



BIOLOGY AND DIVERSITY OF VIRUSES, BACTERIA AND FUNGI (PAPER CODE: BOT 501)



By

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OBJECTIVES

The main objective of the present lecture is to cover the topic and make it easy to understand and interesting for our students/learners.

BLOCK – III : FUNGI – I

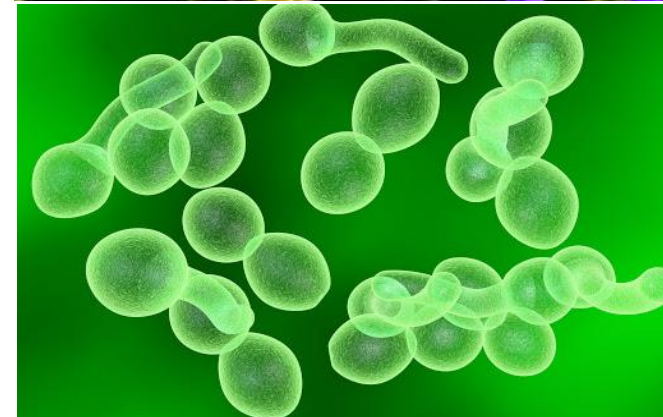
Unit –10 : General Characters and Classification of Fungi

CONTENT

- ❑ Introduction of fungi
- ❑ General characteristics of fungi
 - ❖ Occurance
 - ❖ Thallus organisation
 - ❖ Different forms of mycellium
 - ❖ Cell structure
 - ❖ Nutrition
 - ❖ Heterothallism and Homothallism
 - ❖ Reproduction
- ❑ Classification of fungi
 - ❖ Classification based on taxonomy hierarchy
 - ❖ Classification based on spore Production
 - ❖ Classification of medically important fungi
 - ❖ Classification based on route of acquisition
 - ❖ Classification based on virulence
- ❑ Key points of the lecture
- ❑ Terminology
- ❑ Assessment Questions
- ❑ Bibliography

WHAT IS FUNGI ????

- ❖ Fungi is the plural of word fungus which is derived from the latin word fungour.
- ❖ Fungi are achlorophyllas, heterotrophic eukaryotic thallophytes.
- ❖ According to Alexopoulos (1962), the fungi include nucleated spore bearing achlorophyllas organisms that generally reproduce sexually and whose filamentous branched somatic struture are typically surrounded by cell wall containing cellulose or chitin or both.
- ❖ According to Bessey (1968), fungi are chlorophyll less non vascular plants whose reproductive or vegetative structure do not permit them to be assigned to position among recognized group of higher plants.
- ❖ The branch of botany that deals with the fungi is called mycology and the scientist who is concern with the fungi is called a mycologist.
- ❖ P. A. Micheli known as father of mycology whereas E. J. Butler refer to as father of Indian mycology.
- ❖ Fungi are non-green in color with the capacity to live in all kinds of environments.



DIFFERENCE BETWEEN ALGAE AND FUNGI

Algae	Fungi
The possess chlorophyll which in some of them is masked by other pigments such as brown, red etc.	The fungi lack chlorophyll
With the help of chlorophyll, they are able to synthesize their own food and thus are called autotrophic in their mode of nutrition.	Lacking chlorophyll, the fungi are unable to synthesized their own organic food. They get it readymade sources either by living as parasites or saprophytes. For this resions fungi are refer to as heterotrophic in their mode of nutrition.
The algal thallus is composed of true parenchyma cells. The unit f structure an algal thallus thus is a cell.	The fungal thallus which is termed das mycelium is not formed by the division and differentiation of the cells but composed of a false tissue called pseudoparanchyma. Thus the unit of structure of a fungus thallus is not a cell but hyphae.
The cell wall is typically composed of cellulose.	The cell or hyphae wall is composed of fungus cellulose or often called chitin.
The food reserve is chiefly in the form of starch.	The reserve food invariably accumulated in the form of glycogen and not starch.
The algae grow in the habitat where sun light is present.	They generally have grown in dark and dim light.
They grow in water or in a damp soil and sometime as an epiphytes rarely as endophytes.	They have grown in the wide variety of habitat; as parasites in the tissue of plants and animals.
The sexual apparatus increases in complexity from the simple to the higher forms.	There is a progressively and gradually simplification and ultimate illumination of the sexual apparatus from the lower to higher fungi.

SIMILARITIES BETWEEN ALGAE AND FUNGI

- ❖ Fungi and algae both prefer to live in moist environments. In fact, one of the benefits algae derive from their symbiotic lichen relationship with fungi is their ability to survive on land in a moist environment.
- ❖ Both algae and fungi are thallophytes (plant body not differentiated into root, stem and leaves)
- ❖ Both algae and fungi are placed together in the division thallophyta of cryptogams
- ❖ With the exception of blue green algae, majority of algae and fungi are eukaryotic
- ❖ Both fungi and algae are, in general, examples of organisms possessing a haploid nuclei. This means they have only a single copy of each chromosome. By contrast, diploid organisms, such as humans and most mammals, have two copies of each chromosome.
- ❖ Vascular tissue system is absent in both groups
- ❖ Both algae and fungi processes cell wall made of polysaccharides, chemical nature of cell wall varies in algae and fungi
- ❖ Symbiotic members are present in both groups (algae with animals, fungi with roots of higher plants, between algae and fungi as in lichens)
- ❖ Both groups can reproduce by vegetative reproduction by fragmentation and fission.
- ❖ Both algae and fungi can reproduce asexually by the production of various motile and non-motile spores
- ❖ Sex organs are naked in both groups, no protective covering for sex organs in both groups

GENERAL CHARACTERISTICS OF FUNGI

- ❖ Some of the most important characters of fungi are as follows: 1. Occurrence 2. Thallus organization 3. Different forms of mycelium 4. Cell structure 5. Nutrition 6. Heterothallism and Homothallism 7. Reproduction.

❑ OCCURRENCE:

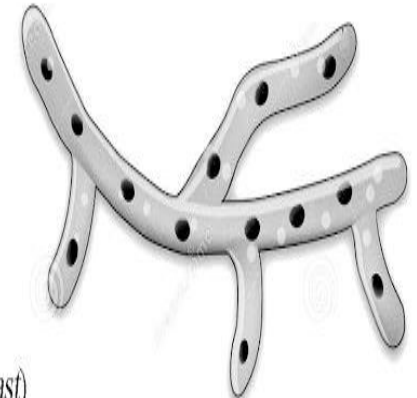
- ❖ Fungi are cosmopolitan and occur in air, water soil and on plants and animals.
- ❖ They prefer to grow in warm and humid places. Hence, we keep food in the refrigerator to prevent bacterial and fungal infestation.

❑ THALLUS ORGANIZATION:

- ❖ Except some unicellular forms (e.g. yeasts, *Synchytrium*), the fungal body is a thallus called mycelium.
- ❖ The mycelium is an interwoven mass of thread-like hyphae (Sing, hypha). Hyphae may be septate (with cross wall) and aseptate (without cross wall). Some fungi are dimorphic that found as both unicellular and mycelial forms e.g. *Candida albicans*.
- ❖ The thallus may be two types: Unicellular and filamentous.



Unicellular thallus (Yeast)



Filamentous thallus (*Mucor*)

- **Unicellular thallus:** In some of the lower fungi, thallus is more or less a spherical, single celled structure. At the time of reproduction it becomes a reproductive unit. Such fungi are called **holocarpic**. In the unicellular holocarpic forms, the mycelium is absent e.g. *Synchytrium*. Some holocarpic fungi (e.g., yeast) producing bud cells in succession and these remain attached to one another in a chain. Such a chain of bud cells is referred to as pseudomycelium.
- **Filamentous thallus:** In most true fungi, the thallus is filamentous composed of Hyphae. Loosely aggregated hyphae are collectively forms a network known as mycelium. Each hypha may vary in shapes and sizes. Branching of hyphae is dichotomous. On the basis of presence or absence of septa the hyphae of mycelical fungi are of two types:
 - ✓ **Nonseptate or aseptate hyphae:** Mycelium contains numerous nuclei, lying in a common mass of cytoplasm, without cross wall in the hyphae, E.g., oomycetes and zygomycetes. Such a condition is known as coenocytic. However, septa may be laid down at the time of formation of reproductive organs to delimit them from the rest of the vegetative hyphae, therefore called Pseudosepta. E.g., *Allomyces*.
 - ✓ **Septate Hyphae:** Hyphae are septate and hyphal segments may contain one, two or more nuclei. E.g., Ascomycotina, Basidiomycotina, and Deuteromycotina. There are two types of septa:
 - **Primary septa:** Primary septa are formed in association with mitotic or meiotic nuclear division, and they separate the daughter nuclei. These types of septa are found in Ascomycotina, Basidiomycotina and their asexual states.
 - **Adventitious septa:** Adventitious septa are formed in the absence of mitosis or meiosis and occur especially in association with change in the local concentration of cytoplasm. These are found in lower groups of fungi as mastigomycotina and zygomycotina.

❑ DIFFERENT FORMS OF MYCELLIUM

❖ Different forms of mycelium refer to as the various shapes and the functions of mycelium which modified according to the circumstances. These includes the following forms:

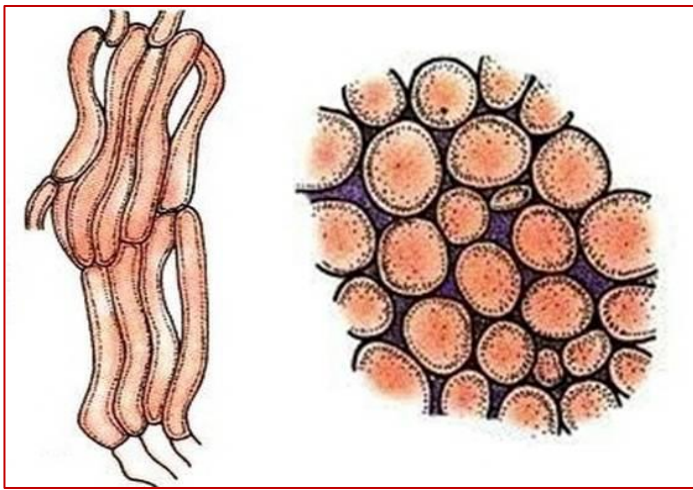
a. **Plectenchyma (fungal tissue):** In a fungal mycelium, hyphae organized loosely or compactly woven to form a tissue called plectenchyma. It is two types:

✓ **Prosenchyma or Prosoplectenchyma:** In these fungal tissue hyphae are loosely interwoven lying more or less parallel to each other.

✓ **Pseudoparenchyma or paraplectenchyma:** In these fungal tissue hyphae are compactly interwoven looking like a parenchyma in cross-section.

b. **Sclerotia (Gr. Skleros=haid):** These are hard dormant bodies consist of compact hyphae protected by external thickened hyphae. Each Sclerotium germinates into a mycelium, on return of favourable condition, e.g., *Penicillium*.

c. **Rhizomorphs:** They are root-like compactly interwoven hyphae with distinct growing tip. They help in absorption and perennation (to tide over the unfavourable periods), e.g., *Armillaria mellea*.



Prosenchyma and Pseudoparenchyma



Sclerotia



Rhizomorphs

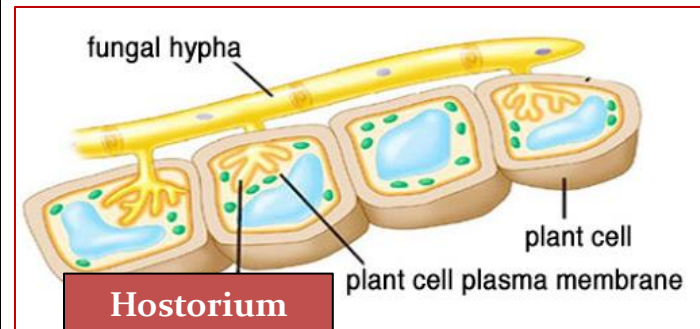
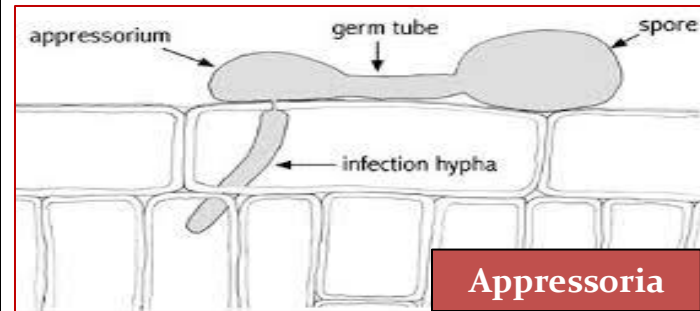
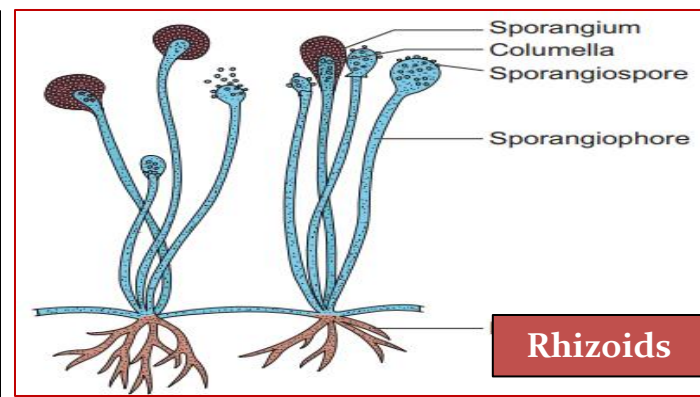
d. Rhizoids: A rhizoid is a short, root like filamentous branch of the thallus, generally formed in tufts at the base of the thallus. These also function as anchoring and absorbing, e.g., *Rhizophydium*, *Rhizopus*.

e. Appressoria (Sing. appressorium): It is a terminal simple or lobed swollen mucilaginous structure of infecting hyphae which adheres to the surface of the host or other substratum and helps in the penetration of the infection hyphae. These are formed by some parasitic fungi such as powdery mildews and rust

f. Haustoria (Sing. haustorium): A haustorium is an organ that is developed from a hypha usually performing the function of absorption. They are characteristic of obligate parasites. They vary in shape and may be knob like or button shaped, elongated, finger-like or branched. They secrete some specific enzymes which hydrolyse the protein and carbohydrates of the host plant.

g. Hyphal traps (Snares): The predacious fungi develop sticky hyphae or network of hyphal loops known as hyphal traps or Snares. They help in capturing nematodes.

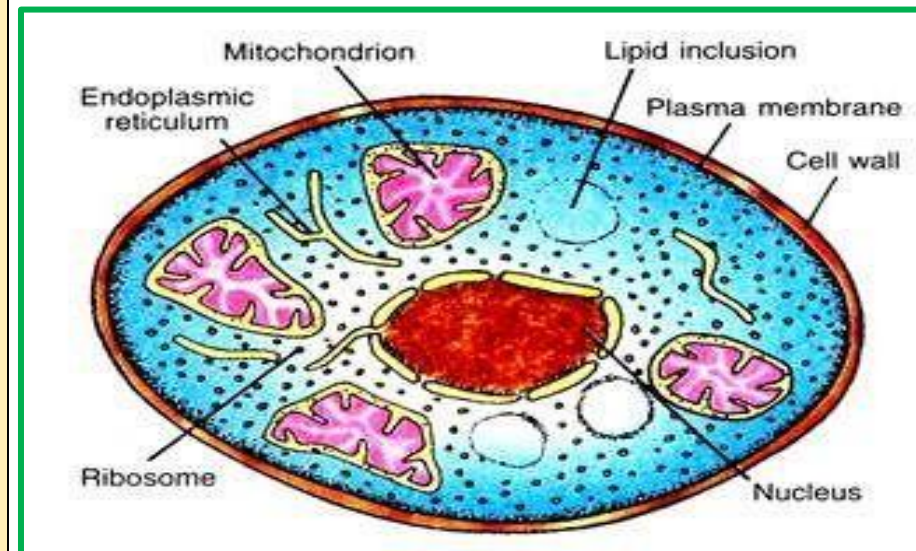
h. Stromata: These are compact somatic structures much like mattresses. Fructifications are generally formed on or in them.



❑ CELL STRUCTURE

- ❖ Fungi are the eukaryotic organisms.
- ❖ The cell wall determines the characteristic shape of a cell. It protects the cell from osmotic lysis and also acts as a binding site for some enzymes.
- ❖ The chemical composition of the cell wall is not the same in all fungi. Chitin is characteristically present in the cell walls of most fungi. The chitin in fungal cell wall is not strictly identical with animal chitin, and the formula $(C_{22}H_{54}N_4O_{21})_n$ has been suggested for the fungal chitin: It is a polymer of N-acetylglucosamine.
- ❖ The cytoplasm at hyphal tip contains Golgi vesicles called chitosomes which filled with cell wall materials.
- ❖ Nucleus and mitochondria are found to connect with ER. Nucleus divides by intracellular mitosis called karyochoresis where nuclear envelop remain intact during nuclear division and internal spindle develop. Reserve food is glycogen and oil.

Cell Wall Category	Taxonomic Group	Representative Genera
Cellulose-Glycogen	Acrasiomycetes	Polysphondylium, Dictyostelium
Cellulose- β -Glucan	Oomycetes	Phytophthora, Pythium
Cellulose-Chitin	Hyphochytridiomycetes	Rhizidiomyces
Chitin-Chitosan	Zygomycetes	Mucor, Phycomyces
Chitin- β -Glucan	Chytridiomycetes	Allomyces
	Ascomycetes	Neurospora
	Deuteromycetes	Aspergillus
	Basidiomycetes	Fomes, Polyporus
Mannan- β -Glucan	Ascomycetes	Saccharomyces, Candida



❑ NUTRITION

❖ The fungi lack chlorophyll. Therefore, they cannot synthesiz their own food. Depending on from where and how they get nutrition, fungi are of following types:

- a. **Saprotrophs:** They obtain food from dead and decaying organic matter. They secrete digesting enzymes to outside which digest the substratum and then absorb nutrients, e.g., *Mucor*, *Agarious*, *Rhizopus* etc.
- b. **Parasitic:** They obtain food from living organisms. They may be facultative or obligate. Facultative parasites grow on a variety of tissues e.g., *Ustilago*. The obiigate- parasites growonly upon suitable host, e.g., downy mildews. The parasitic fungi that grow on surface of host cells and absorb food through haustoria are called ectoparasites or ectophytic parasites (e.g., *Mucor*, *Erisphae*). When parasitic fungi grow inside the host tissue are called endoparasites or endophytic parasites (e.g., *Pythium*, *Puccinia*).
- c. **Predacious:** Some soil fungi develop ring-like noses to trap annelids, nematodes etc. e.g., *Arthrobotrys*, *Zoophagus*, *Dactylella* etc.



Saprotrophs

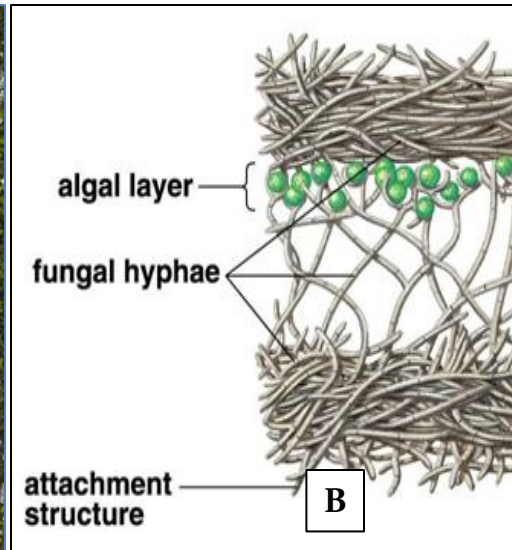


Parasitic fungi on ladybug



Predacious fungi trap nematode

- d. **Symbiotic:** They live in mutualistic relationship with another organism by which both are benefited. The two common examples are lichens and mycorrhiza.
- ❖ Lichens are symbiotic associations between fungi and algae. The fungal partner is a member of ascomycetes or basidiomycetes that provides water and nutrients, while the algal partner is a green alga or cyanobacteria that prepares food by photosynthesis.
- e. **Mycorrhizas:** or mycorrhizae are the mutualistic symbiotic associations between soil fungi and the roots of most plant species. According to the carbohydrate theory (Bjorkman, 1949), the plants that grow in soils deficient in P and N, and high intensity light develop mycorrhizas.
- ❖ The two most common types of mycorrhizas are the ectomycorrhizas (ECM) and the endomycorrhizas (also known as arbuscular mycorrhiza). The two groups are differentiated by the fact that the hyphae of ectomycorrhizal fungi do not penetrate the cell wall of the plant's root cells, while the hyphae of arbuscular mycorrhizal fungi penetrate the cell wall.

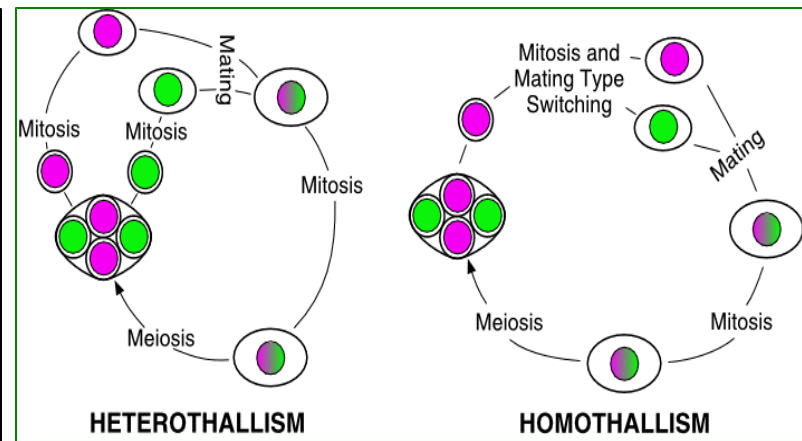


(A) Lichen with (B) internal structure

Plant showing (C) with and (D) without mycorrhizae

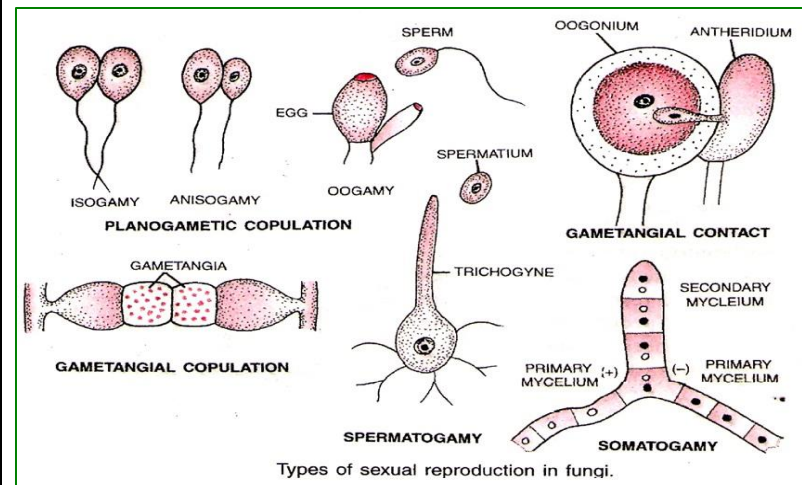
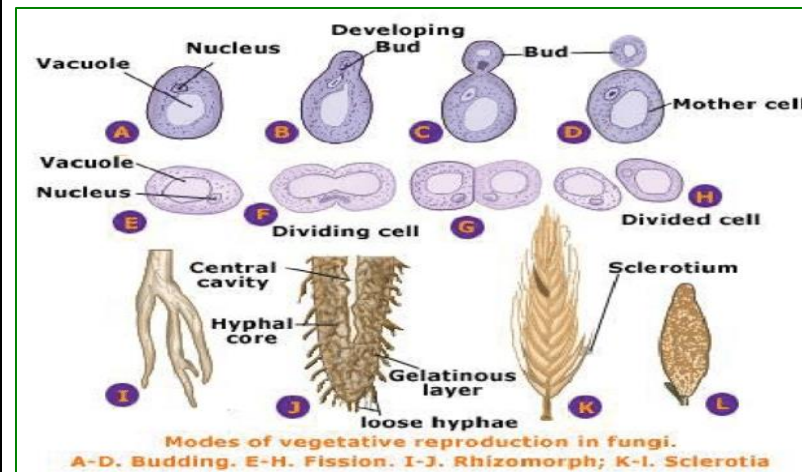
❑ HETEROTHALLISM AND HOMOTHALLISM

- ❖ A. F. Blakeslee (1904) discovered mating types or genetically distinct strains in *Mucor*.
- ❖ He called fungi with different mating types are called heterothallic and fungi without mating types are called homothallic.
- ❖ Nowadays we call some fungi and algae homothallic if both male and female gametes produce in the same individual can fertilize each other and heterothallic if the gametes can only be fertilized by gametes from another individual of the same species. Heterothallism introduces variations in the species.



❑ REPRODUCTION

- ❖ In fungi reproduction may take place by three methods; vegetative, asexual and sexual.
- ❖ During asexual and sexual reproduction processes spores are the essential structures. The spores formed after meiosis are called meiospores (e.g., ascospores, basidiospores and sporangiospores) and those resulting from mitosis, called mitospores (e.g., mitospores, zoospores, aplanospores, conidia, uredospores).

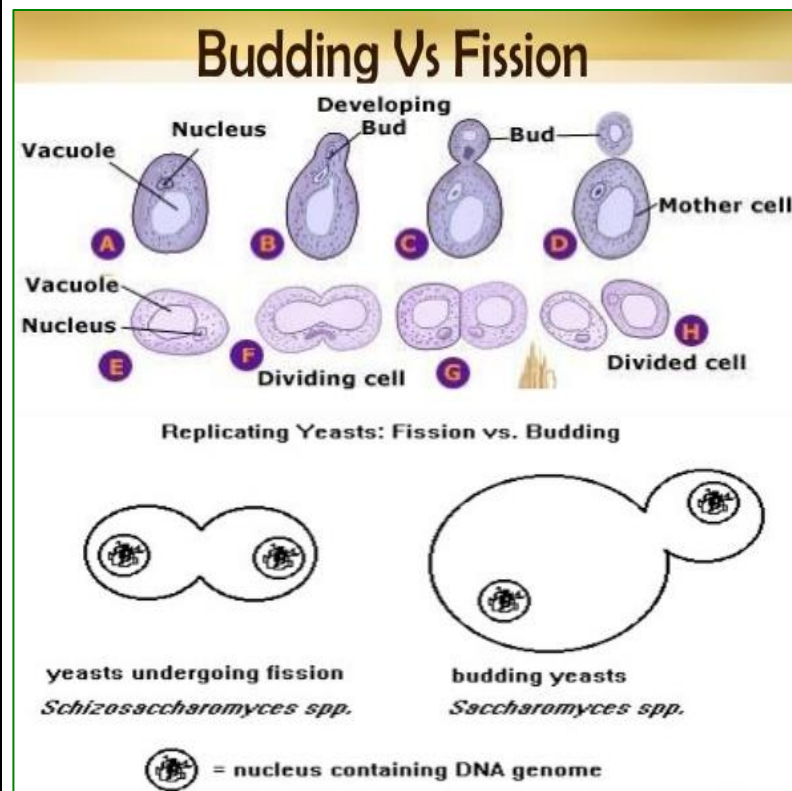


❖ The diploid body produced as a result of sexual fusion is known as zygote which in lower fungi is termed as resting spore, oospore or zygospore.

❖ In higher fungi, the zygote is represented by a diploid nucleus produced in a cell (ascus or basidium). This diploid nucleus after undergoing meiosis results in the formation of haploid nuclei serving as centres for haploid sexual spores called ascospores and basidiospores.

➤ **Vegetative reproduction:** In this type of reproduction, a part of mycelium separate and forms a new individual. The various methods of vegetative reproduction are:

- Fragmentation:** The hyphae break into small fragments. Each piece upon getting suitable conditions, germinates to form a new mycelium.
- Fission:** This method involves the splitting of cells into two daughter cells by the formation of a constriction followed by a cell wall formation.
- Budding:** A small bud formed from the parent cell which gradually increases in size and receives a part of nucleus. A cell wall is formed which separates the daughter cell from the parent cell.



d. **Sclerotia:** These are perennating bodies formed by the compact masses of interwoven hyphae. Sclerotia under suitable conditions germinate to form new individuals e.g. *Claviceps*, *Sclerotinia*.

e. **Rhizomorphs:** These are root-like elongated mycelial strands. They remain dormant under unfavourable conditions and under favourable conditions develop into a new mycelium.

➤ **Asexual reproduction:** It commonly take place through spores, either motile or non-motile and form in a specialized part of mycelium. The various types of spores are:

a. **Zoospores:** These are commonly found in lower fungi e.g., *Saprolegnia*, *Pythium* etc. They are naked spores, which after swarming, encyst, secrete a cell wall and germinate by germ tube into a thallus. They are equipped with one or two flagella

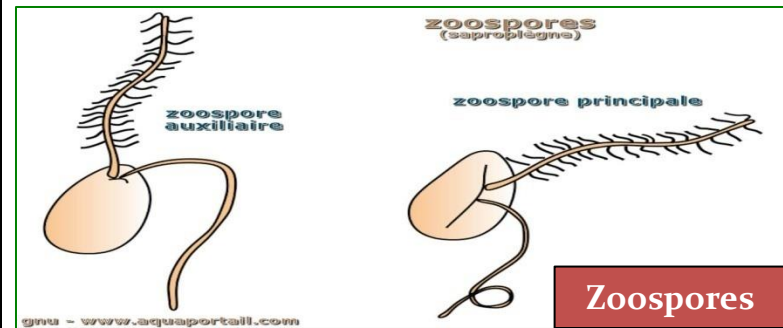
b. **Sporangiospore:** The sporangiospores or aplanospores are nonmotile and lack flagella and are formed inside the sporangium e.g. *Mucor*, *Rhizopus*. These spores may be uninucleate or multinucleate and possess two-layered cell wall.



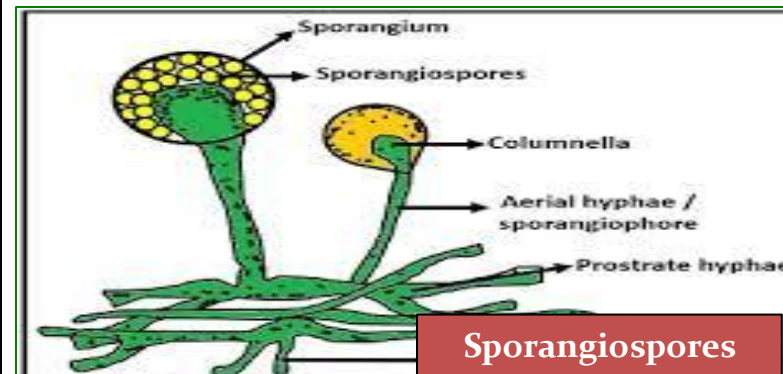
Sclerotia



Rhizomorph



Zoospores



Sporangiospores

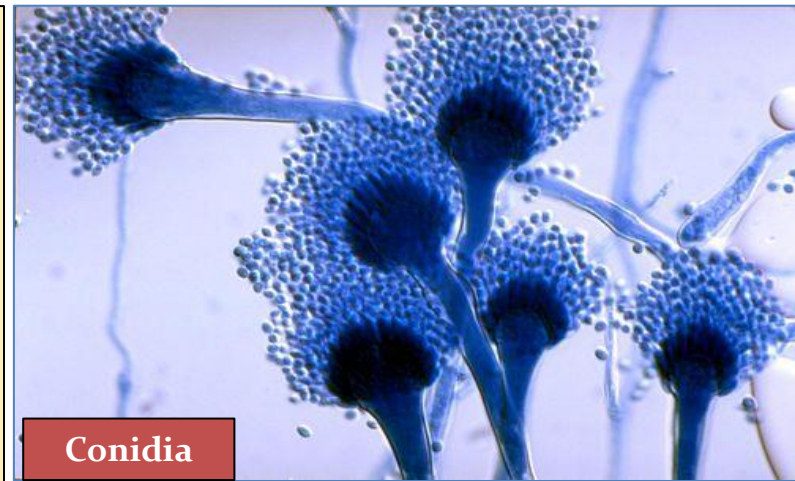
c. **Conidia:** They are produced externally on branched or unbranched hyphal tips termed as conidiophores. The conidia may be formed singly or in chains. The conidial chains may be basipetal or acropetal in succession. Conidia may be uninucleate or multinucleate. The latter type is more common in the members of the form class Deuteromycetes.

d. **Oidia:** They are produced by fragmentation of hyphae from apex to base. Each cell thus formed rounds off and separates as a spore which under favourable circumstances germinates and forms the mycelium.

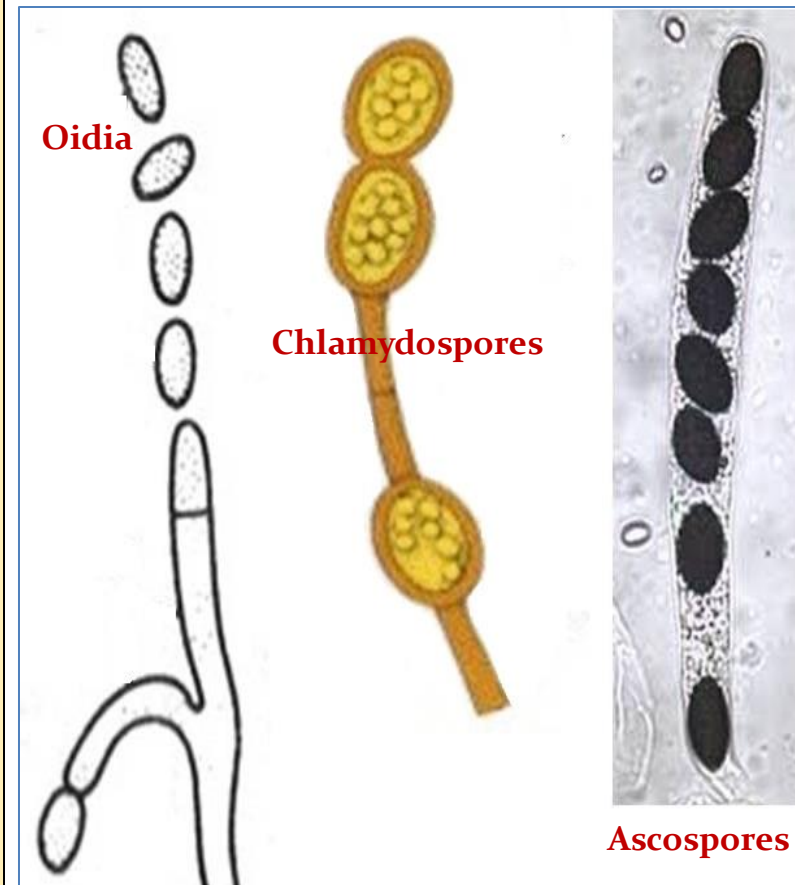
e. **Chlamydospores:** They are formed by rounding off and enlargement of terminal or intercalary cells of a hypha. These can be single or formed in chains. They do not separate from the hyphae but remain viable and germinate under favourable conditions.

f. **Ascospores:** An ascospore are produced inside an ascus during the optimal condition. This kind of spore is specific to fungi classified as ascomycetes.

g. **Uredospores:** A thin-walled, red, summer spore of a rust fungus, produced usually on the leaves or stems of grasses.



Conidia



Oidia

Chlamydospores

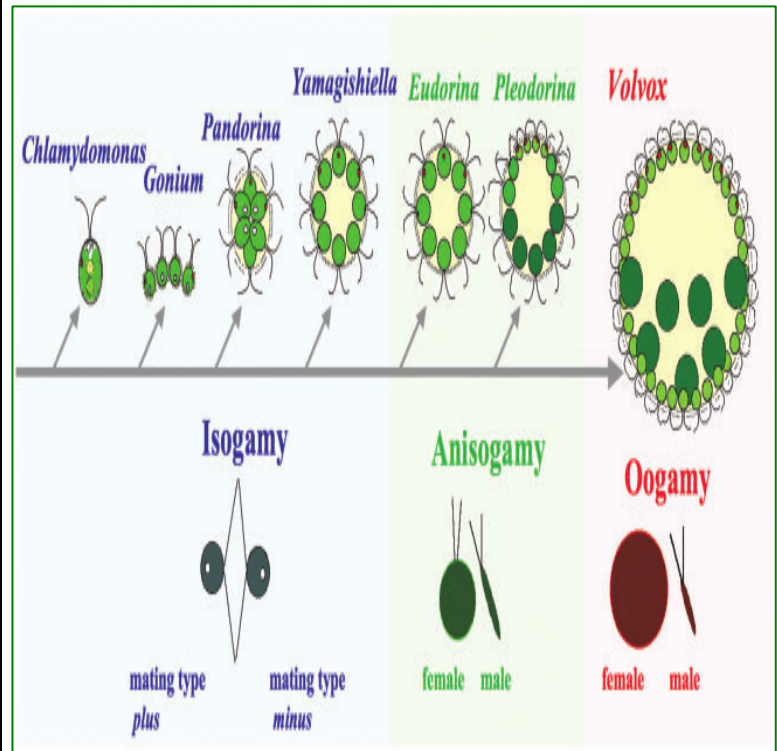
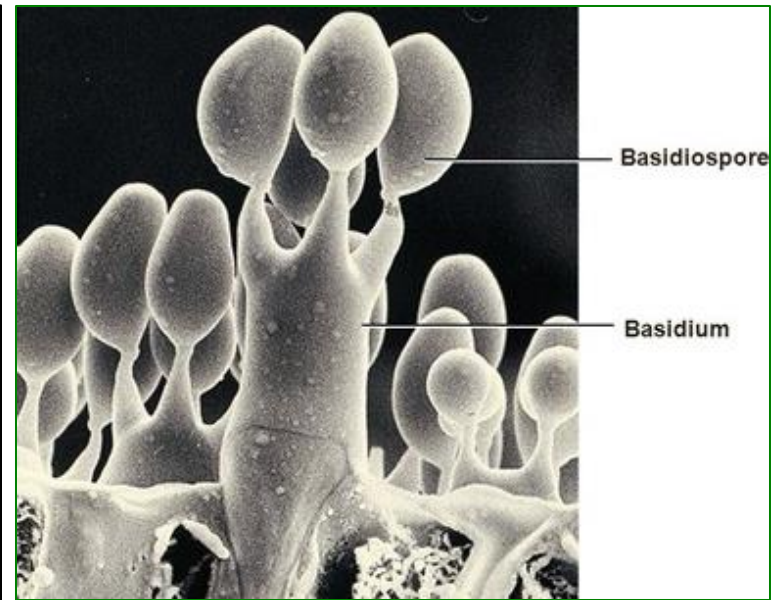
Ascospores

h. Basidiospores: These spore produced by Basidiomycete fungi. They typically each contain one haploid nucleus that is the product of meiosis, and they are produced by specialized fungal cells called basidia.

➤ **Sexual reproduction:** It involves the formation and fusion of gametes. Sexual reproduction found in all groups of fungi except deuteromycetes or fungi imperfecti. Sexual reproduction has three distinct phases i.e. plasmogamy (protoplasmic fusion), karyogamy (fusion of nuclei) and meiosis (reduction division of zygote). The various methods of sexual reproduction in fungi are as follows:

a. Planogametic copulation: This is simplest type of sexual reproduction. In this process fusion of two gametes of opposite sex or strains takes place where one or both of the fusing gametes are motile (flagellated). It results in the formation of a diploid zygote. This process is usually of these types:

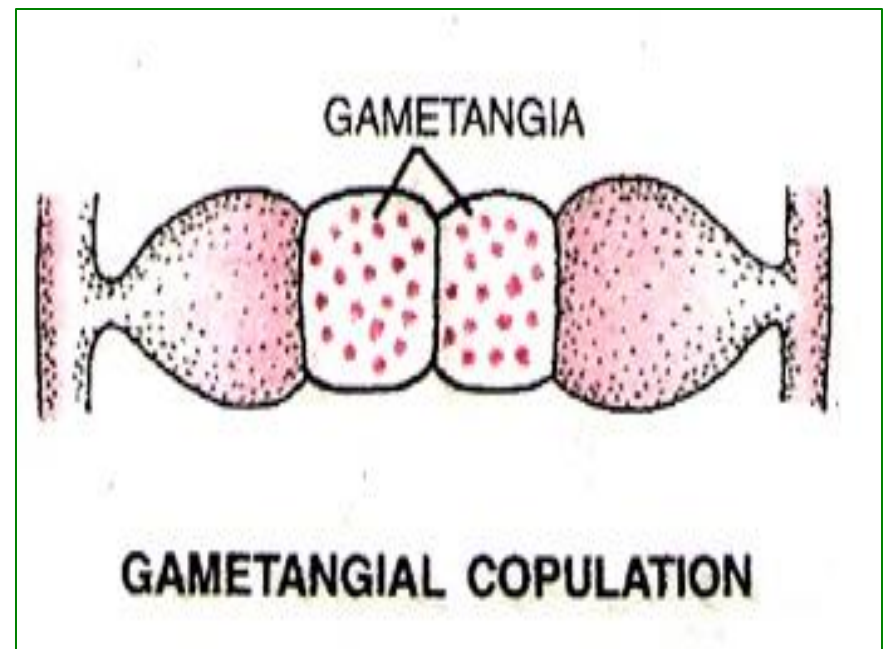
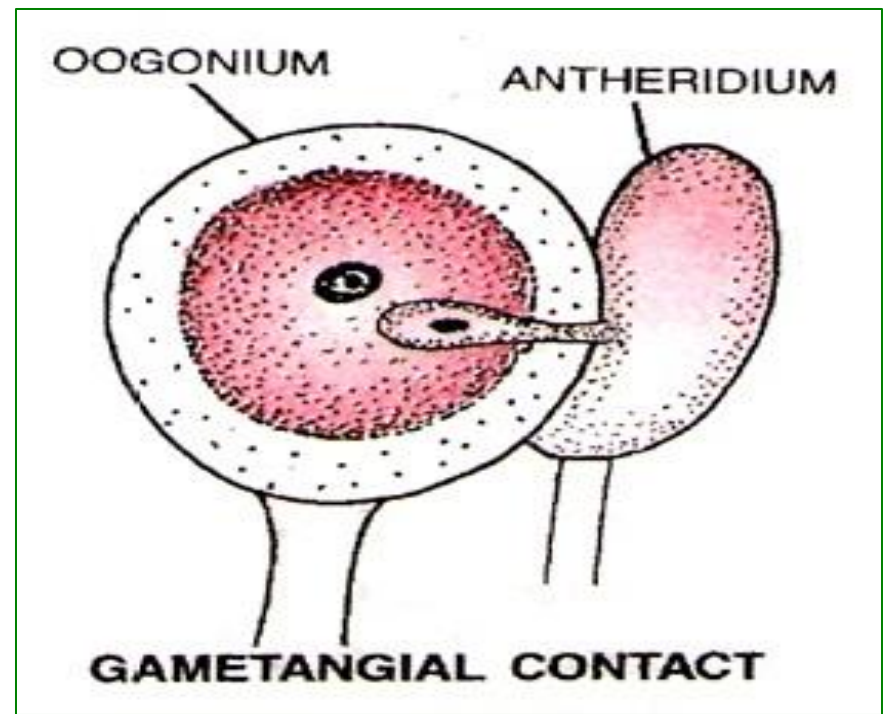
✓ **Isogamy:** In this process fusing gametes are morphologically similar and motile but physiologically dissimilar. These gametes are produced by different parents, e.g. *Synchytrium*.



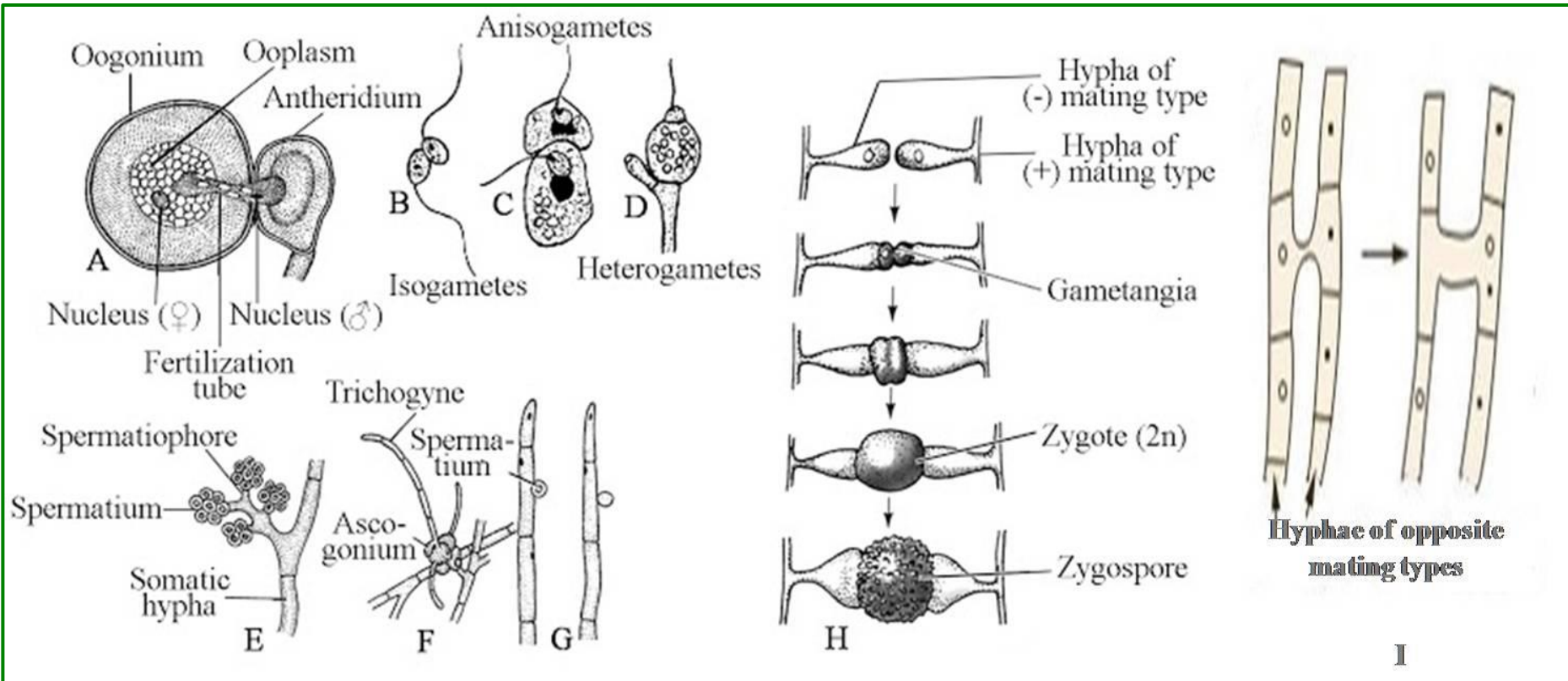
- ✓ **Heterogamy:** When the fusing gametes are morphologically as well as physiologically different, the process is known as heterogamy. Heterogamous reproduction is of two types: anisogamy and oogamy. Anisogamy consists of the fusion of two motile gametes where the male gamete is small and more active than the female gamete, e.g., *Allomyces*. In oogamy the motile male gamete (antherozoid) fuses with the large, non-motile female gamete (egg or ovum) e.g., *Synchytrium* etc.

- b. **Gametangial contact:** In this process two gametangia of opposite sex come in contact with one another. The male gametangium (antheridium) transfer male nucleus or gamete into the female gametangium (oogonium) either through a pore at the point of contact or through a fertilization tube, e.g., *Phytophthora*, *Albugo*, *Pythium* etc.

- c. **Gametangial copulation:** In involves the fusion of entire contents of two gametangia to form a common cell called zygote or zygospore, e.g., *Mucor*, *Rhizopus*.



- d. Spermatization:** Some fungi produce many minute, spore-like, single-celled structures called spermatia (nonmotile gametes). These structures are transferred through agencies like water, wind and insects to either special receptive hyphae or trichogyne of ascogonium. The contents migrate into receptive structure. Thus dikaryotic condition is established, e.g. *Puccinia*.
- e. Somatogamy:** This takes place in fungi where formation of gametes is absent. In such fungi, anastomoses takes place between hyphae and their somatic cells fuse to produce dikaryotic cells, e.g. *Agaricus*, *Peniophora* etc.



Sexual reproduction in fungi: (A) Gametangia contact, (B-C-D) Planogametic copulation, (E-F-G) Spermatization, (H) Gametangia copulation, (I) Somatogamy

CLASSIFICATION OF FUNGI

- ❖ The classification of fungi is designed mainly for practical application but it also bears some relation to phylogenetic considerations.
- ❖ The division of mycota, or fungi and moulds, includes the true slime moulds (Myxomycetes), the lower fungi (Phycomycetes), and the higher fungi (Eumycetes).
- ❖ The fungi can be classified according to the various parameters including;
 - Classification based on taxonomy hierarchy
 - Classification based on spore Production
 - Classification of medically important fungi
 - Classification based on route of acquisition
 - Classification based on virulence
- **Classification based on taxonomy hierarchy:**
 - ❖ Alexopolous and Mims proposed fungal classification in 1979. They place the fungi including the slime molds in the kingdom mycetae of the super kingdom Eukaryota which, in addition, includes four other kingdoms. They divide the kingdom mycetae into three divisions namely:
 - ❑ Gymnomycota
 - ❑ Mastigomycota
 - ❑ Amastigomycota
 - ❖ The division is subdivided into subdivision, classes, sub-classes, and orders.

❑ **Division I: Gymnomycota:** It includes phagotrophic organism devoid of cell walls. This division comprises two subdivisions; Acrasiogymnomycotina and Plasmodiogymnomycotina.

1. **Subdivision : Acrasiogymnomycotina:** It includes a single class Acrasiomycetes.

Class 1. Acrasiomycetes : Lacks flagellated cells except for one species. The class comprises:

Sub class 1. Acrasiomycetidae

Sub class 2. Dictyosteliomycetidae

2. **Subdivision: Plasmodiogymnomycotina:** It is divided into two classes:

Class 1. Protosteliomycetes

Class 2. Mycomycetes: It includes the true slime mold and comprises three sub class namely:

Sub class 1. Ceratiomyxomycomycetidae, 1 Order : Ceratiomyxales

Sub class 2. Mycogasteomycetidae, 4 Orders: Liceales, Echinosteleales, Trichlales, Physarales

Sub class 3. Stemonitomycetidae, 1 Order: Stemonitales

❑ **Division II: Mastigomycota:** Includes fungi with absorptive nutrition, unicellular or filamentous, mycelium coenocytic. It comprises two sub divisions:

1. **Sub division: Haplomastigomycotina:** Includes fungi with uni-or, bi-flagellate zoospores.

Class 1. Chytridiomycetes– Fungi producing zoospores furnished with a single whiplash flagellum inserted at the posterior end.

Class 2. Hyphochytridiomycetes- Motile cells with a single tinsel flagellum inserted at the anterior end.

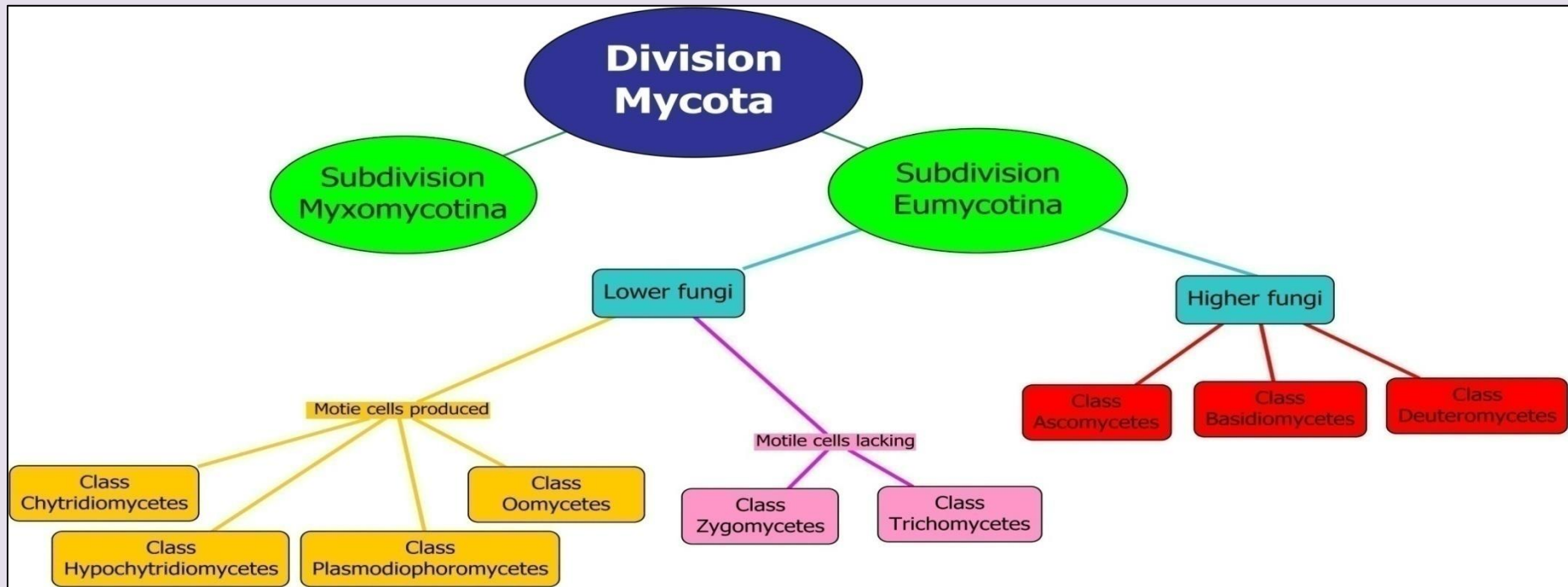
Class 3. Plasmodiophoromycetes- Parasitic fungi producing biflagellate motile cells with both the flagella of whiplash type inserted at the anterior end.

2. **Sub division: Diplomastigomycotina:** Sexual reproduction oogamous, zoospores biflagellate.

Class 1. Oomycetes, 4 Orders: Lagenidiales, Saprolegnales, Leptomitales, Peronosporales

- ❑ **Division III: Amastigomycota:** Fungi with absorptive nutrition, motile cells lacking, mycelium aseptate or septate. This includes four sub divisions:
- 1. Sub division: Zygomycotina**
Class 1. Zygomycetes – it includes six orders.,
Class 2. Trichomycetes – it comprises five orders.
 - 2. Sub division: Ascomycotina:** Fungi usually with a septate mycelium producing haploid ascospores in sac like cells called asci.
Class 1. Ascomycetes: Divided into five sub classes:
Sub class 1. Hemiascomycetidae- comprising three orders.
Sub class 2. Plectomycetidae- Five orders
Sub class 3. Hymenoascomycetidae – Ten orders
Sub class 4. Laboulbeniomycetidae – Two orders
Sub class 5. Lowloascomycetidae – five orders
 - 3. Sub division 3: Basidiomycotina:** Septate mycelium, produces basidiospores, exogenously on various types of basidia.
Class 1. Basidiomycetes: it is split into 3 sub classes:
Sub class 1. Holobasidiomycetidae
Sub class 2. Phragmobasidiomycetidae
Sub class 3. Teliomycetidae
 - 4. Sub division: Deuteromycotina:** It includes imperfect fungi in which sexual stage is unknown. It comprises a single class.
Class 1. Deuteromycetes
Sub class 1. Blastomycetidae
Sub class 2. Coelomycetidae
Sub class 3. Hyphomycetidae

- ❖ Martin (1965) proposed a classification according to the spore formation in fungi. The outline of classification is given;



Division mycota: These include non green, nucleated thallophytes which are saprophytes or parasite in nutrition.

Subdivision Myxomycotine: Thallus is achlorophyllous, multinucleated mass of protoplasm called plasmodium, e.g., slime molds.

Subdivision Eumycotina: All the fungi except the slime molds are included in this subdivision.

Lower fungi: They have simple thallus which are unicellular and others filamentous (mycelium), usually septa is not present.

Class Chytridiomycetes: Motile cells have a single flagellum of whiplash type inserted at the posterior end.

Class Hypochytridiomycetes: Motile cell possesses a single flagellum of tinsel type inserted at the anterior end.

Class Plasmodiophoromycetes: Motile cells are biflagellated (whiplash type), but one is longer than the other one.

Class Oomycetes: Motile cells are biflagellated, nearly equal length, one of these points forwards and the other trails behind.

Class Zygomycetes: Motile cells are absent. Asexual reproduction take place by sporangiospores.

Class Trichomycetes: Motile cells are lacking. Asexual reproduction take place by conidia.

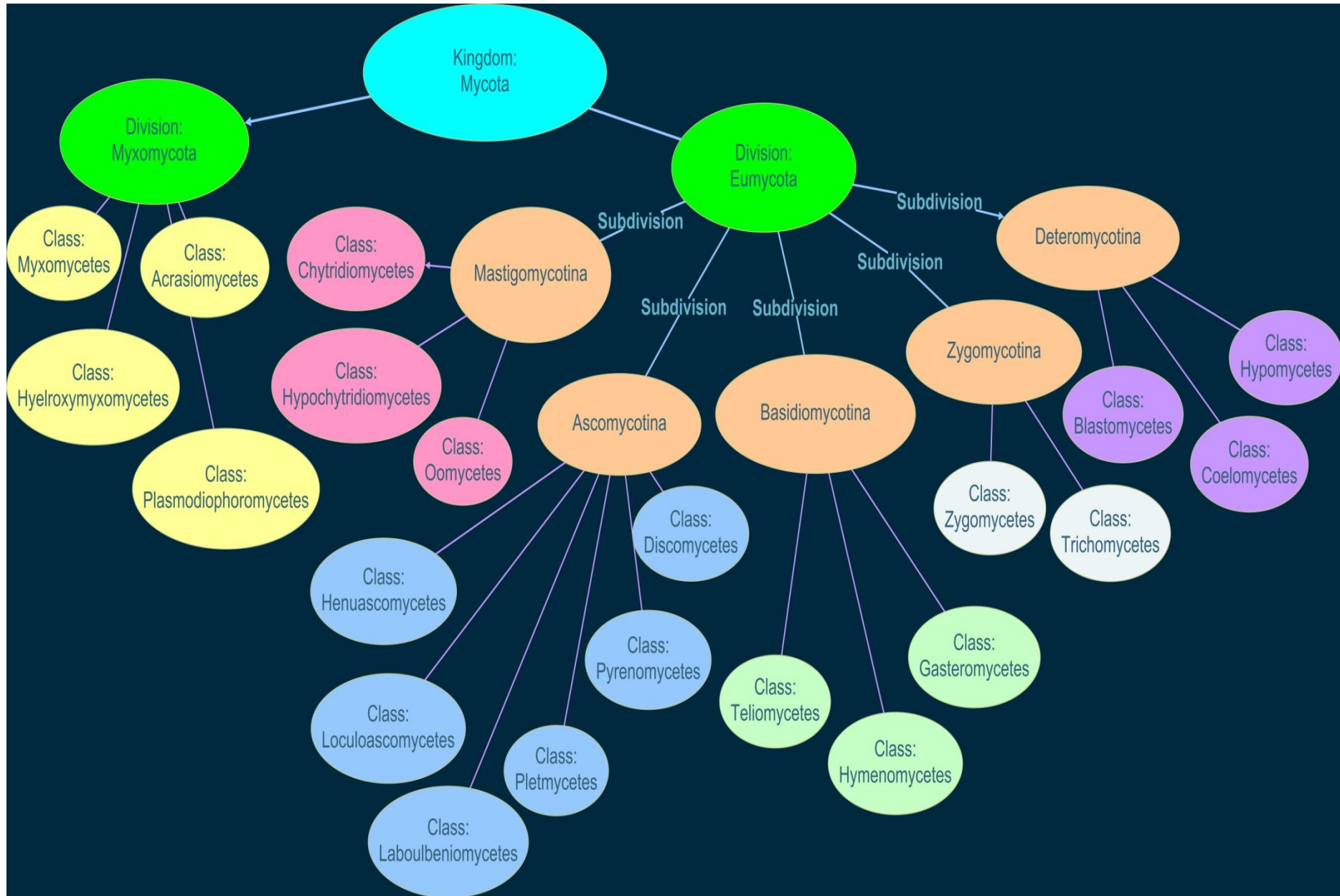
Higher fungi: The somatic phase consists mostly of a mycelium which is usually septate.

Class Ascomycetes: The characteristic spores called ascospores are produced endogenous within sac like structure called asci.

Class Basidiomycetes: Characteristic spores called basidiospores are produced exogenous on club shaped structure called basidia.

Class Deuteromycetes: Sexual stage is unknown. The somatic phase consist a septate mycelium which multiply by conidia.

❖ A more natural system of classification of fungi was proposed by Ainsworth (1973) which has been accepted by many mycologist today like Webster (1980), Bilgrami (1985) and Dube (1987).



○ Classification based on spore production:

❖ On the basis of the organisation of the vegetative thallus, the morphology of reproductive structures, the way of spores production and particular life cycle involved the kingdom mycota is classified into following divisions.

□ Phycomycetes

- It includes the simplest type of fungi. It is also called as Algae-Fungi because most of the characteristics of them are similar to algae like *Vaucheria*.
- They have simple thallus which is unicellular or coenocytic or aseptate filaments.
- They reproduce asexually by the formation of zoospores or non-motile spores.
- Sexual reproduction is isogamous or heterogamous which takes place by gametangial contact.
- The diploid phase is represented by zygote.
- Phycomycetes has been classified into subclasses: oomycetes and zygomycetes.

□ Oomycetes

- It range from a primitive unicellular thallus to a profusely branched filamentous mycelium.
- Many members of them are terrestrial and obligate parasites.
- Asexually they reproduce by biflagellate zoospores.
- Oogamous reproduction that involves the fusion of male and female gametes to form oospore.
- Oospore undergoes meiosis to produce haploid biflagellate zoospores.
- Example; *Phytophthora infestans* (causes potato blight).

❑ Zygomycetes

- The group is named zygomycetes because a diploid resting spore called the zygospore is formed during the life cycle.
- They are mostly saprophytic, some others are parasites on plants and animals.
- The vegetative body is mycelium which is well developed, profusely branched and coenocytic.
- The absence of motile sexual or asexual cells.
- The asexual reproduction takes place by sporangiospores, aplanospores or by conidia.
- Sexual reproduction occurs by conjugation of gametangia resulting in the formation of zygospore.
- Examples; *Rhizopus*, *Mucor* etc.

❑ Ascomycetes

- The species of ascomycetes are called the sac fungi because they produce sexual pores within the sac-like vascus.
- Ascomycetes are mostly terrestrial occurring as saprophytes or parasites.
- They have well-developed, branched, septate mycelium except yeast. Yeast is a unicellular fungus.
- Asexually they reproduce by non-motile spores, conidia, oidia or chlamydospores.
- Sexual reproduction takes place by the fusion of gametangia of opposite mating types.
- There is absence of motile cells.
- Examples, *Saccharomyces cerevisiae*, *Penicillium*, *Aspergillus* etc.

❑ Basidiomycetes

- The members of basidiomycetes are saprophytic or parasitic. The group is named basidiomycetes as they produce the basidiospores at the club-shaped basidium during sexual reproduction.
- Mycelium is highly developed, profusely branched and septate.
- The mycelia are differentiated into two mating types; (+ve) and (-ve).
- There are two kinds of mycelium; primary mycelium and secondary mycelium.
- Asexual reproduction takes place by fragmentation, budding, oidia, conidia or chlamydospore.
- The dikaryotic cell is formed during sexual reproduction.
- The absence of motile cell throughout the life cycle.
- These are the most advanced fungi as their fructifications are often large and prominent.
- Examples; Mushrooms, *Puccinia*, *Ustilago* etc.

❑ Deuteromycetes (The Imperfect Fungi)

- Deuteromycetes comprises more than 17000 species of the diverse habits and habitats. It is considered as an artificial class of fungi.
- The fungi are saprophytes as well as parasites. Parasitic fungi cause serious diseases to plants, animals including human beings.
- Some of them are unicellular while others are multicellular.
- They reproduce asexually by conidia along with some other types of spores.
- The sexual reproduction is entirely absent.
- The asexual stage or imperfect stage in Deuteromycetes is well defined. But the sexual or perfect stage is absent in life cycle, therefore, they are called 'Fungi Imperfecti'.
- Example; *Alternaria*, *Fusarium*, *Helminthosporium* etc.

○ Classification based on medically important fungi

- ❖ Mycoses are classified as superficial, cutaneous, subcutaneous, or systemic (deep) infections depending on the type and degree of tissue involvement and the host response to the pathogen.
- a. **Superficial mycoses** (or **tineas**): Occur in the tropics and are restricted to the outer surface of the hair and skin, e.g., *Piedraia hortae*.
- b. **Cutaneous mycoses**: There are three genera of fungi (*Microsporum*, *Trichophyton* and *Epidermophyton*) that commonly cause disease in the non-living tissues of skin, hair, or nails/claws of people and animals, by growing in a zone just above where the protein keratin is deposited.
- c. **Subcutaneous mycoses**: They are normally saprotrophic inhabitants of soil, particularly in tropical and subtropical areas of Africa, India and South America.
- d. **Systemic mycoses** are infections that affect the whole body. We divide these into mycoses due to primary (usually dimorphic) virulent pathogens, and those due to opportunistic pathogens.

○ Classification based on route of acquisition

- a. Infecting fungi may be either exogenous or endogenous.
- b. When classified according to the route of acquisition, a fungal infection may be designated as exogenous or endogenous in origin.
- c. If classified as exogenous, an infecting organism may be transmitted by airborne, cutaneous, or percutaneous routes.
- d. An endogenously-acquired fungal infection may be acquired from colonization or reactivation of a fungus from latent infection.

○ Classification based on virulence

- ❖ Primary pathogens can establish infections in normal hosts.
- ❖ Opportunistic pathogens cause disease in individuals with compromised host defense mechanisms.
- Deep mycoses are caused by primary pathogenic and opportunistic fungal pathogens.
- The primary pathogenic fungi are able to establish infection in a normal host; whereas, opportunistic pathogens require a compromised host in order to establish infection (e.g., cancer, organ transplantation, surgery, and AIDS).
- The primary deep pathogens usually gain access to the host via the respiratory tract. Opportunistic fungi causing deep mycosis invade via the respiratory tract, alimentary tract, or intravascular devices.
- The primary systemic fungal pathogens include *Coccidioides immitis*, *Histoplasma capsulatum*, *Blastomyces dermatitidis*, and *Paracoccidioides brasiliensis*.
- The opportunistic fungal pathogens include *Cryptococcus neoformans*, *Candida*, *Aspergillus* spp., *Penicillium marneffeii*, the Zygomycetes, *Trichosporon beigeli*, and *Fusarium* spp.

KEY POINTS OF THE LECTURE

- ❖ Fungi is the plural of word fungus which is derived from the latin word fungour.
- ❖ Fungi are achlorophyllas, heterotrophic eukaryotic thallophytes.
- ❖ The branch of botany that deals with the fungi is called mycology and the scientist who is concern with the fungi is called a mycologist.
- ❖ P. A. Micheli known as father of mycology whereas E. J. Butler refer to as father of Indian mycology.
- ❖ Fungi are eukaryotic organisms means they have true nucleus which are enclosed in membranes.
- ❖ They are non-vascular organisms. Xylem and Phloem are absent.
- ❖ Fungi have cell walls (plants also have cell walls, but animals have no cell walls).
- ❖ There is no embryonic stage for fungi.
- ❖ They reproduce by means of spores. There are sexual and asexual spores. Sexual spores are Oospores, Zygosporoes, Ascospores, Basidiospores, etc. and Asexual spores are Sporangiospores, Aplanospores, Zoospores, Conidia, etc.
- ❖ Depending on the species and conditions both sexual and asexual spores may be produced.
- ❖ They are typically non-motile.
- ❖ Fungi exhibit the phenomenon of alteration of generation. They have both haploid and diploid stage.

KEY POINTS OF THE LECTURE

- ❖ Fungi are achlorophyllous, which means they lack the chlorophyll pigments present in the chloroplasts in plant cells and which are necessary for photosynthesis.
- ❖ As they are achlorophyllous, therefore, they do not have the ability to make their own food.
- ❖ The vegetative body of the fungi may be unicellular or composed of microscopic threads called hyphae. Hyphae can grow and form a network called a mycelium.
- ❖ Yeasts are unicellular fungi that do not produce hyphae.
- ❖ The structure of cell wall is similar to plants but chemically the fungi cell wall are composed of chitin $(C_8H_{13}O_5N)_n$.
- ❖ Fungi are heterotrophic organisms. They obtain their food and energy from organic substances, plant and animal matters.
- ❖ Fungi digest the food first and then ingest it to accomplish this the fungi produce exoenzymes like Hydrolases, Lyases, Oxidoreductase, Transferase, etc. Fungi store their food as starch.
- ❖ Fungi are saprophytes (gets energy from dead and decaying matters), or parasites (lives in a host, attack and kill) or symbionts (mutually beneficial).
- ❖ Optimum temperature of growth for most saprophytic fungi is $20-30^\circ\text{C}$ while $(30-37)^\circ\text{C}$ for parasitic fungi. Growth rate of fungi is slower than that of bacteria.
- ❖ Reproduction in fungi is both by sexual and asexual means. Sexual state is referred to as teleomorph (fruiting body), asexual state is referred to as anamorph (mold like).

KEY POINTS OF THE LECTURE

- ❖ Asexual reproduction methods are: fragmentation, somatic budding, fission, asexual spore formation. Sexual methods are: gametic copulation, gamete-gametangium copulation, gametangium copulation, somatic copulation and Spermatization.
- ❖ Some fungi are macroscopic and can be seen by naked eyes. Mold or mushrooms are examples of macroscopic form of fungi.
- ❖ In 1991, a landmark paper estimated that there are 1.5 million fungi on the Earth. Only about 300 species of fungi are infectious to human.
- ❖ The classification of fungi is designed mainly for practical application but it also bears some relation to phylogenetic considerations.
- ❖ The fungi can be classified according to the various parameters including; Classification based on taxonomy hierarchy, Classification based on spore Production, Classification of medically important fungi, Classification based on route of acquisition, Classification based on virulence
- ❖ Alexopolous and Mims proposed fungal classification in 1979. They place the fungi including the slime molds in the kingdom mycetae. They divide the kingdom mycetae into three divisions namely: Gymnomycota, Mastigomycota and Amastigomycota
- ❖ Martin (1965) proposed a classification according to the spore formation in fungi and divide the division mycota into two sundivision; Myxomycotina and Eumycotina.
- ❖ Classification based on medically important fungi divided the fungi into superficial mycoses, cutaneous mycoses, subcutaneous mycoses and systemic mycoses.

TERMINOLOGY

- ❑ **Arbuscular Mycorrhiza (AM):** (A mycorrhiza) where fungi from the Glomeromycota penetrate the roots of a (usually herbaceous) plant and provide the plant with water and nutrients while the plant supplies sugars to the fungus
- ❑ **Ascocarp:** Fruitbody of an ascomycete fungus
- ❑ **Ascomycetes:** A - Class of fungi that produce their spores in sac-like cells called asci
- ❑ **Ascospores:** Sexual spores produced in the asci of ascomycetes fungi
- ❑ **Ascus:** (Pl., asci) the spore-producing cell of an ascomycetes fruitbody
- ❑ **Basidiocarp:** Fruitbody of a basidiomycete fungus
- ❑ **Basidiomycetes:** A - Class of fungi that produce their spores on basidia
- ❑ **Basidiocarp:** Fruitbody of a basidiomycete fungus
- ❑ **Basidiospores:** Sexual spores produced on the basidia of basidiomycetes fungi
- ❑ **Basidium:** (Pl., basidia) spore-producing cell of a basidiomycete fungus
- ❑ **Cellulose:** Component of plant cell walls and of wood composed of glucose units
- ❑ **Chlamydospores:** Asexual spores formed by the breaking up of fungal hyphae
- ❑ **Clamp Connection:** Swollen area formed around septum in a hypha during cell division
- ❑ **Coprophilous:** Growing on dung
- ❑ **Cuticle:** The surface layer of the cap or stem of a fruitbody
- ❑ **Deuteromycetes:** Obsolete term for a group fungi not known to reproduce sexually
- ❑ **Dichotomous:** Forking/divided into pairs – as in logical decision-making trees
- ❑ **Dikaryon:** A pair of closely associated, sexually compatible nuclei
- ❑ **Ectomycorrhiza (EM) :** (A mycorrhiza) where the fungus forms sheathes around plant rootlets (often of a tree), growing between but not penetrating the cells of the plant root, and providing the plant with water and nutrients while the plant supplies sugars to the fungus
- ❑ **Endomycorrhiza:** Mycorrhiza in which fungal hyphae penetrate cell walls of host plant
- ❑ **Endophyte:** Fungus living within a plant without causing visible symptoms of harm

TERMINOLOGY

- ❑ **Hypha:** (Pl., hyphae) filamentous thread of fungal mycelium
- ❑ **Inferior:** (Describing a ring) located near the base of the stem
- ❑ **Lichen:** Organism comprising a fungus and an alga or a cyanobacterium
- ❑ **Mucilaginous:** (Often describing a mushroom cap) covered with slime
- ❑ **Mycelium:** Body of a fungus, most of which is underground or hidden within wood
- ❑ **Mycobiont:** The fungal component of a lichen or of a mycorrhizal partnership
- ❑ **Mycology:** The study of fungi
- ❑ **Mycorrhiza:** Structure by which a fungus and a plant exchange nutrients mutually
- ❑ **Myxomycetes:** A large and commonly encountered group within the slime moulds
- ❑ **Organelle:** A differentiated (separate) structure within a cell
- ❑ **Parasitism:** Process whereby an organism feeds at the expense of another (host)
- ❑ **Photosynthesis:** Process by which plants convert carbon dioxide and water to sugars
- ❑ **Rhizomorph:** A root-like mycelial strand comprising bunched parallel hyphae
- ❑ **Saprophyte:** An organism that obtains its nutrients from dead organic material
- ❑ **Septate:** (Describing hyphae) partitioned by cross walls known as septa
- ❑ **Septum:** (Pl., septa) a cross wall separating cells of a hyphal thread
- ❑ **Slime Moulds:** A group of fungus-like organisms that use spores to reproduce
- ❑ **Spore:** Reproductive structure of a fungus, usually a single cell
- ❑ **Sporophore:** Fungal fruitbody
- ❑ **Superior:** (Describing a ring) located near the top of the stem
- ❑ **Taxonomy:** The - Classification of organisms based on their natural relationships
- ❑ **Thallus:** (Pl., thalli) the body of a fungus or a lichen
- ❑ **Uredinales:** Rust fungi (an order within the Basidiomycota)
- ❑ **Zygomycota:** A - Class of simple fungi whose hyphae generally lack cross walls

SOME QUESTIONS RELATED TO THE LECTURE

- ❑ **Question 1:** What do you understand by fungi?
- ❑ **Question 2:** Highlight the difference between algae and fungi.
- ❑ **Question 3:** What are the characteristic features of fungi?
- ❑ **Question 4:** Describe the habit and habitat of fungi.
- ❑ **Question 5:** Write a note on thallus organization in the fungi.
- ❑ **Question 6:** Discuss the morphology of the fungi in detail.
- ❑ **Question 7:** Give the ultra structure of fungi in detail.
- ❑ **Question 8:** Describe the mode of nutrition in fungi.
- ❑ **Question 9:** Discuss the various mode of reproduction in fungi in detail.
- ❑ **Question 10:** Give the classification of fungi as proposed by Alexopoulos.
- ❑ **Question 11:** Give the outline of classification as given by Martin in 1965.

BIBLIOGRAPHY

- ❑ Vashistha BR and Sinha AK (2010) Botany for degree students: Fungi. S. Chand & company limited, Ram nagar, New Delhi.
- ❑ <https://microbenotes.com/classification-of-fungi/>
- ❑ <https://www.onlinebiologynotes.com/fungi-characteristics-classification/>
- ❑ <https://www.biologydiscussion.com/fungi/8-important-characters-of-fungi-with-diagram/5602>
- ❑ <https://courses.lumenlearning.com/boundless-biology/chapter/characteristics-of-fungi/>
- ❑ <https://www.first-nature.com/fungi/~glossary.php>

श्रद्धावाँलभते ज्ञानं

