Kingdom Fungi
I. Characteristics of fungi
   A. Morphology – what do they look like?
   B. Lifestyle – how do they live?
   C. Basic life cycle – how do they reproduce?
   D. Ecology - who cares about fungi?
II. Evolution of Fungi
   A. Phylogeny
   B-E. Overview of phyla
III. Fungal mutualisms
   A. Lichens
   B. Mycorrhizae

I. The Characteristics of Fungi

- Fungi are NOT plants
- Hyphae = tubular units of construction
- Heterotrophic by absorption
- Reproduce by spores
- Ecologically pivotal roles

A. Morphology
   1. Hyphae & Mycelia
      • Tubular
      • Cell wall of chitin
      • Multinucleate
      • Grow at tips

Hyphal septa
Hyphae are broken into compartments by septa.

Modifications of hyphae

Hyphal growth from spore

- Hyphae grow from their tips
- Mycelium = extensive, feeding web of hyphae
- Mycelia are the ecologically active bodies of fungi
- Mycelia have a huge surface area
- “The humongous fungus”
“Fruiting bodies” are also composed of hyphae

C&R, Fig. 31.1

2. Yeasts
- Single celled fungi
- Adapted to liquids
  - Plant saps
  - Water films
  - Moist animal tissues

Saccharomyces cerevisiae
Candida albicans

B. Fungal Lifestyle:
Heterotrophic by Absorption
- Fungi get carbon from organic sources
- Hyphal tips release enzymes
- Enzymatic breakdown of substrate
- Products diffuse back into hyphae

Products diffuse back into hypha and are used

Candida albicans

The Absorptive Lifestyle
- Saprobes
  - Decomposers
  - Mostly of plants, some animals
- Parasites
  - Harm host
  - Mostly on plants, some animals
- Mutualists
  - Lichens
  - Mycorrhizas
  - Endophytes (see book)

Decomposer
Parasite/pathogen
Mutualist

C. Basic fungal life cycle
- Spores are reproductive cells
  - Sexual
  - Asexual
- Formed:
  - Directly on hyphae
  - Inside sporangia
  - Fruiting bodies

Amanita fruiting body
Pilobolus sporangia

Penicillium conidia

1. Zygotic - haploid phase is dominant

C&R, fig. 13.5b
Plasmogamy - fusion of cytoplasm
Karyogamy - fusion of nuclei (gametes)

Heterokaryotic = dikaryotic

D. Who cares about fungi?

1. Decomposers

Also eat:
- wood in houses, boats, fences;
- food;
- other materials - cloth, paint, leather, waxes, jet fuel, petroleum, paper, wire insulation, photographic film, to name a few.

What do all of these materials have in common?

They are all C-based.

D.2. Agricultural pests

Stem rust
Parasites

Pink ear rot
Food spoilage

D.3. Food - morels, truffles, shitakes, common button mushrooms

Morel

Truffles

D.4. Medicinals

- HUGELY IMPORTANT:
  Source of many antibiotics (active against bacteria)
  Penicillium, etc.

- and hallucinogens:
  - Psilocybin
  - ergot (LSD)
D.5. Yeast for brewing and baking: *Saccharomyces cerevisiae*

II. Fungal Evolution

A. Overview

1. Common eukaryotic ancestor with animals

2. Four phyla of fungi?

According to traditional thinking, there are four phyla of fungi.

- **Chytridiomycota** (make chytrid-like motile spores and gametes)
- **Zygomycota** (make zygote with tough outer coat)
- **Basidiomycota** (make mushroom-like basidiocarps)
- **Ascomycota** (make sac-like ascospores)

B. Chytridiomycota – “chytrids”

- Simple fungi
- Produce motile spores and gametes
- Mostly saprobes and parasites in aquatic habitats

Chytrids are a primary factor resulting in amphibian declines.
C. Zygomycota

1. Examples:
   - Rhizopus (C&R, fig. 31.6)

Pilobolus, with asexual sporangia
C&R, 31.8

http://www.youtube.com/watch?v=TrKJAOjmBH4
http://www.youtube.com/watch?v=9CRNmde0WUc&NR=1

C. Zygomycota

No longer considered one phylum—polyphyletic
Formerly, many endomycorrhizae, too (e.g., Glomus)
Now in their own group (Glomeromycota)

C. Zygomycota

2. Life cycle

a. No dikaryotic growth
b. Both sexual and asexual sporangia

C. Zygomycota

DNA sequence data have revealed that Glomerales, Basidiomycota, and Ascomycota are monophyletic.

D. Basidiomycota—“club fungi”

Mushrooms (e.g., Hygrophorus)

1. structure
   a. Fruiting body: basidiocarp

   Shelf or bracket fungus
   C&R, 31.11

2. Life cycle
   a. Dikaryotic growth
   b. Fruiting body: basidiocarp
   c. Fertile layer on gills with basidia (“clubs”)
   d. Four spores per basidium
   e. Asexual reproduction is rare

Basidiomycota have reproductive structures with many spore-producing basidia.
E. Ascomycota

“sac fungi” or “cup fungi”

Scarlet cup

Morels

Truffles

Many “lichen fungi” too!

F. Deuteromycetes - “fungi imperfecti”

• 1. Not a true phylum (not a natural group): polyphyletic
• 2. Fungi with no known sexual reproduction (“molds”)
• 3. Asexual reproduction by conidia

III. Fungal mutualisms

• Questions:
  • 1. Definitions of mutualism vs. symbiosis, mutualism vs. parasitism vs. commensalism
  • 2. What fungal and photosynthetic partners are involved?
  • 3. What is the “currency” of the mutualism? How do the partners benefit?
  • 4. What is the structure and/or morphology of the organismal interaction?
  • 5. What is the ecological importance?

A. Lichens

1. Partners
   a. Fungal partner
      - gives protection
      - mostly Ascomycetes (~25,000 spp.)
      - only found in lichens (not free-living)
      - provide protection, receive photosyntheate (fixed C)
   b. Photosynthetic partner
      - gives fixed carbon (sugars)
      - green alga or cyanobacterium
      - can be free-living
      - provide photosyntheate (fixed C), receive protection
A. Lichens

2. Anatomy

- a. most of lichen body is fungal hyphae
- b. photosynthetic partner in a distinct layer
- c. sexual reproduction of fungal partner only
- d. asexual reproduction: soredia, fragmentation

3. Morphology

- fruticose
- foliose
- crustose

4. Importance

- a. rock weathering, soil formation in primary succession
  - • acid secretion
  - • trapping particulates
  - • nitrogen fixation (cyanobacteria)
- b. winter food for caribou and reindeer in Arctic
- c. Indicators: susceptible to pollutants

B. Mycorrhizae

- “mycor” = fungus, “rhizae” = root
1. Partners
   - a. Fungus
     - • gets fixed carbon (sugars)
     - • Primarily Basidiomycetes and Glomeromycetes (which were formerly part of Zygomycetes)
   - b. Plant
     - • gets nutrients (mostly N and P) and water
     - • about 80% of all plant species are mycorrhizal!!
2. Structure: two types of fungal/plant contact
   
a. external (ectomycorrhizae)
   - fungal sheath around root
   - Basidiomycetes and about 5000 plant species (mostly woody)
   - many Basidio’s: fairly plant species specific
   
   ![Image of ectomycorrhizae](image1.png)

b. internal (endomycorrhizae) (a.k.a. arbuscular mycorrhizae)
   - hyphae penetrate root cells
   - Glomeromycetes (formerly Zygomycetes)
   - 80% of all plants (many herbaceous)
   - relatively few fungal species: not plant species specific
   
   ![Image of endomycorrhizae](image2.png)

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B. Mycorrhizae

3. Benefits - is it worth it?

   ![Grass comparison](image3.png)

   ![Plant comparison](image4.png)

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The End