INTRODUCTION TO FUNGI

- **Fungi** are non-chlorophyllous eukaryotic organism that inhabit almost every niche in the environment.

- They are studied in botany because they have rigid cell wall like the chlorophyllous plants.

- **Fungus** is the singular term for fungi.

- They include the unicellular yeast you find on freshly tapped palm wine and the multicellular fungi that attack your farm produce like the *Aspergillus flavus* that grows on maize ear.

INTRODUCTION TO FUNGI (contd)

- Fungi are multinucleated that is, a single cell of a fungus can consist of two or more nuclei.

- The Fungal group is a polyphyletic group which is a group of organisms that do not possess a common ancestor.

General Characteristics of fungi

- Fungi are eukaryotic organisms
- Fungi have rigid cell wall therefore they are non-motile.
- The cell wall is made up mainly of chitin which maybe layered with glucans, mannans and other polysaccharides.
- They live as **saprophytes** or as **parasites**.
- Saprophytes are organisms that grow on dead organic matters. For example *Mucor* spp.

General Characteristics of fungi (contd)

- **Parasite** is an organism that grows on/in living organisms and obtain their food from them, for example *Pythium* spp.

- As parasite, they can be **obligate parasite** or **facultative parasite.**

- Obligate parasites live the entire life cycle as parasites, they live and die with the host while

- facultative parasites are opportunistic fungi that live as saprophytes when the conditions (environmental and nutrition) are conducive and as parasite when the condition is/are not conducive.

Basic Characteristics of Fungi

- They are **chemoheterotrophs** that is, they require organic compounds for both carbon and energy sources for growth and other metabolic activities.

- Fungi have extracellular digestion. They obtain their nutrients by absorption after secreting enzymes to externally digest the food particles.

- They reproduce asexually and/or sexually by producing spores. Currently only those organisms that produce non-motile spores and gametes are classified as fungi.

Basic Characteristics of Fungi (contd)

- Food storage in fungi is in form of lipids and glycogen.
- They have indefinite shapes and size.
- The body of a fungus is a mycelium made out of a web of tiny thread-like structures called hyphae.
- Fungi are cosmopolitans, that is, they can be found anywhere you can think of.

Mode of identifying fungi

- Use of cultural characteristics that is, the morphology where the spores, shape, colour are used.

- Source of nutrient (physiological test) whether carbon or nitrogen source.

- The use of microscopic characteristics which involves the use of the fruiting structure.

Mode of identifying fungi (contd)

- Fungi may have similar morphological characteristics but different microscopic characteristics. For example the fruiting structures of *Mucor* and *Rhizopus*

- Use of molecular identification.

Economic importance of fungi

- Some fungi are edible. Examples are mushrooms like *Agaricus camprestis*, *Lycoperdon* spp.

- Fungi cause diseases in human like aspergillosis disease of the lung caused by *Aspergillus flavus*, meningitis and brain tumor caused by *Cryptococcus neoformans*

- Fungi such as *Leptolegnia caudate* and some species of *Aphanomyces* are used to trap mosquito larvae in paddy fields thus helping in malaria control.

Economic importance of fungi (contd)

- They are important in decomposition of organic matters. Example is *Humicola lanuginosa* used in sewage degradation.

- Some fungi cause diseases of plants therefore creating a great economic loss.

- Some fungi including *Aspergillus* spp and yeasts produce vitamins such as ascorbic acid, riboflavin, β-carotene which are essential to man.

Economic importance of fungi (contd)

- Fungi are important commercially, for example *Saccharomyces* production of wine, beer and bread
- In the control of pest like insects many fungi such as *Aschemonia deyroide* and *Isaria ferinosa* help in controlling the infection of plant.

- Many saprophytic fungi cause spoilage of leather goods, wood, books, timber; examples include *Rhizopus stolonifer* and *Aspergillus flavus*.

Classification of fungi

The kingdom fungi is divided into two division

- Division Myxomycota (false fungi)
- Division Eumycota(True fungi)

Classification of fungi

The division Eumycota is divided into five subdivision namely

- Ascomycotina
- Mastigomycotina
- Zygomycotina
- Basidiomycotina
- Deuteromycotina

Classification of fungi (contd)

Fungal classification follows the hierarchical system of classifying a plant.

Kingdom - Fungi

Division – Myxo**mycota**/Eu**mycota**

Sub-division – Mastigomycotina

Class – Chytridio**mycetes**/ Hyphomy**cetes**

Order – Chytridi**ales**/ Eurotia**les**

Family – Saprolegni**aceae**/Peronospor**aceae**

Genus – Saprolegnia /Peronospora

Morphology of Fungi

- The **thallus** which is the body of a filamentous fungus is made up of a network of fine thread-like structures called **hyphae**.

- These can be found growing on/in suitable substratum.

- The filamentous fungi can be **septate** or **non-septate**.

Morphology of Fungi (contd)

- When the thallus is segmented you say the fungus is septate and

- when not segmented you either say such a fungus is non-septate or coenocytic.

- Fungi can be unicellular (one-celled) or multicellular (multiple-celled organisms).

Vegetative (Somatic) Phase of Fungi

- The vegetative phase of a fungus is a thallus**.**
- Thallus is the body of an organism that is not differentiated into leaves, stem and roots.
- This may be unicellular or filamentous.

Unicellular Thallus

There are two forms of unicellular fungi; these are the

- Yeast
- yeast-like fungi.

- The yeast is more or less a spherical, single-celled structure that becomes a reproductive unit at the stage of reproduction.

Unicellular Thallus (contd)

- It can produce both asexual and sexual cells.
- In the lower fungi group a fungus with this type of thallus is said to be holocarpic.
- Mycelium is absent in this type of thallus. Examples include *Synchytrium* and yeasts.

Filamentous Thallus

- Fungus with filamentous thallus is commonly called a mould.

- There are two groups of fungi with this type of morphology.

- One which is purely filamentous e.g. *Aspergillus niger* and the other which is **dimorphic.**

Filamentous Thallus

- A dimorphic fungus exists in two different morphological forms at two different environmental conditions.
- The filamentous thallus is a long strand of cells joined head to head
- . In some species, after germination the spores produce a short, tubular structure of limited growth called a hypha.

Filamentous Thallus

- Collectively, the hyphae make up the **mycelium** and this grows on substratum (medium)**.**
- It consists of a thin, transparent wall filled or lined with a layer of cytoplasm

Lifecycle of a fungus

- In the life cycle of a fungus,

- the mycelium obtains food from the substratum and it also carries out the general activities of a plant cell such as absorption, digestion, respiration, excretion and growth.

- The hyphae exhibit apical growth and spread in all directions within and over the substratum to form a loose and ramifying network.

- The hyphae in some group form various colourations when they are matured or during reproduction and these can be modified to serve various purposes.

Kinds of Mycelium

- The mycelium can be septate or non-septate. Septate
- They may be uninucleate or multinucleate; transverse/longitudinal/oblique.
- The non septate mycelium lacks internal partitioning and the mycelium is a continuous mass.

Modification of Hyphae

Some of these modifications include:

- Plectenchyma: This is a false tissue formed by aggregation of hyphae. There are two types of plectenchyma which are:

➢ Prosenchyma

➢ Pseudoparenchyma:

Modification of Hyphae (contd)

- Rhizomorph
- Sclerotium
- Stromata
- Pseudosclerotium
- Appressorium
- Haustorium

Reproductive Phase of Fungi

There are three kinds of reproduction in fungi these include:

- Vegetative
- asexual
- sexual.

They all vary from one group of fungi to the other.

Types of plasmodium

In some fungi the vegetative phase consists of a naked, multi-nucleate, amoeboid mass of protoplasm called **plasmodium.**

There are three types of plasmodium namely:

- Protoplasmodium
- Aphanoplasmodium
- Phaneroplasmodium

Sporangium of a fungus

- The sporangium (pl. sporangia) is a type of fruiting structure that houses the spore.

- It can be liken to a covered cup

- This is usually formed at the tip of the hyphae. Sporangia
- The spores are formed in the presence of light on the surface of substratum based on species.

Type of sporagium in a fungus

There are four types of sporangium namely:

- Simple multi-sporous sporangium
- Simple monosporous sporangium
- Plasmodiocarp
- Phaneroplasmodium

Aethalium

- An aethalium is a sporangium formed as a result of the aggregation of the entire plasmodium into a single sporangial initial.

- Aethalia are large, sessile, spherical or hemi-spherical and covered by peridia.

- They are compound sporangia.

Division: Eumycota

- **Introduction**
- members of this division the ‘true fungi’.

- It is a group of fungi that possess cell wall which is made up of chitin.

- The lower forms of fungi in this division have **holocarpic** thallus while the higher forms have **eucarpic** thallus.

SUBDIVISION OF FUNGI

There are five sub-divisions in Eumycota namely:

- Ascomycotina
- Zygomycotina
- Mastigomycotina
- Deuteromycotina
- Basidiomycotina

SUBDIVISION: ASCOMYCOTINA

- Members of the ascomycotina are commonly known as ‘sac fungi’.
- This is because they have a sac-like fruiting structure called **ascus**.
- The ascus is the sexual reproductive structure which houses the ascospores (spores).
- It is a special type of sporangium.
- This typically contains 4-8 ascospores which are usually violently discharged.

SUBDIVISION: ASCOMYCOTINA

- Ascomycotina is the largest group of fungi .
- They are found in fresh water, marine, dung and soil as saprophytes.
- A few are parasites of plants and animals.
- Many are of great economic importance for food, industrial uses and causal agents' of plant and animal diseases.
- Antibiotics and many more useful chemicals are actually produced by members of this sub division as metabolic products

Reproduction in ascomycotina

- The vegetative structure of members of this group consists single cells such as found in yeast
- and septate filaments as found in *Penicillium*.
- The septa of the filamentous members are perforated to allow continuous flow of protoplasmic content.
- The mycelia cell may contain several nuclei of more than one genotype and it is therefore said to be **heterocaryotic**.

Fruiting structure of ascomycotina

- Members of ascomycotina may be homothalli or heterothalli.
- Some form sexual organs.
- The female sexual organ is called ascogonium
- while the male organ is called the antheridium.

Fruiting structure of ascomycotina (contd)

- They may also form small unicellular body called spermatium
- However, many ascomycotina do not possess recognizable sex organs and fusion takes place between ordinary hyphae.
- After fertilization, the resultant asci maybe naked as in yeast or maybe surrounded by hyphae in form of a fruiting structure called **Ascocarp.**

Fruiting structure of ascomycotina (contd)

Ascocarp can be in different forms depending on the group of fungi. This can be as listed below:

- GYMNOTHECIUM.
- CLEISTOTHECIUM.
- PERITHECIUM
- APOTHECIUM
- PSEUDOTHECIUM

Formation of Ascus

- In many ascomycotina the ascus is formed by the Hook or **crozier** process (Crozier= a crook or bend).
- During sexual reproduction which involves an antheridium and an ascogonium borne on a single mycelium,
- the antheridium forms a bridge or tube known as trichogyne which connects to the
- ascogonium.
- The cellular content of the antheridium is emptied into the ascogonium through the bridge and the bridge dissolves at this stage.

Classification of Ascomycotina

Fungi found in ascomycotina are divided into six classes based on the presence or absence of Ascocarp and ascus . The classes are:

- Class Hemiascomycetes
- Class Loculoascomycetes
- Class Discomycetes
- Class Pyrenomycetes
- Class Plectomycetes
- Class Laboulbeniomycetes

Class: Discomycetes

- Fungi in this class have cup/saucer/disc shaped ascocarp which is called Apothecium.

- Based on the presence or absence of an operculum at the apex of the ascus members are grouped into two

  operculate

  inoperculate.

Class discomycetes

- The class discomycetes consists of four orders which are:

- Order Pezizales (operculate)
- Order Helotiales (inoperculate)
- Order Lecanorales (inoperculate)
- Order Phacidiales (inoperculate)

Order: Pezizales

- Members of this order are mostly terrestrial and some are coprophilous (dung loving).

- They are usually saprophytic while some are parasitic on plants yet some are mycorrhizals.

- Examples of fungi found here include genera like *Peziza, Ascobolus. Genus Ascobolus*
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- There are about 65 species in this genus.

- Most are coprophilous growing on herbivore dung. For example *A. furfuraceus* and *A. immerses* are common on cow dung and they are heterothalli.

Class: Pyrenomycetes

- This class includes one of the most studied fungi in nature.

- Fungi in this class are known by the presence of the ascocarp called perithecium

- This is a flask-shaped sac with an ostiole lined by periphyses and uninucleate asci.

Classification of Pyrenomycetes

- This class consists of a single order Sphaerales which has about 15 families that include:

- Clavicipitaceae e.g. *Claviceps, Cordyceps*
- Hypocraceae e.g. *Hypocrea, Nectria, Gibberella*
- Melanosporiacae e.g. *Chaetorium*
- Ophiostomataceae e.g. *Ceratocystis, Ophiostoma*
- Sordariaceae e.g. *Sordaria, Neurospora, Podospora*
- Sphaeraceae e.g. *Sphaera,*
- Xylariaceae e.g. *Xylaria, Daldinia*
- Glomerellaceae e.g. *Glomerella*
- Plectosphaerellaceae e.g. *Plectosphaerella*
- Diaporthaceae e.g. *Diaporthe*
- Magnaprothaceae e.g. *Magnaporthe*

Family: Clavicipitaceae

- The perithecium in this family develops on fleshy stroma.
- The asci have thick apical caps with long and narrow ascospores.
- The ascospores escape singly through a narrow core in the ascocarp.
- Some species are parasitic on grasses or insects while some are endophytes of plants.

Genus: *Claviceps*

- There are about 40 known species
- Examples of this genus includes *C. sorghi* and *C. Africana* which causes ergot of sorghum
- But the most common of this genus is called *C. purpurea*.
- This fungus is found in temperate regions
- it causes the disease known as ergot on cereals and grasses.
- It consists of a wide range of host.

Development of Perithecium

- The ascogonium develops from vegetative hyphae or from special ascogenous cells.
- It forms a spherical mass of tissues called perithecia initial.
- The outer layer of the tissue differentiates into perithecial wall while the central portion develops into a mass of pseudoparenchymatous cells.

Class: Hemiascomycetes

- Members of this class include the organisms you find in freshly tapped palm
- They are also the baking yeast used in leavening bread, cake and some other confectionaries.
- Members of this class are yeast and yeast-like fungi without an ascocarp with simple thalli.
- This means that asci are borne naked on the surfaces of the substrate. The asci are formed singly or borne on ascogenous hyphae.
- They are economically very important group of organisms
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Orders found in Hemiascomycetes

There are three orders in this class:

- Order Taphrinales
- Order Endomycetales
- Order Protomycetales

Family: Saccharomycetaceae

- Fungi in this family are generally called **yeast.**
- Yeasts are unicellular non-mycelial fungi that do not form fruit bodies.
- Members of this family reproduce asexually by budding and produce zygote by fusion of two cells or develop parthenogenetically from a vegetative cell.
- Some yeast do not form ascospores and are called asporogenous yeast.

Family: Saccharomycetaceae(CONTD)

- They resemble the ascospore forming yeast called ascosporogenous or ascosporic yeasts.

- Yeasts are widely distributed especially on sugar containing substrates like ripe fruits.

- A few species of the family are parasitic on plants and animals. Examples include important genera like *Saccharomyces, Saccharomycodes, Pichia, Endomyces* and *Eremascus*.

Genus: *Saccharomyces*

- The thallus of members is non-mycelial and produces no hyphae.
- It consists of a single cell.

- The cells may be oval, spherical, elongated or cylindrical in shape of about 2 to 8 x 3 to 15 µm in size
- Members of this genus are naturally found on ripe fruits and in fresh palm wine.

Genus: *Saccharomyces (CONTD)*

- About 40 species of this genus have been successfully described.
- The best known species is *S. cerevisiae* which are used in the fermentation of beer, wine and in baking.
- Yeasts like all fungi are heterotrophic they secrete the enzymes known as zymase on substratum.
- The enzyme digests the complex sugar in the substratum into simple sugar which is absorbed as food through the cell membrane

Asexual Reproduction in yeast cell

- *Saccharomyces* usually reproduce asexually by budding.

- The vegetative cells are mostly diploid but some are polyploidy.

- During budding, a small portion of the cell wall near one pole of the yeast cell softens and thins.

Sexual Reproduction in yeast

- The diploid yeast can develop directly into asci within 12-14 hours.
- The cytoplasm differentiates into four thick-walled spherical spores.
- After which meiotic nuclear division occurs.
- The spores formed then become ascospores (haploid).
- If these ascospores are dispersed out and allowed to germinate, they form haploid buds that are smaller than the diploid yeast and such a structure can be maintained indefinitely in the haploid state.

Sexual Reproduction in yeast (contd)

These can be restored to the diploid state through one of three ways:

- By fusion of ascospores which comes from
- the breakdown of the wall separating ascospores.
- the formation of short conjugation tube between two ascospores to effect fusion of their content. Afterward, nuclear fusion occurs and the zygote develops diploid vegetative buds.
- By fusion of two haploid vegetative cells to become a diploid cell.
- By fusion of a haploid cell with an ascospore.

Classification of a yeast

- Kingdom: Fungi
- Division: Ascomycotina
- Class: Hemiascomycetes
- Order: Endomycetales
- Family: Endomycetaceae
- Genus: Schizosaccharomyces
- Species: *S. octosporus* (fission yeast)

Class: Plectomycetes

- Fungi in this class have globose and evanescent asci which are enclosed in rudimentary ascocarp.
- The ascocarps are invested in loose hyphae and are termed **cleistothecium**.
- The ascocarp is spherical and the asci are found scattered in it.
- The ascospores in this group are small and unicellular; they are passively released after the breakdown of the ascocarp.

Class: Plectomycetes (contd)

Majority of Plectomycetes are saprophytes and many produce antibiotic and mycotoxin are metabolic products.

There are four orders in this class:

- (i)Order Eurotiales
- (ii) Order Onygenales
- (iii) Order Microascales
- (iv) Order Erysiphales.

Order: Eurotiales

- majority almost on any decaying organic matters, in air, soil, water, indoor or on food stuff while a few are parasites of plants and animals.

- They are wide spread, abundant and include one of the most important groups of fungi.

- In this order, you will find fungi of great economic importance used in the production of antibiotics, commercial enzymes, organic acids and in fermentation.

- Some also cause spoilage of food, leather and textiles. They include genera like *Aspergillus, Penicillium*, *Gymnoascus, Petromyces*, and *Byssochlamys*.

Order: Eurotiales

- In the perfect/sexual state, the asci formed are scattered within the ascocarp and the ascospores are released in the cleistothecium by the dissolution of the ascus wall.

- The cleistothecium lacks ostiole and paraphysis.

- Asexually they reproduce by the production of conidia which are produced in large number.

- Several families are recognized in the order. Some like species of *Aspergillus* and *Penicillium* are **xerophilic** (capable of growing on substrates with low water potential).

Genus: *Aspergillus*

- The teleomorph or sexual state of this genus is called *Eurotium.*

- It is a genus of mainly saprophytic fungi which are widely distributed because of the vast number of enzymes they produce.

- Many species are known only in the conidia state which is the asexual stage.

- At maturity, you will notice various colours of the conidia and this gives the characteristic colour of the plate or substrate on which they grow.

Genus: *Aspergillus*

Some of the colour characteristics include:

- Green for *Aspergillus flavus*
- Black for *A. niger*
- Orange for *A. oryzae*

Genus: *Aspergillus*

- One of the distinguishing features of *Aspergillus* is the development of conidiophores from a segment of mycelium called **foot-cell**.
- The tip of the conidiophores swells to form a club-shaped or hemispherical vesicle
- The phialides may be formed directly on the vesicle or on a palisade of sterile cells called metulae.

Genus: *Aspergillus*

- Several conidia states of *Aspergillus* are known and some are of great economic importance.

- For instance, *A. niger* also known as 'black mould' remains the world's most important producer of citric acid and gluconic acid used in the industries.

- It is also considered as a laboratory weed because it causes contaminations of lab cultures. *A. oryzae* and *A. sojae* are used in the making of wine by the fermentation of rice and soybean.

- Many species are used in the production of amylases, lipases, proteases and pectinases which are of industrial importance.

Genus: *Eurotium* - a Perfect state of *Aspergillus*

- Members of this genus are found in the soil and on stored food materials.

- They are xerophilous fungi known to cause spoilage of food stuff and can become pest in museums and herbaria. For instance, *Eurotium repens* causes spoilage of fruits jams.

- In media with low sugar content about 20% sucrose, they develop yellow spherical ascocarps.

- These contain numerous asci surrounded by a single layer of yellow coloured peridium.

Genus: *Eurotium* - a Perfect state of *Aspergillus contd*

- When the ascocarps walls disintegrate the asci become exposed but ascospores are not discharge violently.

- They escape when the ascus wall breaks down. *E. repens* is homothallic and structures derived from the conidia state can produce a perfect state.

- *Emericella* is another perfect state of *Aspergillus* but the phialides of *Emericella* arise from special structures called metula.

- The ascocarps are surrounded by chains of thick cells called HÜLLE CELLS which are absent in *Eurotium*. While the ascospores of *Emericella* are reddish-purple with double equatorial band those of *Eurotium* are colonies with no ornament on the surfaces.

Genus: *Penicillium*

- This genus consists of one of the most common group of fungi that occur in the soil, air and on decaying materials.
- For instance, the contamination of a bacterium culture by *Penicillium notatum* led to the discovery of penicillin by Alexandra Flemings.
- However, today penicillin is being produced by *P. chrysogenum* because *P. notatum* no longer exist in name.
- Just as the *Aspergillus,* most *Penicillium* species are known only in the conidia or imperfect states.
- However, some species can produce sexual spores and have been given some other generic names such as *Eupenicillium* and *Talaromyces*.
- The conidiophores of *Penicillium* are usually septate, branching successively with whorl of branches which ends in cluster of phialides.

Genus: *Penicillium*

- The form of branching assists in the classification of the genus.
- Some species are said to be monoverticillate e.g. *P. spinulosum* where the phialides are borne directly on unbranched conidiophores.
- Some are bi-verticillate with phialides borne on branched conidiophores.
- The colour of *Penicillium* in cultures is usually light-blue (*P. chrysogenum* and *P. pinophilum*); yellow in *P. spinulosum*.
- *Penicillium* species like *P. roqueforti* are used in cheese production and some species also cause diseases in plants and animals. *P. digitatum* and *P. italicum* are well known pathogens of citrus fruits causing soft rot disease.

Reproduction in *Penicillium*

- *Penicillium* reproduces both asexually and sexually. However, the asexual state dominates and constitutes the usual mode of reproduction while the sexual state is rare.

- Asexual reproduction takes place by vegetative reproduction which occurs by fragmentation of the hyphae into short segments.

- Each segment grows into a whole mycelium. Some species form compact resting bodies-sclerotia. This enables the species to survive under unfavorable conditions.

Reproduction in *Penicillium(contd)*

- When the condition for growth is favourable, each sclerotium germinates into a mycelium.
- Non-motile asexual spores (conidia) are then formed exogenously at the tips of long, erect, septate hyphae, the conidiophores.
- After falling on suitable substratum, the conidium absorbs moisture and swells. This then germinates by producing germ-tube.

Order: Erysiphales

This is a monophyletic order consisting of obligate biotrophs parasites of plants.

The members of this order are also called '**powdery mildew'** because of the powdery appearance of the whitish conidiophores on the surfaces of the host.

They cannot be cultured outside a living tissue.

This order possess a completely closed spherical ascocarp that contains one or several asci depending on the genus.

Order: Erysiphales (contd)

This ascocarp is called cleistothecium and become dark when matured bearing external appendages which help to anchor the pathogen to the host and also in dispersal.

They produce airborne conidia and cause great economic damage to crop plants.

The ascospores are discharge violently from oval or club shaped asci and most species are hosts specific.

There is only a single family in this order which is Family Erysiphaceae.

Family: Erysiphaceae

- This powdery mildew is white and common in the leaves and fruits of angiosperms
- The mycelium usually produces superficial mycelia that are confined in the epidermal cell of the host.
- Conidia are produced in chains during asexual reproduction.
- Cleistothecium which are brown spherical, containing one to several asci may be formed in the sexual state.
- The teleomorph in this family to be more distinctive and diverse than the anamorphs.

Life cycle of Erysiphaceae

- In most powdery mildew, only the epidermal cells are attack.

- Infection of the host starts with sexual ascospores or asexual conidia which germinates from the surface of leaf or stem and results in septate mycelium with uninucleate cells.

- The mycelium extent outward the epidermal cell and gives rise to short, erect conidiophores which individually bear a single row of barrel shaped spores.

Life cycle of Erysiphaceae

- When the spores are matured, they become detached and are dispersed by wind.
- The cleistothecia are the resting stage of the fungus.
- The ascospores usually remain dormant through winter/dry season to germinate in spring/wet season.
- As the asci expand, they rupture the cleistothecia wall to release the ascospores into the air. They can be controlled by chemical as well as biological control measures.