MCB 102 · INTRODUCTORY MICROBIOLOGY

Characteristics and Structure of Fungi

Department of Microbiology | Academic Session 2025/2026

Learning Objectives

1. Define fungi and state their position in biological classification.
2. Describe the general characteristics of fungi.
3. Explain the structural features of fungal cells, hyphae, and mycelium.
4. Distinguish between different types of fungi based on morphology.
5. Describe cell wall composition and reproductive structures.
6. Explain the ecological and economic significance of fungi.

What Are Fungi?

Key Facts

- Fungi are either unicellular or multicellular eukaryotic organisms that do not contain chlorophyll, but obtain their nutrients by absorption, and reproduce by spores.
- Moulds and mushrooms are multicellular, consisting of masses of mycelia, which are composed of filaments called hyphae, while yeasts are unicellular.
- Fungi contribute to the food people eat, to medicine, and to the recycling process that releases nutrients from dead organisms back into the environment.

Etymology

Mycology (Greek: mykes = mushroom)
The scientist: Mycologist
Father of Mycology: Anton de Bary (1831–1888).

Historical Note

- Fungi were once classified as plants due to their sessile nature and cell walls. Modern molecular evidence shows they form a distinct kingdom, sharing a more recent common ancestor with animals.

Fungi and Plants

- **Cell Wall Material:** Fungal cell walls are made of chitin (a tough, flexible polymer also found in insect exoskeletons). Plant cell walls are composed of cellulose.
- **Energy Production (Photosynthesis):** Plant cells contain chloroplasts with chlorophyll, which enables the synthesis of glucose through photosynthesis. Fungal cells lack chloroplasts and are heterotrophic, so they must absorb nutrients from their surroundings.
- **Nutrient Storage:** Plants store their excess carbohydrates as **starch**. Fungi store excess carbohydrates as **glycogen** (similar to animal cells).
- **Vacuoles: Both have vacuoles, but plant cells typically possess a single, large central vacuole that regulates turgor pressure. Fungal cells often have smaller, multiple vacuoles**

Fungi and Animal

Feature	Fungi	Animals
Nutrition	**Absorptive heterotrophs:** Secrete digestive enzymes externally, then absorb the nutrients.	**Holozoic heterotrophs:** Ingest solid food and digest it internally.
Cell Walls	Present; made of **chitin** (a strong, structural carbohydrate).	Absent; cells are bounded only by a flexible cell membrane.
Mobility	Generally non-motile; rooted in place.	Motile: capable of moving through muscles, flagella, or other specialised structures
Body Organization	Filamentous or single-celled (yeast); lacks complex, organised organs.	Highly organised with complex tissues (muscle, nerve) and organs.
Energy Storage	Store excess carbohydrates as **glycogen.**	Store excess carbohydrates as **glycogen.**
Reproduction	Reproduce sexually or asexually; spores are primarily used for dispersal.	Mostly sexual; uses gametes (egg and sperm) rather than spores

General Characteristics of Fungi — Part 1

1 Eukaryotic

True membrane-bound nucleus; DNA organised into chromosomes; all cellular organelles present.

2 Heterotrophic Nutrition

Cannot photosynthesise; secrete exoenzymes into substrate; absorb digested nutrients (absorptive heterotrophy).

3 Chitin Cell Wall

Cell walls of chitin + beta-glucans + glycoproteins. Unlike plant cellulose or bacterial peptidoglycan.

4 No Flagella (mostly)

Most fungi are non-motile. Exception: Chytridiomycota produce flagellate zoospores.

General Characteristics of Fungi — Part 2

5 Glycogen Storage

Store carbohydrates as glycogen (like animals), NOT starch (like plants). Enables rapid energy mobilisation.

6 Spore Reproduction

Reproduce through spores — sexual and asexual. Lightweight, easily dispersed; a single fruiting body can release billions.

7 Ergosterol in Membranes

Plasma membranes contain ergosterol (not cholesterol). Target of antifungal drugs: amphotericin B, azoles.

8 Diverse Habitats

Mostly terrestrial; prefer warm, moist environments. Found in soil, decaying matter, on living hosts, and even in extremes.

Nutritional Types in Fungi

Saprotrophic

Feed on dead/decaying organic matter such as fallen leaves, dead wood, and animal carcasses.
Primary decomposers.

E.g. Rhizopus (bread mold), mushrooms, Aspergillus

Parasitic

Absorb nutrients directly from living organisms (hosts), often causing harm, disease, or even death to the host.

E.g. Trichophyton, Puccinia

Mutualistic

Mutually beneficial partnership with another organism. Both partners receive nutritional or environmental benefits.
mycorrhizae (plant roots), lichens (algae

Glomus, Cladonia

Predatory

Trap & digest microscopic animals using specialised hyphae.

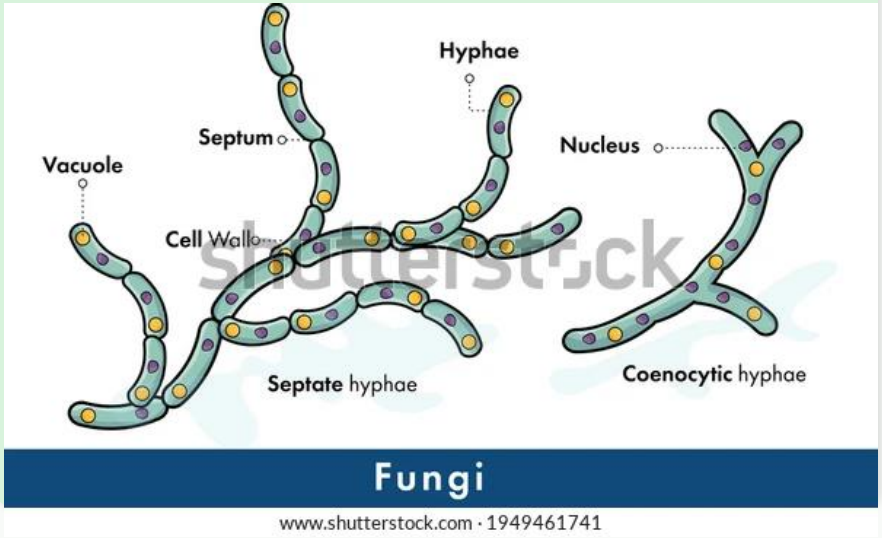
E.g. Arthrobotrys spp.

The Morphology

- Morphologically, fungi range from small yeasts and moulds to large, visible mushrooms, puffballs, and bracket fungi.
- The body or vegetative structure of a fungus is called a **thallus** (pl. thalli).)
- Some are single cells (e.g., the yeasts), but most exist as filaments known as **hyphae (singular, hypha)**.
- Hyphae usually branch extensively, and the collective mass of hyphal filaments is called a **mycelium**

The Hypha: Fundamental Structural Unit

A hypha (pl. hyphae) is a thin, thread-like, tubular filament — the basic building block of a multicellular fungus.
Hyphae can be either septate or non septate (coenocytic).



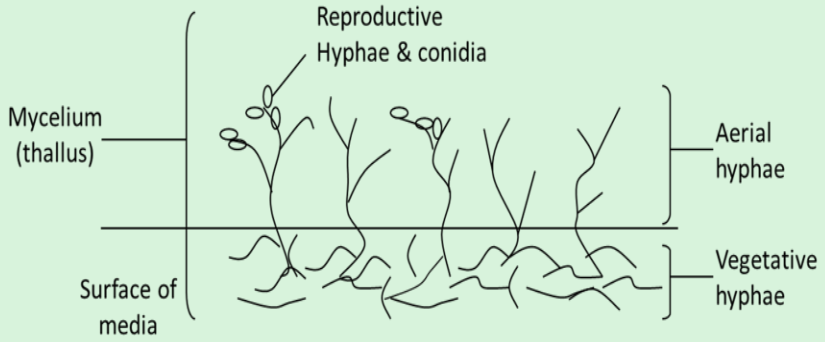
Septate Hyphae

Septate hyphae are divided into compartments separated by cross walls (internal cell walls, called septa, that are formed at right angles to the cell wall, giving the hypha its shape). Found in: Ascomycota, Basidiomycota.

Aseptate (Coenocytic) Hyphae

Aseptate(Coenocytic hyphae) is a continuous tube with many nuclei in shared cytoplasm. Also called coenocytic. Found in: Zygomycota (e.g., Rhizopus, Mucor).

Types of Hypha

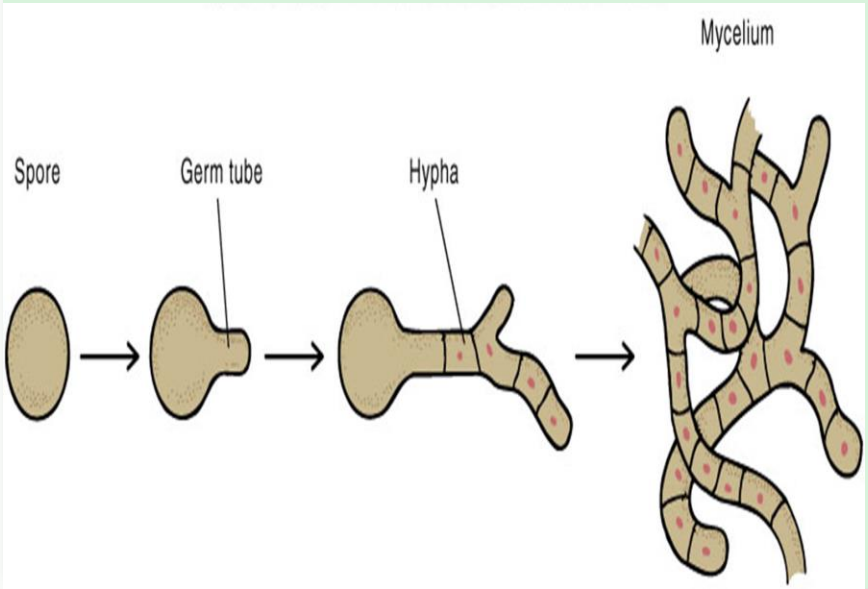


Vegetative hyphae: penetrate the media and absorb food.

Aerial hyphae are directed above the surface of the media.

Reproductive hyphae: Aerial hyphae that carry different spores.

Hyphal growth



Hyphae exhibit apical growth (i.e. they elongate at their tips).

In Theory, they are capable of growing indefinitely, provided that environmental conditions remain favourable for growth.

In reality, their environment eventually limits or restricts their growth.

Hyphae may initially develop from a germ-tube (a short, immature hypha) that emerges from a germinating spore.

Functions of Hyphae

- Hyphae play a role in reproduction and nutrient assimilation.
- The hyphae involved in assimilation are known as vegetative hyphae.
- Vegetative hyphae can grow on the surface of the substrate or within it.
- Hyphae that grow above the surface are known as aerial hyphae.
- Hyphae involved in the appearance of the thallus include the type, height, density, and types of reproductive structures of the aerial hyphae.
- Reproduction may be either aerial or surface

The Mycelium: Fungal Vegetative Body

The mycelium is a mass of interwoven, branching hyphae forming the main body of a multicellular fungus — responsible for growth, digestion, and nutrient absorption.

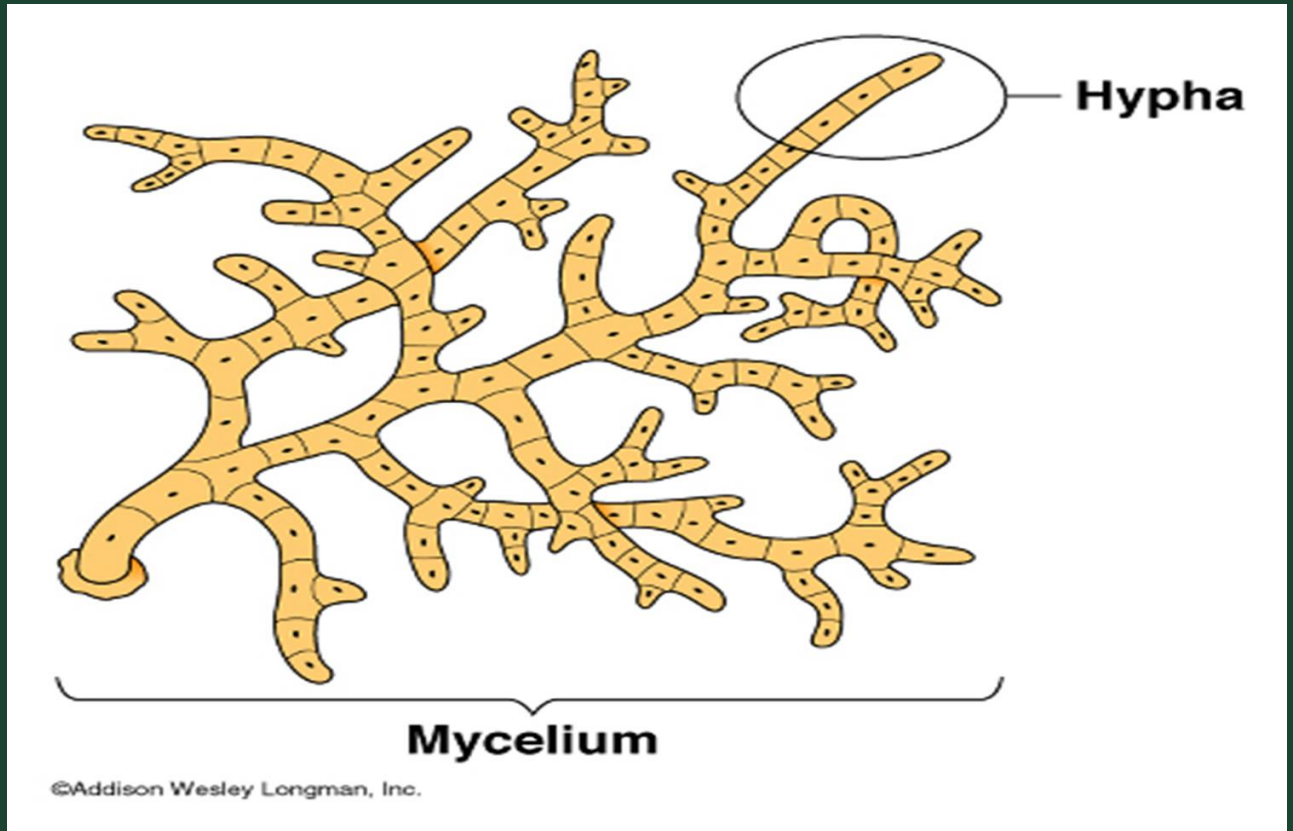
Vegetative Mycelium

- Grows into the substrate
- Functions like a root system
- Secretes enzymes → absorbs nutrients
- Creates a huge surface area-to-volume ratio

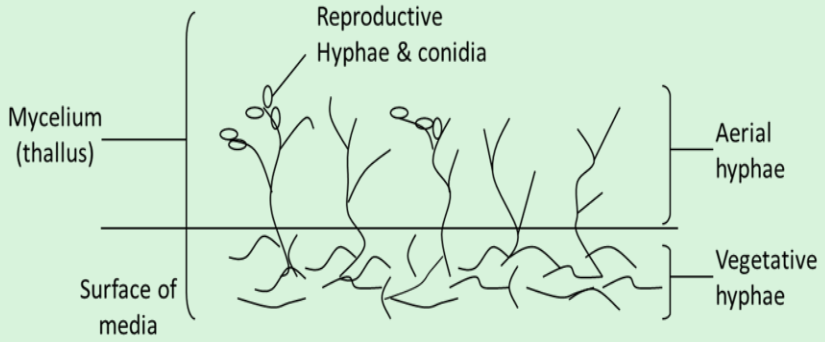
Aerial Mycelium

- Grows above the substrate
- Bears reproductive structures (spores)
- Visible as fuzzy/cottony growth on food
- Also called sporophore in some fungi

The Mycelium: Fungal Vegetative Body



Types of Hypha



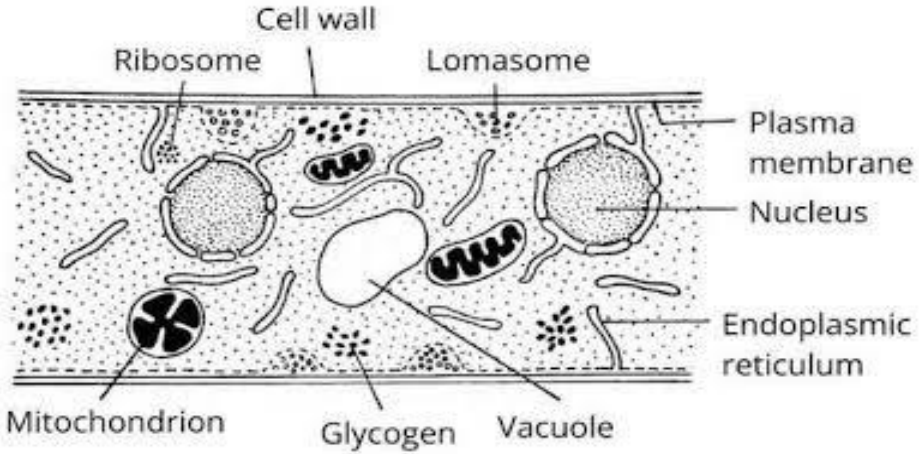
Vegetative hyphae: penetrate the media and absorb food.

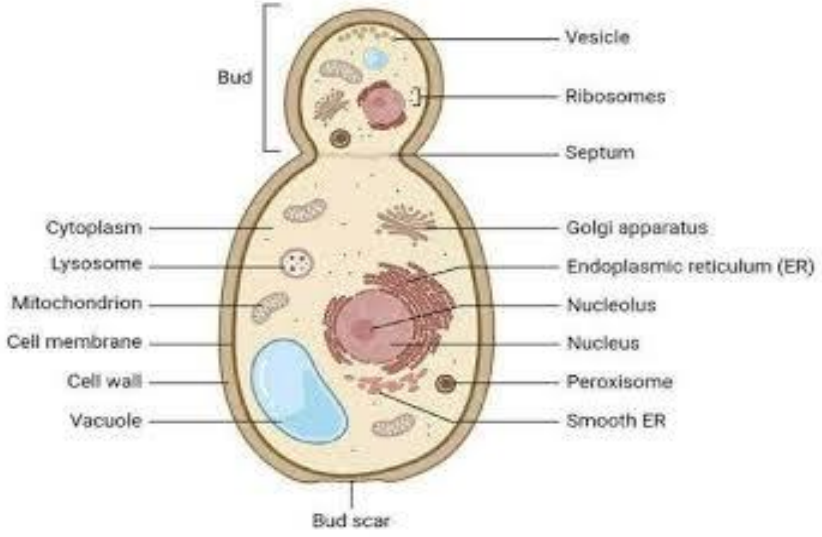
Aerial hyphae are directed above the surface of the media.

Reproductive hyphae: Aerial hyphae that carry different spores.

Fungal Cell: Internal Structure

Structure of Fungal Cell with Diagram





Fungal Cell: Internal Structure

Cell Wall

Cell WallIt is primarily composed of robust chitin and β-glucans

Plasma Membrane

Ergosterol; selective permeability; drug target

Nucleus

True, membrane-bound; contains chromosomal DNA

Mitochondria

Aerobic respiration; ATP production

Ribosomes (80S)

Protein synthesis (same type as animals)

Vacuoles

Storage of metabolites; turgor pressure maintenance

Spitzenkörper

Vesicle supply centre at hyphal tip; coordinates apical growth

Glycogen Granules

Energy reserve (not starch)

Cell structure	Description	Function
Cell wall	Freely permeable layer surrounding cell membrane	Supports and strengthens cell
Cell membrane	Selectively permeable double layer of lipid and protein molecules	Controls which substances can enter and leave the cell
Cytoplasm	Fluid enclosed by the cell membrane, containing organelles and ribosomes	Location of many chemical reactions
Mitochondria	Rod-shaped structures found in cytoplasm	Location where aerobic respiration occurs and most of the cell's ATP is produced
Ribosomes	Small complexes found in cytoplasm	Location where amino acids are connected together to produce proteins
Plasmids	Small circular DNA molecules	Contains genes that help cell to function, eg genes for antibiotic resistance
Nucleus	Compartment in cell where DNA is stored as chromosomes	Controls activities of cell

Yeasts and Dimorphic Fungi

Yeasts

Unicellular growth form of fungi (mainly Ascomycota & Basidiomycota).

Shape: Round/oval/cylindrical; 3–15 µm diameter

Reproduction: Primarily by budding (asexual); some by binary fission

Pseudohyphae: Elongated chains of cells under stress (resemble hyphae but differ structurally)

Examples: *Saccharomyces cerevisiae* (baker's yeast), *Candida albicans*

Dimorphic Fungi

Can exist in two forms depending on temperature:

25°C (room temp) → Mould (filamentous)

37°C (body temp) → Yeast (unicellular)

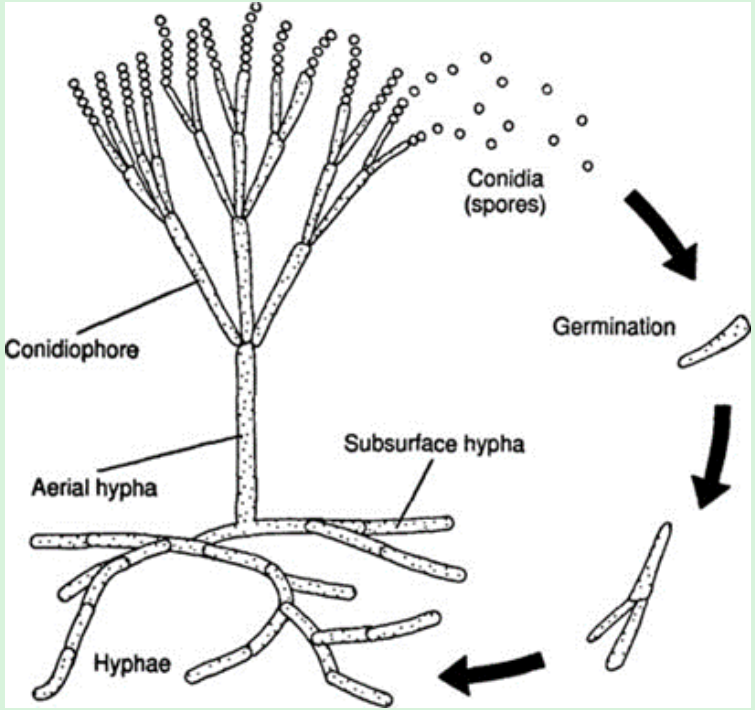
Mnemonic: "Mould in the cold, yeast in the heat"

Examples: *Histoplasma capsulatum, Blastomyces dermatitidis, Coccidioides immitis*

REPRODUCTION IN FUNGI

- Fungi reproduce both sexually and asexually.
- Both sexual and asexual reproductions often result in the production of spores.
- Fungal spores are formed from aerial hyphae and are used for both sexual and asexual reproduction.
- **Asexual spores:** formed by the aerial hyphae of one organism. New organisms are identical to parent.
- **Sexual spores:** Formed by the fusion of nuclei from two opposite mating strains of the same species. New organisms are different from both parents.

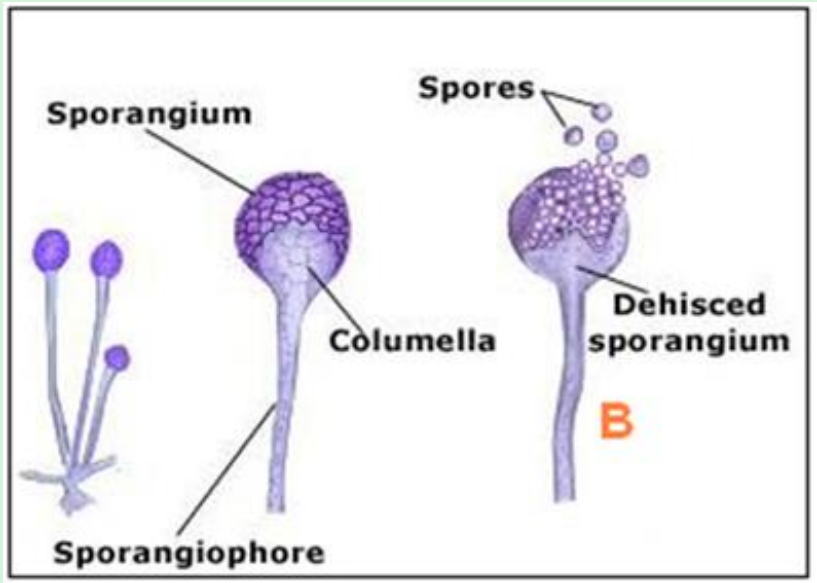
METHODS OF ASEXUAL REPRODUCTION: Sporulation



Spore formation is most common type of asexual reproduction. The process of spore formation is called SPORULATION.

A spore is a small microscopic, unicellular, reproductive unit and the primary agents of fungal dispersal.

Asexual Reproductive Structures: Sporangiospores

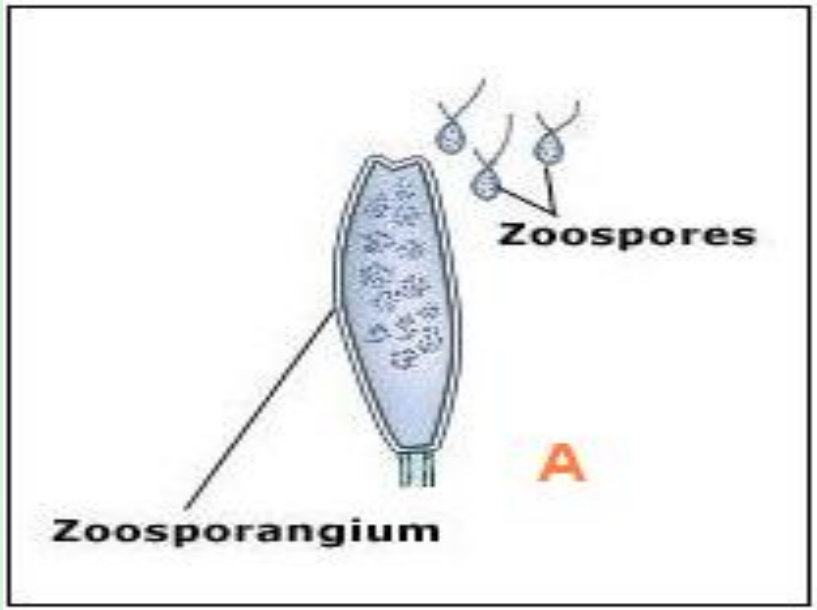


Characteristic of Zygomycota e.g. Rhizopus, Mucor

Sporangiospores are produced within sporangia, which develop on sporangiophores.

Sporangium is a sac-like structure bounded by a membranous wall.

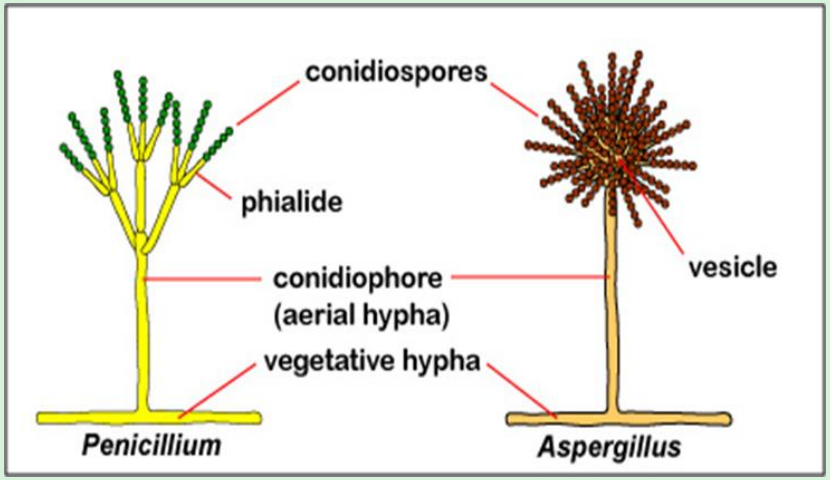
Asexual Reproductive Structures: Zoospores



E.g. Allomyces (Chytridiomycota)

In lower fungi, sporangiospores are motile and are called zoospores.

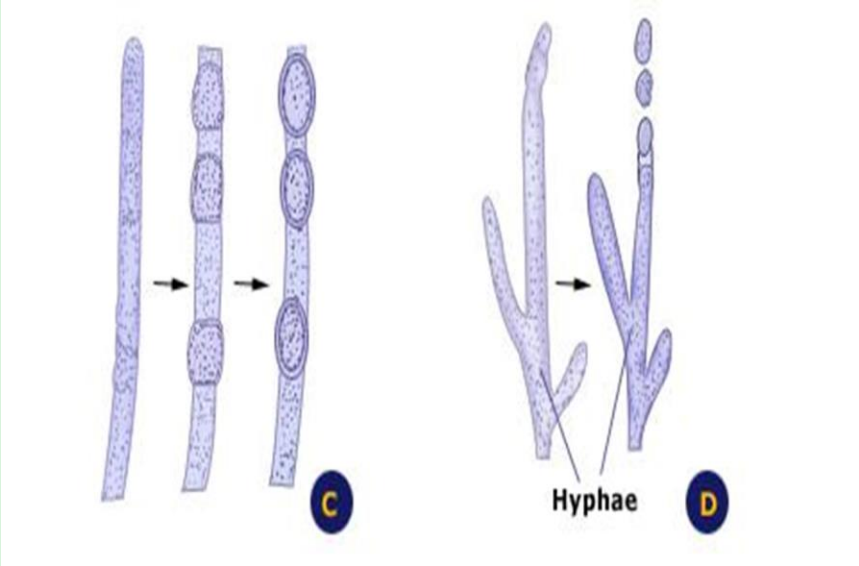
Asexual Reproductive Structures: Conidiospore



Characteristic of Ascomycota. *e.g. Aspergillus, Penicillium, Alternaria*

Conidiospores are not enclosed in a sac but produced at the tips or sides of a hypha; they are called conidiophores.

Asexual Reproductive Structures: Chlamydospores



E.g. Candida albicans

Chlamydospore is the thick-walled, large resting spore of several kinds of fungi that contains stored food.

It rises directly from hyphal cells.

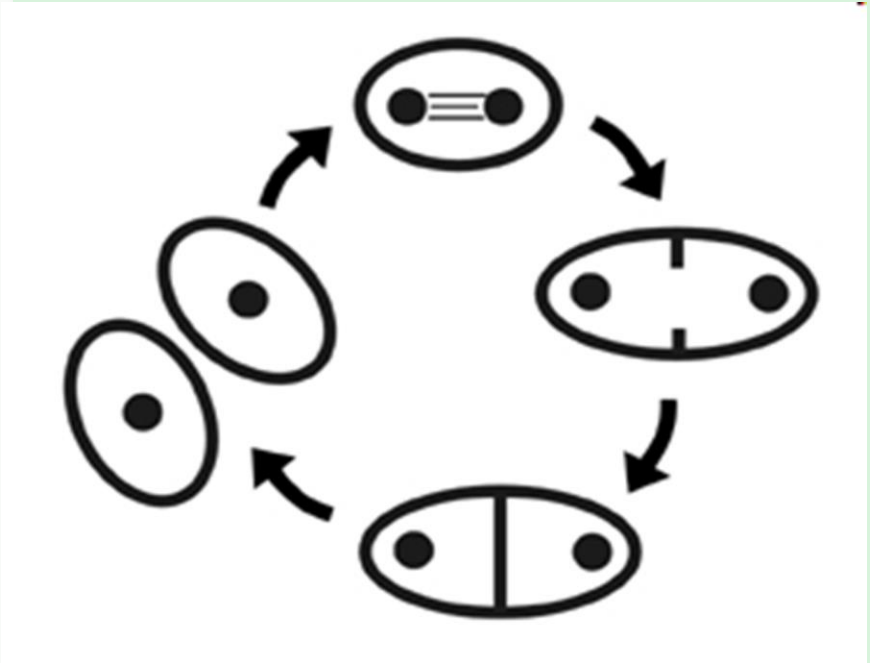
It is the life stage that survives in unfavourable conditions, such as winter.

Chlamydospores can occur singly or occur in chains

METHODS OF ASEXUAL REPRODUCTION: Fragmentation

Fragmentation involves breaking the fungal mycelium into several fragments.
Each of the fragmented parts develops into a new fungus.
Fragmentation is also known as disarticulation.

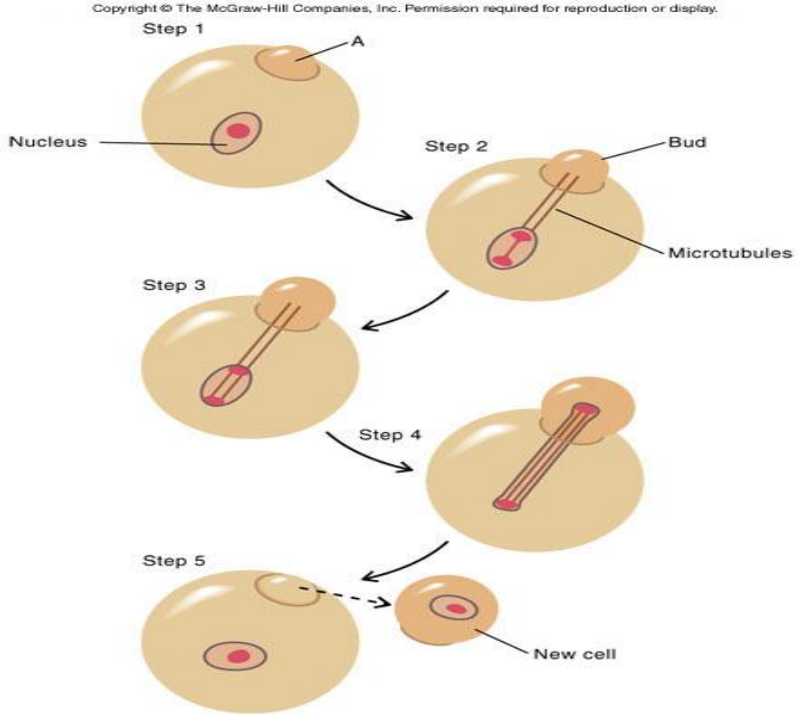
METHODS OF ASEXUAL REPRODUCTION: Fission



Fission involves the simple splitting of a cell into daughter cells by a constriction.

The nucleus divides mitotically, and the cell wall forms.

METHODS OF ASEXUAL REPRODUCTION: Budding



In this process, the parent cell produces one or more projections called buds, which later develop necessary structures and detach to grow into new individuals.

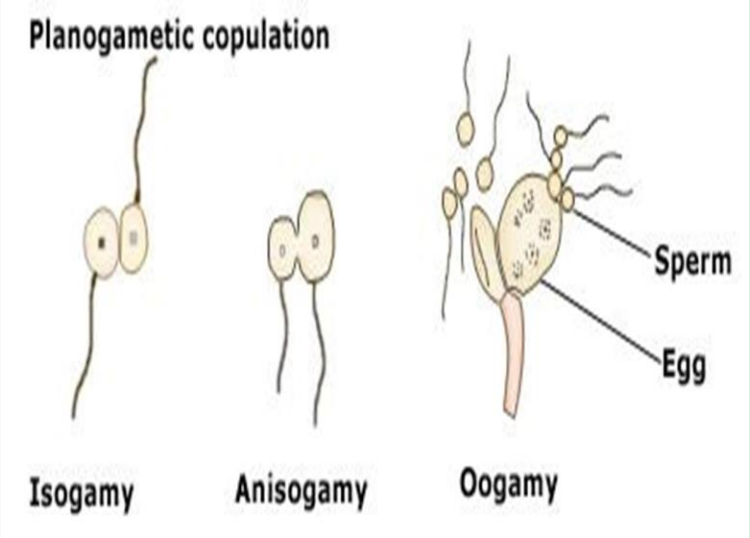
SEXUAL REPRODUCTION IN FUNGI

- Sexual reproduction involves the union of two compatible nuclei with subsequent meiotic division yielding recombinant progeny.
- Among fungi, there are no female and male individuals, and no eggs and sperm.
- Physiological differences among the hyphae do exist, however, and result in different mating types; only compatible strains fuse.
- The compatible nuclei are brought together by one of the following sexual processes: planogametic copulation, gametangial contact, gametangial copulation, spermatization, and somatogamy

SEXUAL REPRODUCTION IN FUNGI

- Three stages in fungal sexual reproduction include: plasmogamy, karyogamy and meiosis:
- **Plasmogamy:** The cytoplasm of two compatible hyphae fuses, bringing their protoplasts together. The nuclei coexist as a pair in a single cell, resulting in a unique dikaryotic (or heterokaryotic) stage, denoted as (N + N).
- **Karyogamy:** The two compatible haploid nuclei of a cell fuse, forming a single, diploid nucleus (2N).
- Meiosis: The diploid zygote undergoes a reductional cell division to form haploid nuclei.

METHODS OF SEXUAL REPRODUCTION: Planogametic copulation



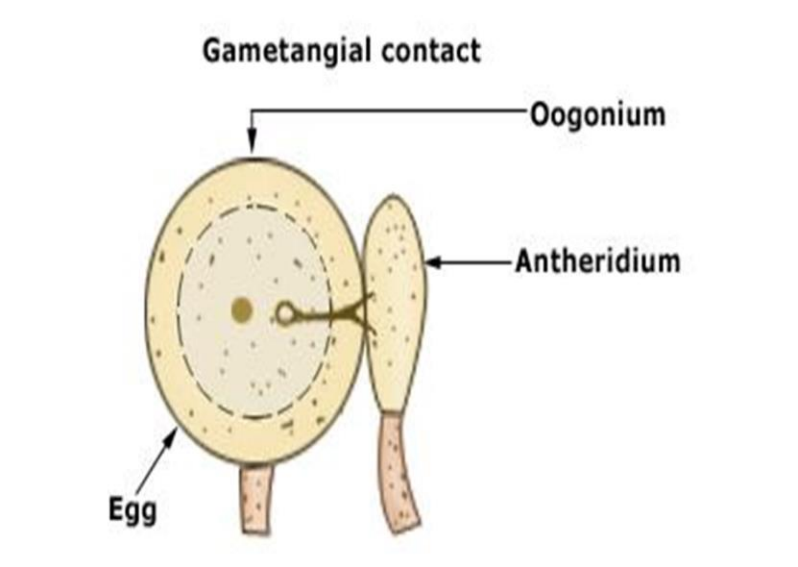
Planogametic Copulation is the fusion motile gametes called planogametes /zoospores.

Isogamy: When both gametes are motile and morphologically similar, Example: Synchytrium .

Anisogamy: When both gametes are motile but differ in their size. Example: Allomyces.

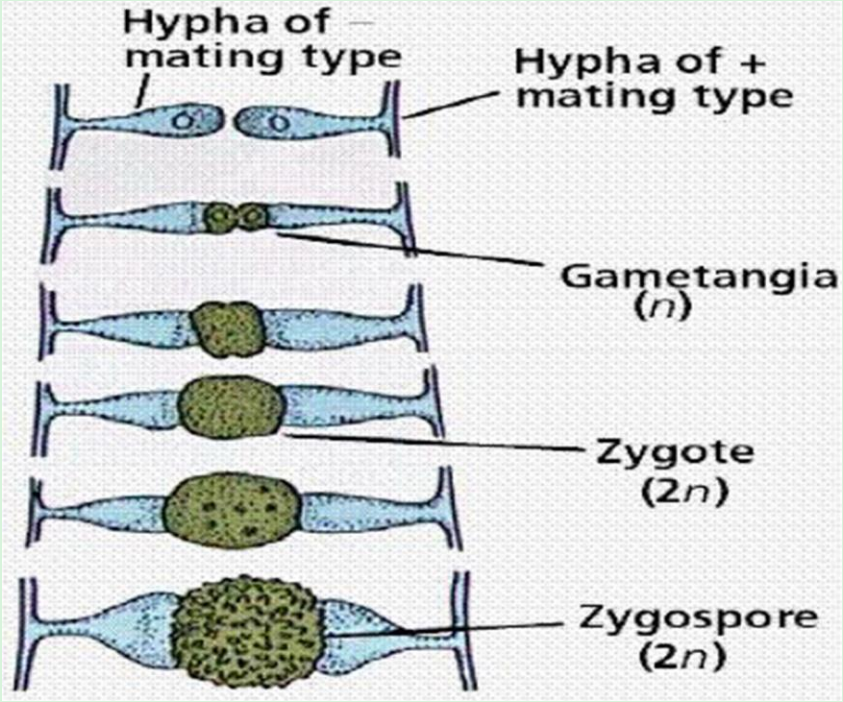
Heterogamy / oogamy: when one gamete (male) is smaller and motile and the other (female) gamete is larger and non motile, the fusion process is called

METHODS OF SEXUAL REPRODUCTION: Gametangial contact



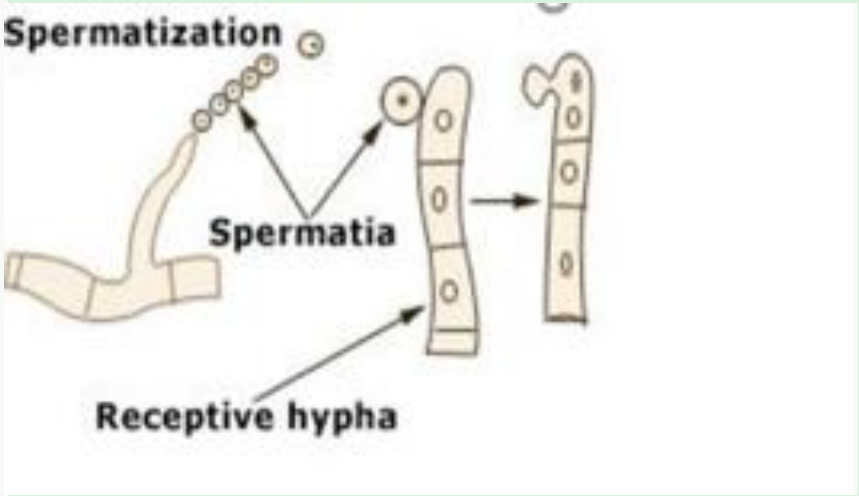
- The gamete bearing structures called **gametangia** come closer to each other and develop a fertilization tube through which the male gamete migrates into the female gametangium.
- Example Phytophthora, Albugo.

METHODS OF SEXUAL REPRODUCTION: Gametangial copulation



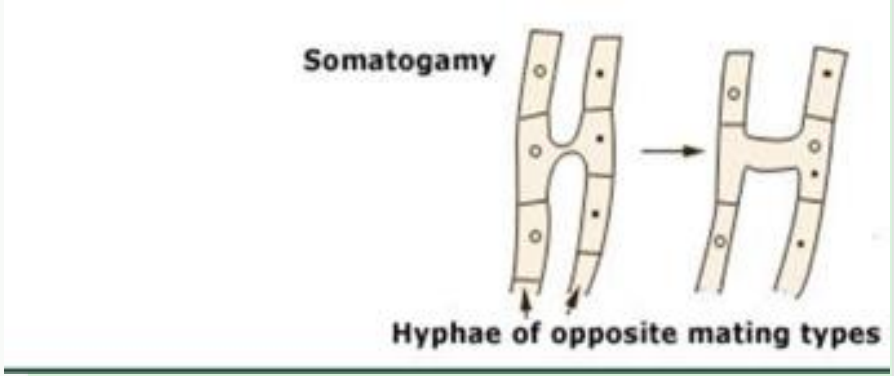
- The gametangia fuse with each other at the point of contact and develop into a zygospore.
- Example Mucor, Rhizopus.

METHODS OF SEXUAL REPRODUCTION: Spermatization



- Spermatisation involves the formation of small spores or seed like structures called spematia.
- Spermatia acts as male gamete and are carried out by wind or insects to the female gametangium.

METHODS OF SEXUAL REPRODUCTION: Somatogamy



- Vegetative hypha acts as a male and female gamete and bring about sexual reproduction.
- Example: Smut Fungi

Fungi vs Plants vs Animals: Key Comparisons

Feature	Fungi	Plants	Animals
Cell Wall	Chitin + beta-glucans	Cellulose + pectin	Absent
Nutrition	Absorptive heterotrophy	Autotrophic (photosynthesis)	Ingestive heterotrophy
Food Reserve	Glycogen	Starch	Glycogen
Membrane Sterol	Ergosterol	Phytosterols	Cholesterol
Motility	Non-motile (mostly)	Non-motile	Motile
Chloroplasts	Absent	Present	Absent

Ecological Importance of Fungi

D

Decomposers

Primary decomposers of dead organic matter. Break down lignin, cellulose, & tough polymers. Cycle nutrients back into ecosystems.

M

Mycorrhizae

More than 90% of plant species form symbiotic associations. Fungi provide phosphorus and nitrogen water; plants provide fixed carbon. Critical for forest ecosystems.

L

Lichen Formation

Fungus + alga/cyanobacterium. Pioneer organisms on bare rock. Contribute to soil formation (pedogenesis).

F

Food Web

Important food source for insects, slugs, squirrels, and humans. Support entire trophic levels in soil ecosystems.

Economic Importance: Beneficial Applications

Food	Edible mushrooms (*Agaricus bisporus,* Pleurotus), truffles, morels — commercially cultivated worldwide.
Fermentation	*Saccharomyces cerevisiae* — bread, beer, wine, bioethanol. Aspergillus oryzae — soy sauce, miso.
Antibiotics	Penicillium notatum → Penicillin (Fleming, 1928). One of the most important medical discoveries in history.
Enzymes & Acids	*Aspergillus niger* → citric acid, amylases, proteases, lipases. Used in food, beverage, and industrial processes.
Biocontrol	*Beauveria bassiana* against aphids & whiteflies. Entomopathogenic fungi as safe biopesticides.
Pharmaceuticals	Cyclosporin A (organ transplant immunosuppression), Lovastatin (cholesterol reduction), Ergotamine (migraines).

Economic Importance: Harmful Effects

Plant Diseases

Wheat rust (*Puccinia graminis*), Rice blast (*Magnaporthe oryzae*), Corn smut (*Ustilago maydis*). Causes billions in annual crop losses.

Human Mycoses

Superficial: ringworm, athlete's foot (Trichophyton).
Systemic: Candidiasis, Aspergillosis, Cryptococcosis, Histoplasmosis.

Mycotoxins

Aflatoxins (*Aspergillus flavus*) — contaminate groundnuts/maize; potent carcinogens. Also: Ochratoxin, Fumonisin, Zearalenone.

Material Decay

Wood-rotting fungi (e.g., *Serpula lacrymans* — dry rot). Billions of dollars in structural timber damage annually.

Review Questions

1. Define fungi and state THREE features that distinguish them from plants.
2. Distinguish between septate and aseptate hyphae with examples.
3. Why is ergosterol clinically important? Name one drug that targets it.
4. What is a dimorphic fungus? Give TWO examples and state their medical significance.
5. Compare asexual and sexual spore types in fungi with examples of each.
6. Outline the ecological roles of fungi in terrestrial ecosystems.
7. What are mycotoxins? Name TWO and state their health effects.

Lecture Summary

- Fungi = eukaryotic, heterotrophic; Kingdom Fungi; closer to animals than plants
- Cell wall: CHITIN (not cellulose); membrane sterol: ERGOSTEROL (not cholesterol)
- Food reserve: GLYCOGEN (not starch); ribosomes: 80S (same as animals)
- Basic unit = hypha; mass of hyphae = mycelium; unicellular form = yeast
- Hyphae: septate (Ascomycota, Basidiomycota) vs aseptate (Zygomycota)
- Asexual spores: conidia, sporangiospores, zoospores. Sexual: ascospores, basidiospores, zygospores
- Dimorphic fungi: mould at 25°C, yeast at 37°C — medically significant
- Ecological roles: decomposers, mycorrhizae, lichens | Economic: antibiotics, fermentation, food

"Without fungi, life on land as we know it would not exist."


Thank you
for your
attention