CHAPTER 7

Subkingdom: Dikarya

Phylum: Ascomycota

(Sac fungi)

It is the largest group of fungi. They occur in a wide variety of habitats: in soil, dung, in marine and fresh water; as saprophytes of plants and animal remains; as animal and plant pathogens, or lichen forming.

Diagnostic feature:

1. Sexually produced spores (perfect spores) are borne in a sac or **ascus (from Greek: ἀσκός (askos), meaning "sac" or "wineskin")**, typically containing **eight spores** (**ascospores**) which are explosively ejected.
2. Some are Anamorphic fungi. They are assigned to Ascomycota based upon similarities in:
   a. some morphological and physiological characters
   b. phylogenetic comparisons of DNA sequences (Lutzoni, et al., 2004; James et al., 2006).
   c. **lamellate** hyphal walls with a **thin** electron-dense outer-layer and a relatively **thick** electron-transparent inner layer is another reason ((Fig.7.1.a)).
3. It is a monophyletic successful group of organisms.
4. Familiar examples are:
   a. morels, truffles, Baker's yeast, Dead Man's Fingers, cup fungi, and the majority of lichens (loosely termed "ascolichens") such as *Cladonia*.
   b. Many plant-pathogenic fungi e.g. apple scab, ergot, black knot, and the powdery mildews.
   c. popular in the laboratory e.g. *Sordaria fimicola*, *Neurospora crassa* and several species of yeasts are used in many genetics and cell biology experiments.
   d. *Penicillium* species on cheeses and in the antibiotic industry. Prior to definitive phylogenetic research, molds such as *Penicillium* were sometimes classified in an artificial phylum, called the *Deuteromycota*.

General characteristics:

1. Thallus: is either of **single cells** (as in yeasts) or separate **filaments**, each segment often containing several nuclei.
2. The **cell walls** of filamentous ascomycetes contain a **microfibrillar skeleton of chitin**, and other compounds such as other **amino-sugars**, **protein**, mannose and glucose.
   b. It is not functionally inert coating, but may contain surface enzymes.
   c. Electron micrographs show that **the septum** is **perforated** by a pore so that the cytoplasmic continuity between adjacent segments occurs (Fig.7.1.a)
   d. The pore is also wide enough to allow **mitochondria** and **nuclei** to pass through.
   e. septal pore associated with woronin bodies.

f. Woronin bodies (Fig. 7.1.b)

1. Membrane bound structures associated with the septum.
2. It is frequently plug the septal pores of hyphae.
3. It is a crystalline peroxisome

It helps in maintaining cellular integrity during hyphal growth and damage

3. Reproduction:

I. Asexual reproduction:

a. It is the dominant form of propagation in the Ascomycota, and is responsible for the rapid expansion of these fungi into areas which were previously not colonized.
b. It occurs by conidia (mitospores) which are genetically identical to the parent and mostly have just one nucleus and derived from mitotically divide nuclei.
c. Conidia are formed on the ends of specialized hyphae, the "conidiophores".
d. Depending on the species they may be dispersed by wind or water, or also by animals.

I.1. Asexual spores

Mitospores are variable in shape, size and colour (Fig.7.2):

1. **amerospores:** <u>single-celled</u> spor. It is the most frequent type.
2. **didymospore:** bicellular spore. It is <u>divided into two</u> by a cross-wall (septum).
3. When there are two or more cross-walls the classification depends on the shape
   a. **phragmospore** If the septa are **transversal**, like the rungs of a ladder
   b. **dictyospore** if they form a **net-like** structure.
4. In **staurospores** ray-like "arms" radiate from a central body.

5. In **helicospores** the entire spore is wound up in a spiral like a spring.
6. **Scolecospores:** very long worm-like spores. The ratio length:diameter is more than 15:1

I.2.Heterocaryosis & parasexuality:

I.2.1. Heterocaryosis occurs simply by:

a. Hyphal anastomosis (merging of two hyphae of different individuals or genotype) or mutation

b. Nuclear migration.

c. Heterkaryon (or heterokaryotic) (nuclei occur in a single cell and they are not always genetically identical).

d. As a result there are more cell nuclei than normal in the mycelium and they come from genetically different parent organisms.

This phenomenon occurs in Ascomycota, Basidiomycota and Fungi Imperfecti.

I.2.3. Parasexuality:

Two cell nuclei merge without any sexual process and the chromosome count is doubled.

1. It involves a **complex** form of **mitosis**, where there is **crossing over or recombination** (an exchange of genetic material between corresponding pairs of chromosomes), that occurs only during **meiosis i**n sexual reproduction.
2. Finally the chromosome count will be restored to normal by **haploidization**, whereby the nucleus splits into two parts each having a single set of chromosomes, with each daughter genetically different from the original parents.

I.3. Sexual Reproduction

The thallus may be **Homothallic** or **heterothallic.**

1. The basis for **heterothallism** is typically a single gene with **two alleles**, “A” and “a” and because of segregation during the meiotic division which precedes ascosopre formation, the eight ascospores normally present in an ascus will include four of one mating type and four of the other.
2. In some heterothallic species eg. *Neurospora crassa*, ascogonia and microconidia are formed on a single strain, but they are self-incompatible-i.e.

   a. The microconidia are unable to fertilize the ascogonia on the same mycelium.

   b. Only when a fertilizing element from the opposite mating type is brought into contact with the ascogonium does fertilization occur.

3. Thus each mating type possesses both kinds of sex organs, and is morphologically indistinguishable from the opposite mating type, this called physiological heterothallism, and also where two alleles are involved it is termed two-allelomorph plysiological heterothallism.

4. In **four-sopred asci**, e.g. ***Neurospora teteasperma***, ***Podospora anserina***:
   a. ascospores are **binucleate**, and commonly contain nuclei of both mating types.
   b.**on germination** would give rise to fully **fertile mycelia**, and so the fungus is **homothallic**.
5. **Secondary homothallism:**
   1. Uninucleate ascospores may formed and germinate to non fertile mycelium
   2. Ascocarps are only formed in 50% of matings between such mycelia.
   3. Because they are heterothallic in their mating behavior, the term **2ry homothallism** is used to describe the behavior of their binucleate ascospores.

I.3.1. Events of Sexual Reproduction :

1- Fusion of two nuclei of compatible mating types to form zygote

2- This process is initiated by the fusion of gametangia (structures that contain gametes)

3- Different types of gametangia occur in phylum Ascomycota

I.3.2. Types of Gametangia

1-Undifferentiated hyphae

2-Morphologically differentiated gametangia:

A- Female gametangium called ascogonium, it is commonly a coiled, multinucleate cell, sometimes surrounded by a receptive trichogyne.

B- Male gametangium called antheridium, it is a selender branche (Fig. 7.3.)

3. Female gametangium differentiated or hyphal; male nucleus in spermatium (pl spermatia) or microconidium or oidium (pl microconidia or oidia).

I.4.Compatibity and incompatiblity

For sexual reproduction to occurs between two individual they are either compatible or incompatible

I.4.1. Incompatibility systems

I.4.1.1. Homogenic incompatibility

This type promotes outcrossing in sexual reproduction. It is controlled by a single genetic locus (MAT) with different mating type factors (MAT1-1 and MAT1-2). MAT1-1 and MAT1-2 lack sequence homology but occupy the same site in the genome and called idiomorphs. Thus only thalli with different mating type factors can mate.

I.4.1.2. Heterogenic incompatibility

Those organisms controls somatic or vegetative fusion. It prevents fusion of genetically dissimilar individuals. Controlled by multiple vegetative incompatibility loci (*vic* or *het*); only those thalli with same alleles at all *het* loci are compatible

I.4.2. Compatibility System.

I.4.2.1. Heterothallic or self-incompatible

Mating occurs between thalli with different mating type

I.4.2.2. Homothallic or self-compatible

Mating occurs in a single thallus; both mating type idiomorphs are present in the same nucleus

I.4.2.3. Secondarily homothallic

A thallus that contains two types of nuclei representing both mating types

1.4.3. Pleomorphy

It is the ability of a fungus to produce more than one form or type of spore in its life cycle

1.4.4. Ascomycota may have two distinct reproductive phases

1. Teleomorph - meiotic: asci and ascospores (meiospores):
2. Anamorph- mitotic: mitotic spores (conidia):
3. Ascomycetes classification is based on teleomorphs, However, Many ascomycetes are known only by their asexual stages.

1.4.5. Holomorph

It is the state of a fungus and all its expressions, the totality of a fungal life cycle,states if they exist

Holomorph = Teleomorph + Anamorph

A holomorph can only have one teleomorph but can have none to several anamorphs

1.4.6. Development of Asci

1. The term Ascus was introduced by Nees (1817) for the sac-like structure that generally contains 8 ascospores.

2. Asci are varying considerably in structure and categoriesed generaly in 3 types: bitunicate, protunicate, unituicate.

4. Ascus develops generally from the ascogenous hypha, which in turn develops from an ascogonium whereas in Yeast and related fungi it is arise directly from a single cell.

Stages (Fig. 7.4).

1. Male nuclei on reaching the ascogonium via trichogyn, form a dikaryon with the female nuclei

2. karyogamy is delayed- thus a dikaryophase intervenes between plasmogamy and karyogamy.

3. Small protuberances appear on the ascogonium (or the smotic cell acting as the female cell), which grow to from the ascogenous hyphae.

4. This hypha is multinucleate, and its tip is recurved to from a crozier (shepherd's crook).

5. Nuclei in ascogenous hypha undergoe division simultaneously.

6. Two septa at tip of the crozier cut off a penultimate binucleate cell destined to become an ascus.

7. The terminal cell of the crozier curves round and fuses with the ascogenous hypha behind the penultimate cell.

8. The region behind the penultimate cell may grow on to from a new crozier in which the same sequence of events is repeated.

9. Repeated proliferation of the tip of the crozier can result in a cluster of asic.

10. In the ascus initial the two nuclei fuse and the fusion nucleus undergoes meiosis to from four haploid daughter nuclei (Fig. 7.5).

11. These nuclei undergo a miotic division so that eight haploid nuclei result.

12. Meanwhile, ascus is elongating, and the plan of the division is parallel to the length of the ascus.

13. Cytoplasm is cleaved out around each nucleus to from an ascospore or

a. the eigh nuclei divide further so that each ascospore is binucleate.

b. In multicellular asco-spores there are repeated nuclear divisions.

c. In some forms more than eight ascospores are formed, or eight ascospores may break up into part-spores.

By observing the order of the ascospores in the ascus one can determine the order in which the chromosomes are segregated (separated) during meiosis. If no crossover events occur, the two genes will segregate during meiosis I and produced a 4:4 arrangement of ascospores. If a crossover event does occur, the two genes will not segregate until meiosis II which will result in a 2:2:2:2 or 2:4:2 sequence of ascospores (Fig. 7.5.1).

I.4.7. Ascosporogenesis

Formation of ascospores occurs by the process of free cell formation enveloping membrane system (EMS).

3. 1.envelopment of a nucleus and cytoplasm by two closely associated membranes (EMS)
4. Ascospore wall deposition between the two membranes.
5. Epiplasm: It is the residual cytoplasm that is not incorporated into developing ascospore (rich in polysaccharides such as glycogen) and Functions: nourishment of developing spores, deposition of spore ornamentation. After ascospore initials delimitation by EMS
5. Spore production (Fig. 7.6).

1. Inner membrane of the EMS becomes the ascospore plasmalemma.

2. outer membrane becomes the "ascospore investing membrane” (aim).

3.aim is displaced gradually by ascospore wall (aw) deposition, much of the wall is deposited by the young ascospore.

4. at least part of the wall and spore ornamentation are deposited by the epiplasm

Fine structure of asci during cleavage of the ascospore have shown that:

1. double membrane continuos with the endoplasmic reticulum extends from the envelope of the fusion nucleus in developing asci (Fig.7.7).

1. The double membrane forms a cylindrical envelope lining the young ascus.

2. The lining layer is termed the ascus vesicle or ascospore membrane.

3. The ascospores are cut out from the cytoplasm within the ascus by invagination of the double membranes.

4. Between the two layers forming the membrane, the spore wall is formed or secreted, and the inner membranes from the plasmamembrane of the ascospore.

The shape of mature ascus is very variable:

1. Globose: In forms with non-explosive ascospore release

2. Cylindrical: in the majority of ascomycota, spores release is explosively (Fig. 7.8).

8. asci may be:

a. operculate, the ascus tip is surmounted by a cap or operculum which is blown aside or actually blown off the tip of the ascus by the force of the explosion (pezizales).

b. inoperculate the ascus tip is perforated by a pore and there is no operculum (Helotiales).

9. In perithecial fungi, as an ascus ripens it elongates and takes up a position inside the ostiole, often gripped in position by periplyses. In this case the asci discharge their spores singly.

I.5. Types of Fruit-Body or sporocarp (ascoma)

1. Ascomata is the sexual fruit-bodies that protect the asci and regulate release of the ascospores.

2. In yeast and related fungi the asci are not enclosed by hyphae, but in most Ascomycota they are surrounded by hyphae to form an ascocarp (ascoma).

3. Ascomata may arise singly or are often clustered together: Perithecia are either scattered on a mass of tissue termed as stroma (e.g. *Nectria cinnabarina*) or may be embedded with only the ostioles visible at the surface (e.g. Xylariaceae & Clavicipitaceae).

4. Ascoma formed during the development of asci, where the surrounding monokaryotic hyphae organize a thick protective coat around the developing asci. The protective coat and the asci are jointly called the ascoma. All the tissues within the ascocarp jointly constituted what is known as the centrum.

5. Ascoma occurs in varous type:

1.Cleistothecia (sing. Cleistothecium). the asci are enclosed in a globose fructification with no opening to the outside (Fig. 7.9) e.g. *Emerciella*, *Eupenicillium* & Erysiphales. A loose open network of hyphae found in *Gymnoascus.*

2.Apothecia (sing. Apothecium): the asci are borne in open saucer-shaped ascocarps, and at maturity the tips of the asci are freely exposed (Fig. 7.10). e.g. Pezizales & Helotiales (Leotiales).

3.Perithecia (sing. Perithecium): flask-shaped fruit bodies opening by a pore or ostiole (Fig. 7.11). The perithecial wall is formed from sterile cells derived from hyphae that surrounded the ascogonium during development. The ascus in these groups is unitunicate. e.g.Xylariales(syn. Sphaeriales) and Hypocereales:

4.Pseudoperithecia: ascomata that are superficially resemble perithecia, but it differs in details of development, and contain bitunicate asci (Fig. 7.12) e.g. The loculoascomycetes.

<u>I.6. Types of Asci:</u> (Fig. 7.13)

Asus is generally round to clavate to cylindrical shape. The wall either persistent or evanescent and reacted +/- with iodone. <u>Ascus occurs mainly in three types</u>:

<u>Ascus type</u>

1.Unitunicate (Fig. 7.13.). Inner and outer ascus walls do not separate during ascospore release. Ascospores released through specialized adaptation at ascus tip.

2. ***Bitunicate*** (Fig. 7.14). Also called “Jack-in-the Box” ascus.

-There are two physically separate wall layers.

- The **outer layer is** termed the **ectoascus** or ectotunica, and the inner layers the **endoascus** or endotunica (Fig. 7.14).

3. ***Prototunicate***

Thin-walled ascus. Ascospores released by breakdown of wall. (Fig. 7.15).

1.<u>Acus tip:</u> Fig. 7.16

It is either operculate or inoperculate and the tip may have Refractive ring, as in Neurospora, or Amyloid ring, as in Xylaria (Fig. 7.16)

Ascospore:

Ascospores are characterized with the following criteria (Fig 7.17)

1. It is either pigmented or not
2. It is either aseptate, or septate (uni or multiseptate)
3. Appendages present or absent
4. mucileagenous sheaths present or abscent
5. It is varied in size and shapes, and also arrangement in ascus

6. It is naormally 8 per ascus.

I.7. Hymenium

It is the fertile tissue of ascocarp (Fig. 7.18.).

1.8. Hamathecium Sterile cells associated with hymenium

2. Paraphyses - hyphae growing amongst the asci
3. Periphyses - hyphae in the ostiolar canal of an ascocarp
4. Pseudoparaphyses-originate above the asci of ascostroma; grow down among the developing asci

Modern classification of Ascomycota

There are 3 subphyla *viz,* **Pezizomycotina, Saccharomycotina and Taphrinomycotina** encompassing ascomycota (Cavalier-Smith,F. 1998, Lutzoni F, et al., 2004 & James TY et al, 2006).

1. Subphylum Taphrinomycotina:

It is a disparate group of Ascomycota and were only recognized as a distinctive group after the advent of molecular (DNA) analyses. It is a basal group to the other subphyla and hence is considered to be more primitive. The taxon was originally named Archiascomycetes alternatively spelled Archaeascomycetes. It includes both hyphal fungi (*Neolecta*, *Taphrina*), and fission yeasts Schizosaccharomyces and the mammalian lung parasite, *Pneumocystis*.

2. Subphylum Pezizomycotina:

It is the largest group and contains all fungi that produce ascocarps, except *Neolecta*. All macroscopic "ascos" such as truffles, ergot, ascolichens, cup fungi, pyrenomycetes, lorchels, and caterpillar fungus (Cavalier-Smith, 1998). many microscopic fungi, e.g. powdery mildews, ring worm fungi, chalkbrood fungus (Lutzoni et al., 2004). Laboulbeniales, and most black molds around sinks and tubs.

3. Subphylum Saccharomycotina:

It comprises most of the "true" yeasts, such as Baker's yeast and *Candida* which are in general single-celled, or short chains of cells, and reproduce vegetatively by budding rather than by the production of hyphae.

Commonly used but neglect class names

Several obsolete class names, based upon morphology, are still used:

Among those based upon the sexual fruitbodies (teleomorphs) are:

a. Discomycetes: all species forming apotheci.

b. Pyrenomycetes: all fungi forming perithecia or even pseudothecia, or any structure approaching these morphological structures.

c. Plectomycetes: fungi that formed cleistothecia .

d. Hemiascomycetes included the yeasts and yeast-like fungi that are now split between Saccharomycotina and Taphrinomycotina.

e. Euascomycetes covered the rest of the sac fungi, now in the Pezizomycotina and *Neolecta* in the Taphrinomycotina.

The phylum ascomycota is classified as follow:

Kingdom: Fungi

Subkingdom: Dikarya

Phylum: Ascomycota Berk (1857) Caval.-Sm. (1998)

Subphylum 1: Pezizomycotina

Classes Laboulbeniomycetes, Eurotiomycetes, Lecanoromycetes, Leotiomycetes, Pezizomycetes,

Sordariomycetes, Dothideomycetes, Lichinomycetes , Arthoniomycetes , Orbilomycetes

"Unplaced orders ": Lahmiales, Medeolariales, Triblidiales

Subphylum 2: Saccharomycotina

Class : Saccharomycetes

Subphylum 3: Taphrinomycotina

Classes : Neolectomycetes, Pneumocystidomycetes, Schizosaccharomycetes, Taphrinomycetes

SUB-Phylum: Taphrinomycotina

1. It is a diverse group of fungi including saprobic and parasitic species.

2. It is delneated primarily on the basis of rDNA sequence analysis.

3. It is considered as a basal group to the other subphyla and so considered to be more primitive.

4. Thallus is hyphal (*Neolecta*, *Taphrina*), or yeasts (*Schizosaccharomyces*) (Fig. 7.19).

   a. Saitoella and *Schizosaccharomyces* are asexual, saprobic soil-living yeasts.

   b. Taphrina and *Protomyces* are dimorphic (saprobic yeast stage and a parasitic mycelial stage).

   c. *Pneumocystis carinii (*was originally believed to be a protozoan), peculiar mammalian lung parasite, causal agent of pneumonia that inffect persons with suppressed immune systems. Asci produced from the zygote not in ascomata.

Diagnostic character

1- lack ascogenous hyphae

2- ascocarps known in only one genus *Neolecta*

3- Ascospore Release - Forcible or passive

4- Ploidy level of nuclei - Examples of haploid or diploid and monokaryotic or dikaryotic

Classification:

Class1: Taphrinomycetes, Taphrinaceae: *Taphrina*

Class2: Schizosaccharomycetes, Schizosaccharomycetaceae *Schizosaccharomyces*

Class: Pneumocystidomycetes, Pneumocystidaceae: *Pneumocystis*

Class: Neolectomycetes, Neolectaceae: *Neolecta*

Class: Schizosaccharomycetes

Family: Schizosaccharomycetaceae

The family comprise 2 genera (+2 syn.) and 4 – species.

1. Mycelium **absent** or poorly developed.
2. Vegetative cells cylindrical with rounded ends, proliferating thallically by fission into 2 ± equal daughter cells.
3. **Asci** formed by **conjugation** of vegetative cells, often irregularly shaped, 4– to 8– spored
4. **Ascospores globose** to shortly cylindrical, blueing in iodine, smooth, without sheaths.
5. **Fermentation positive**.

e.g. ***Schizosaccharomyces*** Linder (1893)

"Fission yeast"

1. Reproduces asexually exclusively by fission.
2. There are four species that can be isolated from high sugar substrate like molasses, cane sugars, grapes juice etc.

Life cycle (Fig. 7.20)

Asexual

1. Individual cells are globose to cylindrical, uninucleate and haploid.
2. Cell division is preceded by **intranuclear mitosis**, toward its end the nucleus constricts and becomes **dumbbell shaped**
3. A centeripetal development of **septum** takes place and cuts the cytoplasm into two.
4. The two sister cells may remain attached for a time or separated at the middle of the septum.

Sexual:

gametangial copulation between to similar haploid cells.

1. Most of species are homothalic, and rarely heterothallic (e.g. ***S. pombe***).
2. If compatible cells are grown together in liquid culture, the cells clumped and the culture flocculated as a result of a strong sexual **agglutination** occurs.
3. Two cells come into **contact** by a portion of the cell wall.
4. A **pore** is formed in the midle of the attachment area and this widens and elongates to form a **conjugation canal**.
5. The **nuclei migrate** toward each other, **fuse** and **elongates** to about half the length of the ascus.
6. **Fused** nucleus **divide** by constriction, the nuclear membrane remaining intact during division.
7. The daughter nuclei migrate to opposite ends of the **ascus** and divide by **meiosis** and

single mitosis, so that eight haploid nuclei result and **eight** ascospores are differentiated.

8. The ascospores are released by breakdown of the ascus wall. Asci are only the **diploid** stage of ***Schizosaccharomyces***.

Sub-phylum: Saccharomycotina

(Ascomycetous yeasts)

1. Comprises most of the "true" yeasts, such as Baker`s yeast and *Candida.*

2- Thallus is generally single-celled, or short chains of cells.

3- It is reproduce vegetatively by budding rather than by the production of hyphae.

Class: Saccharomycetes

General Characters

1. Absence of ascogenous hyphae and ascocarps

2. Mycelium absents or poorly developed, where present usually with septa, which have a series of minute pores, rather than a single simple pore

3. Primarily unicellular and reproduce asexually by budding (blastically) e.g. ***Candida albicans***.

4. Some species are dimorphic (shift between filamentous and yeast stage) under certain conditions

5. Many species exist primarily as yeasts. Others produce a mycelium or pseudomycelium.

6. Cell wall usually lacking chitin except around bud scars. Wall polysaccharides are primarily mannans and B-1,3 and B-1,6 glucans

7. Colonies sometimes producing gel that stains blue in iodine.

8. Asci formed singly or in chains, sometimes not strongly differentiated morphologically from vegetative cells, **prototunicate,** usually at least eventually **evanescent**.

9. Some species produces erect **ascophores**.

10. **Ascosporogenesis** with **EMS** originating in association with the **spindle pole** body.

11. **Ascospores** varied in shape, sometimes with **equatorial** or asymmetric thickenings.

12. **Gamtangial fusion**: yeasts cells may function as gametangia

13. No **dikaryotic** phase in the life cycle. **karyogamy** occurs immediately after **plasmogamy**.

14. **Diploid** stage may persist in some species with cells **multiplying** by **budding**

15. **Zygote** becomes transformed directly into an **ascus.**

Occurrence:

1- Occur in **slime fluxes**, nectar, fresh or decaying fruit—able to grow in high osmotic conditions.

2- Others occur in soil, dung, water, digestive tracts of animals

3- Many species are symbiotic with insects.

The order comprises 8 families, 75 (+57 syn.) and 273 spp. These are; Cephaloascaceae, Dipodascaceae, Endomycetaceae, Lipomycetaceae, Metschnikowiceae, Saccharomycetaceae, Saccharomycodaceae and Saccharomycopsidaceae.

Family: Saccharomycetaceae

The family include 28 genera (+ 31 syn.) and 159 species.

1. Mycelium ± absent; vegetative cells reproduced by multilateral budding ± ellipsoidal, without mucus (Fig. 7.21).

2- **Asci** morphologically similar to vegetative cells, not in well defined chains, ± globose, thin walled, 1- to 4 spored, evanescent or persistent.

3. **Ascospores** ± spherical, often ornamented with equatorial ridges.

4. **Fermentation** positive; coenzyme system usually Q-6.

5. **Cosmopolitant** in a very range of habitats.

e.g. *Saccharomyces* Henn. (1904)

1.Van der Walt (1970) recognizes 41 spp. of ***Saccharomyces***, but the best known is ***S. cerevisiae***,

2. It is used in the fermentation of certain beers and wines, and in baking.

3. ***S. cerevisiae*** is found in nature on ripe fruit.

4. The cell:

a. elliptical and about 6-8×5-6 μm. in suitable conditions, they multiply budding (Fig. 7.22).

b. The thick-walled cells are multiayered;

-outer-layer consists mainly of maman-protein and some chitin.

- middle layer is largely composed of glucan,

- innermost layer contains protein-glucan.

c. Wall components:

- **glucan** (**yeast cellulose**) about of 30% of the dry weight of the **cell wall** is composed of polymers **of β(1→3)-linked land β(1-6)-**linked glucose residues.
- **mannan** (yeast gum), equals in amount to glucan, is branched polymer of mannose with an α(1-6)-linked backbone, and α(1→2)-and α(1-3)-linked side chains.

-Chitin a polymer of β(1→4)-linked **N-acetyl glucosamine**, is present in small quantities, and is especially abundant in the scars.

-Protein makes up about 7% of the dry weight of the wall.

-Skeletal material of the wall is made up of random array of microfibrils of chitin, glucan and manan.

d. P**lasmalemma** is of the usual unit-membrane type, but is unusual in containing a series of shallow, elongated pits or invaginations.

e. Other inclusions as in eukaryotic cells: endoplasmic reticulum, ribosomes, mitochondria, lipid granules (**sphaerosomes**), Golgi apparatus, and a nucleus enclosed in perforated nuclear membrane.

i. **Vacuole** at the cell center, prominent, large and limited by single membrane, the tonoplast.

It contains a watery substance, and granules of polymetaphosphate and lipid.

ii. **Mitochondria** are very variable in shape, depending partly on the conditions under which the yeast is growing. They may be spherical, rod-like, thread-like, unbranched or branched.

h. **Nucleus** is hard to see in living yeast cells.

-In budding yeast cells, it is to be found between the vacuole and the bud.

-It consists of a cup-shaped nucleolus and dome-shaped **nucleoplasm**.

-Mitotic division is **intranuclear** i.e. nuclear membrane remains intact during division, vegetative cells of ***S. cerevisiae*** are generally Diploid.It is termed as uninuclear division.

An intranuclear spindle made up of microtubules stretches between a pair of spindle pole bodies (spindle plaque) on opposite sides of the dividing nucleus, and a four haploid daughter nuclei produced within the original nuclear membrane.

Life Cycle of *S. cerevisiae* (Fig. 7.23).

1- **It is haplo-diplobiontic** type of life cycle, in which both haploid and diploid phases are equally extensive and important.

2- Both types of vegetative cells multiply by budding and eventually transformed into each type.

3- The haploid cells of opposite mating types after fusion (**plasmogamy & karyogamy**) give rise to diploid cells and thus initiate the diploid phase.

4. This fusion occurs by a binding or agglutination process involving the walls of the two cells e.g. ***Hansenula wingei***.

a. The agglutinated cells cohere tightly taking a polygonal shape it is termed sex agglutination.

b. After agglutination, conjugation occurs.

c. The agglutination is brought about by hydrogen binding between protein-like substances of the cell wall of one mating type and a polysaccharide (**manan**) on the other.

d. A sex specific factor produced by **mating-type α** cells of ***S. cerivisiae*** has also been partially purified which inhibit budding in cells of the opposite mating types, and induces them to elongate to form copulatory processes.

4- At the end of the diploid phase, the diploid nucleus undergoes meiosis and forms four haploid nuclei around which four ascospores are produced.

5- In laboratory, the diploid cell can be induced into ascospore formation by adding **5% sodium or potasium acetate** to the culture medium. Thus the diploid cells are potential asci.

6- On release after lysis of the ascus wall, these grow into vegetative cells establishing the haploid phase.

7- The Diploid state may be established in several ways:

A. Fusion of ascospores: may occur inside the ascus. The walls separating ascospores break down, or short conjugation tubes develop which bring the cytoplasm of the two spores into contact.

B. Haploid cells fused to form diploid cells.

C. Fusion between an ascospore and a haploid cell.

Most strains of ***S. cervisia*** are heterothallic, and the ascospores are of two mating types. Mating type or sexual compatibility is controlled by a single gene which exists in **two allelic** states **a** and α, and segregation at the meiosis preceding ascospore formation results into **2 a and α** ascospores. Fusion occurs only between cells of differing mating type, and this has been termed **illegitimate** copulation. Such fusion results in diploid cells that readily form asci with viable ascospores.

<u>There are, however, exceptions to the fusion of cells or nuclei of opposite mating type:</u>

1- Two sister nuclei may fuse spontaneously after the first mitosis of germinating spore to peroform diploidsation stage.

2- ***S. chevalieri*** is hybrids between this yeast and ***S. cerevisiae*** a **gene D** for diploisation may be present. The presence of this gene permits diplodisation to occur in haploid progeny of either mating type. Diploid yeast cells may be **heterozygous for the D gene (i.e. Dd),** and then may give rise to asci from which 2 ascospores will give rise diploid colonies directly and two will not.

Meiosis and Ascosporogenesis (Fig. 7.23)

Two divisions of meiosis occur intranuclear and roughly perpendicular to one another. Nuclear envelope invaginates at the end of the second division, and 4 nuclei are separated. EMS form in association with each nucleus.

Sub-phylum1: Pezizomycotina

1- It is the largest Ascomycota subphylum and contains all fungi that produce ascocarps (fruiting bodies), except for one genus, *Neolecta*, in the Taphrinomycotina.

2-Classes: Laboulbeniomycetes ,Eurotiomycetes, Lecanoromycetes, Leotiomycetes, Pezizomycetes, Sordariomycetes, Dothideomycetes, Lichinomycetes, Arthoniomycetes, Orbilomycetes

Class: Leotiomycetes

1. The majority are serious plant diseases.

2. They are tradtitionaly treated as Discomycetes clade (inoperculate Discomycetes). Molecular studies have recently consider Leotiomycetes a sister taxon to Sordariomycetes in the phylogenetic tree of Pezizomycotina.

General Characteristics:

1. Ascoma are apothecia and seldom cleistothecia.

2. Asci are cylindrical, inoperculum. The spores are hyaline, of various shapes, and are released through an apical circular pore.

3.Asci are usually thin- and single-walled (unitunicate) with an apical perforation pore (inoperculate) for releasing ascospores (Fig. 7.24).

4. It is traditional treated as inoperculate discomycetes (apothecium, opens at a very early stage and hymenium exposed).

Classification

Kingdom: Fungi

Sub-Kingdom: Dikarya

Division: Ascomycota

Subdivision: Pezizomycotina

Class: Leotiomycetes (Eriksson & Winka, 1997)

Orders: Capnodiales, Cyttariales, Erysiphales, Gyalectales, Helotiales, Rhytismatales, Thelebolales

Order: Erysiphales

1- It **is represented** only one family and 15 genera (Braun et al. 2002, Takamatsu et al. 2005a, b).

2-Obligate biotrophs causing **powdery mildew** of about 10,000 plant species (Amano 1986).

3- Their mitosporic stages cover the infected area with a white-powder appearance(Fig. 7.26).

4- There are no support to includ them in the **Leotiomycetes** where all of them have closed, non-ostiolate fruit-bodies with persistent asci and basal hymenium.

Family: Erysiphaceae (Powdery mildews family)

1- They are obligate **biotrophs** of Angiosperms. Their common name derived from the mealy appearance of the conidia on infected foliage of disease called **powdery mildews** (Fig. 7.25).

2- The diseases have economic significance e.g. cereal and grass mildews caused by ***Ersiphe graminis*** and apple mildew caused by ***Podosphaera leucotricha***.

3- Mycelium is largely superficial and hyaline anchored to host epidermis by **appressoria**.

6. Nutrients obtained via intracellular haustoria.

7. Ascoma **cleistothecial**, globose, solitary or aggregated, becoming dark, usually with complex appendages; interascal tissue absent.

8. Asci broadly clavate, thin-walled, bitunicate except toward the apex, dehiscence explosive.

9. Ascospores hyaline, elipsoidal, aseptate, without asheath.

10. Anamorphs hyphomycetous, prominent e.g. ***Didium***, ***Ovulariopsis*** (Fig. 7.26).

11. **Asexual** reproduction by conidia

12.**Sexual** reproduction by ascogonia and antheridia.

Asexual reproduction (by conidia)

1. Erect, hyaline **conidiophores** are usually formed on **superficial** mycelium.
2. Conidia (One-celled, hyaline thin-walled) are produced holoblastically in basipetal chains
3. It is postulated that one colony can produce > 30,000 conidia.

4. Conidia are dispersed by wind.

5. Germination can occur at low relative humidity.

6. Germination involves germ tube, appressorium and infection peg formation (Fig. 7.27).

4. 7. Apex of infection peg enlarges to form haustorium (Fig. 7.28).

Sexual reproduction (by ascospores)

1. Cleistothecia formed on superficial mycelium in late summer/early fall

2. Asci formed in basal layer.

1. Globose to pyriform.
2. Spore discharge by rupture of ascus tip.
3. One to numerous asci per cleistothecium (Number is important character in identification.

3. Ascospores hyaline, one-celled, ovoid, 1-8 ascospores/ascus.

Key to genera of Erysiphaceae (Fig. 7.29.)

Mycelium superficial

A. Perithecia with one ascus

B. Appendages simple …………… ***Sphaerotheca***

C. Appendages dichotomously branched ***Podosphaera (12 spp.)*** Oidium anamorph with fibrosin bodies

AA. Perithecia with several asci

D. Appendage simple ………………….. ***Erysiphe*** (100 spp)*Oidium* anamorph

DD. Appendage dichotomously branched ………… ***Microsphaera(125 spp.)*** *Oidium* anamorph

DDD. Appendage coiled at tips ………………… …………… ***Uncinula-Oidium anamorph***

Mycelium Partly internal

E. Appendages simple………***Leveillula*** (8 spp.), *Oidiopsis* anamorph (emerges through stomate)

EE. Appendages with basal swelling… ***Phyllactinia (24spp.)*** ***Ovulariopsis and Streptopodium***

Phylogeny of powdery mildews based on rDNA sequences (Fig. 7.32.) revealed 6 evolutionary lineages corresponding to conidial stages but not to ascocarp morphology (Saenz & Taylor 1999).

Class: Laboulbeniomycetes

1. E**xternal parasites** of terrestrial and aquatic insects and other arthropods.
2. Thallus: **minute**; their **fruiting** bodies commonly measure less than **one millimeter**.
3. They **live** on the **antennae**, the **mouthparts** or other body regions of their arthropod hosts.
4. Several harmless species produce more or less extensive, root-like hyphal systems (**haustoria**).
   - appear only on **adult hosts**
   - Where immature hosts eliminate them during **ecdysis,** adults are no longer molt.
5. Some fungi have separate female and male individuals, like ***Herpomyces***.

Order: Laboulbeniales
Family: Laboulbeniaceae G.Winter (1886)
e.g. Stigmatomyces H. Karst. (1869)

1. Minute, obligate ectoparasites of insecta (class hexapoda; few on Arachida and Diplopoda) and other arthropods, a few are **coprophilous**.
2. They remain **attached** to the host without **venturing** to the interior.
3. The injury to the host is **negligible**; at most there is a slight irritation but death never occurs.
4. Though not of any economic importance.
5. Most species are highly host specific, while some others not.

Morphology and development

1. Thallus: cellular structure of definite morphology composed of a fixed number of cells for a particular species. It develops from an ascospore by division in a precise sequence.

2. Thallus consists of a blackened foot and a receptacle (Fig. 7.30).

The foot penetrates the host integument and draws nutrition by dissolving chitin.

The receptacle varies in size and structure, it may be consists of a row of three cells:

a.Lower foot cell,

b.Sub-basal cell, bearing one or more perithecia or secondary, fertile or sterile out-growths.

c. Upper cell.

d. The receptacle may be complex due to the longitudinal division of the cells to form a mass of cells from whose periphery the appendages and sex organs arise.

1. The main body is multicellular, pseudoparenchymatous and much wide at the top.

2. The receptacle bears filamentous appendages on or among which antheridia are formed. It also bears the female sex organs around which later the perithecium develops.

3. The species may be Monoicous or Dioicous (Fig. 7.30).

4.Thallus is covered by a thin, tough and imprevious membranes which originates from the gelatinous sheath of the ascospore.

5.Non-motile spermatia, exogenously on appendages or endogenously in flask-shaped antheridia.

6. The antheridia may be simple with free exit tubes or united into a common "antheridium" liberating spermatia into a common chamber before they are freed outside through an opening.

7. The ascogonium is derived from a single cell of the receptacle or one of its branches.

Class: Eurotiomycetes

Sub-Class: Eurotiomycetidae

Order: Eurotiales

General characters:

1. Thin-walled asci (prototunicate).
2. Asci scattered within cleistothecium
3. One-celled ascospores
4. Two familes: a. Trichocomaceae (*Aspergillus, Penicillium* and *Paecilomyces* anamorphs).

   b. Pseudoeurotiaceae

Family: Trichocomaceae

1.Genera with ascomatal wall varied, pseudoparenchymatous or hyphal:

a. cluster of unenclosed asci in ***Byssochlamys***.

b. thick and sclerotioid usually bright in colour (e.g. ***Eupenicillium***).

2. Ascogonia often formed in chains; interascal tissue absent.
3. Asci small, ± globose, often formed in chains.
4. Ascospores ± hyaline, usually bivalvate and often ornamented.
5. Anamorphs ***Aspergillus*** (Fig. 7.39)***, Penicillium, Paecilomyces, Polypaecilum***, etc.

There was a problem in the nomenclature of this family;

a. Perfect and imperfect states of the same fungus have, in the past been given separate generic names, e.g. a. ***Eurotium*** has been given to the perfect state of some species of ***Aspergillus*** (e.g. ***A. repens***), so that **Fennell (1973)** called them **Eurotiaceae**.

Teleomorphs of this order are:

1. ***Aspergillus***: *Eurotium, Neosartorya* and *Emericella*

2. ***Penicillium****: Eupenicillium* and *Talaromyces*

3. ***Paecilomyces***: *Byssochlamys*

b. fungi with similar conidial states may have different perfect states. e.g. ***A. nidulans*** anamorph of the perfect state ***Emericella nidulans***.

c. A further problem is that many species of ***Aspergillus*** they're being classified in the **Deutromycotina** or Fungi Imperfect or **mitosporic** fungi.

6. **Phialoconidia** are developed within a special cell termed as **Phialide**: a conidiogenous cell in which at least the first conidium initial is produced within an apical extension of the cell, but is liberate sooner or latter by the rupture or dissolution of the upper wall of the parent cell.

g. Mature spores are often pigmented; green in *Penicillium*; yellow, green, brown or black in *Aspergillus*.

Class: Lecanoromycetes
Order Lecanorales
Sub-order Lecanorineae

1- It includs most lichen forming fungi with many large foliose, fruticose and crustose spp.

2- Ascoma apothecial, asci inoperculate.

3- It is a heterogenous group including species that lives symbiotic with algae or cyanobacteria in an association termed as Lichen, in addition to saprophytic species.

4- Other fungi also form Lichens, e.g. Pleosporales, Hysteriales, Sphaeriales, Basidiomycota and some anamorphic species. Thus, about quarter of the identified fungi are lichenized.

5- Anton de Bary 1831-1888, discovered the symbiotic nature of lichens (1866) and he was the first used symbiosis in 1879 (Die Erscheinung der Symbiose). Simon Schwendener, the father of modern lichenology, proposed the dual nature of lichens in 1867. He also states that lichens are fungi that parasitize algal hosts

6- Lichens inhabit infertile soil, rocks, trees and so may play important role in weathering processes and soil formation. Lichens were also found attached to the surfaces of rocks in the sea or fresh-water streams and so termed as aquatic lichens.

7- The second partener is usually belonging to Chlorophyceae (green algae) and cyanobacteria.

8- both parteners in many lichens can grew separately on culture media.

Lichens are stable self-supporting association of a fungus (mycobiont) and an alga and/or cyanobacterium (photobiont or phycobiont).

1- They are about 13,500 species; more than 95% of all species of lichens consist of an ascomycete mycobiont and a green algal photobiont.

2- It is about 42% of all ascomycetes. The photobionts parteners are 25 green algal genera; 15 cyanobacterial genera. Most occur as free-living forms (exception *Trebouxia*).

3- Lichens are dominant vegetation for ~8% of the earth's terrestrial surface.

4- Lichen nomenclature follows that of the fungus

Thallus:

Lichens thallus occurs in several forms: the photobionts are confined to a special region called photobionts zone

Interspersed by mycobionts hyphae.

Above the photobionts, there is a cortex of tightly packed fungal cells.

Below the photobionts, there is medulla of loosely wooven and thick walled hyphae (Fig. 7.42). The thallus occurs in several forms:

1- Foliose: Upper Cortex, Algal layer, Medulla, Lower cortex

2- Fruticose: Cortex, Algal layer, Medulla, core

3- Squamulose: thallus of minute, scale-like squamules

4- Crustose: cortex, algal layer, medulla.

5-Gelatinous: mostly foliose, cyanobacteria is not located in a specific layer but is dispersed

throughout the medulla.

Reproduction: Asexual reproduction occurs by isidia (Fig. 7.44) (photobiont containing projection from the cortex) and soredia(Fig. 7.43) (noncortex combination of photobiont and mycobiont).

Sexula reproduction occurs by means of violently discharged ascospores. The ascoma may be apothecia (in this order, Fig. 7.45) or perithecia (Fig. 7.46). Spore germinates close to the suitable photobiont and initiating a new lichen thallus.

Lichens are sensitive to aerial pollutants, and especially to sulphur oxides, so that they disappear from industrial areas. Thus because of its sensitivity to certain pollutants can enable them to be good indicator of pollution. They can also retain radioactie nuclides in their tissues.

The most common lichens are *Xanthoria*, *Peltigera*, *Lecanora* and *Cladonia*

Chapter 8
Mitosporic Fungi
Ascomycota anamorphs

1. Fungi that never observed reproduce sexually, or are not known to produce asci or basidia.
2. They are called "**Mitosporic** fungi" because of mitotically derived conidia (mitospores), and other asexual structures, all collectively called anamorphic taxa.
3. In some classifications these would have been placed in a separate artificial phylum, the **Deuteromycota** (Greek "second fungi"). It is commonly called **Fungi Imperfecti**, or imperfect fungi (means lack of sexual reproduction).
4. There are about 25,000 species that have been classified in the **Deuteromycota**. e.g. fungi producing the antibiotic **penicillin** and those that cause athlete's foot and yeast infections, and some are edible, e.g. ***Penicillium*** spp. that provide the distinctive taste of **Roquefort** and **Camembert** cheese.
5. Other, more informal, names besides **Deuteromycota** ("**Deuteromycetes**"), **fungi imperfecti**, and **mitosporic** fungi, are **anamorphic** fungi, but these are terms without taxonomic rank.
6. Anamorphic species have only been observed to produce asexual or no spores. Thus, mycologists are using a dual system for their nomenclature. Dual naming is permitted by Article 59 of the International Code of Botanical Nomenclature (governs the naming of plants & fungi). Thus, a name for an asexually reproducing fungus is considered a *form taxon*.

   e.g.1 *Aspergillus niger* lack sexual state and so considered a *form taxon*.

   e.g.2. *Aspergillus nidulans*, possess a sexual state and named *Emericella nidulans w*here a teleomorph name override the anamorph name. Molecular analyses can now be used to link most anamorphic fungi place them either in Ascomycota or Basidiomycota.

7. There are over 250 years of names available (since Linnaeus' Species Plantarum, 1753) for both **teleomorph** and **anamorph** of the same fungi. e.g. **teleomorph** of the kerosene fungus is known as ***Amorphotheca resinae*** while the **anamorph** is called ***Hormoconis resinae***.
9. **Most anamorphic fungi are Ascomycota**, and therefore the obsolete classification of the **Deuteromycota** is largely that of **Ascomycota anamorphs**. (Cavalier-Smith, 1998, Lutzoni, et al., 2004 & James et al, 2006).

General Characteristics:

1-Absence, or presumed absence, of teleomorphs or perfect or sexual state.

2-Absence or presumed absence, of any meiotic or mitotic reproductive structures (agonomycetes)

3-Presence of conidia formed by mitosis (or presumed mitosis).

Types of conidial Fructification

*Conidial fructification (**condiomata**) is varied.*

Conidiophore - specialize hyphae that produces conidiogenous cell.

b. simple hypha produced off of somatic hyphae or

c. complex hyphae that are comprised of many hyphal segments or cell.

1. Micronematous: conidiophores are little differentiated from hyphae or are inconspicuous.

2. Macronematous: conidiophores are well-differentiated (Fig. 8.1).

3. Mononematous : conidiophores occur singly(Fig. 8.1).

Conidiogenous cell is a spore producing cell from which a conidium is formed whereas Phialide is conidiogenous cell with an open end through which conidia develop in basipetally (Fig. 8.2).

4. Synnema or **coremium**: conidiophores are aggregated to form parallel fascicles of closely appressed hyphae. e.g. ***Doratomyces*** (Fig. 8. 3).

5. **Sporodochia**: shorter aggregations of synnematous conidiophores e.g. ***Fusarium*** (Fig. 8. 3).

6. Acervulus: pseudoparenchymatous aggergation of hyphae beneath the surface of host plant, and

eventually forms a superficial layer of conidiophores e.g. ***colletotrichum*** (Fig. 8. 4). **Acervular** conidiomata, or acervuli, which develop in the host and can thus be:

a- subcuticular, lying under the outer layer of the plant (the cuticle),

b- intraepidermal inside the outer cell layer (the epidermis),

c- subepidermal, under the epidermis, or deeper inside the host. Mostly develop a flat layer of relatively short conidiophores

which then produce masses of spores. The increasing pressure finally leads to the splitting of the epidermis and cuticle and so allows the conidia to escape.

6. **Pycnidia**: flask-shaped or globose (like a bulging vase) fructifications lined by conidiogenous cells (of various types) and opening to the exterior usually by a circular ostiole e.g. *Phoma* spp. (Fig. 8. 5).

Pycnidia may be immersed or superficial. They may be grouped in a pynidial stroma.

The type of conidial fructification is important in classifiying Mitosporic fungi.

a. Monomatous or **synnematous** conidiophores are characteristic of the **Hyphomycetes**,

b. Acervuli and **pycinidia** are characteristic to **Coelomycetes**.

Variation in conidial (Mitospores) shape and colour:

a. **Nonmotile**, asexual propagules or spores,

b. Dispersal by wind, water, insects

c. **Septation** and shape are variable (amerospore, didymospore helicospore, staurospore, dictyospore, phragmospore). **It is also important in classification**

1. **Septation**: unicellular, bicellular or multi-cellular, and multicellular may be divided by septa in one to three planes.
2. The **shape**: globose, ellipticl, ovoid, cylindrical, branched, spirally coiled.
3. The **colour** of the conidia (and the mycelium and conidiophores) may be hyaline e.g colourless, brightly coloured (e.g. Pink or green) or dark. The dark pigments are probably melanins.

Conidiogenesis and dehiscence:

They are important characteristics of the **anamorphs** of the **Ascomycota.**

a. conidiogenesis: the fashion in which the spores are formed:

b. dehiscence: how conidia separate from the parent structures.

1. Conidiogenesis: Concepts of conidiogenesis have been used since **Hughes (1953)** in classification of mitosporic fungi especially hyphomycetes, on basis of

a. methods by which conidia develop from conidiophores.

b. the ways in which conidiophores (or conidiogenous cells) grow before, during and after conidia are produced.

Conidiogenesis can be divided into two fundamental forms of development: **blastic and thallic**.

(a) Thallic:

where there is no enlargement of the conidium initial, or it takes place after the initial has been delimited by a septum or septa. e.g. *Geotrichum candidum* (Fig.8.8).

(b) Blastic:

Marked enlargement of the conidium's initial takes place before it is delimited by a septum:

Two types of this development have been distinguished:

i. Holoblastic: both the outer and inner walls of conidiogenous cell contribute in formation of conidia. e.g. *Cladosporiam* and *Stemphylium*

ii. Enteroblastic: the inner wall only of the conidiogenous cells or neither wall contributes in the formation of conidia. This may be:

a. Tretic: conidia developed by protrusion of the inner wall through a channel in the outer wall (*Helminthosporium*).

b. Phialidic: conidia develop in basipelal succession from a specialized conidiogenous cell termed as phialides. e.g. *Trichoderma, Aspergillus* (Fig. 8. 9).

Historical classification

These groups are no longer formally accepted because they do not adhere to the principle of **monophyly**. They are traditionally reviewed by Kendrick (1981) and separated into the following:

Class Hyphomycetes lacking fruiting bodies

Order Moniliales (producing spores on simple conidiophores)

Order Stilbeliales(producing spores on synemmata)

Order Tuberculariales (producing spores in sporodochia)

Class Coelomycetes spores produced in fruiting bodies

Order Melanconiales (producing spores in acervuli)

Order Sphaeropsidales (producing spores in pycnidia)

Class: Agonomycetes lacking spores

Class: Hyphomycetes *(Syn. Hyphales)*

1. This class comprises 1700 genera (+775 Syn.) and 11000 species.
2. They are widespread in most ecological niches.
3. This artificial class is traditionally separated into three orders, based on the presence or absence of conidia and the degree of aggregation of the conidiophores into more complex structures (conidiomata). Conidiophores are mostly isolated but sometimes also appear as bundles of cells or *synnemata* or as cushion-shaped masses (*sporodochia*) .

1. Hyphomycetales (= Moniliacease + Dematiaceae)

This is the main body of the hyphomycetes;

1. Conidiophores are separated, not organized on synnematal or sporodochial conidiomata.

2. The full range of conidiogenous events occurs.

2. Stilbellales (Coremials, Synnematomycetes, stilbellaceae)

1. Conidiophores are aggregated as synnemata.
2. Conidiogenous events are various but the basauxic type is absent.

4. Tuberculariales (Tuberculariaceae)

1. Conidiophores are aggregated on sporodochial conidiomata
2. Wide range of conidiogenous events occurs.

Class: Coelomycetes

1. The term "**Coelomycetes**" merely indicates that conidia are formed within activity lined by fungal or fungal/host tissue. This class comprises 700 genera (+775 syn.) and 9000 species.
2. **Saprobic** or **parasitic** on higher plants, fungi lichens, vertebrates, and recovered from the widest range of ecological niches.
3. Conidia produced in small flyspeck, flask-shaped conidiomata, or structures resembling or approximating them in structure as pycnidial (Fig. 8.3), pycnothyrial, acervular, cupulate or stromatic conidiomata.

This artificial class has been traditionally separated into three orders, **sphaeropsidales**, characterized by pycnidial conidiomata, **Melanconiales** with acervular conidiomata, and **pynothyriales**, with pycnothyrial conidiomata. The differences in condiogensis were used for separation of taxa at the class, sub-class and ordinal levels with conidiomatal structure used at subordinal level (**Sutton 1980**).