Sub-Division: Basidiomycotina

- This group deals with fungi that produce their spores in a club-shaped fruit body.
- You can also call this sub-division the ‘club fungi’.
- Fungi here are characterized by bearing **Basidium**.
- The basidium is a sexually produced structure which is club-shaped and the basidiospores are externally borne on it.
- The spores in basidiomycotina are called **Basidiospores.**
- The basidium formed the fruiting structure called **Basidiocarp**.

Sub-Division: Basidiomycotina(contd)

- All members have microscopic basidium which usually borne 4 basidiospores on a short protuberance called **Sterigma** (pl. sterigmata).
- Some species may produce one basidiospores while like species of *Phallus* produce more than four basidiospores.
- Basidiomycotina are filamentous fungi and some reproduce asexually.
- You will find interesting fungi such as mushrooms, smuts, rusts, polypores, bracket fungi, earth stars and toad stools in the group.
- Some like mushrooms are saprophytic while some like rusts are parasitic fungi.

The vegetative phase of basidiomycotina

- The vegetative phase of basidiomycotina comprises dikaryotic phase (two nuclei in a cell).
- The hyphae are septate and there is the presence of dolipores (openings) on the septa.
- Members form **clamp connection** which helps to coordinate and re-establish pairs of compatible nuclei after mitotic nuclear division.
- After nuclei fusion in the basidium, four exogenous basidiospores are borne on sterigmata.
- Basidiospores are dispersed by hydrostatic pressure between the sterigma and the basidiospores on the basidium.
- When the basidium is cylindrical and undivided it is termed **Holobasidium/homobasidiomycetidae.**
- If the basidium is divided by a cross or longitudinal wall it is known as **Heterobasidium/phragmabasidiomycetidae.**

The vegetative phase of basidiomycotina(contd)

- These basidia have membranous wall, they are gelatinous and can produce secondary spores from the basidiospores while the basidia of Holobasidiomycetidae do not produce secondary spores but they form majority of the species.

- The mycelium of Basidiomycotina consists of a mass of branched, septate hyphae which usually spread in a fan-shaped form.

- It passes through three stages in the life cycle of a Basidiomycotina. These are the primary, secondary and tertiary stages.

- In the primary stage, a primary mycelium or homokaryon is formed. This arises by the germination of the basidiospores.

- When conditions for growth are favourable it develops to form uninucleate cells and constitutes the haplophase. It bears no sex organ, basidium nor basidiospores.

The vegetative phase of basidiomycotina(contd)

- It multiplies by conidia
- The cells of the secondary mycelium are bi-nucleate and represent the dikaryotic phase. This phase is independent, long live and plays important role in the life cycle of Basidiomycotina.
- The clamp connection develops at this stage

- The tertiary mycelium is formed by the differentiation of the specialized secondary mycelium. This forms the fruiting body and it is binucleate.

Classification of Basidiomycotina

- Formally, members of the Basidiomycotina being classified into classes and orders based on the morphology of basidium.

- This however was changed towards the end of the last century due to more biochemical, molecular, and ultra-structural evidences.

- The morphology of the Basidiocarp and basidium are the characteristics which are now being used in the classification of this group of fungi.

- There are three major classes in this group which are:

  Class Gasteromycetes
  Class Hymenomycetes
  Class Teliomycetes

Class: Gasteromycetes

- Literally, you call this group of fungi ‘stomach fungi’ because their basidiospores mature inside the basidiocarp and they are not dispersed forcefully from the basidia.

- They are holobasidiomycetidae (one-celled) in which the fertile portion is called **gleba** and enclosed in a **peridium**.

- The peridium is the outer covering of the basidiocarp that may consists of a single layer in some taxa and up to three layers in others.

- This class was recently regrouped with hymenomycetes under a new sub-division Agaricomycotina.

- This group of fungi however differs from class hymenomycetes in having symmetrically attached basidiospores on sterigmata instead of the asymmetrical situation in as hymenomycetes.

Class: Gasteromycetes (contd)

- The basidium opens into cavity within a fruit body and the basidiospores are released into this cavity by the collapse of the basidium.
- The basidiospores are dispersed as dust or in a slimy mass. In some cases, for example in the genus *Lycoperdon*, the fruit body opens by a pore through which the spores escape.
- In *Phallus*, the spores are exposed in a sticky mass and are dispersed by insects.
- Members are saprophytic growing on soil, rotten wood and on dung.
- Some members form their fruit body underground. They include puffballs, bird's nest fungi and earthstars.
- There are 9 orders in this class, these include: Order Lycoperdales and order Phallales which we shall be discussing.

Order: Lycoperdales

- You will find all puffballs and some earthstars in this order and they are recognized by producing globose pear-shaped or ovoid fleshy basidiocarps which may be sessile or have stalk-like base.

- In the common earthstar fungi called *Gaestrum*, the matured fruit bodies are found on the surface of soil.
- Some genera in this order include *Lycoperdon, Calvatia, Bovista*.

- These are the common puffballs that grow on tree stump, on decaying logs or on the ground.

- The fruit bodies are pear-shaped and arise on mycelia cord.

- The longitudinal section of *L. pyriforme* shows that the fruit bodies are surrounded by two layers of peridium and as the fruit body expands, the outer layer (exoperidium) which is warty, spiny and granular wears off or cracks into numerous scales or wax while the inner (endoperidium) thinner, membranous layer, remains intact.

- The endoperidium has pores (ostioles) from where the spores are puffed when the surface of the basidiocarp ruptures.
- The tissue within the peridium is differentiated into a non-fertile portion which is the sub-gleba section that forms a columella and a fertile (upper part) portion that bears the gleba.
- The gleba tissue is spongy and contains numerous cavities lined by hymellae.
- The basidia line the cavity of gleba and bear 1-4 basidiospores that are symmetrically arranged on sterigmata of varying length.

Order: Phallales

- Most species in this order are saprobes on dead plant materials while some are mycorrhiza with trees and shrubs.
- Members of this order are the ones you call stinkhorns because of the nauseating odour that comes out of a matured basidiocarp.
- This odour is caused by the combination of some chemicals.
- The order is divided into five families based on the type of receptacle each possesses.
- For instance, the family Phallaceae have simple, column-like receptacle that bears the gleba on its outer surface near the top.
- Figure 12.2 is a representation of members of the order. The basidiospores of members are dispersed in a sticky mass attractive to insects.
- Figure 12.4: *Phallus* sp showing rigid cap/pileus. (Source: www.google)
- In some species, a young stinkhorn is a whitish, egg-shaped structure that may be as large as a hen's egg.
- Conspicuous rhizomorphs can be noticed at the base of the basidiocarp and this extends into the substrate.
- Development of the parts of the fungus takes place in the egg which is surrounded by three layers of peridium.
- The structure of the receptacle varies and the family Phallaceae is differentiated into genera based on this. For example, in *Phallus* the receptacle is thick and spongy with rigid pileus that bears the gleba on its outer surface.

Class: Hymenomycetes

- In this session you shall be learning about the largest class in the sub-division basidiomycotina.
- You will find most of the edible well known macro fungi such as mushroom, boletes, earth star, bunts, toad stool, bracket fungi and polypore in this class.
- Here, the basidiocarp (fruit body) is well developed with basidium arranged in a hymenial layer that becomes exposed at maturity.
- Basidiospores are not violently discharge but are liberated by the collapse of the basidium and vivaciously dispersed as dust or in a slimy mass.
- Basically, fungi in this group can be differentiated on the bases of the disparity of the basidiocarp.

Orders found in hymenomycetes

- This class is divided into two sub-classes on the bases of the structure of the basidium.

These are

Phragmobasidiomycetidae

Holobasidiomycetidae.

- **The sub class phragmobasidiomycetidae** contain phragmobasidia with cross-wall and they are also called heterobasidia while Holobasidiomycetidae have holobasidia that is to say they are without cross-wall.
- **Sub-Class: Holobasidiomycetidae**
- This group has the following orders:
- Order Agaricales
- Order Aphyllophorales (polyporales)
- Order Dacrymycetales (Dacrymycetes)

Order: Aphyllophorales (Polyporales)

- This order is characterized by the production of a single-celled club-shaped Holobasidium.
- The fruiting structure does not develop within a universal vein, they are exposed.
- That is, it is not enclosed by the vein of the basidiocarp even when the basidiospores are immature.

The polypore resembles mushroom but are hard and tough.
They also possess leathery, corky, and woody basidiocarps.
Members consist of three types of hyphae which are:

(1) Generative hyphae
(2) Skeletal hyphae
(3) Binding hyphae.

- The hymenium of members is usually lined by tubes which open into the exterior by means of pores. For this reason, they are known as polypores.
- Sometimes the openings have spines or branching gills or anatomizing gills. Sometimes, the gills may have smooth surfaces.
- You will find the bracket fungi, tooth fungi and coralloid fungi in this group.
- There are nine families in this order but we shall only be discussing family polyporaceae.
- Figure 13.1: Polypore of *Ganoderma lucidum* (Source: http://mycorance.free)

Family: Polyporaceae

- There are about 1000 species of fungi in this family.
- Members are known as pore fungi and they are of economic importance because many of them are pathogenic and decomposers of wood and trees.
- The pores of fungi in this group may be circular, angular or elongated.
- The basidiocarp in some species is composed mainly of generative hyphae.
- Polypores are essentially wood rotting fungi or destroyer of timbers while some are found growing in the soil. For instance, *Coriolus vesicolor* is a common saprophyte on hardwood stumps and log where it causes white rot.
- The mycelium and fruiting bodies are resistant to desiccation.
- The fruit body has a zone of velvety upper surface that rarely absorbs rain. *Fomes annosus* causes heart rot and bark rot of conifer or coniferous trees.
- The fruit bodies are formed at the base of the stalk.
- They are identified by their brown-orange colour with white margins.
- They have dimitic type of hyphal system which is composed of the generative and the skeletal/binding hyphae. Genera in this family include *Fomes* (shelf fungi) and *Polyporus*.

Genus: *Polyporus*

- Fungi in this genus have inconspicuous and subterranean mycelia which are formed by the germination of the basidiospores.
- They first grow on the soil near the host but later attack the root and grow beneath the bark of the tree.
- Members all grow parasitically on the roots, trunk and branches of tree. They cause brown wood rot of various forest and shade trees. The cells of the primary mycelium are uninucleate and later become binucleate as a result of hyphal fusion.
- The dikaryotic/binucleate cells then elongate and divide by clamp connection to form dikaryotic mycelia.
- As these mature, they form complete thick hyphae around the central woody cylinder.
- They secrete enzymes to degrade the lignified walls of the wood cells.
- The basidiocarp of this genus develops from the dikaryotic mycelium. *P. betulinus* is a destructive parasite of many conifers but its fructification is used for the manufacture of charcoal crayon. *Polyporus* are also used in the production of single celled proteins.
- Figure 13.2: *Polyporus squamosus*. (Source: http://en.wikipedia.org)
-

Structure of the Member of Polyporaceae

- **Generative Hyphae:** These produce the basidium, the skeletal and binding hyphae. They are thin walled and make up most of the basidiocarp. They are usually un-branched and have distinct cytoplasmic content which are present in all polypore fruiting bodies.

- **Skeletal Hyphae:** These are un-branched, thick walled hyphae with a narrow hymenium. They arise as lateral branches of the generative hyphae and form rigid walls.

- **Binding Hyphae:** These are much branched, narrow and thick-walled of limited growth. They tend to weave themselves between the two other kinds of hyphae.

- When you have the three hyphae in a genus, it is termed *Trimitic*, e.g. is found in *Coriolus vesicolor.* When only two types are present, it is *Dimitic* e.g. is found in *Latiporus sulphureus* (generative and binding hyphae). If the generative hypha is the only hyphae present, the genus is termed *Monomitic*. In heterobasidium like *F. annosus* only the generative and skeletal hyphae are present. The longitudinal section of the fruit body presents the hymenium in a circular form.
-

Order: Agaricales

- This is order that you commonly refer to as mushroom and toad stool.
- Members are mostly saprophytic and they play major roles in the decomposition of food, dung, compost, wood, land and grassland litters.
- A few are parasitic (facultative).
- Many species form mycorrhizal association with forest trees. As saprophytes they are involved in the decomposition of the two more abundant carbon sources on earth- cellulose and lignin thereby releasing the nutrients locked up in wood and leaves to the earth.
- Some species are edible while some are poisonous.
- Currently, there are about twenty-three families in the order Agaricales among which are:
- Family: Agaricaceae
  FamilyStrophariaceae
- Family: Amanitaceae
- FamilyHygrophoraceae
- Family: Coprinaceae
- FamilyTricholomataceae
- Family: Boletaceae
- Family: Cortinariaceae
- Family: Russulaceae
- FamilyConiophoraceae
- You shall only be studying three of the families in this study session.

Family: Boletaceae

- These are pore bearing fungi.
- Members have fleshy body and the hymenium may or may not be protected by a vein.
- The basidiocarps of most members are beautifully coloured and some are quite tasty.
- They resemble some gill bearing fungi.
- The lowest side of the thallus however have pore instead of lamella while the hymenium side is present inside the pores.
- Example is the species *Boletus edulis* (Figure 13.3) which is sometimes called 'the king of mushroom' because of its flavor and texture. Species of Boletaceae are ecto-mychorrhizals
-
- Figure 13.3: *Boletus edulis* showing the basidiocarp (Source: http://www.awl.ch)

Family: Strophariaceae

- Most members are characterized by yellow thallus. For example, *Stropharia semiglobata* is found on dung,
- Figure 13.4 gives a representation of this species. *S. aeruginosa* is bluish in colour with white scale and found in grass and woodlands.
- Other genera in this family include *Hypholoma*, *Pholiota*.

- Figure 13.4: *Stropharia semiglobata* (Source: http://mushroomhobby.com)

Family: Agaricaceae

- **Family: Agaricaceae** **Genus: *Agaricus***
- *Agaricus* are fleshy, edible and can be cultivated.
- They occur almost (all) over the world and their habitat is restricted to humid-moist wood, land, forest and bush.
- They can also occur in rich humus or on dead log.
- The *Agaricus* fungus is made up of two major parts;
- **Basidiocarp** (b) **Stipe.**
- The basidiocarp is composed of a cap often called pileus and lamellae (gills).
- The gills in turn bear the basidia on exposed hymenium.
- The young gills are white in colour but turn purple as they become mature.
- The stem which is also called the stipe is like a stalk that holds the basidiocarp. It is a thick fleshy, cylindrical structure that is pinkish-white in colouration.
- The stipe is usually broader and centrally holds the pileus in a proper position for spore dispersal.
- It bears a membranous ring called **annulus** and ends in a bulbous structure known as **volva**.
- It also transports nutrients and water from the mycelium to the pileus and gills.
- In species like *A. psailiota*, the annulus is free (can move up and down the stipe).
- Examples of *Agaricus* spp are shown in Figures 13.5 and 13.6 below. *Agaricus bisporus* is a white spored mushroom and it is commercially cultivated all over the world.

Life Cycle of *Agaricus*

- There are three phases in the life cycle of *Agaricus*
  - (1) Diploid phase
  - (2) Haploid phase
  - (3) Dikaryotic phase.
- Agaricus secondary or Dikaryotic mycelium
- Rhizomorphs
- Fructification (Sporophores)
- In the life cycle of *Agaricus,* you observe the reproduction taking place in the basidium. The basidium is formed by plasmogamy between mycelia from two different spores. Plasmogamy results in binucleate hypha. In the gills of the fruit body, some cells undergo fusion by these two nuclei. The diploid cell formed becomes the basidium and it is diploid phase short lived. Later meiosis occurs resulting in four haploid nuclei. The nuclei migrate to the terminus of the basidium and form four independent projections which are then separated by cell walls to become spores. The figure below gives a graphical representation of the life cycle.

Internal Structure of the Sporocarp (Fruiting Body)

- Basidiocarps of this order are typically fleshy and have a stipe (stalk), pileus (cap) and lamellae (gills) where the basidia and basidiospores are borne.

- The **sporophore** (the stalk that bears the sporocarp) consists of pseudoparenchymatous tissue which is made up of an aggregation of hyphae that are thin wall and karyotic.

- The fruiting body expands as a result of enlargement of cells which may form specialized tissue.

- In *Agaricus campestris* and *Coprinus cinercus* for instance, the stipe contains two types of cells; the wide enlarge and narrow thread-like cells.

- There are two main types of gills in this order; (a) Acqui-hymenium (b) Inacqui-hymenium. There is a central group of longitudinal hyphae called **Trama**.
- This is surrounded by layers of short cells called the sub-hymenial layer on which the hymenium consist both the basidia and sterile hyphae. This type of structure is formed in *A. campestris* (edible fungus).

Figure 13.8: A*garicus campestris* showing the various parts.
(Source: https://encrypted-tbn1.gstatic.com)

Class: Teliomycetes

- In this study session you shall be studying the basidiomycotina members that are predominantly parasites.
- Members of this class constitute the rust and smut fungi which cause diseases of higher angiosperms.
- All are terrestrial parasites of great economic importance. Fungi in this group do not have distinct male and female thalli.
- Normally, the haploid mycelia fuse through plasmogamy during reproduction.
- Teliomycetes is made up of two orders namely:
  - Order Ustilaginales and
  - Order Uredinales.

Order: Ustilaginales

- Members of the ustilaginales are also known as smut fungi.
- The smut fungi are parasitic on angiosperm and cause diseases of economic importance. They attack the flowers of members of the grass family (Poaceae).
- They are **necrotrophic** parasites; these are parasites that can also live as saprophytes. Infection of host by these organisms begins with the dikaryotic mycelium (teliospore) that penetrates host's surrounding.

Life Cycle of a Smut Fungi

- Each basidiospore is capable of budding to produce more basidiospores and this is known as the yeast phase.
- Many smut fungi are capable of a prolonged saprophytic growth but are incapable of infecting the host.
- However, in some **dimorphic** stages, it is the yeast phase that infects the host.
- Example is found in the genus *Filobasidiella* where basidia are formed on hyphae but the infectious stage is the anamorphic yeast named *Cryptococcus.*
- The basidiospores of smut fungi are **heterothalli** (having positive strain and negative strain).
- Each may germinate into a hyphae and each of these hyphae (positive and negative) can fuse to produce a dikaryotic mycelium. The dikaryotic mycelium grows to produce a mature teliospore.
- **Box 14.1 Examples of smut diseases in some plants**
- Corn smut is the name of the disease when *Ustilago zeae/ U. maydis* attack Maize (*Zea mays*).
- Oat smut is the name of the disease when *U. avenae* attack Oat (*Avena sativa*).
- Loose smut of wheat is the name given when Wheat (*Triticum aestivum*) is attaked by *U. tritici.*

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Smut of maize

- The smut of corn/maize is caused by *Ustilago maydis* which exists as seed borne diseases.
- The pathogen affects maize seed which may look normal and appear apparently healthy.
- The **propagules** of the fungus may be growing as saprophytes in the soil or on corn straws from the last cropping season and resume growth on planted seeds.
- As the seeds germinate, the mycelia will grow as the plants grow.
- The mycelia later colonize the meristematic regions of the plant and also obtain its food from the crop.
- These activities of the fungal mycelia result in a stunt growth of the plant. As the plant flowers, the mycelia will colonize the floral parts and replace most of the floral tissues.
- These eventually produce masses of teliospores which will cover the entire floral region.
- These teliospores are black and sooty. They are responsible for the characteristic black and sooty symptoms associated with smut disease.
- However, smut disease of maize can be prevented in the following ways:
    - The planting of resistant varieties.
    - The use of hot water treatment on seeds before dispersing or sowing.
    - Some fungicides can be used but the seeds must also be allowed to dry before dispersing.
    - The use of crop rotation system can be encouraged. This is done by completely removing formal plant debris

Order: Uredinales (Rust)

- Fungi in Uredinales were recently reclassified as Pucciniales due to rDNA sequence analysis.
- They are also called ‘rust fungi’. They are called rust fungi because they cause disease known as ‘rust’ in higher plants.
- Rusts are the reddish-brown or brick-red patches on the leaves of infected plants.
- They destroy the photosynthetic tissues of the leaves thus resulting in the reduction in the quantity of starch produced by the leaves during photosynthesis.
- Rusts are **biotrophic** parasites (they are difficult to culture outside living host).
- May rust have complex life cycle involving five distinct types of spore on two different host plants in two unrelated host families.
- However, modification can occur in which one or more of the stages is/are lacking.
- The fungus which produces all the five spore stages is said to be **Macrocyclic**. Different names have been given to each spore stage and the fustles on which they occur. The spore stages are designated in Roman numeral for convenience.