant mutualists; one group of major importance is mycorrhizal

Diverse lineage; freshwater, marine and terrestrial; includes yeasts, cup fungi; serious plant pathogens and saprobes. About half are algae mutualists; some form plant mycorrhizae. Some are mutualists in leaf tissue; molds; 60,000+ spp

important wood saprobes, incl. lignin; incl. mycorrhizae-forming plant mutualists, and plant pathogens --rusts and smuts; includes familiar mushrooms, shelf fungi, puff balls; 25,000+ spp.

Ascomycota pedestal-like basidium

Basidiomycota sac-like ascus

These four phyla are distinguished based on reproductive structures

Ecological types (eg, yeast, mycorhizal mutualists…) occur across lineages

“Imperfect fungi” - 65,000 spp. whose phylogenetic position in Fungi is undetermined; have secondarily lost a sexual reproductive phase

Cladogram indicating probable phylogenetic relationship among four phyla of Fungi, supported mainly by molecular evidence.

chytridiomycota (chytrids).
The common mold *Rhizopus* decomposing strawberries.

The zygomycete *Pilobus* decomposes animal dung.

Edible morel (*Morchella esculenta*). Copyright Dr. Phil Gates, Durham U./BPS.

Scarlet cups (*Sarcoscypha coccinea*). Copyright BPS.
Scarlet hood (Hygrocybe coccinea) is native to northern Europe and North America. The tissue above ground are the reproductive structures — most of the organism is underground (Freeman 2002).
Growing under snow, the mycelium of snow mold (Typhula sp.) kills turf grass. Copyright BPS.

Brewer's or baker's yeast, the hemiascomycete Saccharomyces cerevisiae. LM. Copyright James Solliday/BPS.

Fruiting body (mushroom) of the reddening lepiota (Lepiota americana), showing gills. Copyright Barbara J. Miller/BPS.

Two growth forms occur in Fungi
- Mycelia
- Yeast

The familiar "mushroom" is a reproductive structure- a fruiting body.

A fungal mycelium grows from a spore that germinated in a suitable habitat.

The mushroom is a reproductive structure that produces spores.

The above-ground, visible (mushroom) is comprised of hypae and is continuous with the less visible hypae (near and below the ground in this case).

Mushrooms grow each fall from the mycelium beneath.

Vegetative part of a mycelium (white, thread-like) decomposing brown conifer needles.

Source: Campbell et al (2002)
Vegetative (nutritionally active) bodies of fungi other than single celled yeast

Vegetative (feeding) body of fungi other than yeast consists of a nearly microscopic tubular filaments that grow in a network like mycelium

In most species, hyphae are multi-nucleate - either coenocytic or septate; not multicellular; septa are porous to organelles

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Cellulose is the most common carbohydrate on earth. It is a highly insoluble, unbranched polysaccharide used by plants as their major supporting material. Chitin is the polysaccharide that serves as the major structural component of insect exoskeletons and fungal cell walls, and is functionally equivalent to cellulose. Cellulose is composed of long chains of beta linked glucoses. Chitin is composed of beta linked acetylglucosamines (glucoses with a combined acetyl-amino side group)

Cellulose

Chitin
Predatory fungus with hyphae adapted for trapping and killing prey. Portions of the hyphae in this soil fungus (Arthrobotrys) are modified into constricting loops; constriction is stimulated by worm touching inside of loop. Constriction occurs in less than a second. Fungus then penetrates worm with hyphae and digests inner tissues. (Campbell 2002)

Armillaria is a pathogenic fungus. It is shown here affecting three areas of coniferous forest in Montana.
Sexual reproduction

Asexual reproduction

Haploid
Heterokaryotic (unfused nuclei form different parents)
Diploid (2n)

Zygote

Karyogamy (fusion of nuclei)
Plasmogamy (fusion of cytoplasm)

Heterokaryotic Stage

Generalized Life Cycle of Many Fungi
(sexual phase absent in some species)
(after Campbell 2002)

Spore release from pathogenic poplar rust

Keeton & Gould 1993

Raven et al 2002

Sexual reproduction in the common bread mold (a Zygomycete).
Sexual reproduction in the common bread mold (a Zygomycete).

**Fusion of gametangia of black bread mold (Rhizopus stolonifer); septum present**

**Fused gametangia of black bread mold (Rhizopus stolonifer); septum dissolving**

**Zygote (zygosporangium) resulting from fused gametangia of Rhizopus stolonifer. LM.**

**Two zygosporangia of Rhizopus stolonifer; resistant zygospores. LM.**

**Hypha of + mating type**

**Gametangia**

**Zygosporangium**

**Zygospores within zygosporangium**

III. Ecological Roles and Relationships

The action of Fungi that digest lignin and cellulose is a major determinant of the global cycling of Carbon

Source: Freeman 2002
The spike in fungal fossils at the end Permian extinction corroborates the hypothesis that terrestrial ecosystems, not only marine systems, experienced mass extinctions; the spike suggests fungi that decompose wood proliferated with the massive die-off of trees.

Hyphae of the fungus Pisolithus tinctorius form an ectomycorrhiza on the root of a eucalyptus. SEM.

Copyright R. L. Peterson, Univ. Guelph/BPS.
The chestnut blight fungus, an Ascomycete, was introduced in New York early in the 20th century; by mid century it had killed almost all Chestnut trees in North America.

Source: Solomon et al 2002