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)

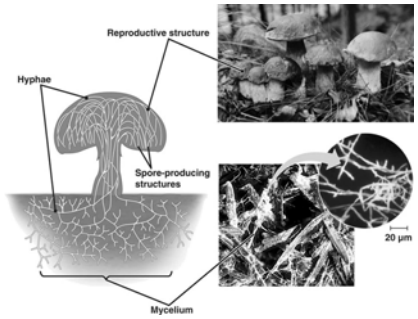


Fig. 31.2

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*

Septate and coenocytic hyphae

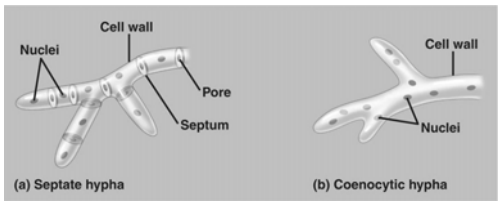
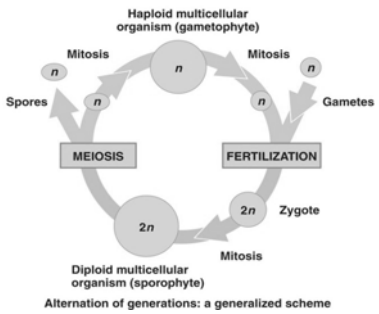


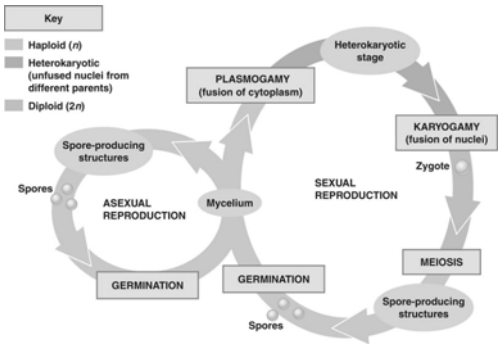
Figure 31.3

Plant life cycles involve alternation of generations (but fungal life cycles do not)



Alternation of generations: a generalized scheme

Fungal life cycles. Fig. 31.5 (overview)



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

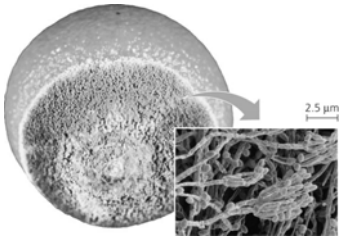
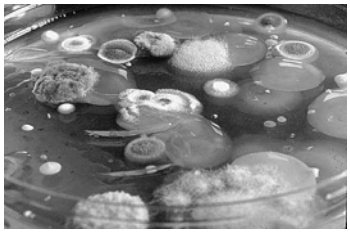
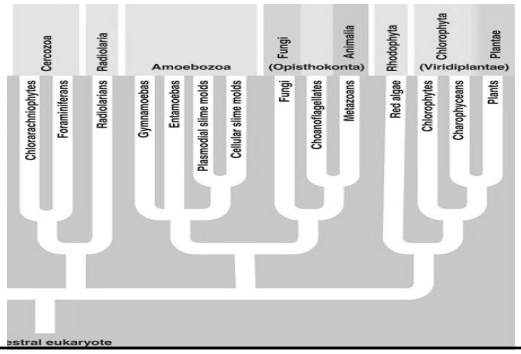


Figure 31.6. *Penicillium,* a common mold on food

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

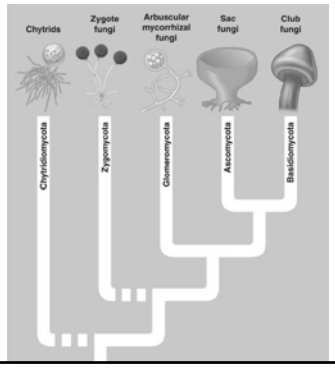
- Common ancestor of animals and fungi lived ca. 1.5 BYA
- Fungal ancestor was
  - Unicellular
  - Aquatic
  - Produced flagellated cells
- Fungi moved to land with plants, many as symbionts with plants.

Fungal lineages

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

Phylogeny of fungi

Figure 31.9



Chytrids

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

Chytrids

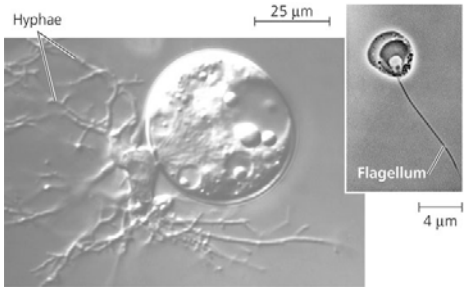


Figure 31.10

Chytrids may be implicated in worldwide amphibian decline

Healthy frog

Frog sick with chytridiomycosis

Fungal lineages

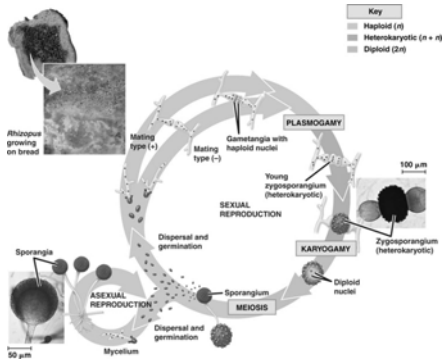
- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- “Deuteromycetes” or imperfect fungi

Zygomycetes

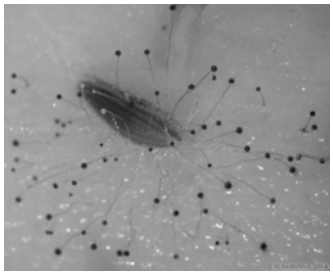
- Many fast growing “molds”
- A few parasites and symbionts
- Hyphae are coenocytic
- Reproduce sexually (occasionally) and asexually (mostly)

Rhizopus – a common mold

Zygomycete life cycle: Figure 32.12

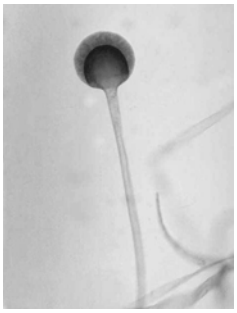


Rhizopus on a germinating seed

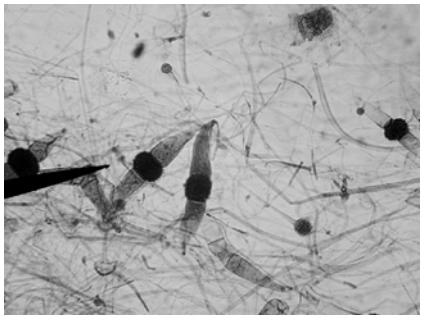


The black dots are asexual sporangia

Rhizopus asexual sporangium



Rhizopus sexual zygosporangia form after plasmogamy



Rhizopus zygosporangia are heterokaryotic

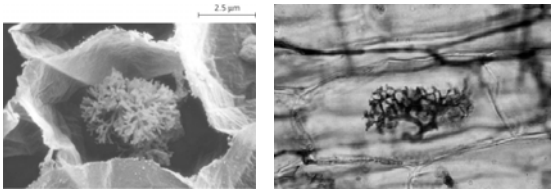
- They form as a result of *plasmogamy* between mycelia of different mating types.
- They contain many nuclei from each parent.
- During zygosporangial development *karyogamy* produces diploid nuclei.
- Meiosis of the diploid nuclei produces haploid spores which disperse to establish new mycelia.

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 Glomeromycytes, but all Glomeromycytes are mycorrhizal

Fungal lineages

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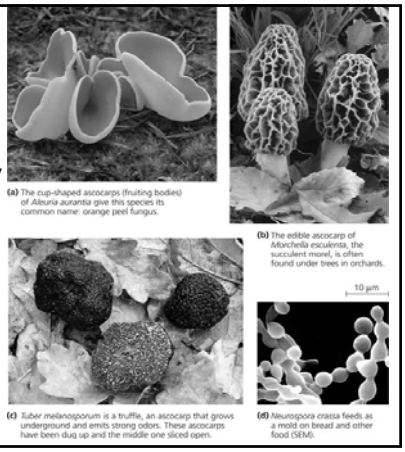
- Ascomycetes
- Basidiomycetes
- "Deuteromycetes" or imperfect fungi

Ascomycetes

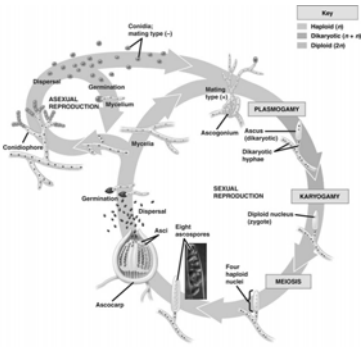
- This is a large group: > 32,000 species
- Wide range of life histories and morphologies:
  - From single-celled yeasts to complex "cup fungi"
  - Saprobes
  - Pathogens
  - Symbioses with algae to form lichens
  - Mycorrhizal
- Hyphae are septate

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*

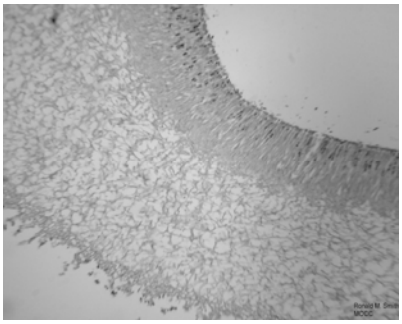
Ascomycetes can reproduce sexually

- 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

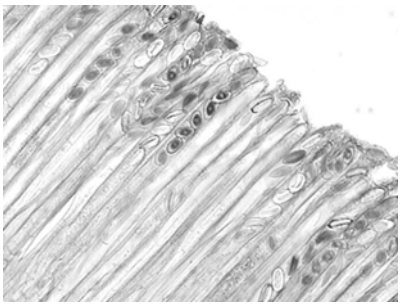
Ascocarps

- 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)



A slice through an ascocarp (2)



Fungal lineages

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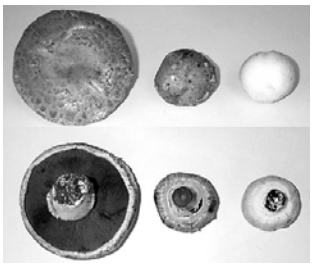
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
- “Deuteromycetes” or imperfect fungi

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

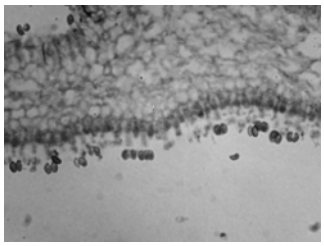
Amanita muscaria – the world’s deadliest mushroom. Lethal dose = 0.1 mg/kg of body weight

Polyporus betulinus, a shelf fungus on birch

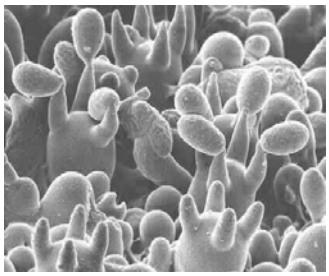
Basidiomycetes mostly reproduce sexually

- 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



Basidiospores and basidia under the electron microscope



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)

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

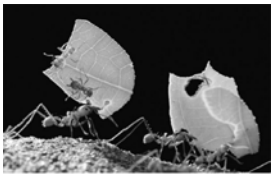
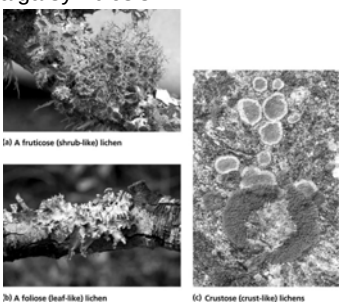


Figure 31.22

Some ecological roles of fungi (2)

– Lichens (fungus/alga symbiosis

Figure 31.23



Some ecological roles of fungi (3)

– Pathogens, especially on crops

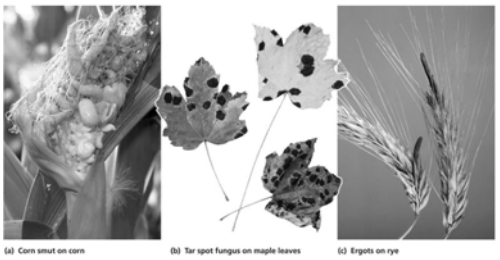


Figure 31.25

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