Chapter 23
Fungi
Fungal Traits and Classification

• Fungi structure and function
  – Walled cells
  – Spend their lives fixed in place
  – Produce haploid spores by meiosis
  – Heterotrophs that store excess sugar as glycogen
  – Most are decomposers
  – Some are parasites
Fungal Traits and Classification

- Fungi can digest cellulose, lignin, and keratin
  - Ability to digest tough structural materials makes them important
- Yeasts
  - Single-celled fungi
- Most fungi are multicelled
  - Examples: molds, mildews, and mushrooms
Fungal Traits and Classification

• Mycelium
  – Network of microscopic, interwoven filaments
  – Each filament (hypha) is a strand of walled cells arranged end to end

• Fungal cell walls
  – Polysaccharide

• Structure of fungal hyphae
  – Some have cross-walls
  • When present, cross-walls are porous

Micrograph: Garry T. Cole, University of Texas, Austin/BPS
Fungal Traits and Classification

- Fungus can share nutrients and water with cells in another part of its body
- Presence of cross-walls also makes fungus more resistant to drying out
  - Sac fungi
  - Club fungi
Fungal Traits and Classification

• Fungi produce spores sexually and asexually
  – This process is shown in Figure 23.4 on next slide
1 Asexual reproduction occurs when a haploid mycelium produces spores by mitosis at the tips of specialized hyphae.

2 Sexual reproduction begins when haploid hyphae of two individuals meet and cells at their tips fuse. This cytoplasmic fusion produces a dikaryotic cell (a cell with two nuclei).

3 Fusion of nuclei in a dikaryotic cell creates a diploid zygote.

4 The zygote undergoes meiosis and produces a haploid spore-bearing structure.

5 Haploid spores form by mitosis and germinate to form a new haploid mycelium.
23.3 Flagellated Fungi

• Chytrids
  – Include the only fungal lineages that form flagellated spores through mitosis
  – Spores form in a vessel-like sporangium
  – Some live as single cells
    • Others form hyphae
  – Thrive in a variety of habitats
    • Freshwater, saltwater, soil, and inside animal gut
    • Some are parasitic
Flagellated Fungi

• Amphibian population currently threatened by spread of a parasitic chytrid
  – Causes chytridiomycosis
  – Thickens animal’s skin
    • Prevents sufficient water from being absorbed
    • Animal dies of dehydration
23.4 Zygote Fungi and Related Groups

- Zygote fungi live in damp places
  - About 1100 species
  - Many are molds
    - Grow over or through organic matter as a mass of asexually reproducing hyphae

- Example: black bread mold
  - When food is plentiful, it grows as a haploid mycelium
    - Produces spores by mitosis
  - Can reproduce sexually if food supply dwindles
1 As long as food is plentiful, a haploid mycelium grows in size and produces spores by mitosis on specialized hyphae.

2 When nutrients are limited and hyphae of two compatible individuals come into close proximity, they produce branches (gametangia) that grow toward one another. As these branches grow, haploid nuclei stream into them and accumulate at their tips.

3 Cytoplasmic fusion of the gametangia produces a zygospore that contains many haploid nuclei from each parent.

4 Nuclei within the zygospore pair up and fuse to produce a mature zygospore with many diploid nuclei.

5 The zygospore germinates, and an aerial hypha emerges. Meiosis of cells within this hypha gives rise to haploid spores, which are released from its tip.

Meiosis

Fusion of nuclei

Dikaryotic

Haploid (n)

Cytoplasmic fusion

Diploid (2n)

Spores at tip of aerial hypha

Mature zygospore

Assexual reproduction

Gametangia

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Zygote Fungi and Related Groups

• *Rhizopus*
  – Many species spoil food
  – Others used to produce tempeh

• *Pilobolus*
  – Deposited in the feces of grazing animals
  – Spores germinate and grow into mycelium that produces spore-bearing hyphae
  – Can eject spore sacs up to six feet away
  – Animals ingest, and process begins again
Microsporidia – Intracellular Parasites

• About 1300 named species of microsporidia exist
  – Single-celled parasites
  – Fish and insects are common hosts

• Microsporidium spore has a tough coat
  – Allows it to survive adverse conditions for years
  – Beneath the coat, cytoplasm contains a long coiled tube
Microsporidia – Intracellular Parasites

- Microsporidia infection process
  - Tube uncoils and perforates the host cell
  - Nucleus and cytoplasm flow into the host
Glomeromycetes – Partners of Plants

• Mycorrhiza
  – Root-fungus partnership
• Glomeromycete hypha grows into a root and branches inside the wall of a root cell
• Fungus shares nutrients it takes up from the soil with its host
sporangium

plant root

hypha branching inside a plant cell wall

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23.5 Sac Fungi – Ascomycetes

• Most diverse fungal lineage
  – More than 64,000 known species
  – Some are yeasts (single-celled)
  – Most are multicelled

• Life cycles
  – Sac fungi typically reproduce asexually
  – Yeasts often reproduce by budding
    • Mitosis, followed by unequal cytoplasmic division
Asexual reproduction by budding in a yeast (Saccharomyces).

Conidia (asexually produced spores) of the mold Eupenicillium.

Cup fungi reproduce sexually by producing an ascocarp (left). Spores (right) form by meiosis of cells on the cup’s concave surface.

(A) Biophoto Associates/Science Source; (B) © Dennis Kunkel Microscopy, Inc.; (C) left, Dave Pressland/FLPA/Science Source; right, Biophoto Associates/Science Source.
Sac Fungi – Ascomycetes

- Most sac fungi can reproduce sexually
- Ecological roles of sac fungi
  - Decomposers living in the soil
  - Others form mycorrhizae with plant roots
  - Fungi most commonly found in lichens
- Pathogenic sac fungi
  - Powdery mildews that grow on plant leaves
  - Fungi that commonly cause yeast infections
Sac Fungi – Ascomycetes

• Morels and truffles
  – Examples of edible ascocarps
  – Truffles form underground and are rooted out by female pigs

• Aspergillus
  – One species ferments soybeans and wheat to create soy sauce

• Saccharomyces cerevisiae
  – Baker’s yeast
A Morels. Asci line pits on the upper part of the fruiting body.

B Truffles. These ascocarps form underground; asci are inside.

(A) © ostromec/Shutterstock.com; (B) © agefotostock/SuperStock
Club-shaped cells, each dikaryotic \((n+n)\), form at the margins of mushroom gills. After cytoplasmic fusion, cells of the mycelium are dikaryotic \((n+n)\). Spore-bearing mushrooms form from this mycelium.

The end club-shaped cell becomes a diploid \((2n)\) zygote when its two nuclei fuse. After nuclear fusion, the \(2n\) cell undergoes meiosis and bears four haploid spores at its tips.

Spores are released, germinate, and give rise to a haploid mycelium.

Haploid \((n)\) stage
Dikaryotic \((n+n)\) stage
Cytoplasmic fusion
Nuclear fusion
Meiosis

1. Cytoplasmic fusion
2. After cytoplasmic fusion, cells of the mycelium are dikaryotic \((n+n)\). Spore-bearing mushrooms form from this mycelium.
3. Club-shaped cells, each dikaryotic \((n+n)\), form at the margins of mushroom gills.
4. The end club-shaped cell becomes a diploid \((2n)\) zygote when its two nuclei fuse.
5. After nuclear fusion, the \(2n\) cell undergoes meiosis and bears four haploid spores at its tips.
6. Spores are released, germinate, and give rise to a haploid mycelium.

left, Micrograph Garry T. Cole, University of Texas, Austin/BPS; right, Eye of Science/Science Source; art, © Cengage Learning.
Sac Fungi – Ascomycetes

• Medical uses
  – Initial source of the antibiotic penicillin was the soil fungus *Penicillium chrysogenum*
  – Antibiotic cephalosporin first isolated from *Cephalosporium*
  – Cyclosporin from *Trichoderma* helps prevent rejection of transplanted organs
23.6 Club Fungi – Basidiomycetes

• Club fungi
  – Form spores inside club-shaped cells during sexual reproduction
  – Spores form on a basidiocarp composed of dikaryotic hyphae
  – Do not produce spores asexually

• Example of club fungi
  – All commercially grown mushrooms
Club Fungi – Basidiomycetes

• Many club fungi make toxins that fend off predators, including humans
  – Eating poisonous mushrooms sickens thousands of people per year

• *Amanita phalloides*
  – Death cap mushroom
  – Can cause severe symptoms and death

• Other mushrooms can cause hallucinations
23.7 Ecological Roles of Fungi

• Decomposers break down complex compounds in organic wastes and remains
  – Fungus secretes digestive enzymes
  – Soluble nutrients escape into nearby soil and water
    • Plants and other producers can take up these substances
  – Fungal hyphae can extend deep into a dead log and break it down from the inside
Ecological Roles of Fungi

• Lichen
  – Composite organism
  – Consists of a sac fungus and cyanobacteria or green algae
    • Fungus makes up most of a lichen’s mass
  – Photosynthetic cells provide the fungus with sugar
  – Example of mutualism
    • Interaction that benefits both partners
Ecological Roles of Fungi

- Lichens disperse by fragmentation or releasing spores
  - May also release structures containing cells of both partners
- Lichens colonize places too hostile for most organisms
  - Example: exposed bedrock
    - Break down rock by releasing acids that freeze and thaw
    - When soil conditions improve, plants take root
photosynthetic cell
fungal hyphae
Ecological Roles of Fungi

- 80 percent of vascular plants today form mycorrhizae with glomeromycete fungi
  - Hyphae increase the absorptive surface area of the plant partner
  - Hyphae grow more easily between soil particles
    - Thinner than roots
  - Plant supplies sugar to the fungus
A Mycorrhiza formed by a fungus and root of a hemlock tree.

B Six-month-old juniper seedlings grown with or without mycorrhizal fungi in sterilized, phosphorus-poor soil.
Ecological Roles of Fungi

- Fungi can also enhance the nutrition of some animals
  - Break down cellulose in stomachs of cattle, deer, and moose
  - Serve as an external digestive system for some ants and beetles
Fungal Parasites and Pathogens

• Powdery mildews, rusts, and smuts
  – Grow in living plants
  – Hyphae extend into stems and leaves
    • Suck up photosynthetically produced sugars
    • Loss of nutrients stunts the plant and may eventually kill it

• Armillaria
  – Causes root rot in trees and woody shrubs
  – Fungus decomposes the stumps left behind
Fungal Parasites and Pathogens

• Some fungi infect animals
  – Those with lower body temperature more susceptible

• White nose syndrome
  – Fatal to North American bats
  – Sac fungus causing the disease introduced to North America from Europe
    • European bats have evolved resistance to the disease
Fungal Parasites and Pathogens

• Human fungal infections mostly involve the skin and nails
  – Athlete’s foot
  – Ringworm
Points to Ponder

• Fungi play several important roles in many ecosystems. What are these roles and what would be the impact of losing fungal diversity in an ecosystem?

• What might happen if the global environment deteriorates to a degree where no more lichen species are surviving (consider the old-growth forests in your answer)?