MAJOR FUNGI PHYLA*

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Based on Classifications of Fungi† by OpenStax

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Abstract

By the end of this section, you will be able to:

• Classify fungi into the five major phyla
• Describe each phylum in terms of major representative species and patterns of reproduction

The kingdom Fungi contains five major phyla that were established according to their mode of sexual reproduction or using molecular data. The five true phyla of fungi are the Chytridiomycota (Chytrids), the Zygomycota (conjugated fungi), the Ascomycota (sac fungi), the Basidiomycota (club fungi) and the recently described Phylum Glomeromycota.

Note: “-mycota” is used to designate a phylum while “-mycetes” formally denotes a class or is used informally to refer to all members of the phylum.

1 Chytridiomycota: The Chytrids

The only class in the Phylum Chytridiomycota is the Chytridiomycetes. The chytrids are the simplest and most primitive fungi. The evolutionary record shows that the first recognizable chytrids appeared during the late pre-Cambrian period, more than 500 million years ago. Like all fungi, chytrids have chitin in their cell walls; a few form multicellular organisms and hyphae, but most are single celled. They produce gametes and diploid zoospores that swim with the help of a single flagellum.

The ecological habitat and cell structure of chytrids have much in common with protists. Chytrids usually live in aquatic environments, although some species live on land. Some species thrive as parasites on plants, insects, or amphibians (Figure 1), while others are saprobes. The chytrid species Allomyces is well characterized as an experimental organism. Its reproductive cycle includes both asexual and sexual phases. Allomyces produces diploid or haploid flagellated zoospores in a sporangium.

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Figure 1: The chytrid *Batrachochytrium dendrobatidis* is seen in these light micrographs as transparent spheres growing on (a) a freshwater arthropod and (b) algae. This chytrid causes skin diseases in many species of amphibians, resulting in species decline and extinction. (credit: modification of work by Johnson ML, Speare R., CDC)
2 Zygomycota: The Zygote Fungi

The zygomycetes are a relatively small group of fungi belonging to the Phylum *Zygomycota*. They include the familiar bread mold, *Rhizopus stolonifer*, which rapidly propagates on the surfaces of breads, fruits, and vegetables. Most species are saprobes, living off decaying organic material; a few are parasites, particularly of insects. Zygomycetes play a considerable commercial role. The metabolic products of other species of *Rhizopus* are intermediates in the synthesis of semi-synthetic steroid hormones.

Zygomycetes usually reproduce asexually by producing sporangiospores (Figure 2). The black tips of bread mold are the swollen sporangia packed with black spores (Figure 3). When spores land on a suitable substrate, they germinate and produce a new mycelium. Sexual reproduction starts when conditions become unfavorable.
Figure 2: Zygomycetes have asexual and sexual life cycles. In the sexual life cycle, plus and minus mating types conjugate to form a zygosporangium.
Figure 3: 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)

3 Ascomycota: The Sac Fungi

The majority of known fungi belong to the Phylum **Ascomycota**, which is characterized by the formation of an **ascus** (plural, asci), a sac-like structure that contains haploid ascospores. Many ascomycetes are of commercial importance. Some play a beneficial role, such as the yeasts used in baking, brewing, and wine fermentation, plus truffles and morels, which are held as gourmet delicacies. *Aspergillus oryzae* is used in the fermentation of rice to produce sake. Other ascomycetes parasitize plants and animals, including humans. For example, fungal pneumonia poses a significant threat to AIDS patients who have a compromised immune system. Ascomycetes not only infest and destroy crops directly; they also produce poisonous secondary metabolites that make crops unfit for consumption. Filamentous ascomycetes produce hyphae divided by perforated septa, allowing streaming of cytoplasm from one cell to the other. Conidia and ascospores, which are used respectively for asexual and sexual reproductions. During sexual reproduction, thousands of ascospores fill a fruiting body called the **ascocarp**. 

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**Figure 4:** 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.
Figure 5: The bright field light micrograph shows ascospores being released from asci in the fungus *Talaromyces flavus* var. *flavus*. (credit: modification of work by Dr. Lucille Georg, CDC; scale-bar data from Matt Russell)
4 Basidiomycota: The Club Fungi

The fungi in the Phylum Basidiomycota are easily recognizable under a light microscope by their club-shaped fruiting bodies called basidia (singular, basidium), which are the swollen terminal cell of a hypha. The basidia, which are the reproductive organs of these fungi, are often contained within the familiar mushroom, commonly seen in fields after rain, on the supermarket shelves, and growing on your lawn (Figure 6). These mushroom-producing basidiomycetes are sometimes referred to as “gill fungi” because of the presence of gill-like structures on the underside of the cap. The “gills” are actually compacted hyphae on which the basidia are borne. This group also includes shelf fungus, which cling to the bark of trees like small shelves. In addition, the basidiomycota includes smuts and rusts, which are important plant pathogens; toadstools, and shelf fungi stacked on tree trunks. Most edible fungi belong to the Phylum Basidiomycota; however, some basidiomycetes produce deadly toxins. For example, Cryptococcus neoformans causes severe respiratory illness.

![Figure 6: The fruiting bodies of a basidiomycete form a ring in a meadow, commonly called “fairy ring.”](http://cnx.org/content/m48079/1.2/)

The best-known fairy ring fungus has the scientific name *Marasmius oreades*. The body of this fungus, its mycelium, is underground and grows outward in a circle. As it grows, the mycelium depletes the soil of nitrogen, causing the mycelia to grow away from the center and leading to the “fairy ring” of fruiting bodies where there is adequate soil nitrogen. (Credit: "Cropcircles"/Wikipedia Commons)
The lifecycle of basidiomycetes includes alternation of generations (Figure 7). The club-shaped basidium carries spores called basidiospores. Eventually, the mycelium generates a **basidiocarp**, which is a fruiting body that protrudes from the ground—this is what we think of as a mushroom. The basidiocarp bears the developing basidia on the gills under its cap.

Figure 7: The lifecycle of a basidiomycete alternates generations.

Which of the following statements is true?

a. A basidium is the fruiting body of a mushroom-producing fungus, and it forms four basidiocarps.
b. The result of the plasmogamy step is four basidiospores.
c. Karyogamy results directly in the formation of mycelia.
d. A basidiocarp is the fruiting body of a mushroom-producing fungus.

5 Glomeromycota
The Glomeromycota is a newly established phylum which comprises about 230 species that all live in close association with the roots of trees. Fossil records indicate that trees and their root symbionts share a long evolutionary history. It appears that all members of this family interact with the root cells forming a mutually beneficial association where the plants supply the carbon source and energy in the form of carbohydrates to the fungus, and the fungus supplies essential minerals from the soil to the plant.

The glomeromycetes do not reproduce sexually and do not survive without the presence of plant roots. DNA analysis shows that all glomeromycetes probably descended from a common ancestor, making them a monophyletic lineage.

6 Section Summary
Chytridiomycota (chytrids) are considered the most primitive group of fungi. They are mostly aquatic, and their gametes are the only fungal cells known to have flagella. They reproduce both sexually and asexually; the asexual spores are called zoospores. Zygomycota (zygote fungi) produce non-septated hyphae with many nuclei. Their hyphae fuse during sexual reproduction to produce a zygospore in a zygosporangium. Ascomycota (sac fungi) form spores in sacs called asc during sexual reproduction. Asexual reproduction is their most common form of reproduction. Basidiomycota (club fungi) produce showy fruiting bodies that contain basidia in the form of clubs. Spores are stored in the basidia. Most familiar mushrooms belong to this division. Deuteromycota (imperfect fungi) belong to a polyphyletic group that does not reproduce through sexual reproduction. Glomeromycota form tight associations (called mycorrhizae) with the roots of plants.

7 Art Connections
Exercise 1
(Solution on p. 12.)
Figure 7 Which of the following statements is true?

a. A basidium is the fruiting body of a mushroom-producing fungus, and it forms four basidiocars.
b. The result of the plasmogamy step is four basidiospores.
c. Karyogamy results directly in the formation of mycelia.
d. A basidiocarp is the fruiting body of a mushroom-producing fungus.

8 Review Questions
Exercise 2
(Solution on p. 12.)
The most primitive phylum of fungi is the ________.

a. Chytridiomycota
b. Zygomycota
c. Glomeromycota
d. Ascomycota

http://cnx.org/content/m48079/1.2/
**Exercise 3**  
(Solution on p. 12.)  
Members of which phylum produce a club-shaped structure that contains spores?

a. Chytridiomycota  
b. Basidiomycota  
c. Glomeromycota  
d. Ascomycota

**Exercise 4**  
(Solution on p. 12.)  
Members of which phylum establish a successful symbiotic relationship with the roots of trees?

a. Ascomycota  
b. Deuteromycota  
c. Basidiomycota  
d. Glomeromycota

9 Free Response

**Exercise 5**  
(Solution on p. 12.)  
What is the advantage for a basidiomycete to produce a showy and fleshy fruiting body?

**Exercise 6**  
(Solution on p. 12.)  
For each of the four groups of perfect fungi (Chytridiomycota, Zygomycota, Ascomycota, and Basidiomycota), compare the body structure and features, and provide an example.
Solutions to Exercises in this Module

to Exercise (p. 10)
Figure 7 D

to Exercise (p. 10)
A

to Exercise (p. 11)
B

to Exercise (p. 11)
D

to Exercise (p. 11)
By ingesting spores and disseminating them in the environment as waste, animals act as agents of dispersal. The benefit to the fungus outweighs the cost of producing fleshy fruiting bodies.

to Exercise (p. 11)
Chytridiomycota (Chytrids) may have a unicellular or multicellular body structure; some are aquatic with motile spores with flagella; an example is the *Allomyces*. Zygomycota (conjugated fungi) have a multicellular body structure; features include zygospores and presence in soil; examples are bread and fruit molds. Ascomycota (sac fungi) may have unicellular or multicellular body structure; a feature is sexual spores in sacs (asci); examples include the yeasts used in bread, wine, and beer production. Basidiomycota (club fungi) have multicellular bodies; features includes sexual spores in the basidiocarp (mushroom) and that they are mostly decomposers; mushroom-producing fungi are an example.

Glossary

**Definition 7: asco carp**
fruiting body of ascomycetes

**Definition 7: Ascomycota**
(also, sac fungi) phylum of fungi that store spores in a sac called ascus

**Definition 7: basidiocarp**
fruiting body that protrudes from the ground and bears the basidia

**Definition 7: Basidiomycota**
(also, club fungi) phylum of fungi that produce club-shaped structures (basidia) that contain spores

**Definition 7: basidium**
club-shaped fruiting body of basidiomycetes

**Definition 7: Chytridiomycota**
(also, chytrids) primitive phylum of fungi that live in water and produce gametes with flagella

**Definition 7: Glomeromycota**
phylum of fungi that form symbiotic relationships with the roots of trees

**Definition 7: mold**
tangle of visible mycelia with a fuzzy appearance

**Definition 7: Zygomycota**
(also, conjugated fungi) phylum of fungi that form a zygote contained in a zygospore

**Definition 7: zygospore**
structure with thick cell wall that contains the zygote in zygomycetes