SUB-DIVISION: MASTIGOMYCOTINA

In the recent classification of fungi, members of this group have been reclassified into three major divisions of

- Chytridiomycota

- Neocallimastigomycota

- Blastocladiomycota

Characteristics: Sub-division Mastigomycotina

- Presence of coenocytic mycelium and reproduce by means of flagellated spores.
- These spores are termed ‘zoospores’ they are asexual and haploid.
- Members produce three distinct types of zoospores and show centric nuclear division.

- These zoospores are:

  zoospore with a single posterior flagellum that is the whiplash type

- zoospore with a single anterior flagellum that is the tinsel type

- zoospore which is bi-flagellated. This can be apically or laterally attached flagella.

  - one of the flagella is the whiplash type while the other is the tinsel type.

- The members of the third group may possess pear-shaped or kidney-shaped zoospore.

- Based on the type of flagellation, members of the Mastigomycotina are grouped into three classes :

  - Chytridiomycetes with whiplash flagellum

  - Hyphochytridiomycetes with tinsel flagellum

  -Oomycetes with bi-flagella of kidney or pear shape.

Class- Chytridiomycetes

- Fungi found in this class are called chytrids.
- The class consists of mostly aquatic fungi which reproduce by the production of a single posterior flagellum.
- Members are found in soil, fresh water, estuaries, saline.

Class- Chytridiomycetes (contd)

- They grow as saprophytes on plant and animal debris
- They can also grow as parasites in the cells of algae and small aquatic animals like zooplanktons.
- Some members may attack the underground part as well as the aerial parts of higher plants and cause diseases of economic significant
- Example include *Phyosderma maydis* causes brown spot disease of maize.

Class- Chytridiomycetes (contd)

The class consists of five orders which are:

- Order- Chytridiales
- Order- Monoblepharidiales
- Order- Spizellomycetales
- Order- Neocallimastigales
- Order- Blastocladiales

Order- Chytridiales

Members of this order either lack a vegetative system or possess a specialized rhizoidal vegetative system.

The zoospore usually has a single conspicuous oil globule flagellum and germination is mono-polar.

In this order, the morphology of the thallus varies.

Order- Chytridiales (contd)

Two types of thallus exist in the order:

- **Holocarpic**: It is a type of unicellular thallus whereby the whole vegetative structure is reproductive in function. A matured thallus is usually a spherical or cylindrical sac which is surrounded by a wall. There are no rhizoids and the entire cytoplasm is transformed into zoospores/gamete.

Order- Chytridiales (contd)

- **Eucarpic:** This type of thallus is differentiated into a vegetative rhizoidal part which is concerned with absorption of nutrient and a reproductive part which gives rise to zoospores or gametes.
- The vegetative parts are distinct from the reproductive parts.
- The relationship between the rhizoidal part, the sporangium and the substrate vary in different genera.
- Based on this, there are three types of eucarpic thallus.

Order- Chytridiales (contd)

- **Epibiotic:** The rhizoids here penetrate the host cell while the sporangium is superficial. The thallus is said to be epibiotic on the host.
- **Endobiotic:** In this type, the entire structure (sporangium and rhizoid) are formed within the host cell.
- **Polycentric:** In this type a complete system of sporangia develop at the tip of a complex rhizoidal system. This is represented in the diagram below where you see one of the sporangia dispersing the spores.

Reproduction in Chytridiales

- In this order, the sporangium usually bears one or more discharge tubes.
- This can either be **inoperculate** or **operculate** sporangium**.**
- Sporangia with the inoperculate thalli form a discharge tube that penetrates to the exterior of the host cell.
- This discharge tube becomes gelatinous and dissolves for the zoospores to escape.
- The tip of the discharge tube either cuts open at a special line of weakness, then becomes detached or one side of the tube opens causing the operculum to fall like a hinge to allow the zoospores to escape.
- The number of zoospores formed in a sporangium varies with the size of the zoospores.

Reproduction in Chytridiales contd

- The period of zoospore movement also vary, some flagellated zoospores swim while some seem to be incapable of active swimming so they assume amoeboid movement.
- In some, swimming may last for only a short period while others can swim for several hours.
- After awhile, the zoospores come to rest or encyst.
- During germination the flagellum maybe cut off.
- The behaviour of the encysted zoospores differs in different species.
- In holocarpic parasites where the zoospores encyst on the host cell, its wall and parts of the host cell become dissolved and the cytoplasmic content of the zoospores enter the host cell.
- However, the structure is different and varies in eucarpic organisms.

Class – Oomycetes

- This class is commonly called ‘white moulds’ or ‘white rust’.
- Most members are aquatic but a few are terrestrial.
- The cell wall lack chitin but some amount of cellulose is present however the chief component is glucans.
- Members possess zoospores with two flagella and the thallus varies in different genera.
- They usually reproduce both asexually and sexually through **oogamy**.
- Oogamy is a type of reproduction involving gametes whereby a small motile male cell fuses with a large female sessile cell.

Class – Oomycetes (contd)

- The gametes are the only haploid structure in the life cycle of members of this class.

There are four orders in this class namely:

Order: Lagenidales (inoperculate)

Order: Saprolegniales (operculate)

Order: Leptomitales (operculate)

Order: Peronosporales. (Operculate)

Order: Saprolegniales

- Fungi found in this order have either holocarpic thallus or eucarpic thallus.
- They are abundant in wet soil, lakes, marsh and fresh water as saprophytes on plant and animals debris.
- A few can be found in brackish water. Members are known to attack algae, other fungi, crayfish, zooplankton; they sometimes cause disease epidemics in zooplanktons.
- Some species of the genus *Saprolegnia* are predominately parasites of fish and fish eggs.
- A species of *Aphanomyces* causes root rot of peas.

Asexual Reproduction in order saprogeniales

- Two types of zoospores are found in some genera.
- The first type is usually the pear shaped type with apically attached flagella.
- This is often referred to as the primary zoospore.
- After swimming for sometimes, the zoospore encyst and withdraws the flagella.
- The cyst then germinates to produce the secondary type of zoospore which is the bean-shaped type with laterally attached flagella.
- This swims for a short period, encyst and germinates to form either another secondary zoospore or a germ-tube in which a filament or thallus develops.

Sexual Reproduction in order saprogeniales

- Sexual reproduction in saprolegniales is oogamous where the female reproductive organ is called **oogonium** and the male organ is called the **antheridium**.
- The oogonium is a large spherical and non-motile organ.
- It contains one to several eggs depending on the species.
- The unfertilized egg is termed oosphere whereas the fertilized egg is known as oospore.

- During reproduction, the antheridium produces branches which adhere themselves to the wall of the oogonium and penetrate through a fertilization tube.

Sexual Reproduction in order saprogeniales

- A single male nucleus then enters each egg and fertilization takes place.
- The oospore formed is a survival structure which grows, matures and become released from the oogonium.
- Under favourable environmental conditions, the oospore germinates to form a new fungus.

Order Peronosporales

- These are mostly terrestrial fungi, living in soil or on vascular plants as obligate parasites.

- The zoospores are laterally bi-flagellated and the zoosporangia are the parasitic forms which function as conidia.

- Many species cause the disease known as downy mildew which is of great economic importance.

- Example is late blight of potato, black spot of cocoa, downy mildew of grape vine.
- Some species are obligate parasites.

There are three families in this order namely:

- Family: Albuginaceae
- Family: Peronosporaceae
- Family: Pythiaceae

Family: Albuginaceae

- There are only one genus in this family with about 240 known species of obligate parasites of land plants especially crucifers.
- They cause the disease known as ‘white blisters’ or ‘white rust’.
- The disease is detected by the destruction of the stem and by the appearance of shinning white blisters on the leaves, stem and fruits before the host epidermis is ruptured.
- Dry pustules (fungi tissues) are exposed as the epidermis ruptures.
- The mycelia in host tissues are intercellular but at interval may send small spherical haustoria into the cells.

Family: Albuginaceae

- The intercellular mycelia aggregate beneath the host epidermis to form palisade of cylindrical sporangiophores.
- The sporangiophores bear one-cell conidia or sporangia in chains. These form white powdery masses and are dispersed by wind.
- If the sporangia fall on suitable host leaf, they germinate within a few hours in a film of water to form about eight bi-flagellated zoospores.
- After swimming for sometimes the zoospores encyst and later germinate to form germ-tubes which penetrate the host epidermis.
- A new set of sporangia maybe produced within ten days of germination.

Reproduction in Albuginaceae

- The oogonium of the genus *Albugo* grows in the intercellular spaces of the stem and leaves of the host.
- At first, both the oogonium and the antheridium are multinucleated but there is only one functional male and one functional female nucleus.
- After fusion of the male and female nuclei, a thin membrane first develops around the oospore.
- This is followed by several mitotic divisions resulting in as many as 32 nuclei in a matured oospore.
- A brown warty thick wall then develops around the oospore. The oospore germinates after a resting period to form a spherical thin-walled vesicle which maybe sessile or maybe suspended by a wide cylindrical tube.
- Later, 40-60 zoospores differentiate within the vesicle and are released as the vesicle ruptures.

Family: Peronosporaceae

- Generally, you are likely to find the obligate or biotrophic parasites of higher plants in this family.
- They cause the disease known as ‘downy mildews’.
- These organisms cannot be cultured easily in the laboratory but some have been grown on tissue cultures.
- The mycelia in the host tissues are coenocytic and they are found in the intercellular spaces of the living host cells.

Family: Peronosporaceae

- This group of organisms penetrates the host cells by means of haustoria.
- Sporangiophores are from the mycelia within the host tissue and go outside the host through the stomata bearing sporangia at the tips.
- The sporangia are dispersed by wind.
- A few species germinate by means of bi-flagellated zoospores while majority directly produce germ-tubes.
- Genera in this family include: *Peronospora, Plasmospora, Sclerospora* and *Bremia.*

Genus: *Peronospora*

- Members of this genus cause disease of high economic importance. For example *P. pisi* attacks peas;
- *P. destructor* attacks onion.
- A diseased plant is detected by the appearance of swollen distorted stems which bear white hair-like sporangiophores.
- They cause yellow patches on the upper surface of leaves while white sporangiophores protrude from the under surface.
- The sporangiophores usually emerge singly or in groups.
- They consist of a stout main axis which branches dichotomously to produce oval-shaped sporangia at the tip as the branches curve.

Genus: *Peronospora*

- The sporangia become detached as a result of hygroscopic twisting of the sporangiophore induced by changes in humidity.
- In reproduction, a thick wall oospore is formed after fertilization.
- Oospores of some species germinate directly but others produce zoospores.
- Some species are homothallic while others are heterothallic.
- In *P. parasitica,* when a sporangium falls on a suitable host, it germinates directly by means of germ-tube.
- The germ-tube then penetrates the host epidermal wall.
- This is seen in the diagram below where the conidiophore is emerging from the stoma and bearing conidia at the tip of its branches.

Family: Pythiaceae

- Members of this family are non-obligate parasites or saprophytes.
- The parasitic species can live as saprophytes while the saprophytic species can live as parasites.
- They include both aquatic and terrestrial species.
- Members produce conidiophores/sporangiophores that are not differentiated from the mycelium.
- For example, they may branch intermittently and resume growth after the production of conidium or sporangium either below or within the previous empty sporangium.
- The saprophytic members can grow on plant and animal remains while as parasites of plant and animals, they grow within the host tissues.
- Important genera in this family are *Pythium* and *Phytophthora*.

Genus: *Phytophthora*

- *Phytophthora* literally means a plant destroyer.
- Many species are parasites of flowering plants causing leaf blight and fruit diseases.
- An important example is *P. infestans* which causes Late blight of potato, a condition which resulted in an epidemic in Ireland in 1848.
- It consists of profusely branched, coenocytic, thick mycelia.
- Glucan is the chief component of the hyphae wall.

Formation of Haustoria in *Phytophthora*

- This forms both intercellular and intracellular hyphae.
- The intracellular hyphae emerge from the host cell into an intercellular space or directly into a neighbouring host cell.
- They both have similar ultra-structure. Haustoria develop on the intercellular hyphae when they come in contact with primary walls of the host mesophyll cells.
- The haustoria are variously shaped in this genus. For instance, in *P. infestans* they are small globes, occasionally short, straight or curved pegs.

Formation of Haustoria in *Phytophthora*

- There may be one or more haustoria in each host cell.
- The intracellular haustoria are connected to the intercellular hyphae by a neck-like constriction at the penetration site.
- Thus the long haustorial neck usually associated with this organ is lacking.
- The haustoria are more commonly found in the tubers. In severe cases of infection the entire plant above the ground is killed.

Asexual Reproduction in P*hytophthora*

- Under favourable conditions, aerial hyphae arise from the stoma of leaves or from the lenticels or injured portion of the tuber.
- These hyphae have indeterminate growth and are called sporangiophores (conidiophores).

- *Phytophthora* differ from other members of the family in having sporangiophores distinct from the somatic hyphae.
- Sporangium is then formed by the inflation of the tip of the side branch of the sporangiophores. This is then cut off by a transverse septum.
- The hyphal branch having the young terminal sporangium continues to grow.
- As it reaches maturity, the branched tip swells slightly and proliferates pushing the sporangium, this process may be repeated.
- Sporangia are then borne terminally and are subsequently shifted to a lateral position.

Asexual Reproduction in P*hytophthora*

- The sporangia are lightly attached and bear nodular swellings that show the point of detachment.
- The sporangia are dispersed by wind, rain splash or contact with other leaves.
- They may also be washed into the soil.
- Under favourable conditions of moisture and temperature they germinate after landing on healthy leaf of a host plant either indirectly by producing zoospores (12-15°C) thus functioning as zoosporangia or directly into germ-tubes (20-25°C) thus functioning as conidia.
- They lose their viability if they fail to germinate within a few hours.
- The librated zoospores swim for some time in a film of water, encyst and germinate to produce germ-tube.
- This grows over the epidermis of the leaf and produces appressorium at its tip which develops a fine tubular, peg-like outgrowth, this is the infection hypha that pierces the cuticle and penetrates the epidermis into the host tissue to cause infection.

Sexual Reproduction in *Phytophthora*

- Sexual reproduction in *Phytophthora* is oogamous.
- Some species are homothallic while some are heterothallic.
- All species in the genus are **monoecious** that is, the mycelium is capable of producing both antheridia and oogonia.
- The antheridium arises from a short lateral hypha from a mycelium with its tip inflated while the oogonium arises from a short, lateral hypha without an inflation of the tip.
- The antheridium and oogonium grow towards each other.
- When they come in contact, the oogonium penetrates the antheridium to the other side where it forms a globose structure.

Sexual Reproduction in *Phytophthora*

- The antheridium then forms a collar-like structure surrounding the base of the oogonium (amphigynous condition).
- There is only one functioning nucleus in the oogonium and one functioning nucleus in the antheridium.
- The antheridium forms a fertilization tube that penetrate the oogonial wall to transfer its nucleus, fertilization of the **oosphere** occurs thereafter.
- The fertilized egg secretes a thick wall around it and becomes an **oospore**. The oospore serves as a survival structure and increases with age. It germinates under favourable conditions after the decay of the host tissues.