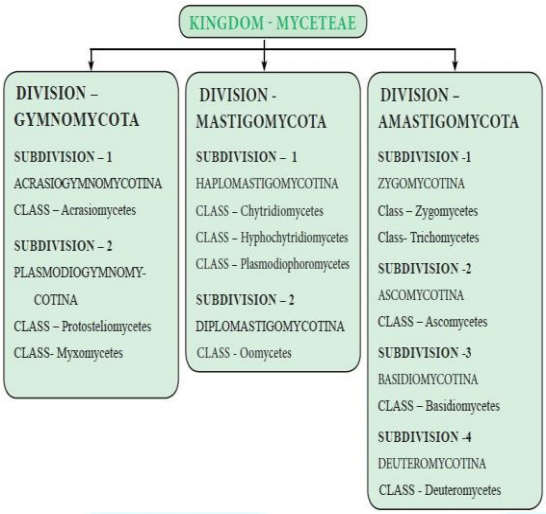
MYCOLOGY

CLASSIFICATION OF FUNGI

1. ALEXOPOULOS AND MIMS CLASSIFICATION OF FUNGI – 1979



- C. J. Alexopoulos and C. W. Mims (1979) placed fungi and slime molds under the kingdom of their own, called Myceteae under the superkingdom Eukaryonta.
- The kingdom is divided into three divisions and further the divisions are divided into sub-division, class and form-class.

Kingdom. Myceteae (Fungi):

- Achlorophyllous, saprobic or parasitic organisms.
- With unicellular or more typically, filamentous soma (thallus),

- Usually surrounded by cell walls that characteristically consists of chitin and other complex carbohydrates, nutrition absorptive, except in the slime molds

(Division Gymno- mycota)

- It is phagotrophic.
- Propagation typically by means of spores produced by various types of sporophores.
- Asexual and sexual reproduction usually present.
- They divide the kingdom mycetae into three divisions namely:

1. Gymnomycota
2. Mastigomycota and
3. Amastigomycota

Division 1- Gymnomycota:

- Phagotrophic organisms with somatic structures devoid of cell walls.
- This division comprises two subdivisions.

a) Acrasiogymnomycotina and
b) Plasmodiogynomycotina.

Subdivision 1. Acrasiogymnomycotina

- It includes a single class Acrasiomycetes.
- Class 1. Acrasiomycetes
    - Lacks flagellated cells except for one species.
    - The class comprises two subclasses.

a) Acrasiomycetidae
b) Dictyosteliomycetidae

Subdivision 2. Plasmodiogymnomycotina

- It is divided into two classes:
  - Class 1 Protosteliomycetes
  - Class 2 Mycomycetes
- It includes the true slime mould and comprises three sub classes namely:

  - Sub class 1. Ceratiomyxomycomycetidae
    - Order – Ceratiomyxales
  - Sub Class 2. Mycogasteomycetidae

    It comprises four orders.

1. Liceales
2. Echinosteleales
3. Trichlales
4. Physarales

Sub Class 3. Stemonitomycetidae

Order 1. Stemonitales

Division 2. Mastigomycota

Fungi with

- Centrioles.
- Flagellate cells typically produced during the life cycle.

- Nutrition typically absorptive.
- varying from unicellular that becomes converted into a sporangium, to an extensive, filamentous, coenocytic mycelium.
- Asexual reproduction typically by zoospores.
- Sexual reproduction by various means.

Sub division 1 Haplomastigomycotina

- Includes fungi with uni-orbi-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.

Sub division 2. Diplomastigomycotima

- Sexual reproduction ooagamous, zoospores biflagellate.
- **Class 1 Oomycetes** – It comprises four orders:
  - Order 1 Lagenidiales
  - Order 2 Saprolegnailes
  - Order 3. Leptomitales
  - Order 4. Peronosporale

Division 3- Amastigomycota

- Fungi without centriole,

- No motile cells.
- Nutrition absorp¬tive.
- Single-celled to mycelial with a limited or extensive, septate or aseptate mycelium.
- Asexual reproduction by budding, fragmen¬tation, sporangiospores or conidia.
- Sexual reproduction, where known by various means; haplobiontic-haploid life cycle with zygotic meiosis.
- This includes four sub divisions.
  - Sub division 1 Zygomycotina
  - Class 1 Zygomycetes – it includes six orders.
  - Class 2 Trichomycetes – it comprises five orders.
  - Sub division 2- 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

Sub division 3- Basidiomycotina

- Septate mycelium,
- produces basidiospores exogenously on various types of basidia.

Class 1 Basidiomycetes: it is split into 3 sub clases:

Sub class 1 Holobasidiomycetidae

Sub class 2 Phragmobasidiomycetidae

Sub class 3 Teliomycetidae

Sub division 4-Deuteromycotina

- It includes imperfect fungi in which sexual stage is unknown.
- It comprises a single form class.
- Form Class Deuteromycetes with three form sub classes namely

a) Blastomycetidae,
b) Coelomycetidae and
c) Hyphomycetidae

2. AINSWORTH & BISBY'S CLASSIFICATION OF FUNGI

- 7 Phyla
- 10 Subphyla
- 35 Classws
- 12 Subclasses
- 129 Orders

PHYLUM

1. **Chytridiomycota**

2. **Neocallimastigomycota**
3. **Blastocladiomycota**
4. **Microsporidia**
5. **Glomeromycota**
6. **Ascomycota**
7. **Basidiomycota**

Ainsworth & Bisby- 1971

Division- Gymnomycota

Division- Eumycota

Sub div- Mastigomycotina

Class- Oomycetes

Class- Chytridiomycetes

Sub div- Zygomycotina

Sub div- Ascomycotina

Sub div- Basidiomycotin

Sub div- Deuteromycotina

GENERAL FEATURES OF FUNGI

- Study fungi is known as mycology.
- The word mycology comes from the Greek word mykes which means "mushroom" and logos means "discourse".
- They are cosmopolitan in distribution.

NUTRITION OF FUNGI

- Fungi don't produce their food by own because they lack chlorophyll.
- Based on the type of source fungi are classified into 3 groups

1. **Saprotrophtic**

    - Saprotrophs get their nutrition from dead and decaying organic matter by releasing digestive enzymes which digest the substratum and then absorb nutrients.
    - Example: *Mucor, Agarious. Rhizopus* (bread mould) etc.

2. **Parasitic**

- Parasitic fungi get their nutrients from living cells.
- They can be facultative or obligate.
- They grow on the host cell surface and absorb nutrients through haustoria.
- e.g., *Ustilago, Pythium, Puccinia, Mucor, Erisphae*

3. **Symbiotic**

    - Fungi can be found in a mutualistic relationship with another organism, where both organisms are benefited.
    - Example: *lichens and mycorrhiza*.

ENTRI

THALLUS STRUCTURE OF FUNGI

- If both male and female gametes produce in the same individual can fertilize each other homothallic.
- On the other hand if the gametes can only be fertilized by gametes from another individual of the same species are known as heterothallic. Heterothallism is responsible for the variations in the species.
- There are present two types of thallus in fungi such as
    1. Unicellular Thallus
    2. Filamentous Thallus.

- Fungal plant body is known as Mycelium.
- It consists of network of long, slender, thread like structure called hyphae.
- Mycelium later forms the thallus.
- Hyphae may be septate (with cross wall) or aseptate (without cell wall).
- In aseptate condition hyphae will be multinucleated and is called coenocytic.
- The septate mycelium in its cell may contain only one (monokaryotic), two (dikaryotic) or many nuclei (multinucleate) with vacuolated protoplasm.
- In Basidiomycotina, except rust and smuts, the complicated type of pore with single opening is called **dolipore** (dolium, a large Jar or cash, i.e., barrel) septum.
- This dolipore septa was first described by **Royall Moore** and **James McAlear** in 1962.
- Dolipore septa have a barrel- shaped swelling around their centre pore. This structure is typically capped at either end by specialized membranes, called "parenthesomes" or simply "pore caps".

FUNGAL CELL WALL

- The most common cell wall material is chitin.

- But in some other fungi, cellulose or other glucans are present.

- According to **Aronson** (1965) and **Bartnicki-Garcia** (1970), the cell wall consists of about 80-90% polysaccharides along with proteins (1-15%) and lipids (2-10%).

- The composition of cell wall varies in different groups of fungi.

- These are cellulose- glycogen (Acrasiomycetes), cellulose-glucan (Oomycetes), cellulose-chitin (Hyphochytridiomycetes), chitin-chitosan (Zygomycetes), chitin- glucan (Chitridiomycetes, Asco-, Basidio- and Duteromycotina), mannan-glucan (Saccharo- mycetaceae and Cryptococcaceae), mannan- chitin (Sporobolomycetaceae), Polygalacto- samine-galactan (Trichomycetaceae).

HETEROTHALLISM

Morphological heterothallism

- Morphological heterothallism may be defined as the condition when morphologically different male and female sex organs are produced in two closely associated mycelia.

- The two sex organs or gametes are so morphologically different that it is easier to term one of them as male and the other as female-examples of such type of morphological heterothallic fungi are: *Achlya ambisexualis*, *A. bisexualis, Blastocladiella variabilis.*

Physiological Heterothallism:

- In physiological heterothallism, the interacting thalli differ in mating type or incompatibility, irrespective of the presence or absence of the sex organs or gametes.

- This means that sexual reproduction takes place by two morphologically similar but physiologically different hyphae in physiological heterothallism.

- The gametangia as well as gametes do not show morphological differentiation but physiologically they behave differently.

- The following types are observed:

(i) **Two-allelomorph**, e.g. *MucorMucedo, Ascobolusmagnificus, Sclerotinia Gladioli, Neurospora sitophila, Puccinia graminis.*

(ii) **Multiple-allelomorph:**

a. **Bipolar,** e.g. *Coprinus comatus.*

b. **Tetrapolar,** e.g. *Coprinus fimetarius*

REPRODUCTION IN FUNGI:

The fungi reproduces by all the three means:

- Vegetative,
- Asexual
- Sexual.

1. VEGETATIVE REPRODUCTION:

It takes place by the following ways:

(a) Fragmentation:

- It is common in filamentous fungi (*Rhizopus, Alternaria, Fusarium*) where the hyphae break up into two or more fragments due to some external force and each one develops into a new individual.

(b) Budding:

- It takes place in unicellular fungi (*Saccharomyces, Schizosaccharo- myces*).
- A small outgrowth, the bud emerges out from the parent cell.
- Nucleus divides into two and one passes to the bud.
- The bud is then separated by partition wall, but continues its growth.
- Later on, it breaks off from the mother and grows individually.
- Sometimes, the process repeats very fast and the buds remain attached with the mother in chain, that looks like mycelium, called pseudomycelium.

(c) Fission:

- Normally unicellular fungi (*Saccharomyces, Schizosaccharomyces*) reproduce by this method.
- In this vegetative cell elongates, and divides into two daughter cells of equal size by simple constriction in the middle with simultaneous nuclear division.

2. ASEXUAL REPRODUCTION:

- It takes place by means of several types of spore generally form during favourable condition.
- The spores may be unicellular (*Penicillium, Aspergillus*) or multicellular (*Fusarium, Helminthosporium*).
- They may be exogenous, developed on conidiophore (*Penicillium*) endogenous, developed in sporangium (*Mucor*) or pycnidium (*Ascochyta pisi*).

Some of the spores are:

(a) Zoospore:

The zoospores may be uni- or biflagellate, generally pear-shaped, produced in sporangium, e.g., *Synchytrium, Phytophthora*.

(b) Conidia:

These are exogenously produced non-motile spores develop by constriction at the end of specialised hyphal branches, called conidiophores. They may produce singly (*Phytophthora, Pythium*) or in chain (*Penicillium, Aspergillus*).

(c) Oidia:

In some fungi *(Mucor mucedo*), the hyphal tips often divide by transverse wall into large number of small segments, may remain in chain or becomes free from each other, these are known as oidia. The oidia on germination develop into new plants.

(d) Chlamydospore:

The chlamydospores are thick walled round to oval in outline, coloured brown or black. They produce either terminally or in intercalary at some intervals throughout the length of hyphae, e.g., *Fusarium*.

(e) Sporangiospores:

These are globose, multinucleate, non-motile aplanospores, formed inside the sporangium. The sporangiospore germinates by producing germ tube. Later on, it develops profusely branched mycelium.

SEXUAL REPRODUCTION:

It is the process of union between two compatible nuclei. The nuclei in some members are contributed by two well-organized gametes.

The whole process of sexual reproduction consists of three phases, in the sequence of plasmogamy, karyogany and meosis:

(i) **Plasmogamy**:

It involves the union of two protoplasts, brings two haploid nuclei close together in the same cell.

(ii) **Karyogamy**:

It involves the fusion of two haploid nuclei brought together during plasmogamy. This results in the forma¬tion of diploid nucleus i.e., zygote, which is ephemeral (short-lived).

(iii) **Meiosis**:

It follows karyogamy and reduce the number of chromosome from diploid zygote nucleus to original haploid number in the daughter nuclei.

The plasmogamy i.e., the first phase of sexual reproduction, differs in different fungi.

The different methods of plasmogamy are:

(a) Planogametic Copulation:

Planogametes are motile gametes. This process involves the fusion of two gametes, where either one or both are motile.

Depending on the structure and nature of gametes, it is of three types:

Isogamy, Anisogamy and Oogamy:

(i) Isogamy:

The uniting gametes are morphologically similar, but physiologically different. This process is common in primitive unicellular fungi, e.g., *Synchytrium*

(ii) Anisogamy:

Both the uniting gametes are morphologically similar, but different physiologically and in size. The smaller one is more active, considered as male and the larger less active one as female, e.g., Allomyces

(iii) Oogamy:

Both the uniting gametes are morphologically and physiologically different. The male gamate is smaller and motile, and the female gamete is larger and non-motile, e.g., *Monoblepharis*

(b) Gametangial Contact:

- The uniting gametes are present in different gametangium, thus the male and female gametangia are known as antheridium and Oogonium (Ascogonium in Ascomycotina), respectively.
- The gametes are never released from gametangium. Both the gametangia come in close contact and transfer male gamete to the egg through fertilization tube.
- The gametangia do not lose their identity, e.g., *Ascobolus, Pythium*

(c) Gametangial Copulation:

- The process involves the fusion of the entire content of the uniting gametangia.

Such fusion occurs in the following two ways:

(i) The two gametangia fuse by the dissolution of their common wall resulting into the formation of a single cell in which content of both the gametangia mix with each other and their morphological identity are completely lost, e.g., *Rhizopus, Mucor .*

(ii) The entire thallus acts as gametangium. Both the gametangia come in close contact and the male gametangium transfer its entire content to the female gametangium through the pore developed in contact area e.g., *Rhizophidium, Polyphagus.*

(d) Spermatisation:

- Certain fungi produce many unicellular non-motile, male cells, the spermatia.
- The spermatia are brought in contact by agents like wind, water and insect either to the trichogyne of the ascogonium or to somatic hyphae or even to special receptive hyphae.
- The wall at the point of contact dissolves and content of spermatia passes to the female organ, e.g., *Puccinia, Podospora*

(e) Somatogamy:

- In many higher fungi belonging to Asomycotina and Basidiomycotina, the development of gametes and gametangia are completely lacking.
- In such fungi, somatic hyphae anastomose with each other to bring together the compatible nuclei.
- It is regarded as a reduced and efficient form of sexuality, designated as somatogamy, e.g., *Polyporus, Agaricus, Morchella*

PARASEXUAL CYCLE IN FUNGI

• In some fungi, true sexual cycle comprising of nuclear fusion and meiosis is absent. These fungi derive the benefits of sexuality through a cycle known as Parasexual Cycle.

• The Parasexual Cycle is defined as a cycle in which plasmogamy, karyogamy and meiosis (haploidisation) take place but not at a specified time or at specified points in the life-cycle of an organ.

• Generally parasexual cycle occurs in those fungi in which true sexual cycle does not take place. The members of class Deuteromycetes (Deuteromycotina) in which sexual cycle does not occur, exhibit parasexual cycle generally.

• Parasexual cycle was first discovered by **Pontecarvo** and Roper of University of Glasgow in 1952 in *Aspergillus nidulans*, the imperfect stage of Emericella nidulans.

Steps Involved in Parasexual Cycle:

i) Formation of heterokaryotic mycelium

(ii) Fusion between two nuclei (Karyogamy)

(a) Fusion between like nuclei

(b) Fusion between unlike nuclei

(iii) Multiplication of diploid nuclei

(iv) Occasional Mitotic crossing over.

(v) Sorting out of diploid nuclei

(v) Occasional haploidisation of diploid nuclei, and

(vii) Sorting of new haploid strains.