Sub-Division: Zygomycotina

Members of the Zygomycotina take the name from the type of sexual reproduction that occurs in them.

Fungi here undergo sexual reproduction that involves the production of conjugating gametangia which leads to the production of zygospores / zygosporangia.

Asexual reproduction is by non-motile **aplanospores** contained in sporangia.

Sub-Division: Zygomycotina

- The spores maybe violently dispersed but in many species, the spores are passively dispersed by rain, wind or animals.

- Zygomycotina fungi are terrestrial, filamentous with coenocytic hyphae and chitinous cell wall.

- They are very invasive, ecologically diverse and of great economic importance.

- Members of this group include the organisms you find growing on your left over ‘eba’ and bread.

Classification of Zygomycotina

- The sub-division zygomycotina is polyphyletic and as such has been broken down into three groups of
  Glomeromycotina,
  Mucoramycotina and
  Microsporidia.

- The sub-division is divided into two classes which are: class Trichomycetes
  class Zygomycetes.

- Members of the trichomycetes have affinity with the guts of arthropods and they are studied under animal science.

- They are found growing commensally in the guts of animals like crustaceans, insects and millipedes.

Class: Zygomycetes

- Members of the class can be found in terrestrial moulds

- Existing in a wide range of habitats.

Distinctive features of the class zygomycetes

- The hyphae are composed mainly of chitin - chitosan and well developed mycelium.
- They completely lack motile cells in the life cycle.
- Chlamydospore formation is frequent.
- Asexual reproduction is by non-motile sporangiospores /aplanospores

Class zygomycetes (contd)

- Sexual reproduction is by gametangial copulation.
- The sexually produced zygospore has thick-wall and it is also a resting spore.
- The zygospore germinates to produce hyphae which form promycelium bearing terminal sporangia.

This class consists of two orders namely:

Order Mucorales and

Order Entomophthorales (parasitic on animals).

Order: Mucorales

- Members of the mucorales constitute the largest and most studied of the zygomycetes.
- They are sometimes called pin moulds because of the way the sporangium is positioned on the upright sporangiophore.
- They are generally fast growing saprophytes while a few are facultative parasites of plants and animals.
- They are commonly found in soil and dung (coprophilous fungi).
- In many genera numerous asexual spores are contained in a globose sporangium which surrounds a central core of columella.

Order: Mucorales (contd)

- Some members possess few spores which are usually dispersed as a unit termed 'SPORANGIOLA'. An example is found in *Thamnidium elegans.*

- Others may possess unicellular sporangia called CONIDIA (one-celled) as found in *Choanephora cucurbitarum* (Choanephoraceae)

- some members with no columella and the spores are termed MEROSPORES.

- These spores are arranged in rows inside a cylindrical sac termed MEROSPORANGIUM.

- Example of merosporangium is found in *Syncephalastrum rasemosum* (Piptocephalidaceae).

Sexual reproduction in order mucorales

- Sexual reproduction is by isogamous
- (identical gametes) gametangial conjugation in which equal gametangial derived from branched tips fuse to form thick-walled zygospores.
- The zygospores are resistance survival spores of the mucorales.
- Members of this group utilize a wide range of sugars.
- Although, starch can be decomposed by most spp, cellulose is not used by most members of the mucorales because they lack cellulose degrading enzymes.
- Under anaerobic conditions, ethanol and numerous organic acids can be produced by members in culture media.

Sexual reproduction in order mucorales (contd)

In 1961, Martin, W.W. divided the order into 9 families of:

- Family Mucoraceae e.g. *Mucor*
- Family Pilobolaceae e.g. *Pilobolus*
- Family Thamnidiaceae e.g. *Thamnidium*
- Family Cunninghamellaceae e.g. *Cunninghamella*
- Family Choanephoraceae e.g. *Choanephora*
- Family Piptocephalidaceae e.g. *Syncephalis*
- Family Kickxellaceae e.g. *Kickxella*
- Family Mortierellaceae e.g. *Mortierella*
- Family Endogonaceae e.g. *Endogone*

- Members of the family Endogonaceae have been identified as mycorrhizae fungi and they now belong to the Glomeromycota group.

Family: Mucoraceae

- Fungi in this family are saprobes that possess columellate sporangia with numerous spores which have thin-non persistence membrane.
- The spores are liberated by the breakage of the sporangial wall. The sporangiophores are erect with aerial hyphae.
- Members are abundant in soil, dung and moist fresh organic matters in contact with the soil.
- They occur in early succession on dung or soil substratum.
- Species like *Rhizopus stolonifer* causes spoilage of food stuff.
- Some are opportunistic in human suffering from diabetes, leukemia, cancer and immune-suppressed systems where they cause the fungal disease known as mucormycosis.

Family: Mucoraceae (contd)

- This can lead to lesions in the brain, lungs and the digestive system.
- M**o**rphologically, this group of fungi has coarse, coenocytic mycelium with numerous branches which usually end in fine tips.
- Septum may appear in older culture and thick-walled **chlamydospores** may be formed and cut off from the mycelium by such septa.
- Chlamydospores are survival structures for this group of fungi
- Members of this family include *Mucor, Rhizopus, Absidia, Actinomucor* and *Phycomyces*.

Asexual reproduction in family **Mucoraceae**

- This is by non-motile spores called aplanospores contained in spherical or pear-shaped sporangium which may be borne singly at the tip of an erect sporangiophore or it may occur on branched sporangiophores.
- The sporangiphores usually arise from the mycelium. In *Cunninghamella elegan* the sporangia may be arranged in whorl on aerial branches while in *Rhizopus* spp the sporangiophores arise in a group to form a clump of rhizoids.
- The sporangiophores of many species of *Phycomyces* and *Mucor are* phototrophic.
- *Phycomyces* have been extensively used in the study of phototrophism.

Sexual reproduction in family mucoraceae

- **Sexual Reproduction**
- A few members of the mucoraceae are homothalli producing zygospores in cultures derived from a single sporangiospore e.g. is *Rhizopus sexualis*. The majority of the mucoraceae are heterothalli requiring two opposite strains for zygospore formation. When two compatible strains (positive and negative strain) are inoculated in opposite sides of a solid culture medium, they grow towards each other and zygospores are produced where they meet. The diagram below gives a representation of sexual reproduction in mucoraceae.

Zygospore Formation in subdivision zygomycotina

The formation of zygospore follows several steps divided into three (3) main stages A-C.

Stage A = Zygophore Formation

- In this stage, aerial hyphae are induced to come together at their tips by trisporic acid which is produced in abundance in heterothalli species
- when the positive and negative strains are in contact. Trisporic acid assists in the identification of compatible sexual partner.
- It pulls two potentially compatible hyphae to grow towards each other.
- Club-shaped zygophores or protuberances containing β-carotene are produced at this stage.

Zygospore formation in subdivision Zygomycotina (contd)

Stage B = Zygotrophic reaction

- In the stage, the zygophore are directed to grow towards each other in response to a volatile chemical stimulus until they are in contact with each other at their tips.

Zygospore formation in subdivision Zygomycotina (contd)

- **Stage C = Thigmotrophic Reaction**

- This stage shows the events that occur after the positive and negative zygophores are in contact.
- The tip of each zygophore develops into a progametangium or gametangium proper and each become cut off by a septum to separate the multinucleate distant gametangium from the suspensor.
- After awhile, the wall separating the two gametangia breaks down and the cytoplasmic content fuses.
- The nuclei fuse to produce a diploid nucleus.
- The resulting zygote swells and develops a dark, thick, slimy outer layer.
- After resting for a period, the zygospore may germinate by producing a sporangiophore bearing a sporangium at its tip or may develop directly into mycelium.

Development of Sporangiophore in order mucoraceae

- In mucoraceae, a sporangiophore develops as a long, blunt-tipped aerial hypha growing from the mycelium away from the substratum.
- The tip expands to form the sporangia initial (the beginning of the sporangia).
- This is then cut off by a septum from a central spore free columella. The sporangial wall darkens and may develop a spiny surface.
- In many spp. of *Mucor* the sporangia wall dissolves and the spores absorb water, so that the tip of the sporangiophore bears a drop of liquid containing spores.
- This is termed ‘sporangial drop’ and it adheres to the columella.

Development of Sporangiophore in order mucoraceae (contd)

- The remnant of the sporangial wall can be seen as a frill at the base of the columella.
- In *Mucor mucedo* and *Phycomyces spp*., the spores are embedded in mucilage and when the sporangium is touched, a slimy content is exuded causing the sticky spores to be dispersed by insects or rain splash.
- In *M. plumbens*, the sporangial wall breaks into pieces and air current or mechanical agitation readily liberates the spores
- while in *R. stolonifer* the sporangium dries, the columella collapses and becomes inverted at the tip of the sporangiophore.
- The sporangial wall then breaks into fragments and dry spores become dispersed by wind.
- The sporangiospores germinate on fresh medium to produce mycelium with new crop of sporangiophores.