Chapter 24 Fungi
Kingdom Fungi
- Eukaryotic
- Single or multicellular
- Heterotrophic
- Saprobic/decomposers
Symbiotic relationships
Worldwide
Many species of fungus produce the familiar mushroom (a) which is a reproductive structure. This (b) coral fungus displays brightly colored fruiting bodies. This electron micrograph shows (c) the spore-bearing structures of *Aspergillus*, a type of toxic fungi found mostly in soil and plants. (credit “mushroom”: modification of work by Chris Wee; credit “coral fungus”: modification of work by Cory Zanker; credit “Aspergillus”: modification of work by Janice Haney Carr, Robert Simmons, CDC; scale-bar data from Matt Russell)
Fungal hyphae may be
(a) septated or
(b) coenocytic (coeno- = “common”; -cytic = “cell”) with many nuclei present in a single hypha.
Fungal body structure

Reproductive structure

Hyphae

Spore-producing structures

Mycelium

Fig. 31-2

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Fig. 31-4

(a) Hyphae adapted for trapping and killing prey

(b) Haustoria

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Mycorrhizae

- **Ectomycorrhizae (10%)**
  - Over root surface
  - Into extracellular spaces of root cortex

- **Arbuscular mycorrhizae (85%)**
  - Within cortical root cells

Function? Minerals & PO$_4$ to plants
Generalized Life Fungal Lifecycle

Key

- Haploid \( (n) \)
- Heterokaryotic (unfused nuclei from different parents)
- Diploid \( (2n) \)

Asexual Reproduction

Spore-producing structures

Spores

Mycelium

Germination
Generalized Life Fungal Lifecycle

Key
- Haploid (n)
- Heterokaryotic (unfused nuclei from different parents)
- Diploid (2n)

Spore-producing structures
- ASEXUAL REPRODUCTION
- GERMINATION

Mycelium
- HETEROKARYOTIC stage
- KARYOGAMY (fusion of nuclei)
- PLASMOGAMY (fusion of cytoplasm)
- Zygote
- SEXUAL REPRODUCTION
- MEIOSIS
- Spores

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Asexual reproduction

- Mycelia
- Haploid spores
Asexual reproduction → budding

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Origin of Fungi

UNICELLULAR, FLAGELLATED ANCESTOR

Animals (and their close protistan relatives)

Nucleiids

Chytrids

Other fungi

Opisthokonts
Figure 31.10

**Fungal Taxonomy**

- **Chytrids** (1,000 species)
- **Zygomycetes** (1,000 species)
- **Glomeromycetes** (160 species)
- **Ascomycetes** (65,000 species)
- **Basidiomycetes** (30,000 species)
Phylum Chytridiomycota

- Found: lakes & soil
- Decomposers
- Mutualistic relationship (gut flora)
- Parasitic
- Produce flagellated zoospores

Chytrids (1,000 species)
Chytrids
Zygomycetes
Glomeromycetes
Ascomycetes
Basidiomycetes
Phylum Zygomycetes/Zygomyctota
- Spore production from sporangium
- The “Molds”
- Coenocytic hyphae
- Asexual & sexual reproduction
- Worldwide

Zygomycetes (1,000 species)
Figure 31.12e/Fig 24.9

Rhizopus growing on bread

Hyphae

Sporangium

25 μm
**SEXUAL REPRODUCTION**

**Young zygosporangium** (heterokaryotic)

**Gametangia with haploid nuclei**

**Mating type (+)**

**Mating type (–)**

**PLASMOGAMY**

**KARYOGAMY**

**Dispersal and germination**

**Sporangium**

**Spores**

**Diploid nuclei**

**Diploid (2n)**

**Haploid (n)**

**Heterokaryotic (n + n)**

---

**Key**

- Haploid (n)
- Heterokaryotic (n + n)
- Diploid (2n)

**Fig 24.11**

*Rhizopus* growing on bread
**Fig. 24.11**

**Rhizopus growing on bread**

**SEXUAL REPRODUCTION**
- **Gametangia with haploid nuclei**
- **Mating type (+)**
- **Mating type (−)**
- **Young zygosporangium (heterokaryotic)**

**PLASMOGAMY**

**KARYOGAMY**

**MEIOSIS**

**ASEXUAL REPRODUCTION**
- **Dispersal and germination**
- **Sporangia**
- **Mycelium**
- **Spores**

**Key**
- Haploid (n)
- Heterokaryotic (n + n)
- Diploid (2n)
• Zygomycetes asexual and asexual life cycles
• Sexual life cycle: plus and minus mating types conjugate form zygosporangium
• Sporangia grow at the end of stalks, which appear as (a) white fuzz seen on this bread mold, *Rhizopus stolonifer*. The (b) tips of bread mold are the spore-containing sporangia. (credit b: modification of work by “polandeze”/Flickr)
Glomeromycetes (160 species)

Chytrids
Zygomycetes
Glomeromycetes
Ascomycetes
Basidiomycetes

Fungal hypha
Phylum Glomeromycetes

- Arbuscular mycorrhizae (once in zygomycetes)
- Mutualistic relationship with plant roots
(a) Ectomycorrhiza and (b) arbuscular mycorrhiza have different mechanisms for interacting with the roots of plants. (credit b: MS Turmel, University of Manitoba, Plant Science Department)
Ascomycetes (65,000 species)

Chytrids
Zygomycetes
Glomeromycetes
Ascomycetes
Basidiomycetes
Phylum Ascomycetes (Ascomycota)

- Sac fungi → ascus/asci within ascocarp
- Worldwide (terrestrial, marine & fresh water)
- Pathogens, decomposers, symbionts
- Long lived dikaryotic stage

*Morchella esculenta*, the tasty morel

*Tuber melanosporum*, a truffle
Phylum Ascomycetes (Ascomycota)

• Types of ascocarp:
  - Apothecium “cuplike”
  - Cleistothecium
  - Perithecium “flasklike”
  - Asexual condia
Haploid spores (conidia)

Dispersal

Germination

Hypha

Conidiophore

Mycelium

ASEXUAL REPRODUCTION

Key

- Haploid (n)
- Dikaryotic (n + n)
- Diploid (2n)
**ASEXUAL REPRODUCTION**

- **Conidiophore**
- **Mycelium**
- **Germination**
- **Dispersal**

**SEXUAL REPRODUCTION**

- **Conidia; mating type (-)**
- **Mating type (+)**
- **Dikaryotic hyphae**
- **Ascus** (dikaryotic)
- **Mycelia**
- **Karyogamy**
- **Diploid nucleus** (zygote)

**Key**

- Haploid ($n$)
- Dikaryotic ($n + n$)
- Diploid (2$n$)

**Dispersal**

- **Asci**
- **Ascospores**
- **Eight ascospores**
- **Four haploid nuclei**

**Meiosis**

**Plasmogamy**

**Karyogamy**
The lifecycle of an ascomycete is characterized by the production of asci during the sexual phase. The haploid phase is the predominant phase of the life cycle.
Basidiomycetes (30,000 species)

- Chytrids
- Zygomycetes
- Glomeromycetes
- Ascomycetes
- Basidiomycetes
Phylum
Basidomycetes/Basidomycota
• “Club fungus” → basidium/basidia
• Symbionts, plant parasites, decomposers
• Long lived dikaryotic stage

Maiden veil fungus (*Dictyphora*), a fungus with an odor like rotting meat

Phylum
Basidomycetes/Basidomycota

Puffballs emitting spores

Shelf fungi, important decomposers of wood
Basidomycetes Sexual Lifecycle

**Basidium**
- Diploid (2n)
- Haploid (n)
- Dikaryotic (n+n)

**Key**
- Haploid (n)
- Dikaryotic (n+n)
- Diploid (2n)

**PLASMOGAMY**
- Mating type (+)
- Haploid mycelia
- Gills lined with basidia

**SEXUAL REPRODUCTION**
- Mating type (-)
- Dikaryotic mycelium

**KARYOGAMY**
- Diploid nuclei

**MEIOSIS**
- Basidium containing four haploid nuclei

**Dispersal and germination**
- Basidiospores (n)
- Basidium with four basidiospores

**Basidiocarp** (n+n)
- Basidium with four basidiospores
- Basidiospore (1 µm)

**Haploid mycelia**
- Basidium mycelia

**Dikaryotic mycelium**
- Basidium mycelia

**Fig. 31-19-4/Fig 24.16**

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Fairy ring $\rightarrow$ mycelium expansion
Dueteromycetes/Dueteromycota

- Imperfect fungi
  - Only asexual reproduction
  - No known sexual stage
Role of Fungi

• Decomposers
  • Cycling nutrients (C, N)

• Mutualism
  • Plants
    – Mycorrhizae
      » Ecto & arbuscular
RESULTS

- Endophyte not present; pathogen present (E–P+)
- Both endophyte and pathogen present (E+P+)

**Leaf mortality (%)**
- E–P+: 30%
- E+P+: 10%

**Leaf area damaged (%)**
- E–P+: 15%
- E+P+: 5%
Role of Fungi

• **Decomposers**
  - Cycling nutrients (C, N)

• **Mutualism**
  - Plants
    - Mycorrhizae
      » Ecto & arbuscular
  - Animals
  - Lichens
Animal symbiosis
Fig. 31-24/Fig 24.23

Lichen $\rightarrow$ cyanobacteria & ascomycetes species

- Algal cell
- Ascocarp of fungus
- Fungal hyphae
- Algal layer
- Soredia
- Fungal hyphae

20 $\mu$m
Types of Lichens

A fruticose (shrublike) lichen

Crustose (encrusting) lichens

A foliose (leaflike) lichen
Fungi Plant Pathogens

(a) Corn smut on corn

(b) Tar spot fungus on maple leaves

(c) Ergots on rye

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Fungal Animal Pathogens

- **Mycosis**
  - Skin (cutaneous) mycoses
  - Systemic mycoses
  - Opportunistic mycoses
Fungal Uses

• Food!
• The emerald ash borer is an insect that attacks ash trees. It is in turn parasitized by a pathogenic fungus that holds promise as a biological insecticide. The parasitic fungus appears as white fuzz on the body of the insect. (credit: Houping Liu, USDA Agricultural Research Service)
Antibiotics (Alexander Fleming)

*Staphylococcus*  

*Penicillium*  

Zone of inhibited growth
<table>
<thead>
<tr>
<th>Fungal Phylum</th>
<th>Distinguishing Features of Morphology and Life Cycles</th>
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<tbody>
<tr>
<td>Chytridiomycota (chytrids)</td>
<td>Flagellated spores</td>
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<tr>
<td>Zygomycota (zygote fungi)</td>
<td>Resistant zygosporangium as sexual stage</td>
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<tr>
<td>Glomeromycota (arbuscular mycorrhizal fungi)</td>
<td>Form arbuscular mycorrhizae with plants</td>
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<tr>
<td>Ascomycota (sac fungi)</td>
<td>Sexual spores (ascospores) borne internally in sacs called asci; ascomycetes also produce vast numbers of asexual spores (conidia)</td>
</tr>
<tr>
<td>Basidiomycota (club fungi)</td>
<td>Elaborate fruiting body (basidiocarp) containing many basidia that produce sexual spores (basidiospores)</td>
</tr>
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