REPRODUCTION IN FUNGI

Reproduction is the formation of new individuals having all the characteristics typical of the species. Two general types of reproduction are recognized: asexual and sexual. Asexual reproduction, sometimes called somatic or vegetative, does not involve the union of nuclei, sex cells, or sex organs. Sexual reproduction, on the other hand, is characterized by the union of two nuclei. Typically, fungi reproduce both asexually and sexually.

But here we describe, reproduction in fungi are of three kinds:

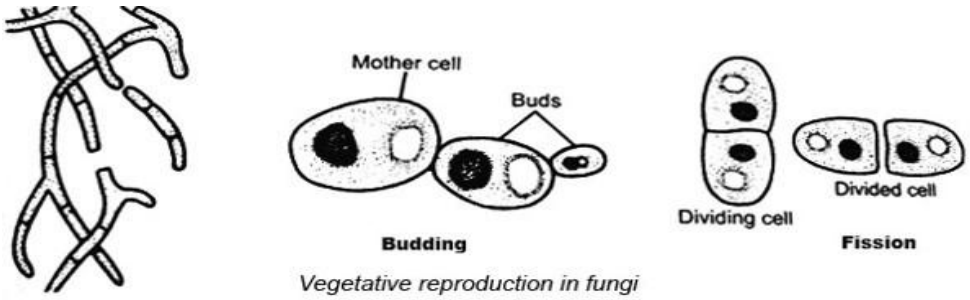
1. Vegetative reproduction
2. Asexual reproduction
3. Sexual reproduction

VEGETATIVE REPRODUCTION

1. **Fragmentation:** Fragmentation may also occur accidentally by the tearing off of parts of the mycelium through external forces. Such bits of mycelium under favourable conditions will start a new individual. The hyphal bits broken through any kind of injury grow into new individuals.

2. **Fission:** The splitting of a cell into two daughter cells by formation of transverse septa, e.g. yeast.

3. **Budding:** Budding is the production of a small outgrowth (bud) from a parent cell. As the bud is formed, the nucleus of the parent cell divides and one daughter nucleus migrates into the bud. The bud increases in size while still attached to the parent cell and eventually breaks off and forms a new individual. The parent cells bud-off new cells. The bud spores are also called **Blastospores** (Gk. *Blastos*: bud; *Spore*: Seed), e.g. yeast.



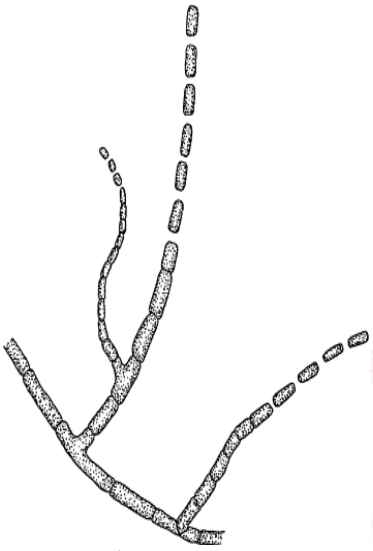
Vegetative reproduction in fungi

4. **Sclerotium:** It is a hard pseudoparenchymatous structure formed by intertwining of the hyphae. The sclerotia are very hard and highly resistant to the adverse environmental conditions which may remain dormant for long periods of time and germinate on the return of the favourable conditions. The examples are *Rhizoctonia, Claviceps* and *Sclerotinia.*

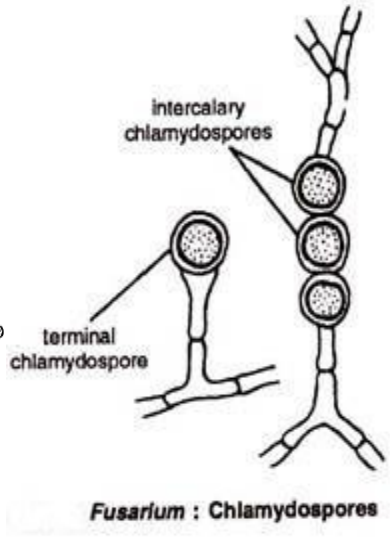
5. **Chlamydospores:** Irregularly spherical, thick-walled, swellings at any place along the hypha are known as chlamydospores. They are separated by the septa. They may be terminal or intercalary and may remain in

chains. The examples are *Fusarium oxysporum*. They have long dormant periods and are the survival spores (resting spores) of the fungi.

6. Oidia or Arthrospores: The hyphae become divided by transverse walls which are not thickened, often formed into chains and do not have any dormant period (ready-to-germinate spores). They are formed only terminally and are never intercalary.

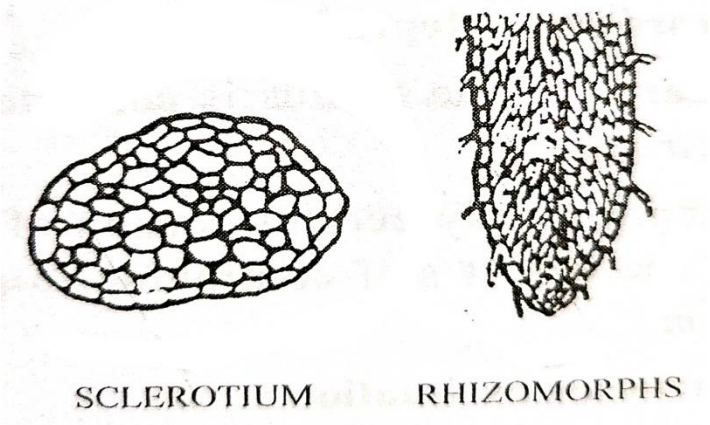


Arthrospore



***Fusarium* : Chlamydospores**

7. Rhizomorph: Longitudial aggregation of hyphae to form thick strand like structures are known as rhizomorphs. Morphologically, they are dark brown, hard and thick. They may be smooth, hairlike, rootlike structures. They also serve as resting structures. The example is *Armillaria mellea.*



SCLEROTIUM RHIZOMORPHS

ASEXUAL REPRODUCTION

Asexual reproduction is a method of reproduction which does not involve any sexual act and chiefly meant for quick production and dissemination. Their formation does not involve karyogamy and meiosis and they are always derived mitotically, hence also called **mitospores**.

A spore (Gr. *spora* = seed, spore) is a minute, simple propagating unit without an embryo that serves in the production of new individuals of the same species.

Types of Asexual Spores: The asexually produced spores are of two types:

1. Sporangiospores
2. Conidiospores or conidia

1. Sporangiospores: These are endogenously produced within a sac-like structure called sporangia (sing. sporangium). The sporangiospores are the characteristics of the lower fungi. Sporangium is a sac-like enclosure whose entire contents are converted into one or more, usually many spores through cleavage of the cytoplasm held within. Sporangiospores are of two types:

a) Planospores/motile/zoospores: They are found in the lower forms. The zoospores are always naked, that is, they do not have a rigid cell wall and the cytoplasm is surrounded only by the cell membrane. The zoospores are formed within a **vesicle** or directly in the sporangium. The zoospores are either roughly spherical or reniform (kidney-shaped). The zoospores are characterized by the presence of flagella being either uni- or biflagellate. Structurally the flagella are of two types: whiplash and tinsel type.

b) Aplanospores/non-motile sporangiospores: They are non-motile spores. They are uni- or multinucleate, and are formed only at the periphery of the sporangium, Leaving a large gap at the centre and the base, which is known as **Columella,** being separated by a wall from the rest of the sporangium. They are released by the dissolution of the sporangial wall or by the breakdown of the entire sporangium.

2. Conidiospores/Conidia: These are exogenously produced asexual spores. Conidia are formed singly or in chains in **basipetal** or **acropetal** succession from the structures differentiated from the thallus, i.e. conidiophores.

A conidium is a non-motile, asexual spore formed at the tip or side of a sporogenous cell/conidiogenous cell Conidia are not produced as a result of a progressive cleavage of cytoplasm (as in the formation of sporangiospores). Conidia may be spherical, ovoid, elongated, cylindrical, threadlike, star-shaped etc. and they may be unicellular or multicellular with either transverse septa or both, transverse and longitudinal septa (muriform conidia). They may be hyaline or coloured.

Conidia are of various shape, size, uninucleate to multinucleate, unicellular to multicellular, without pigments or with pigments ranging from light olive to deep black. The conidiophore may be free, simple branched and distinct from each other of may be aggregated to form compound sporophore called as fruiting bodies.

The asexual fruiting bodies produced by the fungi are:

1. Synnemata
2. Sporodochia
3. Acervuli
4. Pycnidia
5. Sorus

1. Synnema (Pl . Synnemata)

It is nothing but the loose aggregation of erect conidiophore so as to form a dense fasicle, similar to mycelial strand. It may split in different ways near the apex, sometimes resembling a feather duster. Such arrangement is called as *coremium* and the conidia are produced at its apex, example *Ceratocystis* sp, *Graphium* sp.

2. Sporodochium (Pl. Sporodochia)

It is a fruiting body peculiar to the fungi *Fusarium* sp. It is a cushion shaped aggregation of hyphae which breaks through the host surface and bears conidiophore. These structures may also be formed in the mass of hyphae lying superficially over the substrate.

3. Acervulus (Pl. Acervuli)

Most of the fungi belonging to the order melonconiales of the deuteromycotina sub division produce acervuli. It is nothing but a saucer shaped depressed mass of aggregated hyphae bearing conidiophore in a compact layer on its exposed surface. In between the conidiophore, long pointed dark coloured structures called *setae* are present. On the host, acervuli are initially developed below the cuticle or epidermis and become erumpent on maturity. example *Colletotrichum* sp, *Pestalotia* sp.

4. Pycnidium (Pl. Pycnidia)

It is a hollow, flask shaped or globose fruiting body with a narrow mouth (*Ostiole*) whose pseudo parenchymatous inner walls (*Peridium*) are lined with conidiophore which bear conidia. example *Macrophomia phaseolina, Botrydiplodia theobromae, Diplodia natalensis*.

5. Sorus (Pl. *Sori)*

Sorus in Greek means heap. ie., the spore bearing hyphae are grouped into small to large masses or clusters. Example, smut sori, rust sori.

SEXUAL REPRODUCTION

Sexual reproduction in fungi as in other living organisms involves the union of two compatible nuclei. It is a method through which fungi create diversity of genetic makeup among themselves. It helps them to adapt to new environments.

The sexual spores may be derived as a result of fusion (diplospores) or further followed by meiosis (haplospores or meiospores), while asexual spores are formed always by mitosis (mitospores).

In true fungi, three kinds of sexual spores are recognized:

1. Resting spores
   a) Oospores — Diploid
   b) Zygospores — Diploid
2. Ascospores — Haploid
3. Basidiospores — Haploid

Phases of Sexual Reproduction:

The sexual reproduction occurs in three distinct phases or stages:

1. **Plasmogamy:** Plasmogamy is the union of cytoplasm from two uniting cells by means of which two nuclei are brought together.
2. **Karyogamy:** It is the union of two nuclei brought close by means of plasmogamy.
3. **Meiosis:** Meiosis is the reduction division by which four haploid cells are obtained.

To summarize

plasmogamy brings two haploid nuclei together in one cell; karyogamy unites them into one diploid, zygote nucleus; and meiosis restores the haploid condition in the four nuclei that result from it. In a true sexual cycle these three processes occur in a regular sequence and usually at specified points.

Some fungi do not produce sex organs. In such fungi, the somatic hyphae of the same or different compatible thalli combine and perform sexual reproduction. The fungal sex organs are termed as **Gametangia (sing. gametangium)**. The gametangia may form differentiated sex cells called **Gametes** or may contain, instead, one or more gamete nuclei.

We use the term **isogametangia (Gr. ison = equal)** when the gametangia and gametes are morphologically indistinguishable. We use the term **anisogametangia** when they are dissimilar and **Heterogametangia** when one of them is motile and the other is non-motile. When the gametangia are dissimilar, the male gametangium is called the **antheridium** and the female one is known as **oogonium** in Mastigomycotina and **Ascogonium** in Ascomycotina.

On the basis of compatibility fungi are:

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. Obviously, no dioecious fungus can be homothallic. Fungi in this category exhibit no mating types.

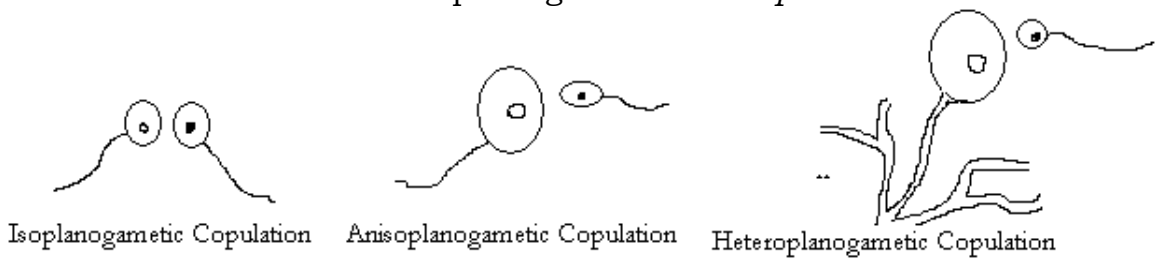
2. Heterothallic Fungi. Those in which every thallus is sexually self-sterile, regardless of whether or not it is hermaphroditic (Monoecious), and requires the aid of another compatible thallus of a different mating type for sexual reproduction.

The following are the different methods of plasmogamy, in fungi, which are sometimes referred to as methods of sexual reproduction.

Methods of sexual reproduction:

1. Planogametic Copulation
2. Gametangial Contact
3. Gametangial Copulation
4. Spermatization
5. Somatogamy

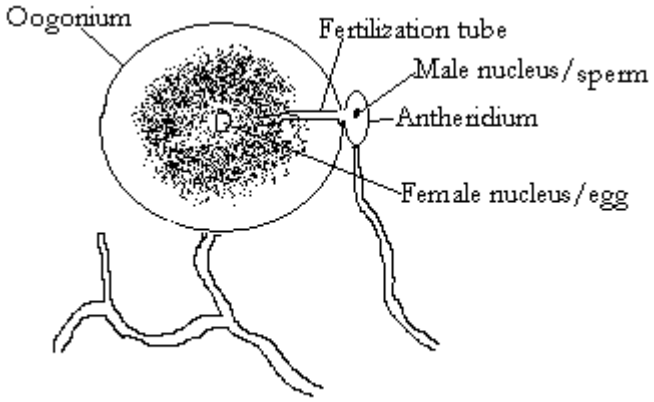
1. **Planogametic Copulation:** This is the method of fusion of two gametes, at least one of which is a planogamete (motile gamete). This is of the following three kinds:
   a) **Isogamy or isoplanogametic copulation:** The planogametes are morphologically similar. The example is genus *Olpidium.*
   b) **Anisogamy/anisoplanogametic copulation:** The planogametes are dissimilar and usually male gamete is smaller than the female gamete. The example is genus *Allomyces.*
   c) **Heterogamy/heteroplanogametic copulation:** The two gametes are dissimilar and only male is motile whereas the female remains immotile. The example is genus *Monoblepheris.*



Planogametic Copulation

2. **Gametangial Contact/Oogamy/Siphonogamy:** A group of aplanogametic fungi produce nonmotile gametes. The aplanogametes are never released from the gametangia to the outside. The gametangia are highly differentiated. The male gametangium is called **antheridium** and the female either **Oogonium or Ascogonium**. The female gametangia may contain one to many eggs/gametes/nuclei. At the time of sexual act, both gametangia come close and contact each other. The wall at the point of mutual contact is dissolved and the male nucleus/gamete from antheridium is transferred to the female gametangium/ascogonium together with some cytoplasm.

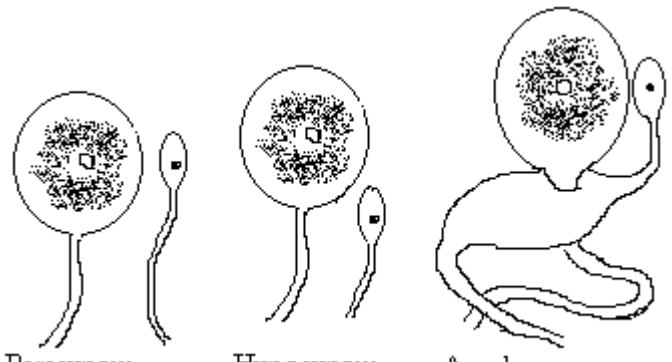
Another method of plasmogamy resembling gametangial contact is **oogamy/siphonogamy** found in the Class-Oomycetes. In this case, the antheridium develops a papilla at the point of contact with the oogonium. This papilla keeps on growing; thrusting forward and ultimately penetrates the oogonial wall. It reaches to the **Oosphere** in the form of a thin, slender tube called **Fertilization tube**. The fertilization tube ruptures at the tip giving a safe passage to the male nucleus to the oosphere where only one functional female nucleus is lying. Karyogamy takes place between the two nuclei and fertilized Oogonium develops into a sexual, diploid, resting spore called **Oospore**.



Oogamy/Siphonogamy

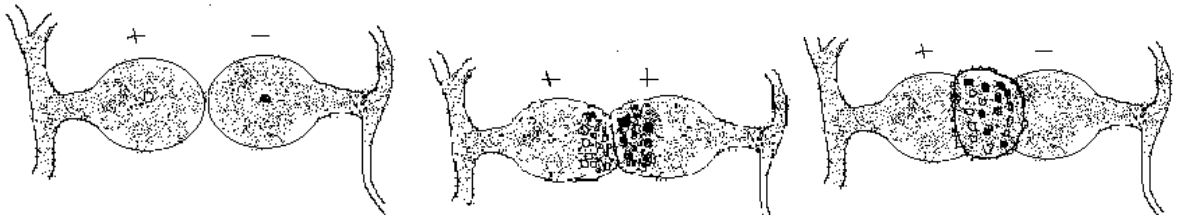
This method is also called siphonogamy due to the presence of the fertilization tube. The antheridium may be of the following kinds:

1. **Paragynous:** The antheridium is parallel to the oogonium.
2. **Hypogynous:** The antheridium is shorter than the oogonium and penetrates it often from below.
3. **Amphygonous:** The antheridial hypha is first penetrated by the oogonial hypha and only then, the development of gametangia takes place. The mature gametangia perform siphonogamy.

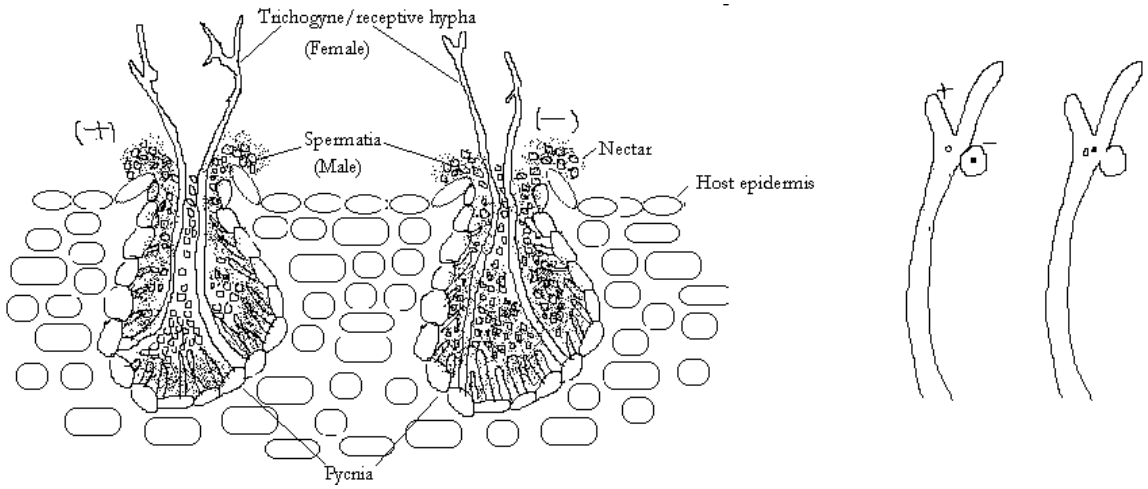


3. **Gametangial Copulation:** In another group of aplanogametic lower fungi which are strictly terrestrial (Order Mucorales of Subdivision Zygomycotina) gametic union is brought about by the fusion of gametangia. The uniting gametangia lose their identity in the sexual act. This type of gametic union is

called Gametangial Copulation. The uniting gametangia are usually morphologically similar (isogamous). Rarely they are dissimilar and unequal in size (anisogamous).

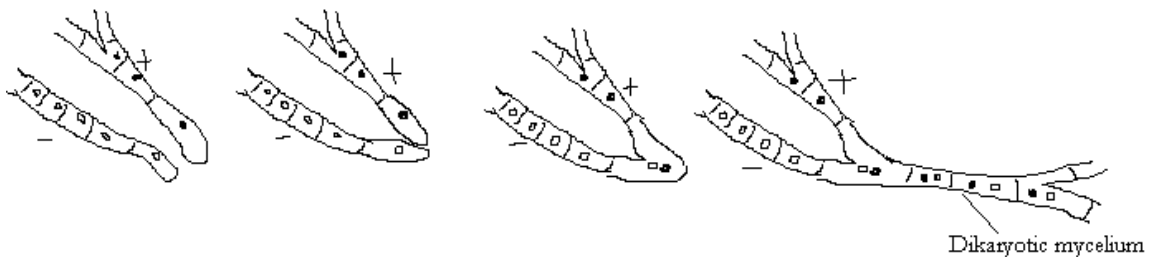


4. **Spermatogamy/Spermatization:** Some fungi produce numerous minute, uninucleate, spore like structures known as spermatia (sing. spermatium). The spermatia behave as male gametes and are usually carried out through insects, wind, water or other agencies to the female sex organ, be it the female gametangium or special receptive hypha, or even to the somatic hypha itself. They attach themselves at such places and on dissolution of the cell walls at the point of mutual contact, the entire content of the spermatium passes into the particular female sex organ. This method is characteristic of some members of sub division Ascomycotina and the order Uredinales of the sub division Basidiomycotina.



Spermatization

Somatogamy: Usually, no sex organs are formed in such a type of sexual reproduction. The somatic hyphae of two compatible mycelia perform as sex organs. The two somatic hyphae of opposite strain (+ and -) come in contact of each other and the intervening wall is dissolved. The nuclei of the cells in contact come together to lie side by side in the fusion cell, which, thus, becomes binucleate (dikaryotic). This type of plasmogamy is called Somatogamy. Somatogamy is observed in higher ascomycetous and basidiomycetous fungi.



Somatogamy

Some of the major differences between asexual and sexual reproduction are as follows:

	Asexual Reproduction	**Sexual Reproduction**
1.	It occurs in lower invertebrates and lower chordates and plants with simple organisations.	It occurs almost in all types of animals and mostly in higher plants.
2.	It is always uni-parental.	It is usually bi-parental.
3.	Gametes are not formed.	Gametes are always formed.
4.	No fertilization.	Fertilization takes place.
5.	It involves only mitosis.	It involves both meiosis and mitosis.
6.	Daughter organisms are genetically identical to the parent.	Daughter organisms genetically differ from the parents.
7.	Multiplication occurs rapidly.	Multiplication is not as rapid as in asexual reproduction.
8.	Since there is no variation, so it does not contribute to evolution of the species.	Since there are variations, so it contributes to evolution of the species.