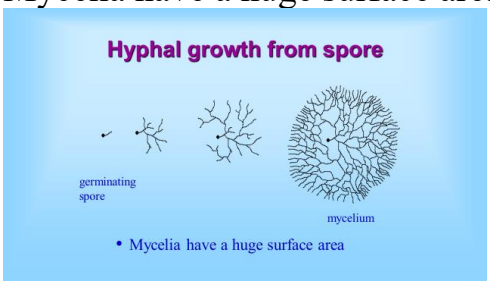
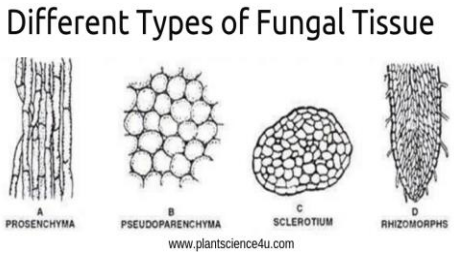
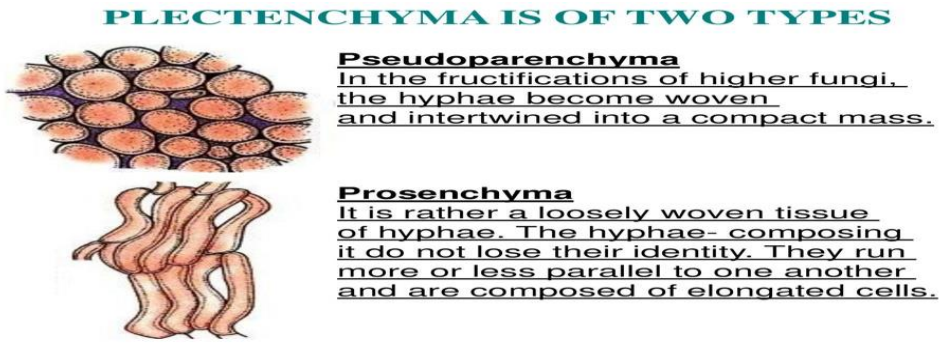
Hyphal growth from spore
Mycelia have a huge surface area



Fungal mycelial aggregates



Modification of hyphae in fungi
1- Plectenchyma
a-Prosenchyma b- pseudoparenchyma
2-Sclerotium (Pl.Sclerotia)
3-Rhizomorph
4- Appressorium (Pl. Appressoria)
5- Haustorium (Pl. Haustoria)



SCLEROTIUM

A sclerotium is a compact globose or elongated structure formed by the aggregation and adhesion of hyphae. It may survive for long periods of time sometimes for several years and thus represent the resting stage of the fungus. The sclerotia usually germinate to form hyphae or may form reproductive structures. Sclerotia are commonly formed in *Claviceps purpurea*, *Rhizoctonia solani* and *Macrophomina phaseoli*

RHIZOMORPH

A thick strand or root like aggregation of somatic hyphae is called Rhizomorph. The hyphae loose their identity and individuality and the whole mass behaves as an organised unit. It is believed that rhizomorph has a higher infection capacity than individual hyphae Examples of Rhizomorphs are found in Armillariella mellea.

APPRESSORIUM (PL. APPRESSORIA)

These are common in parasitic fungi mostly ectoparasites. An appressorium is a terminal simple or lobed swollen structure of germtubes or infection hyphae. It adheres to the surface of the host and helps in the penetration of hyphae of the pathogen. Appressoria are commonly formed by the parasitic members of the order Erysiphales .

HAUSTORIUM (PL. HAUSTORIA)

These are mostly produced as intracellular absorbing structures of obligate parasites. Haustoria are usually produced in those fungi in which intercellular mycelium are found. They vary in shape and may be knob shaped or branched finger shaped.
They secrete certain specific enzymes which hydrolyse the proteins and carbohydrates of the host cell and thus they absorb nutrients from the host without killing it. Haustoria also provide a greater surface area for the exchange of materials. Details of the structure of haustorium are being described elsewhere.

Stromata

Stroma (pl. **stromata**) **fungal** tissue mass of pseudoparenchyma in or on which the reproductive structures (perithecia) are formed in some sac **fungi**.

Fruit bodies
Aggregation to form reproductive organs

In Ascomycota and Basidiomycota and Deuromycota

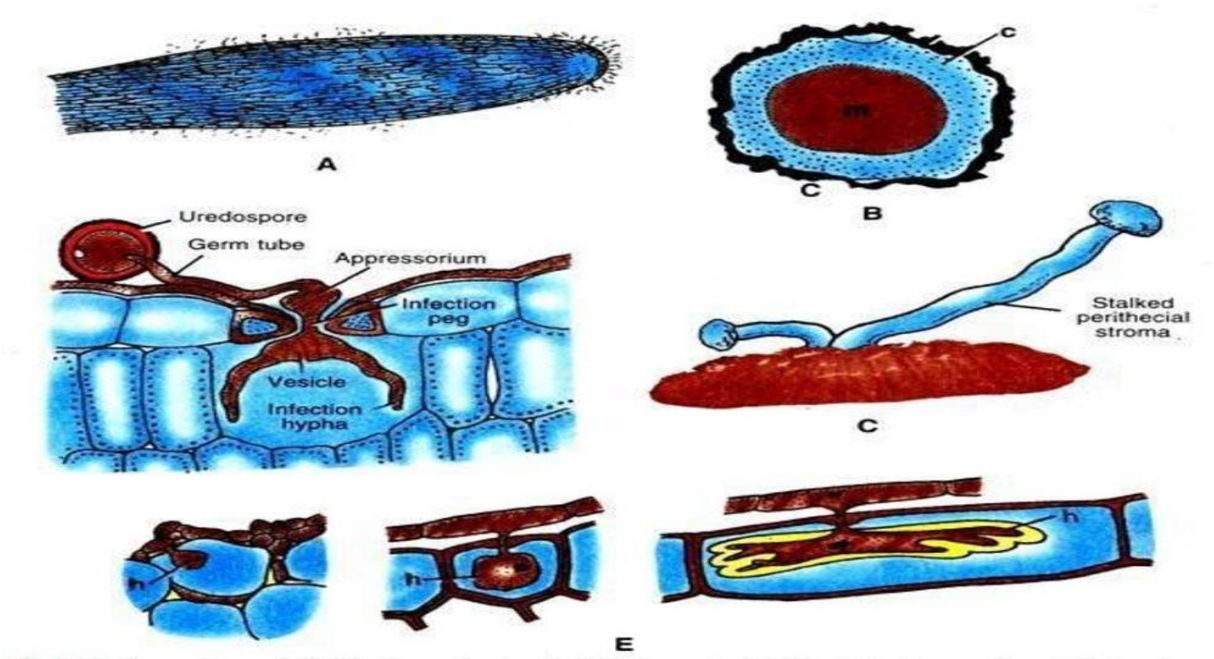


Fig. 1.14. Aggregation and Modifications of hyphae. A-B, Rhizomorph; C, Sclerotia; D, Appressorium; E, Haustorium.

Reproduction in fungi:

Some simple types of thalli are converted entirely into reproductive cells and are termed holocarpic .In eucarpic thalli,which are typical of most fungi, only part of the thallus becomes reproductive and the cells formed for this purpose are usually highly specialized in form and development.

Vegetative, Asexual and Sexual methods

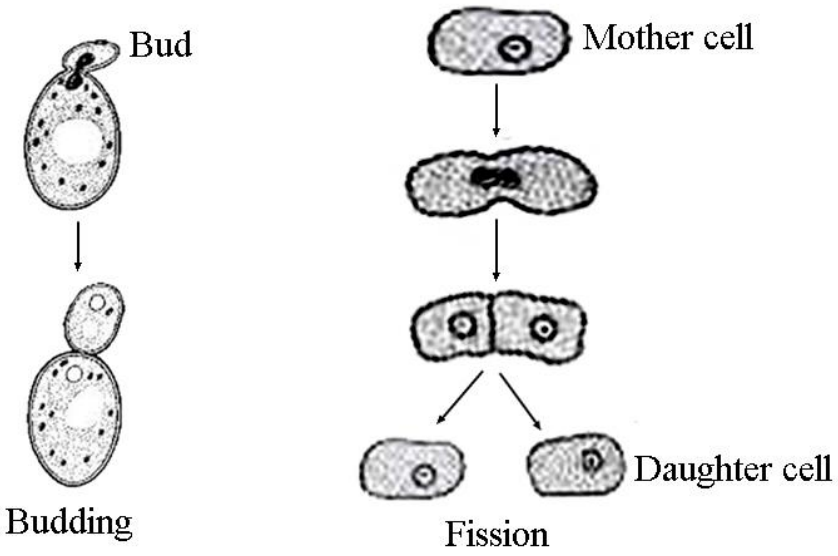
1- **Vegetative reproduction**: The most common method of vegetative reproduction is fragmentation. The hypha breaks up into small fragments accidentally or otherwise. Each fragment develops into a new individual. In the laboratory the hyphal tip method is commonly used for inoculation of saprophytic fungus.It occurs by

   1- Fragmentation: Mycelium gets fragmented into small fragments, each of which is able to develop into new individual. It is common in filamentous fungi.

2- Fission occurs in unicellular fungi such as yeasts. Mature cells divided mitotically into two and the two daughter cells separates and give rise to two individual.

3- Budding Bud like growth emerges out from the mature cells. It is commonly occurs in unicellular forms such as yeast.

4- Formation of gemmae: Gammae are specialized thick walled aggregation of chlamydospores like structures. They are formed in unfavorable condition.



Asexual reproduction

It is the more important type of reproduction as it occurs several times throughout the season. Progeny is genetically identical to the parent. Asexual reproduction takes place during favorable condition by the formation of variety of spores. Such spores produced by asexual reproduction are called mitospores. Spores may be unicellular or multicellular so they are classified into

1- Amerospores one celled spore

2- Didymospore two celled spore

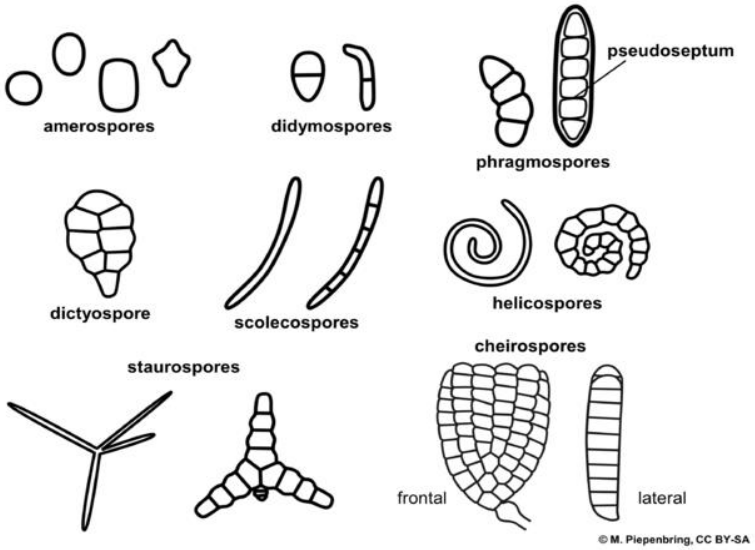
3- Phragmospore spore with two or moretransverse septa

4-Dictyospores sporeswith one or more transverse and vertical septa

5- Scolecospores vermiform or filiform shaped spores

6- Staurospores stellate or spores with radiating arms

7- Helicospores spirally coiled spores



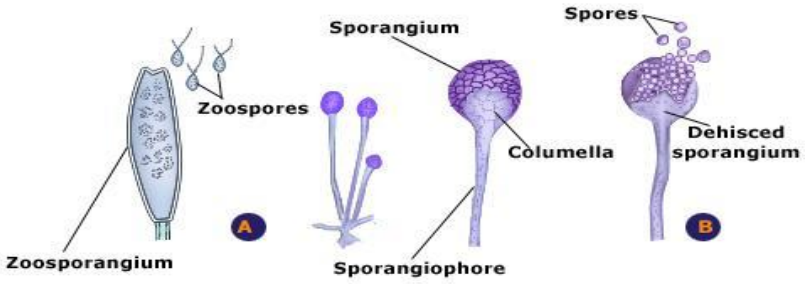
Fungi produce two major types of asexual spore: sporangiospores and conidia.
Types of Asexual Spore:

Sporangiospores: ENDOGENOUS formed and contained within a sporangium as a result of the cleavage of protoplasm around nuclei and followed in some cases by formation of a wall around each nucleate portion of protoplasm.

Two main types Zoospores (motile) and Aplanospores (non- motile).

a) Aplanospores: a nonmotile, asexual spore formed within cell, the wall of which is distinct from that of the parent cell.

b) Zoospores : Zoospores are MOTILE SPORANGIOSPORES and the sporangia in which they are formed are called ZOOSPORANGIA. Because zoospores are motile, the fungi that produce them will require water at some stage during their life cycle. Three different types of zoospore distinguish the Chytridiomycota, Hyphochytridiomycota and Oomycota.



Exogenous spores

The spores produced externally are either called the exogenous spores or conidia. They are produced externally on the branched and unbranched conidiophore which may be septated or non –septated (aseptated). The conidia borne upon the terminal apices of the conidiophores or the end of the branches of conidiophores. The conidia may be produced singly on each sterigma or in chain. The conidial chains may be basipetal or acropital in succession. The conidia are diverse in shape and size. Two main types - THALLIC and BLASTIC

a) **Thallic conidia**: Develop by septation and fragmentation of a hypha. May develop at the tip of hypha or in an intercalary (central) position. In both cases, all layers of the hyphal wall are involved in spore formation. It is further divided into 2 types: Arthrospores and Chlamydospores.

1. Arthrospores: Formed by septation and fragmentation of an existing hypha. Elements of the hypha (incl. all wall layers) become converted into conidia. Each fragment is rounded off and liberated in succession. Separation of the conidia from :one another is due to breakdown of the middle region of each septum.

2-Chlamydospores: A type of resting (survival) spore. An intercalary or apical hyphal cell or compartment enlarges, rounds up and develops a thickened, often pigmented wall. Contain dense cytoplasm and nutrient storage compounds. All wall layers are involved in their formation. Become isolated from adjacent hyphal compartment(s) by the sealing of septal pores (if present). Usually develop under conditions of stress that are unfavourable for normal somatic growth.

b) **Blastic conidia:** Develop by a budding or swelling process. May develop as single spores or in succession to form a chain of spores.

1. Blastospores: • Formed by budding of a hypha or yeast cell. • Both wall layers are involved. • The spore may remain attached and bud further blastospores - giving rise to a branched chain of spore.

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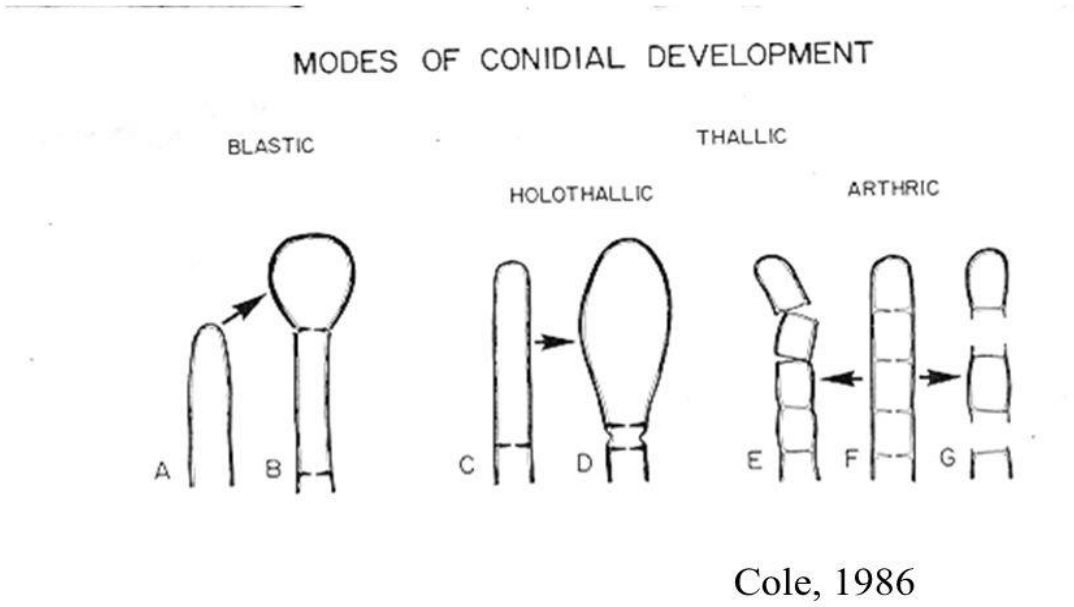
Blastic versus **thallic**



Cole, 1986

Porospores: • The developing spore emerges through a distinct 'pore' in the hyphal wall. • Only the inner layer of the hyphal wall is involved in spore development. • The new spore then develops its own new inner wall layer. • The outer spore wall is often thickened and pigmented. • A scar is usually obvious at the point of detachment from the hypha (conidiophore).

Aleuriospores: • Develop as single, terminal spores. • Conidiophore apex inflates and becomes separated by a septum at an early stage in spore development. Both wall layers are involved in spore formation . • The spore possesses a wide, truncate scar. • Normally no further development of spores occurs at the point of detachment. So the next spore usually has to develop by production of a branch below the scar on the conidiophore.

Annellospores: • In some species that form conidia in a manner similar to that described for aleuriospores a new growing point develop at the scar. A chain of spores may develop. • The conidiophore gets a little longer with each spore produced. • Annellations (ring-like scars) are observed around this elongating portion. • Each annellation represents the production of one annellospore.

Phialospores: • Form in succession. • Each spore is pushed up from the tip of the conidiophore, which is now called a PHIALIDE. • The spore wall is new and distinct from both wall layers of the phialide. • The first spore has a cap, which represents the tip of the phialide wall through which the spore emerged - all other spores in the chain are smoothly rounded.

3-Sexual Reproduction

In fungi, as in other organisms, sexual reproduction greatly increases variability in a species. In fungi, sexual reproduction often occurs in response to adverse environmental conditions.

Sexual reproduction in fungi consists of three sequential stages: plasmogamy, karyogamy, and meiosis .

1- Plasmogamy, the fusion of two protoplasts (the contents of the two cells), brings together two compatible haploid nuclei .

2-Karyogamy, two nuclei types are present in the same cell, but the nuclei have not yet fused. Karyogamy results in the fusion of these haploid nuclei and the formation of a diploid nucleus (i.e., a nucleus containing two sets of chromosomes, one from each parent). The cell formed by karyogamy is called the zygote.

3-Meiosis (cell division that reduces the chromosome number to one set per cell) generally follows and restores the haploid phase. The haploid nuclei that result from meiosis are generally incorporated in spores called meiospore

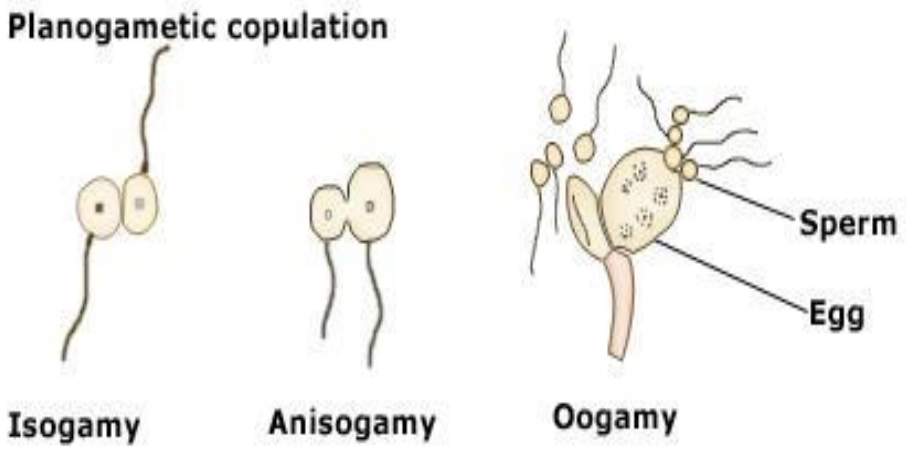
In most of the lower fungi plasmogamy is immediately followed by karyogamy and meiosis. In higher fungi karyogamy is often delayed so that the hyphae remain dikaryotic. This phase of fungal life cycle is called dikaryophase. Such fungi complete their life cycle in three phases :

a haplophase, The phase in the life cycle of an organism in which its nuclei are haploid. A dikaryophase In higher fungi, karyogamy is delayed and occurs just before meiosis. In the stage intervening between plasmogamy and karyogamy the cells often contain two nuclei or Dikaryons (n+n). Such cells are called dikaryotic cells. The phase is known as Dikaryophase which takes place in Ascomycetes and Basidiomycetes. A diplophase The phase in the life cycle of an organism in which its nuclei are haploid.

The types of sexual reproduction in different groups of fungi:

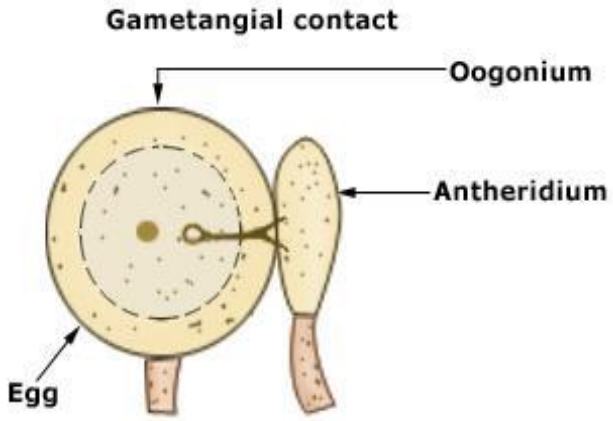
Planogametic Copulation

Here motile gametes called planogametes undergo fusion. When both the gametes are motile and morphologically similar, the fusion process is called isogamy. But Anisogamy two motile gametes are fused and morphologically different .



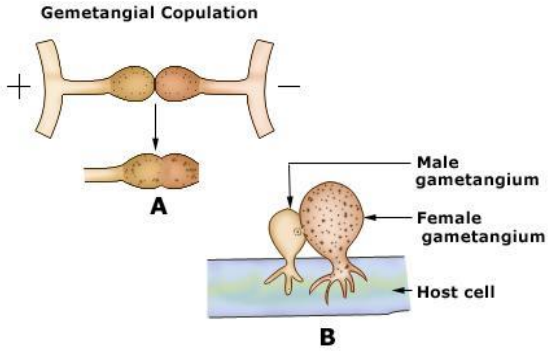
Gametangial Contact

Here, gamete bearing structures called gametangia (Antheridium male gametanium , Oogonium female gametangium) come closer to each other and develop a fertilization tube through which the male gamete migrates into the female gametangium.



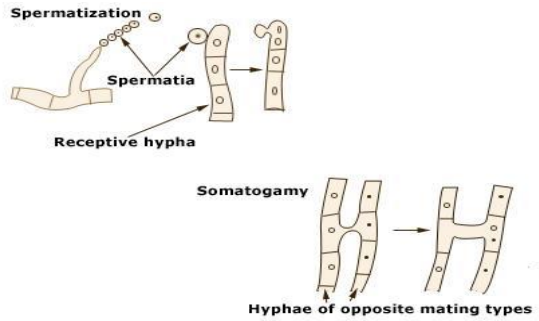
Gametangial Copulation

Here, the gametangia fuse with each other, lose their identity and develop into a zygospore.

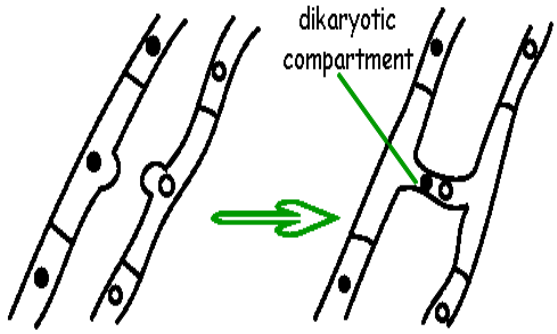


Spermatisation

In some fungi like Puccinia, tiny unicellular spore like structures (1n) called spermatia bearing on spermatophore and They get transferred to (receptive hypha) through various agencies (wind , insects , air ,water etc) , A pore develops at the point of contact between the hypha and the spermatium then the contents of spermatium(including its nucleus) pass into the hyphal compartment, which as a result becomes dikaryotic.



Somatogamy : this type occurs in higher fungi , The fusion of somatic hyphae of two compatible mycelia results in a dikaryon from which a dikaryotic mycelium may develop. the dikaryotic phase is limited to mycelium within the fruiting body.



Life Cycle

In general, fungi begin their lives as a spore, then germinate and develop into mycelium. in the life cycle of a sexually reproducing fungus, a haploid phase alternates with a diploid phase. The haploid phase ends with nuclear fusion, and the diploid phase begins with the formation of the zygote (the diploid cell resulting from fusion of two haploid sex cells). Meiosis (reduction division) and initiates the haploid phase, which produces the gametes. In the majority of fungi, all structures are haploid except the zygote. Nuclear fusion takes place at the time of zygote formation, and meiosis follows immediately

Fungi usually reproduce both sexually and asexually. The asexual cycle produces mitospores, and the sexual cycle produces meiospores. Even though

both types of spores are produced by the same mycelium, they are very

different in form and easily distinguished . The asexual phase usually precedes the sexual phase in the life cycle and may be repeated frequently before the sexual phase appears

Homothallism and Heterothallism Based on the compatibility in sexual reproduction the fungal hyphae can be distinguished into two types homothallic and heterothallic.

In homothallic forms (monoecious) , fusion occurs between the genetically similar strains or mating types. In such forms, meiosis results in the formation of genetically identical spores. Homothallic (monoecious) refers to the possession, within a single organism, of the resources to reproduce sexually; i.e., having male and female reproductive structures on the same thallus.

In the heterothallic forms, fusion occurs between the genetically different mating types or strains. The strains are genetically compatible and are designated as + strain and strain. In such forms meiosis results in the formation of both the strains, in equal numbers. Heterothallic species have sexes that reside in different individuals. The term is applied particularly to distinguish heterothallic fungi, which require two compatible partners to produce sexual spores, from homothallic ones, which are capable of sexual reproduction from a single organism.

Sexually produced spores of the higher fungi result from meiosis and are formed either in sac-like structures (asci, typical of the Ascomycota) or on the surface of club-shaped structures (basidia, typical of the Basidiomycota). Asci and basidia may be borne naked, directly on the hyphae, or in various types of sporophores called ascocarps (also known as ascomata) or basidiocarps (also known as basidiomata), depending on whether they bear asci or basidia respectively.

Since fungi are often classified according to their spore-producing structures, these spores are often characteristic of a particular taxon of the fungi: • Zygospores: spores produced by a zygosporangium, characteristic of zygomycetes. • Ascospores: spores produced by an ascus, characteristic of ascomycetes. • Basidiospores: spores produced by a basidium, characteristic of basidiomycetes. • Aeciospores: spores produced by an aecium in some fungi such as rusts or smuts. Urediniospores: spores produced by a uredinium in some fungi such as rusts or smuts.

Teliospores: spores produced by a telium in some fungi such as rusts or smuts. • Oospores: spores produced by an oogonium, characteristic of oomycetes.

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