Fungi

- Dr. Ekta Khare

Fungi

- Microbiologists use the term **fungus** [pl., fungi; Latin *fungus,* mushroom] to include eucaryotic, spore-bearing organisms with absorptive nutrition, no chlorophyll, and that reproduce sexually and asexually.
- Scientists who study fungi are **mycologists** [Greek *mykes,* mushroom, and *logos,* discourse].
- The scientific discipline dealing with fungi is called **mycology.**
- The study of fungal toxins and their effects is called **mycotoxicology,** and the diseases caused by fungi in animals are known as **mycoses.**
- According to the universal phylogenetic tree, fungi are members of the domain *Eucarya*.
- The kingdom *Fungi* is believed to constitute a monophyletic group referred to as the true fungi or ***Eumycota.***

Distribution

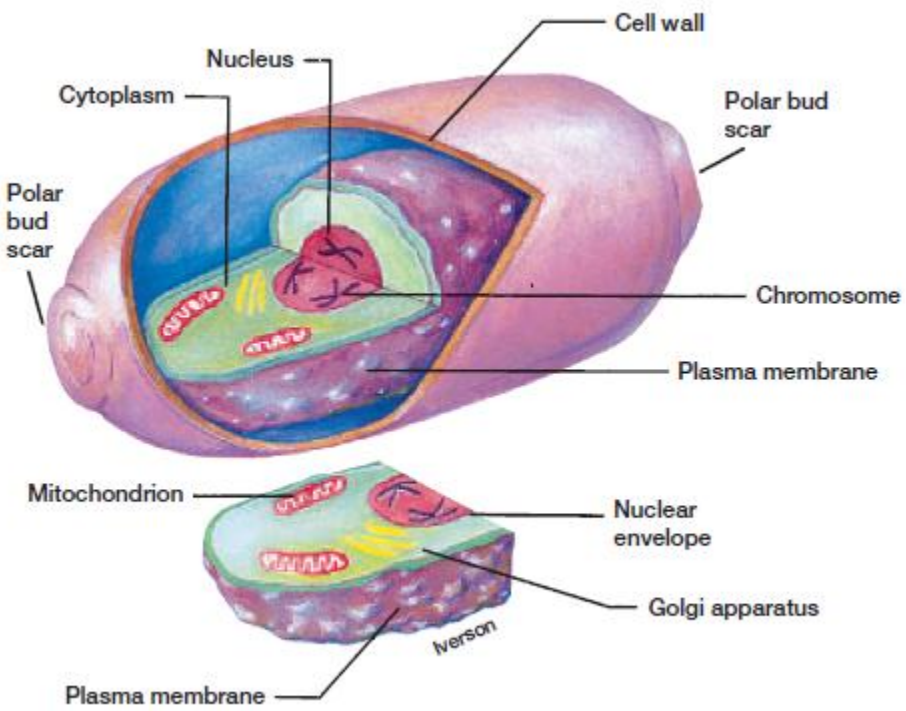
- Fungi are primarily terrestrial organisms, although a few are freshwater or marine.
- Many are pathogenic and infect plants and animals.
- Fungi also form beneficial relationships with other organisms. For example, .lichen, mycorrhiza.

Structure

- The body or vegetative structure of a fungus is called a **thallus** [pl., thalli].
- It varies in complexity and size, ranging from the single-cell microscopic yeasts to multicellular molds, macroscopic puffballs, and mushrooms.
- The fungal cell usually is encased in a cell wall of **chitin.**
- Chitin is a strong but flexible nitrogen-containing polysaccharide consisting of *N*-acetylglucosamine residues.

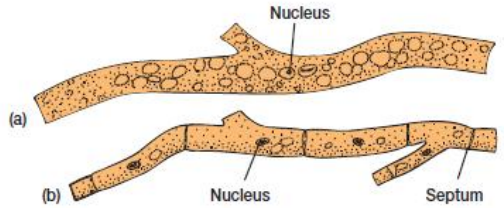
Yeast

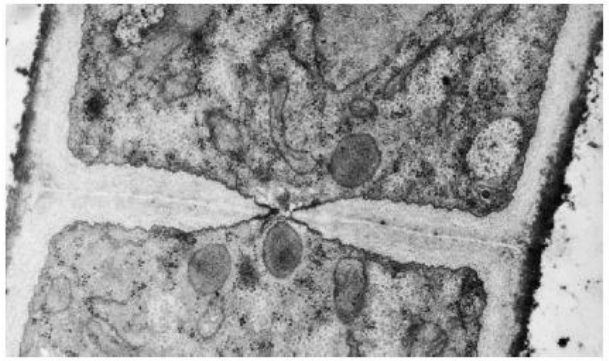
- A **yeast** is a unicellular fungus that has a single nucleus and reproduces either asexually by budding and transverse division or sexually through spore formation.
- Each bud that separates can grow into a new yeast, and some group together to form colonies.
- Generally yeast cells are larger than bacteria, vary considerably in size, and are commonly spherical to egg shaped.
- They have no flagella but do possess most of the other eucaryotic organelles.



Mold

- A **mold** consists of long, branched, threadlike filaments of cells called **hyphae** [s., hypha; Greek *hyphe,* web] that form a **mycelium** [pl., mycelia], a tangled mass or tissue like aggregation.
- In some fungi, protoplasm streams through hyphae, uninterrupted by cross walls. These hyphae are called **coenocytic** (**figure 25.5*a***).
- The hyphae of other fungi (figure 25.5*b*) have cross walls called **septa** [s., septum] with either a single pore (figure 25.5*c*) or multiple pores (figure 25.5*d*) that permit cytoplasmic streaming. These hyphae are termed **septate.**
- Hyphae are composed of an outer cell wall and an inner lumen, which contains the cytosol and organelles.
- A plasma membrane surrounds the cytoplasm and lies next to the cell wall.





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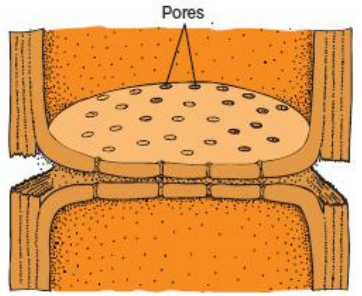

(d)

Figure 25.5 Hyphae. Drawings of (**a**) coenocytic hyphae and (**b**) hyphae divided into cells by septa. (**c**) Electron micrograph (×40,000) of a section of *Drechslera sorokiniana* showing wall differentiation and a single pore. (**d**) Drawing of a multiperforate septal wall structure.

YM Shift

- Many fungi, especially those that cause diseases in humans and animals, are dimorphic (**table 25.2**)—that is, they have two forms.
- Dimorphic fungi can change from (1) the yeast (Y) form in the animal to (2) the mold or mycelial form (M) in the external environment in response to changes in various environmental factors (nutrients, CO_2 tension, oxidation-reduction potentials, temperature).
- This shift is called the **YM shift.**
- In plant-associated fungi the opposite type of dimorphism exists: the mycelial form occurs in the plant and the yeast form in the external environment.

Table 25.2 Some Medically Important Dimorphic Fungi

Fungus	Disease[a]
Blastomyces dermatitidis	Blastomycosis
Candida albicans	Candidiasis
Coccidioides capsulatum	Coccidioidomycosis
Histoplasma capsulatum	Histoplasmosis
Sporothrix schenckii	Sporotrichosis
Paracoccidioides brasiliensis	Paracoccidioidomycosis

Nutrition and Metabolism

- Most fungi are **saprophytes,** securing their nutrients from dead organic material.
- They are chemoorganoheterotrophs and use organic compounds as a source
- of carbon, electrons, and energy.
- Glycogen is the primary storage polysaccharide in fungi.
- Most fungi use carbohydrates (preferably glucose or maltose) and nitrogenous compounds to synthesize their own amino acids and proteins.
- Fungi usually are aerobic.
- Some yeasts, however, are facultatively anaerobic and can obtain energy by fermentation, such as in the production of ethyl alcohol from glucose.
- Obligately anaerobic fungi are found in the rumen of cattle.

Reproduction

- Reproduction in fungi can be either asexual or sexual. Asexual reproduction is accomplished in several ways:
- 1. A parent cell can divide into two daughter cells by central constriction and formation of a new cell wall (**figure 25.7*a***).
- 2. Somatic vegetative cells may bud to produce new organisms. This is very common in the yeasts.
- 3. The most common method of asexual reproduction is spore production. Asexual spore formation occurs in an individual fungus through mitosis and subsequent cell division. There are several types of asexual spores:
  - a. A hypha can fragment (by the separation of hyphae through splitting of the cell wall or septum) to form cells that behave as spores. These cells are called **arthroconidia** or **arthrospores** (figure 25.7*b*).
  - b. If the cells are surrounded by a thick wall before separation, they are called **chlamydospores**.
  - c. If the spores develop within a sac [**sporangium;** pl., sporangia] at a hyphal tip, they are called **sporangiospores**.
  - d. If the spores are not enclosed in a sac but produced at the tips or sides of the hypha, they are termed **conidiospores**.
  - e. Spores produced from a vegetative mother cell by budding are called **blastospores.**

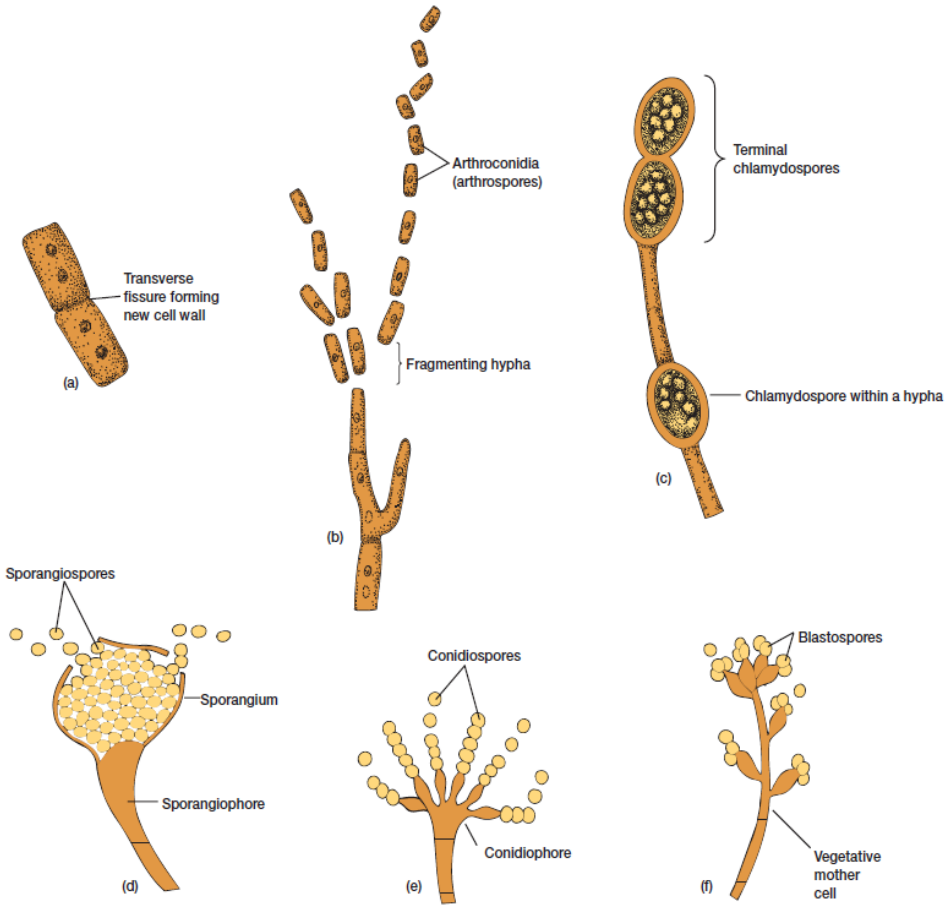

Figure 25.7 **Diagrammatic Representation of Asexual Reproduction in the Fungi and Some Representative Spores.** (a) Transverse fission. (b) Hyphal fragmentation resulting in arthroconidia (arthrospores) and (c) chlamydospores. (d) Sporangiospores in a sporangium. (e) Conidiospores arranged in chains at the end of a conidiophore. (f) Blastospores are formed from buds off of the parent cell.

Sexual Reproduction

- Sexual reproduction in fungi involves the union of compatible nuclei.
- Some fungal species are self-fertilizing and produce sexually compatible gametes on the same mycelium (homothallic).
- Other species require outcrossing between different but sexually compatible mycelia (heterothallic).
- Depending on the species, sexual fusion may occur between haploid gametes, gamete-producing bodies called **gametangia,** or hyphae.
- Sometimes both the cytoplasm and haploid nuclei fuse immediately to produce the diploid zygote.
- Usually, however, there is a delay between cytoplasmic and nuclear fusion.
- This produces a **dikaryotic stage** in which cells contain two separate haploid nuclei, one from each parent. After a period of dikaryotic existence, the two nuclei fuse.
- This sexual reproduction yields spores. For example, in the zygomycetes the zygote develops into a **zygospore**; in the ascomycetes, an **ascospore**; and in the basidomycetes; a **basidiospore.**

Characteristics of the Fungal Divisions

- The traditional taxonomic scheme used by mycologists classifies the fungi into four divisions (**table 25.3**), based primarily on variations in sexual reproduction. (In mycology a division is equivalent to a phylum in animal classification schemes.)
- Based on 18S rRNA studies, molecular microbiologists place the *Deuteromycota* (Fungi Imperfecti) among their closest relatives in either the *Zygomycota, Ascomycota,* or *Basidiomycota* and add the class *Chytridiomycetes.*

Table 25.3 Divisions of Fungi*

Division	Common Name	Approximate Number of Species
Zygomycota	Zygomycetes	600
Ascomycota	Sac fungi	35,000
Basidiomycota	Club fungi	30,000
Deuteromycota[a]	Fungi Imperfecti	30,000

Zygomycota (Zygomycetes)

General Characteristics

- Mostly terrestrial fungi.
- Hyphae are **coenocytic (aseptate)**.
- Fast-growing saprophytes on bread, fruits, and decaying organic matter.
- Some species are parasites.

Reproduction

- **Asexual**
- By **sporangiospores** formed inside sporangia.
- **Sexual**
- Fusion of two compatible hyphae produces a thick-walled **zygospore**, the characteristic sexual spore.

Importance

- Food spoilage.
- Industrial production of organic acids.
- Some cause mucormycosis in humans.

Examples

- *Rhizopus* (bread mold)
- *Mucor*
- *Absidia*
- *Pilobolus*

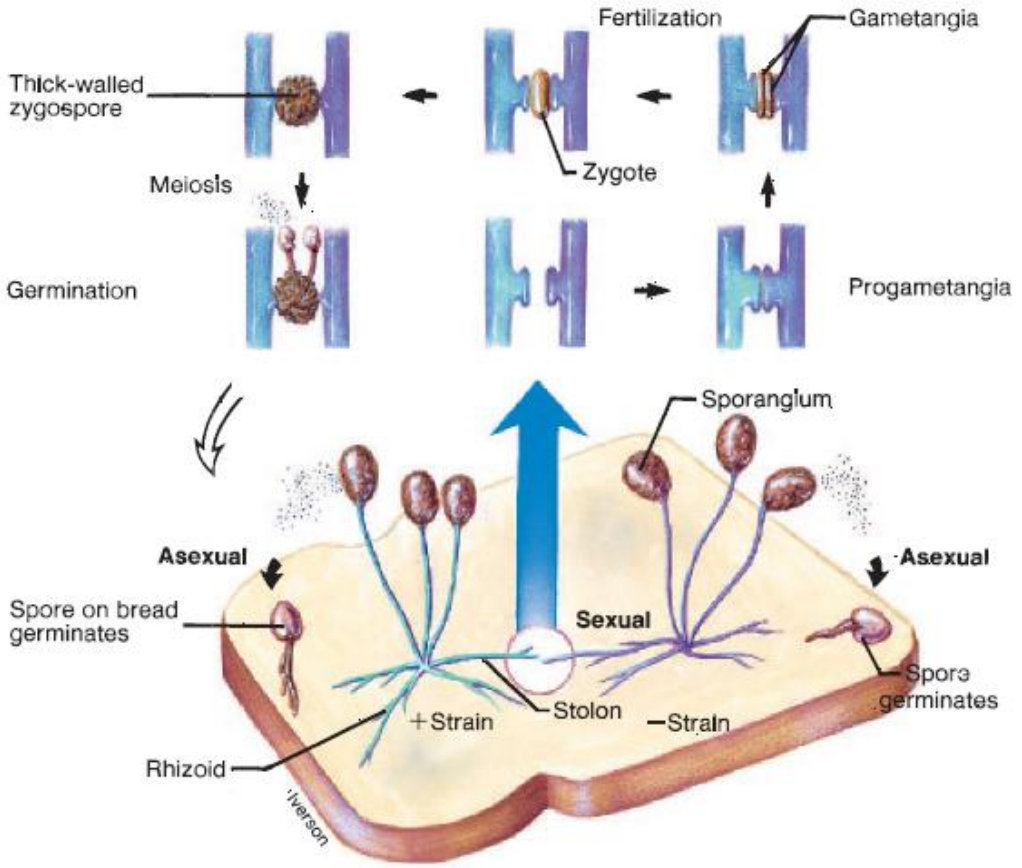

Figure 25.9 **Division *Zygomycota.*** Diagrammatic representation of the life cycle of *Rhizopus stolonifer.* Both the sexual and asexual phases are illustrated.

Ascomycota (Sac Fungi)

General Characteristics

- Largest fungal division.
- Hyphae are **septate**.
- Includes unicellular yeasts and multicellular molds.
- Characterized by formation of **asci (singular: ascus)**.

Reproduction

- **Asexual**
- By **conidia** produced externally.
- **Sexual**
- By **ascospores** (usually eight) formed inside an ascus.
- Asci are often grouped into fruiting bodies called **ascocarps**.

Types of Ascocarps

- Cleistothecium (closed)
- Perithecium (flask-shaped)
- Apothecium (cup-shaped)

Importance

- Bread, beer, and wine production.
- Cheese manufacture.
- Antibiotic production.
- Plant pathogens.

Examples

- *Saccharomyces cerevisiae* , *Penicillium, Aspergillus. Neurospora, Morchella*

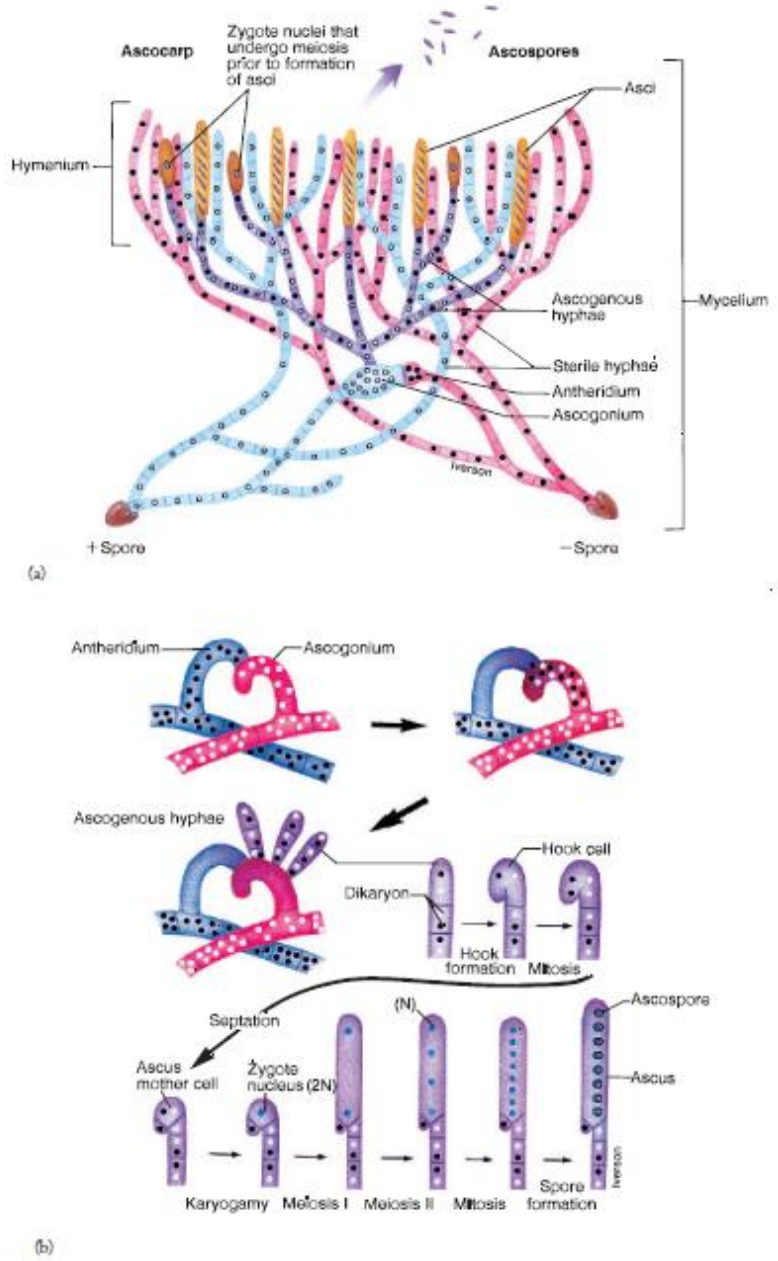

Figure 25.12 The Life Cycle of Ascomycetes. Sexual reproduction involves the formation of asci and ascospores. Within the ascus, karyogamy is followed by meiosis to produce the ascospores. (a) Sexual reproduction and ascocarp morphology of a cup fungus. (b) The details of sexual reproduction in ascogenous hyphae. The nuclei of the two mating types are represented by unfilled and filled circles. See text for details.

Basidiomycota (Club Fungi)

General Characteristics

- Most advanced fungi.
- Hyphae are **septate**.
- Long-lived **dikaryotic (n+n)** mycelium is common.
- Produce **basidia**, the characteristic reproductive structures.

Reproduction

- **Asexual**
- Rare; by conidia or fragmentation.
- **Sexual**
- By **basidiospores** produced externally on club-shaped **basidia**.
- Basidia are arranged on large fruiting bodies called **basidiocarps** (mushrooms).

Importance

- Edible mushrooms.
- Poisonous mushrooms.
- Wood decomposers.
- Plant pathogens (rusts and smuts).
- Form mycorrhizal associations.

Examples

- *Agaricus* (button mushroom), *Pleurotus* (oyster mushroom)
- *Puccinia, Ustilago*

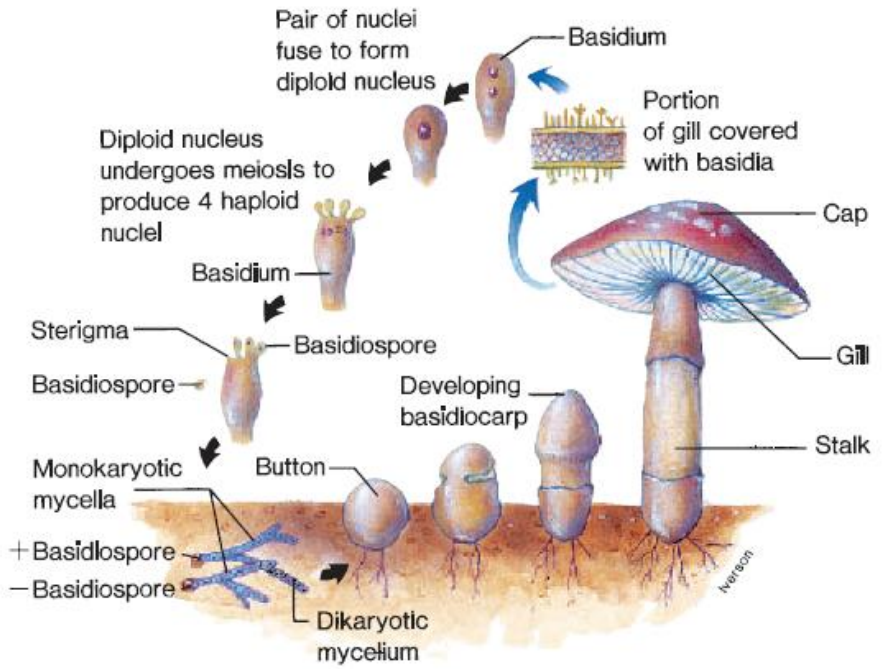

Figure 25.14 **Division *Basidiomycota.*** The life cycle of a typical soil basidiomycete starts with a basidiospore germinating to produce a monokaryotic mycelium (one with a single nucleus in each septate cell). The mycelium quickly grows and spreads throughout the soil. When this primary mycelium meets another monokaryotic mycelium of a different mating type, the two fuse to initiate a new dikaryotic secondary mycelium. The secondary mycelium is divided by septa into cells, each of which contains two nuclei, one of each mating type. This dikaryotic mycelium is eventually stimulated to produce basidiocarps. A solid mass of hyphae forms a button that pushes through the soil, elongates, and develops a cap. The cap contains many platelike gills, each of which is coated with basidia. The two nuclei in the tip of each basidium fuse to form a diploid zygote nucleus, which immediately undergoes meiosis to form four haploid nuclei. These nuclei push their way into the developing basidiospores, which are then released at maturity.

Deuteromycota (Fungi Imperfecti)

General Characteristics

- Artificial group used for fungi whose **sexual stage was unknown**.
- Most have **septate hyphae**.
- Reproduce only by **asexual spores (conidia)**.
- With the discovery of sexual stages and molecular studies, most species have been reassigned to **Ascomycota** or **Basidiomycota**.

Reproduction

- Only **asexual reproduction** by conidia was known.
- **Importance**
- Industrial enzyme production.
- Antibiotic production.
- Food fermentation.
- Plant diseases.
- Human diseases (dermatophytes).

Examples

- *Trichophyton*
- *Microsporum*
- *Epidermophyton*
- *Alternaria*
- *Fusarium* (formerly placed here)

Chytridiomycota (Chytrids)

General Characteristics

- Most primitive and earliest-diverging true fungi.
- Mostly **aquatic** or found in moist soils.
- Vegetative body is **unicellular** or has simple **coenocytic (aseptate) hyphae**.
- Cell wall contains **chitin**.
- The only fungi that produce **motile reproductive cells (zoospores)** with a **single posterior flagellum**.

Reproduction

- **Asexual:** By flagellated zoospores.
- **Sexual:** Isogamy, anisogamy, or oogamy, producing resting spores.

Nutrition

- Saprophytic
- Parasitic
- Symbiotic

Importance

- Decompose organic matter.
- Cause diseases such as potato wart.
- Some species cause chytridiomycosis in amphibians.

Examples

- *Allomyces*
- *Synchytrium*
- *Olpidium*
- *Batrachochytrium dendrobatidis*