Chapter 31. Fungi

Nutrition and fungal lifestyles
- All fungi are heterotrophic, digest food by releasing exoenzymes into their environment.
- Decomposers (saprobes)
- Parasites and pathogens
- Mutualists (symbionts)

Structure of a multicellular fungus
(This is a basidiomycete)

Structure of the fungal body
- The mycelium is a network of branching hyphae (singular, hypha)
- In some fungi, the mycelium can become organized into a complex reproductive structure (e.g., a mushroom or basidiocarp)
- Depending on the fungal group, hyphae can be septate or coenocytic

Plant life cycles involve alternation of generations (but fungal life cycles do not)
Fungal life cycles: what’s new?

- Sporophyte/gametophyte concepts not applicable to fungal life cycles.
- One nucleus per cell? Not necessarily.
- Some new terms:
  - Plasmogamy: fusion of cytoplasm of two parents.
  - Heterokaryotic mycelium: contains nuclei from two parents.
  - Dikaryotic mycelium: ditto, but each cell contain two nuclei.
  - Karyogamy: fusion of nuclei of two parents.

Fungi can also reproduce asexually

Soil fungi on a plate

Fungi and animals are sister kingdoms (this is part of Fig. 28.4)

Origin and evolution of of the fungi

- Common ancestor of animals and fungi lived ca. 1.5 BYA
- Fungal ancestor was
  - Unicellular
  - Aquatic
  - Produced flagellated cells
- Fungi moved to land with plants, many as symbionts with plants.
Fungal lineages

- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- "Deuteromycetes" or imperfect fungi

Chytrids

- Unicellular or developing simple mycelia
- Aquatic
- Produce flagellated spores (this is a "primitive" trait)
- Saprobes and parasites

Phylogeny of fungi

Figure 31.9

Chytrids may be implicated in worldwide amphibian decline

Healthy frog  Frog sick with chytridiomycosis

Fungal lineages

- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- "Deuteromycetes" or imperfect fungi
Zygomycetes

- Many fast growing “molds”
- A few parasites and symbionts
- Hyphae are coenocytic
- Reproduce sexually (occasionally) and asexually (mostly)

Rhizopus – a common mold

Zygomycete life cycle: Figure 32.12

Rhizopus on a germinating seed

The black dots are asexual sporangia

Rhizopus asexual sporangium

Rhizopus sexual zygosporangia form after plasmogamy
**Rhizopus zygosporangia are heterokaryotic**

- They form as a result of *plasmogamy* between mycelia of different mating types.
- They contain many nuclei from each parent.
- During zygosporangial development *karyogamy* produces diploid nuclei.
- Meiosis of the diploid nuclei produces haploid spores which disperse to establish new mycelia.

**Fungal lineages**

- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- "Deuteromycetes" or imperfect fungi

**Glomeromycetes**

(Figure 31.5)

*Arbuscular mycorrhizae*

**Glomerocytes and the mycorrhizal relationship**

- Mycorrhiza = fungus-root
- Mycorrhizal symbiosis involves a partnership between fungi and roots of host plant
- Fungal mycelium penetrates host roots.
- Plant "donates" carbohydrate to fungus, fungus "donates" mineral nutrients (especially phosphorous) to host plant.
- > 90% of all plant species have mycorrhizae
- Not all mycorrhizal fungal are Glomeromycetes, but all Glomeromycetes are mycorrhizal

**Fungal lineages**

- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- "Deuteromycetes" or imperfect fungi

**Ascomycetes**

- This is a large group: > 32,000 species
- Wide range of life histories and morphologies:
  - From single-celled yeasts to complex "cup fungi"
  - Saprobes
  - Pathogens
  - Symbioses with algae to form lichens
  - Mycorrhizal
- Hyphae are septate
Ascomycete diversity

Figure 31.16

The Ascomycete life cycle has asexual and sexual phases

Figure 31.17

Ascomycetes can reproduce asexually

Production of conidia (asexual spores) by Neurospora

Ascomycetes can reproduce sexually

• Plasmogamy between mycelia of opposite mating types forms a dikaryotic mycelium.
• Some of the hyphae become organized into an ascocarp.
• Within the ascocarp certain hyphal tips develop into asci (singular, ascus)
• Karyogamy occurs in the asci
• Meiosis produces spores (ascospores) in the asci

Ascocarps

• Cells of the ascocarp are dikaryotic.
• The feeding mycelia (both parents) are underground.
• Each cell of the feeding mycelium contains one haploid nucleus.

A slice through an ascocarp (1)
Fungal lineages

- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- “Deuteromycetes” or imperfect fungi

Basidiomycetes

- This is a large group: > 30,000 species
- Wide range of life histories and morphologies
  - Mushrooms and shelf fungi
  - Very effective saprobes, good at degrading lignin.
  - Some species are mycorrhizal.
  - Some species are serious crop pathogens
  - Some species are lichen forming

“Mushrooms” are basidiocarps

- Agaricus bisporus, portobello and pizza mushrooms
- Amanita muscaria – the world’s deadliest mushroom. Lethal dose = 0.1 mg/kg of body weight
- Polyporus betulinus, a shelf fungus on birch
Basidiomycetes mostly reproduce sexually
- Plasmogamy between mycelia of opposite mating types forms a dikaryotic mycelium.
- Some of the hyphae become organized into an basidiocarp.
- Within the basidiocarp certain hyphal tips develop into basidia (singular, basidium).
- Karyogamy occurs in the basidia.
- Meiosis produces spores (basidiospores) in the basidia.

Basidiospores and basidia on a gill of a basidiocarp

Some important features of fungal morphology and life cycles
- The fungal body is a mycelium composed of filamentous hyphae.
- Hyphae can be septate or coenocytic.
- No alternation of multicellular generations, as in plants and some algae.
- Plasmogamy and karyogamy are separate events.
- Life cycles have haploid, diploid and heterokaryotic phases.
- The only diploid nuclei are the "zygotes" resulting from karyogamy.
- In fungi with septate hyphae, the heterokaryotic phase is dikaryotic (2 nuclei/cell).

Basidiospores and basidia under the electron microscope

Some ecological roles of fungi (1)
- Major decomposers (saprobes)
- Symbionts
  - Mycorrhizae
  - Fungal-animal symbiosis (e.g. the fungus gardens of leaf cutting ants, next slide)

Leaf cutting ants: harvest leaves, feed them to fungi, consume the fungi

Some ecological roles of fungi (1)
Some ecological roles of fungi (2)

– Lichens (fungus/alga symbiosis

Figure 31.23

Some ecological roles of fungi (3)

– Pathogens, especially on crops

Figure 31.25

…and let’s not forget that beer is brewed with yeast, an Ascomycete