

## Chapter 30: Fungi: Recyclers, Killers, and Plant Partners

### I General Biology of the Fungi

- Fungi secrete digestive enzymes that break down large food molecules.
- They absorb the breakdown products.
- The kingdom Fungi encompasses heterotrophic organisms with absorptive nutrition.
- Some are saprobes (feed on dead matter); others are parasites.
- See Figure 30.1.
- A few have mutually beneficial symbiosis with other organisms.
- All produce spores, but only one phylum (Chytridiomycota) has gametes with flagella.
- Their cell walls have at least some chitin.
- Some protists look like fungi, but phagocytize their food.
- The kingdom Fungi consists of four phyla: Chytridiomycota, Zygomycota, Ascomycota, and Basidiomycota.
- Primarily the methods and structures of reproduction distinguish these.
- See Table 30.1.
- Some fungi reproduce asexually only.
  - These are called fungi imperfecti or deuteromycetes.
  - Deuteromycetes are considered a "holding group".

#### A. Some fungi are unicellular.

- Unicellular forms are found in all of the fungal phyla.
- Those of Zygomycota, Ascomycota and Basidiomycota are called yeast.
- See Figure 30.2.

#### B. The body of a fungus is composed of hyphae

- Most fungi are multicellular.
- The vegetative body is called mycelium (mycelia is plural).
- It is composed of thread-like hyphae (hypha is singular).
- Some hyphae have no internal separations and even nuclei can move around.
- Some hyphae are subdivided into cell-like compartments by incomplete cross-walls.
- These are called septa (singular is septum).
- Other hyphae are coenocytic and have no septa.
- See Figure 30.3.
- Rhizoids are modified hyphae, which anchor Chytridiomycota to substrate.
- Some parasitic fungi may have modified hyphae that take up nutrients.
- Fungal parasites of plants can invade at wounds on plants, and grow mycelium throughout the plant and their fruit.
- See Figure 30.4.

#### C. Fungi are in intimate contact with their environment

- The mycelium has a very high surface to volume ratio.
- They are tolerant to highly hypertonic environments.
- Many can tolerate temperatures as low as 5 to 6°C below freezing. Some can tolerate temperatures as high as 50°C or more.

#### **D. Fungi are absorptive heterotrophs**

- The majority of fungi are saprobes, living on dead organisms.
- Saprobic fungi (and also bacteria) are the major decomposers, recycling the elements used by living things.
- Fungi are the principal decomposers of cellulose and lignin, the major components of plant cell walls.
- Many fungi can use ammonia ions or nitrate as a sole source of nitrogen.
- Most fail to synthesize their own thiamine or biotin.
- They can synthesize some vitamins that animals cannot.
- Facultative parasites can be grown by themselves on defined media.
- Obligate parasites only grow on their specific host.
- Some fungi are active predators.
  - Most secrete sticky substances from the hyphae.
  - Trapped prey are penetrated by hyphae and eventually killed.
  - Some species of *Arthrobotrys*, *Dactylaria*, and *Dactylella* form a ring with modified hyphae and constrict around nematodes.
  - The crawling nematode triggers these rings to swell and trap. Fungal hyphae quickly invade and digest the worm.
  - See Figure 30.5.
- Lichens are associations of a fungus with either cyanobacteria or a unicellular photosynthetic eukaryote.
- Mycorrhizae are associations of fungi and plant roots.
  - The fungi obtains organic compounds, while the plant is provided with readier access to soil minerals.

#### **E. Most fungi reproduce both asexually and sexually**

- Both asexual and sexual reproduction are common among fungi.
  - Asexual reproduction include:
    - The production of haploid spores within sporangia.
    - The production of naked spores (not within sporangia) called conidia, at the tips of hyphae.
    - Cell division by unicellular fungi.
    - Simple breakage of mycelium.
- Sexual reproduction involves fusion between two different mating types.
  - Some fungi have more than two mating types.
  - Mating is between different, not the same mating types.
  - This prevents self-fertilization.
  - In many fungi, the zygote nuclei are the only diploid nuclei of the life cycle.
  - These nuclei undergo meiosis, producing haploid nuclei.
  - Haploid spores divide mitotically to form haploid hyphae.

#### **F. Many fungal life cycles include a dikaryon stage**

- In some species, opposite mating types fuse to produce hyphae with two genetically different haploid nuclei.
- This type of hypha is called a dikaryon or heterokaryon.
- Later, when specialized fruiting structures form, dissimilar nuclei fuse to form zygotes.

- These then undergo meiosis producing four haploid nuclei.
  - Fungi have some unusual reproduction features.
  - There are no gamete cells, just gamete nuclei.
  - There are no true diploid tissues.
  - If a dikaryon, a harmful recessive allele can be masked by a normal allele.
  - Zygomycota, Ascomycota and Basidiomycota do not have motile gametes, so water is not required for fertilization.

### **G. Some fungi are pathogens**

- Fungal pathogens are a major cause of death among people with compromised immune systems.
  - Most patients with AIDS die of fungal disease, such as *Pneumocystis carinii*.
  - *Candida albicans* and other yeasts also cause severe diseases in those with AIDS.
  - Other less severe and common diseases include ringworm and athlete's foot.
  - Plant diseases include black stem rust and others.

## **II Diversity in the Kingdom Fungi**

### **A. Chytrids probably resemble the ancestral fungi**

- These are the earliest diverging fungal lineage.
- They are aquatic microorganisms and have sometimes been classed with protists.
- They are currently classed with fungi because of the chitin in their cell walls.
- Chytrids are either parasitic on aquatic plants, invertebrates, or saprobic.
- The exception are those found in the rumen of ruminants.
- Most live in fresh water or moist soil; some live in marine environments.
- They reproduce both sexually and asexually.
- Allomyces display alternation generations.
  - A haploid zoospore comes to rest on dead matter. See Figure 30.7.
  - It germinates to form a small haploid organism, which later forms female and male gametangia. (Male are smaller than female.) Both are motile, using flagella.
  - The female gametes produce an attractant "pheromone", which attracts male gametes.
  - The male and female gametes fuse.
  - Cell division produces a small diploid organism, which produces numerous diploid flagellated zoospores.
  - These disperse and produce more diploid organisms.
  - These eventually produce resistant resting sporangia that can survive dry and freezing weather.
  - The nuclei in sporangia eventually undergo meiosis to produce haploid zoospores.
  - Chytrids are one of the few fungi with alternation generations (both a haploid and diploid life cycle).
  - It is speculated that protists ancestors of fungi had flagella.

- See Figure 30.6.

**B. Zygomycetes reproduce sexually by fusion of two gametangia.**

- These have coenocytic hyphae (no regular septa), produce no motile cells, and only one diploid cell, the zygote.
- Most do not form fleshy fruit, but just occasional stalked sporangiophores reaching up into the air.
- Almost 900 species have been described.
- These include the fungal species in mycorrhizal association.
- Black bread mold is *Rhizopus stolonifer*.
- Sporangiophores are the fruiting bodies.
  - In *Rhizopus*, each sporangiophore has a single sporangium at the tip, containing hundreds of spores.
  - Other zygomycetes have many sporangia on each sporangiophore.
- Sexual reproduction
  - This occurs when adjacent hyphae of the same species but different mating types release pheromones, which stimulates them to fuse together.
  - See Figure 30.9b for details.
  - Zygospores may remain dormant for months, but eventually undergo meiosis and sporangium sprout from the zygospore.
  - See Figure 30.8.

**C. The sexual reproductive structure of ascomycetes is an ascus**

- Ascomycetes (phylum Ascomycota) are a large and diverse group, distinguished by the production of asci (ascus is singular).
- The ascus contains the products of meiosis.
- Ascomycete hyphae are septated.
- A pore in each septum permits systolic movement, even of nuclei.
- There are so far about 30,000 species, which are divided into two groups, based on whether asci are contained in special fruiting structures.
  - Those with an ascocarp are called euascomycetes.
  - See Figure 30.10
  - Those without are called hemiascomycetes.
    - Hemiascomycetes:
      - Most are microscopic.
      - Some are unicellular.
      - Well known are baker's or brewer's yeast (*Saccharomyces cerevisiae*), which makes ethanol of sugar and CO<sub>2</sub> to make bread rise.
      - Hemiascomycetes yeast reproduce asexually by budding or fission depending on the species.
      - Sexual reproduction occurs when two haploid cells of opposite mating types fuse.
        - In some species, diploid cells divide.
        - In others, the zygote immediately undergoes meiosis. The entire cell becomes an ascus.
        - Four or eight ascospores are produced depending on whether the cells divide once after meiosis.
    - Euascomycetes:

- These include fungi known as mold.
- *Neurospora* is pink bread mold.
- Many are plant parasites.
- Chestnut blight and Dutch elm disease are caused by euascomycetes.
- Powdery mildews infect cereal, lilacs, roses, and other plants,
- Cup fungi are euascomycetes. See Figure 30.11a and b. These produce huge numbers of spores and can be several centimeters in diameter.
- Morels are edible cup fungi. See Figure 30.11.
- Truffels are cup fungi that grow underground, on roots of some species of oak.
- *Penicillium* is a genus of green molds.
  - Some produce the antibiotic with the same name.
  - *P. roquefortii* and *P. camembertii* provide the flavors to the cheeses Roquefort and Camembert.
- Brown molds of the genus *Aspergillus* are used in food preparation.
  - *A. tamaris* is used to ferment soybeans to make soy sauce.
  - *A. oryzae* is used in brewing the Japanese alcoholic beverage, sake.
  - Some *Aspergillus* that contaminate peanuts and pecans produce powerful mutagens called aflatoxin.
- Euascomycetes reproduce asexually using conidia that form at the tips of specialized hyphae. See Figure 30.12.
- Small chains of conidia are produced by the millions and can survive for weeks.
- Sexual reproduction of euascomycetes includes formation of a dikaryon.
  - The nuclei from a male structure on one hyphae enters a female mating structure.
  - Ascogenous hyphae develop from the dikaryotic female.
  - Asci form at the tips of ascogenous hyphae. Both fusion of nuclei and meiosis occurs within individual asci.
  - Meiotic products are incorporated into ascospores.
  - See Figure 30.14.

#### **D. The sexual reproductive structure of basidiomycetes is a basidium**

- About 25,000 species of basidiomycetes have been described.
- They produce a wide variety of fruiting structures: puffballs, mushrooms, and giant bracket fungi. See Figure 30.14.
- There are more than 3,250 species of mushrooms.
  - *Agaricus campestris* is the common edible one; *Amanita* are poisonous.
  - Bracket fungi are tree parasites.
  - Smut fungi parasitize cereal grains.
- Basidiomycetes are septated.
- Basidia are swollen cells at the tips of hypha.
- Nuclear fusion and meiosis occur within basidia.
- See Figure 30.15 for their life cycle.
- The elaborate fruiting structures of some, such as the gill mushroom is topped with a cap, called a pileus.

- Vast numbers of spores form between the gills.

#### **E. Imperfect fungi lack a sexual stage**

- Fungi not yet been placed in any existing phyla are grouped as imperfect fungi. Deuteromycetes currently holds 25,000 species.
- The sexual cycle has yet to be observed in these. although DNA sequences can be used to find actual relationships.

### **III Fungal Associations**

#### **A. Mycorrhizae are essential to many plants**

- Almost all tracheophytes have mycorrhiza.
- See Figure 30.16.
- The fungi help make water and minerals more available.
- In ectomycorrhizae, the fungus wraps the root tips.
- It acts as a sponge.
- Endomycorrhizae infect the interior of the root.
- The fungi get sugars, amino acids and some vitamins; the plants get improved water and mineral supplies.
- The fungus might supply hormones as well.
- Fungal-plant root interactions have existed for 100's of millions of years.

#### **B. Lichens grow where no eukaryotes have succeeded**

- Lichens are a meshwork of two different organisms.
- See Figure 30.17.
- One is a fungus and the other is a photosynthetic organism.
- The flora of Antarctica has 100 times as many species of lichens than plants.
- They can survive harsh environments.
- They are sensitive to air pollution.
- The fungi of most lichens are ascomycetes.
- The photosynthetic component might be either a cyanobacteria or a unicellular green alga.
- There are about 13,500 "species" of lichens.
- The reindeer of use lichens in their diets.
- The photosynthetic cells from lichens grow more rapidly on their own than when combined with a fungus.
- Lichens can reproduce simply by fragmentation of the vegetative body, called thallus.
- They can also reproduce by means of specialized structures called soredia (singular soredium).
  - These are composed of fungal hyphae and a few photosynthetic cells.
- If ascomycetes or basidiomycetes, the fungus might undergo a sexual process, but the spores are released alone into the environment and fail to reestablish the lichen relationship.
- See Figure 30.18b.