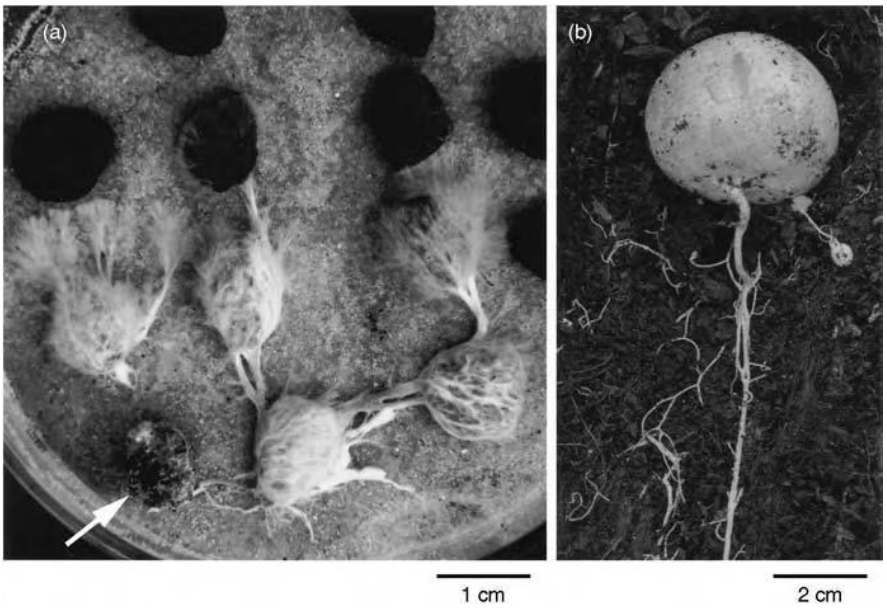
Lecture 2: Fungal Structures and Reproduction

Hyphal aggregates

Fungi are capable of producing complex and characteristic multicellular structures which resemble the tissues of other eukaryotes. This must be controlled by the positioning, growth rate and growth direction of individual hyphal branches. Further, instead of spacing themselves apart as during invasive growth, hyphae must be made to aggregate. Very little is known about the signalling events leading to the synchronized growth of groups of hyphae. These aggregates include:

Mycelial strands

The formation of aggregates of parallel, relatively undifferentiated hyphae is quite common in the Basidiomycota and in some Ascomycota. For instance, mycelial strands form the familiar 'spawn' of the cultivated mushroom *Agaricus bisporus*. Strands arise most readily from a well-developed mycelium extending from an exhausted food base into nutrient-poor surroundings. When a strand encounters a source of nutrients exceeding its internal supply, coherence is lost and a spreading assimilative mycelium regrows. Alternatively, mycelial strands may be employed by fungi which produce their fructifications some distance away from the food base, as in the stinkhorn, *Phallus impudicus*. Here the mycelia strand is more tightly aggregated and is referred to as a **mycelial cord**.



Strands of *Podosordaria tulasnei* (Ascomycota) extending from a previously colonized rabbit pellet (arrow) over sand (left). Excavatedmycelial cords of the stinkhorn Phallus impudicus, which can be traced back from the egg-like basidiocarp primordium to the base of an old tree stump (right).

Rhizomorphs

A central core of larger, thin-walled, elongated cells embedded in mucilage is surrounded by a rind of small, thicker-walled cells which are darkly pigmented due to melanin deposition in their walls. These root-like aggregations are a means for Armillaria to spread underground from one tree root system to another. In nature, two kinds are found _ a dark, cylindrical type and a paler, flatter type. The latter is particularly common beneath the bark of infected trees.

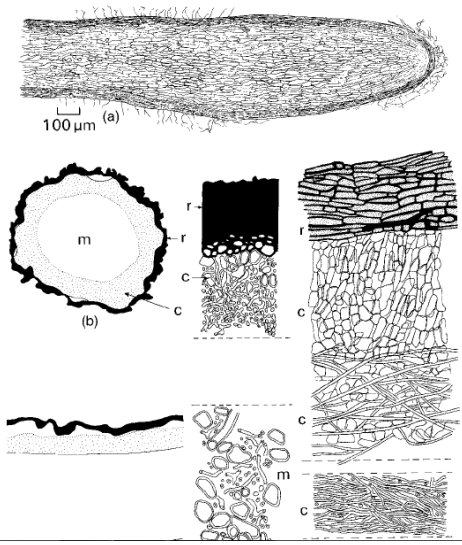


Fig. I.14 Rhizomorph structure of *Armillaria mellea* (Basidiomycota). (a) Longitudinal section. (b) Transverse section, diagrammatic. (c) L.S. diagrammatic. (d) T.S. showing details of cells in the rind (r), cortex (c) and medulla (m). (e) L.S. showing details of cells.

Sclerotia

Sclerotia are pseudoparenchymatous aggregations of hyphae embedded in an extracellular glucan matrix. A hard melanized rind may be present or absent. Sclerotia serve a survival function and contain intrahyphal storage reserves such as polyphosphate, glycogen, protein, and lipid. The glucan matrix, too, may be utilized as a carbohydrate source during sclerotium germination. Sclerotia may also have a reproductive role and are the only known means of reproduction in certain species. They are produced by a relatively small number of Asco- and Basidiomycota, especially plantpathogenic species such as Rhizoctonia spp.

Plant pathogenic fungi

Hyphae of plant pathogenic fungi growing within the tissues of their hosts exhibit three basic patterns of growth:

1- **Perthrotrophs**, also called necrotrophs: use enzymes and toxins to kill host cells in advance of their hyphae and then grow between and into dead and dying cells

2- **Biotrophs**: are ecologically obligate parasites and obtain nutrients only from living host cells. The hyphae of most biotrophs grow primarily between host cells and give rise to specialized hyphal branches that penetrate the host cell wall and then into host cell plasma membrane

without killing the cell. These branches are known as haustoria (sing. haustorium; houstor = drinker) which involved in the uptake of nutrients from the host cell.

3- **Hemibiotrophs**: this group of pathogens initially requires living host cells but soon cause the death of host cells in advance of their hayphae like the perthrotrophs noted above.

In mentioning the topic of plant pathogenic fungi, we need to mention **appressoria** (sing. appressorium). These are specialized infection structures formed at the tips of germ tubes. Appressoria adhere to host surfaces and form penetration pegs that enter the host either by growing into stomatal openings or by directly penetrating the host epidermis.

Reproduction of fungi:

Reproduction: is the formation of new individuals having all the characteristics typical of the species.

Two general types of reproduction are recognised:

1- **Sexual reproductio**n which characterized by the union of two nuclei followed by meiosis. The significance of sexual reproduction is that results of new genotypes.

2- **Asexual reproduction** which sometimes called somatic reproduction, does not involve karyogamy (karyon = nut + gamos = marriage), the fusion of nuclei and meiosis. Likewise, specialised sex cells or sex organs are not involved.

Typically, fungi reproduce both sexually and asexually. In general, asexual reproduction is more important for the colonization of the species because it results in the production of large numbers of individuals and particularly since the asexual cycle is usually repeated several times during the season, whereas the sexual stage of many fungi may be produced only once a year. Therefore, two stages of life cycle of fungi are exist:

1- Teleomorph is used to describe the sexual stage of a fungus

2- Anamorph is used to describe for asexual stage of fungi

Asexual reproduction of fungi:

Common asexual reproduction of fungi summarised as follows:

1- **Fragmentation** of the soma. Each fragment growing into a new individual

2- **Fission** of somatic cells into daughter cells

3- **Budding** of somatic cells of spores, each bud producing a new individual

4- **Production of mitotic spores**, each spore usually germinating to form a germ tube that grows into the mycelium.

The most common method of asexual reproduction in fungi is by means of spores. **Asexual spores vary greatly in:**

1- Morphology:
   a. Thin wall
   b. Thick wall

2- In colour:
   a. Hyaline
   b. Transparent
   c. Through green
   d. Yellow
   e. Orange
   f. Red
   g. Brown
   h. Black

3- In size
   a. Minute
   b. Large

4- In shape
   a. Globose
   b. Oval
   c. Oblong
   d. Needle-shaped
   e. Helical

5- In number of cells
   a. One-celled

b. Multi-celled

Fungal spores are also differing in the way in which the spores themselves are borne. Some spores develop directly from simple hyphae while others rise from elaborate structures. Some fungi produce only one type of spores; others produce as many as four types.

Fungal spores produced asexually are either:

1- Born in sporangia (sing. sporangium; spora = seed, spore + angion = vessel) and then called **sporangiospores**

2- Produced at the tips or sides of hyphae in various ways and are then called **conidia** (sing. conidium; konis = dust + -idion, dimin.suffix).

A sporangium is a saclike structure whose entire contents are converted through cleavage onto one or more, usually many, spores. The spores produce within a sporangium are called sporangiospores. Sporangiospores of nearly all true fungi are non-motile and are called aplanospores. Some other spores are motile are called zoospores. These spores usually are equipped with a single whiplash flagellum attached to the posterior end of the spore.

Sexual reproduction of fungi:

The process of sexual reproduction

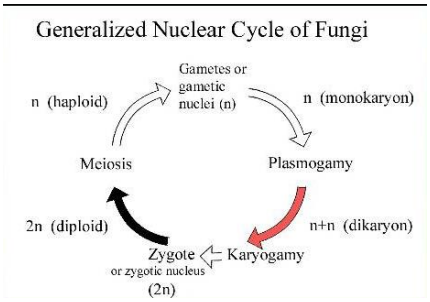
Sexual reproduction in fungi, as in other living organisms, involves the union of two compatible nuclei. The process of sexual reproduction consists of three distinct phases:

1- Plasmogamy: a union of two protoplasts brings the nuclei close together within the same cell.

2- Karyogamy: the fusion of the two nuclei that brought together by plasmogamy as noted in the phase one already.

Karyogamy follows plasmogamy almost immediately in some species, while in other species such a pair of nuclei may not fuse until later times of life history of the fungus.

3- Meiosis: is followed by nuclear fusion which takes place in all sexually reproducing fungi. In this phase the number of chromosomes reduces to the haploid.



Sexual spores of fungi

Sexual reproduction in most of the fungi involves the formation of specialized spores. Four types that have been given special names are:

1- Oospores

2- Zygospores

3- Ascospores

4- Basidiospores

Sexual organs categories in fungi:

Sexual organs involved in sexual reproduction of fungi may be classified in to three categories:

1- Hermaphroditic: produce distinguishable male and female sex organs on each thallus. A single thallus of hermaphroditic species can produce sexually by itself if it is self-compatible. Here each thallus bears both male and female organs that may or may not be compatible.

2- Dioecious: thalli producing only male and others only female sex organs. The sexes separated in two different individuals. A single thallus of a dioecious species cannot reproduce sexually by itself normally since it is either male or female (very few of dioecious fungi have been discovered).

3- Sexually undifferentiated: in which sexually functional structures are produced that are morphologically indistinguishable as male or female (the majority of fungi fall into this category).

Forms of sex organs of fungi

In general, the sex organs in fungi are called gametangia. They may form different sex cells called gametes or simply may contain nuclei that are the functional gametes. Sex organs in fungi are in two major forms:

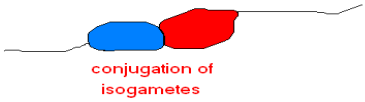
1- Isogametangia and isogametes: to designate gametangia and gametes that is morphologically indistinguishable.

2- Heterogametangia and heterogametes: to designate male and female gametes that are morphologically different. In this case, the male gametangium is called antheredium and female gametangium is called either an oogonium or an ascogonium depending on functional group.

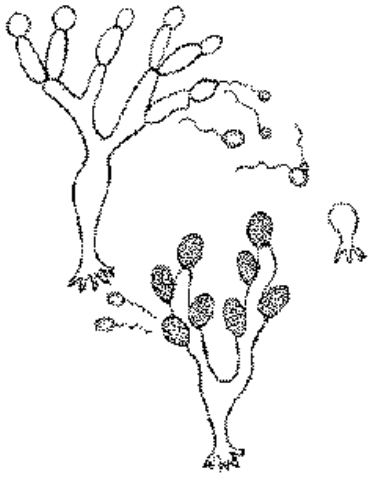
There are the following sexual reproductions that belong to the above major groups:

1. **Planogametic conjugation**: planogamete is a motile gamete or sex cell. Planogamete conjugation involves fusion of two gametes, one or both of which may be motile. It takes place only when free water is available at this critical stage of the life cycle. Such reproduction is accomplished by one of the following:

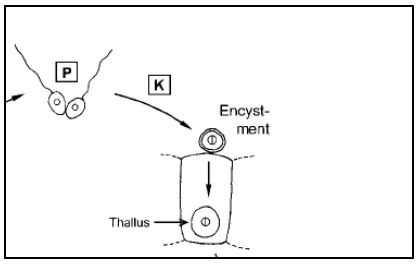
    a. conjugation of the isogamous planogametes (*Olpidium, Synchyterium*) the motile gametes are morphologicaly similar but physiologically different. Unite in the water to form motile zygotes



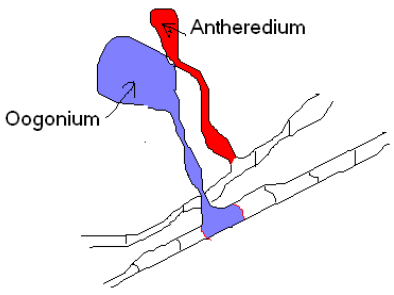
    b. conjugation of the anisogamous planogametes: one planogamete is considerabley larger than other. Fusion takes place in water and motile zygote is formed. In this some species of Blastocladiales produces separate male and female gametangia in which gametes are distinct from each other.



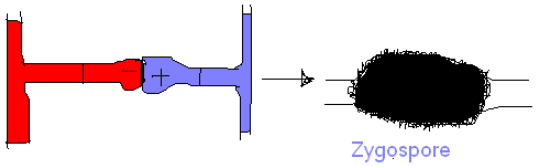
2. **Gametangial copulation**: (in *Chytridium*) the process of sexual reproduction involves the transfer of entire protoplast of one gametangium into another one. In these members female thalli appears to be nothing more than sporangial thallus with its oxogenous growth arrested at an early stage by the enlargement of the male thallus. Later ensysted male cell empties its contents into female thallus and the combined protoplasts moves into endobiotic swelling increasing in size and soon becoming surrounded by a thick warty wall (oospore).



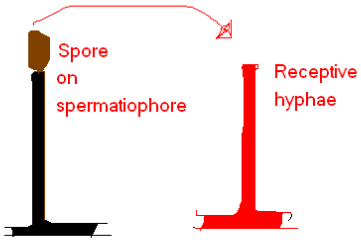
3. **Gametangial contact**: (oomycetes, some Ascomycetes). This type of union is heterogamous, neither male nor female gamete is motile (i.e. reproduction is always heterogamete). The male and female gametangia come into close contact and the male gamete (non motile) consisting mainly of the nuclear material are directly transformed into the female gametangia through pore dissolved in a common wall at the point of contact or even through a short fertilization tube (trichogyne). Oogamous condition which results into formation of the non motile zygote (oospore) is a specialized form of gametangieal contact because here the male (nuclear material) fertilizes one or more oospore (egg within the oogonia). In higher fungi (Ascomycetes) there are no oospores and female gametes are represented by nuclei. The terms used in ascomycetes are antheridia and ascogonia for respective male and female gametania. Since both gametes are non motile, gametangial contact is possible in non-aquatic fungi and fungus achieves a measure of independence from free water in situation which are liable to dry up.



4. **Gametangial conjugation**: (fusion of similar cells for reproduction) found in Zygomycota. It is the fusion of two multinucleate gametangia that are mainly similar in structure but may differ in size.



5. **Spermatization**: consists of copulation of spermatia or microconidia or ooidia produced in special receptacles (spermagonia), with the female sex cells. The acogonia are produced in in the ascocarp initials, through the medium of the receptive hyphae (trichogyne) through which the spermatial nucleus reaches the ascogonia where it pair with the female nucleus resulting in plasmogamy. The spermatia are minute, bacillary of helicoid , uninucleate cells incapable of germination.



Sexual compatibility

Fungi in the categories outlined above belong to one or another of the following three groups on the basis of compatibility:

1- Homothallic fungi: those in which every thallus is sexually self-fertile and can, therefore, reproduce sexually by itself without the aid of another thallus.

2- Heterothallic fungi: those in which every thallus is sexually self-sterile, regardless of whether or not it is hermaphroditic, and requires the aid of another compatible thallus of a different mating type for sexual reproduction.

3- Secondary homothallic fungi (pseudohomothalism): they are heterothallic fungi but behave as homothallic. To explain, in some heterothallic fungi and during spore formation, two nuclei of opposite mating types are incorporated regularly into each spore or at least some spores. Germlings arising from these spores are therefore self-fertile and behave as if they are homothallic when in reality they are actually heterothallic.

Possible questions of this section

1. What is mycology? What is the origin of the word?
2. What is the medicinal importance of fungi?
3. What is the economic importance of fungi?
4. What does it mean by antagonistic fungi?
5. What are the differences between eukaryotic and prokaryotic organisms?
6. Why fungi are not motile microorganisms?
7. Where would be the position of symbiotic fungi in existence of saprobes and parasites?
8. What will be the benefits of fungi being septate or aspetate?
9. What are the reasons of having a unique feature of fungi?
10. Sclerotia, as a mycelium aggregate, are a useful structure in some fungi?
11. Biotrophs normally don’t kill their hosts?
12. Mitotic spores are vary greatly