

REPRODUCTION IN FUNGI

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

Types of reproduction:

1. Asexual /non-sexual / vegetative / somatic reproduction
2. Sexual reproduction.

1.Asexual reproduction :

Asexual reproduction stage is also known as imperfect stage and technically called as anamorphic stage. There is no union of nuclei /sex cells/ sex organs. It is repeated several times during the life span of a fungus producing numerous asexual spores. Hence, it is more important for fungi than sexual reproduction. Asexual spores are formed after mitosis ,hence also called mitospores

1. Fragmentation
2. Fission.
3. Budding
4. Sporulation (production of spores)

1. Fragmentation : It is the most common method. Hypha of fungus breaks into small pieces, each broken piece is called a fragment, which function as a propagating unit and grows into a new mycelium.The spores produced by fragmentation are called arthrospores (arthron=joint) (spora=seed) or oidia..

Eg. Oidium, Geotrichum.

Sometimes, the contents of intercalary cells or terminal cells of hypha rounded off and surrounded by thick wall and formed as **chlamydospores** which are thick walled resistant spores produced either singly or in chains.

Eg. Fusarium oxysporum, Ustilago tritici.

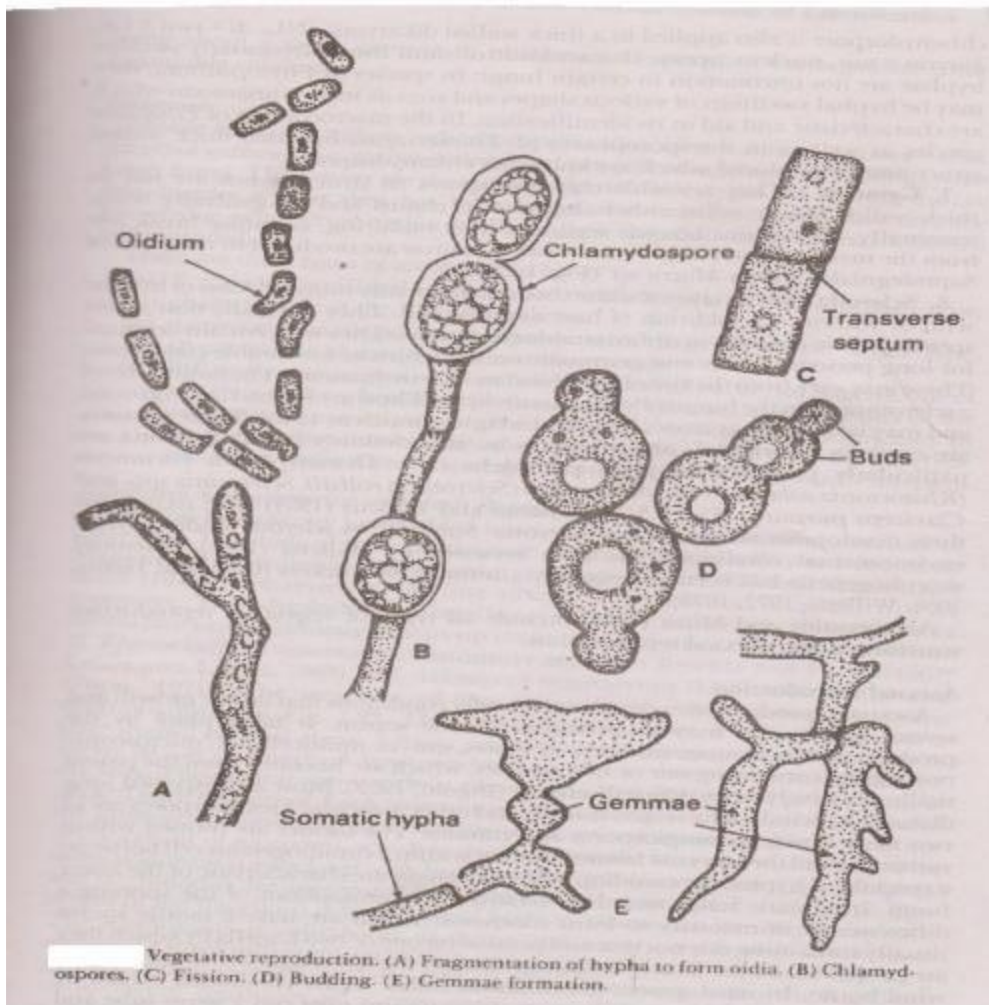
2. Fission / Transverse fission: The parent cell elongates,nucleus under go mitotic division and forms two nuclei, then the contents divide into equal halves by the formation of a transverse septum and separates into two daughter cells.

Eg.Saccharomyces cerevisiae.

3.Budding:

The spores formed through budding are called blastospores. The parent cell puts out initially a small out growth called bud / blastos ie.,sprout or out growth which increases in size and nucleus divides, one daughter nucleus accompanied by a portion of cytoplasm migrates into bud and the other nucleus remains in the parent cell. Later, the bud increases in size and a constriction is formed at the base of bud, cutting off completely from parent cell . Bud, when separated from parent cell, can function as an independent propagating unit.Sometimes multiple buds are also seen i.e., bud over bud and looks like pseudomycelium.

Eg. Saccharomyces cerevisiae.



4. Sporulation (spores):

The process of production of spores is called sporulation.

Spore: It is a minute, simple propagating unit of the fungi, functioning as a seed but differs from it in lacking a preformed embryo that serves in the reproduction of same species. Spores vary in colour, size, number of cells and the way in which they are borne.

There are 2 main types of spores.

1. Sporangiospores
2. Conidia

1.Sporangiospores:

When the asexual spores are produced internally, within the sporangia, such spores are called sporangiospores. The sac like structure which produces sporangiospores is called sporangium. The special hypha bearing sporangium is called sporangiophore which may or may not be distinguishable from hypha. A small sporangium with or without columella

containing a few or single spore is called as **sporangiolum**. Eg. Choanephora trispora. Sporangium which is cylindrical in shape is called as **merosporangium**. Eg. Syncephalastrum racemosum. Sporangium with columella is called as **columellate sporangium**. Eg. Rhizopus stolonifer.

Sporangiospores are of 2 types.

a. Zoospores /planospores

b. Aplanospores a. Zoospores / planospores

a. Zoospores /planospores

sporangiospores which are motile by flagella are called **zoospores**. Also known as **planospores**.

Eg. Pythium, Phytophthora.

b. Aplanospores: Sporangiospores which are non motile without flagella are called aplanospores Eg. Rhizopus stolonifer, Mucor.

Flagellation in fungi:

Flagella : (sing. flagellum) Flagella are thin, hair like delicate structures attached to a basal granule called blepharoplast in cytoplasm and these are the organs of motility in lower fungi and aquatic fungi.

Types of flagella : Flagella of zoospores are of 2 types.

a. Whiplash b. Tinsel

a) Whiplash : A flagellum with long, thick, rigid basal portion and with a short, narrow, flexible, upper portion. It gives a whip like appearance to flagellum.

b) Tinsel : It is a feathery structure consisting of a long rachis with lateral hair like projections called mastigonemes or flimmers on all sides along its entire length.

2. Conidia / Conidiospores: (konis=dust; oides=like)

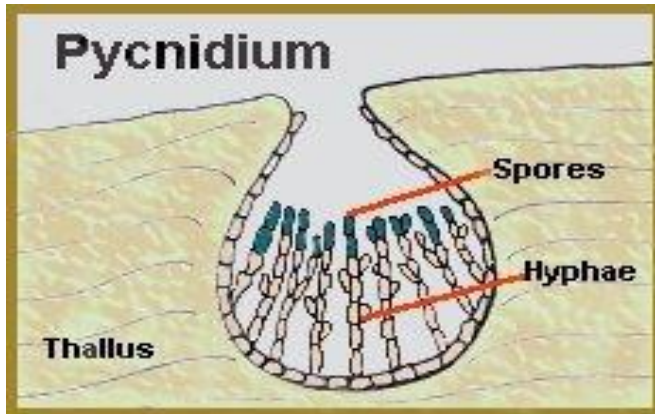
Conidia are non- motile asexual spores which may arise directly from somatic hyphae or from specialized conidiogenous cells (a cell from which conidia are produced) or on conidiophore (hypha which bear conidia). Conidia are produced freely on conidiophore i.e., at the tips or sides of conidiophore or may be produced in specialized asexual fruiting bodies viz., pycnidium, acervulus, sporodochium and synnemata.

Asexual fruiting bodies :

(a) **Pycnidium:** (**pl. pycnidia**) It is a globose or flask shaped fruiting body lined inside with conidiophores which produce conidia. It may be completely closed or may have an opening called ostiole.

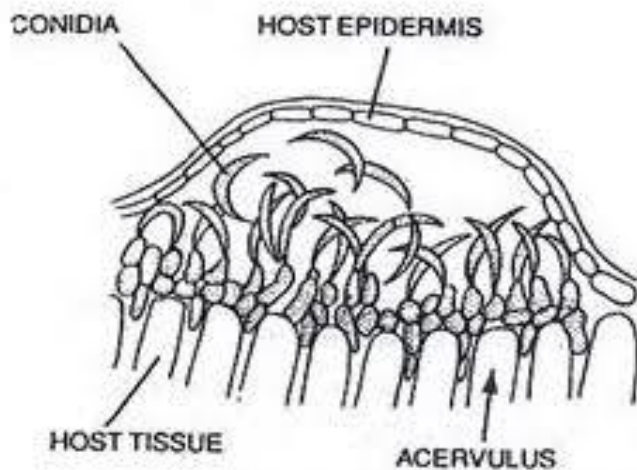
Pycnidium may be provided with small papillum or long neck.

Eg. Phomopsis.



(b) Acervulus: (pl.acervuli) A flat or saucer shaped fruiting body with a stromatic mat of hyphae producing conidia on short conidiophores. An acervulus lacks a definite wall structure and not having an ostiole or definite line of dehiscence. Intermingled with the conidiophores, setae (sing. seta; L. seta = bristle) are found. Setae are long, pointed, dark coloured, sterile structures.

Eg. Colletotrichum, Pestalotiopsis.



(c) Sporodochium : (pl.sporodochia)

A cushion shaped asexual fruiting body. Conidiophores arise from a central stroma and they are woven together on a mass of hyphae and produce conidia.

Eg. Fusarium.

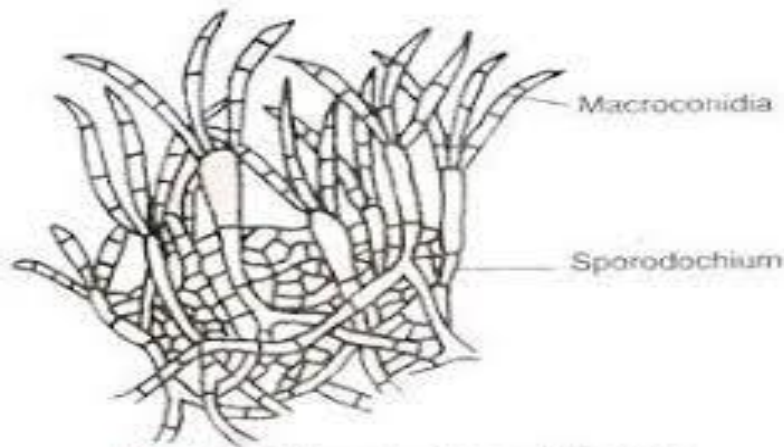
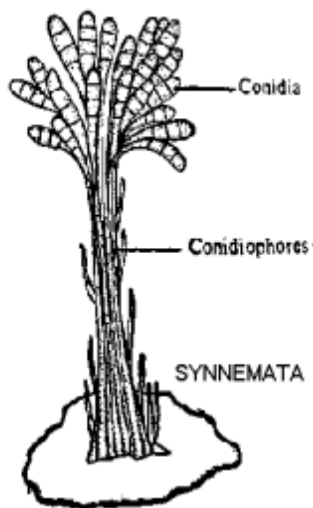


Fig. 22.21. Sporodochium of *Fusarium*

(d) Synnemata: (pl.synnema) A group of conidiophores often united at the base and free at the top. Conidia may be formed at its tip or along the length of synnema, resembling a long handled feather duster.

Eg. Graphium.



4. SEXUAL REPRODUCTION

Sexual reproduction involves union of two compatible nuclei or sex cells or sex organs or somatic cells or somatic hyphae for the formation of new individuals. Sexual stage is perfect stage and technically called as teleomorphic stage.

Sexual spores or sexual structures which contain sexual spores are thick walled, resistant to unfavourable conditions and are viable for longer period and thus these spores help the fungus to perpetuate from one season to another, hence these are called as resting spores. Sexual spores are definite in number.

Sex organs of fungi :

Gametangia: Sex organs of fungi are called gametangia containing gametes or gamete nuclei.

Gametes: Sex cells are called as gametes .

Antheridium: (**pl.antheridia**) Male gametangium is called as antheridium. Male gametangium is small and club shaped.

Oogonium / Ascogonium:(pl.oogonia/ascogonia):

The female gametangium is called Oogonium (oomycetes) or ascogonium (ascomycotina).Female gametangium is large and globose shaped. Male gametes are called antherozoids or sperm or spermatozoids. Female gametes are called egg or oosphere.

Classification of fungi based on sex :

1. Monoecious fungi / hermaphroditic fungi: (mono=single,oikos=home)

The fungi which produce distinguishable male and female sex organs on the same thallus, which may or may not be compatible are called monoecious/ hermaphroditic fungi. Eg. *Pythium aphanidermatum*.

2. Dioecious fungi: (di=two, oikos=home)

The fungi which produce distinguishable male and female sex organs on two different thalli ie., there will be separate male and female thalli . Eg. *Phytophthora infestans*.

Classification of fungi based on compatibility ;

Homothallic fungi: Fungi in which both sexes occur on same thallus, which can reproduce sexually by it self with out the aid of another thallus ie., self compatible / self fertile are called homothallic fungi.

Eg. *Pythium aphanidermatum*.

Heterothallic fungi:

A fungal species consisting of self sterile (self incompatible) thallus requiring the union of two compatible thalli for sexual reproduction, regardless of the possible presence of both male and female organs on the same thallus. Heterothallic fungi are dioecious

Eg. *Phytophthora infestans*..

Phases in Sexual reproduction:.There are 3 phases in sexual reproduction.

1. Plasmogamy: union of two protoplasts takes place.As a result of it the two nuclei come together within the same cell.

2. Karyogamy: union of 2 sexually compatible nuclei brought together by plasmogamy to form a diploid nucleus ($2n$) i.e., zygote.

3. Meiosis: This is reduction division. The number of chromosomes is reduced to haploid (n) i.e., diploid nucleus results into haploid nucleus.

In lower fungi (Phycomycetes-Mastigomycotina and Zygomycotina) plasmogamy, karyogamy and meiosis occurs at regular intervals / sequence i.e., karyogamy follows immediately after plasmogamy. In higher fungi (Ascomycotina, Basidiomycotina), karyogamy is delayed, as a result the nuclei remain in pairs (dikaryotic phase- $n+n$ condition), which may be brief or prolonged. **Dikaryon**: A pair of genetically different nuclei, lying side by side without fusion for a considerable period of time is called dikaryon. A cell containing **dikaryon** is called dikaryotic cell. And the process is known as **dikaryogamy**.

Methods of sexual reproduction :

1. Planogametic copulation. 2. Gametangial contact 3. Gametangial copulation 4. Spermatisation 5. Somatogamy.

1. Planogametic copulation (gametogamy): This involves the union of 2 naked gametes one or both of which are motile.

a. Isogamy (Isogamous planogametic copulation) : If both gametes are motile and similar.

Eg. Plasmodiophora brassicae.

b. Anisogamy (Anisogamous planogametic copulation) : If both gametes are motile but dissimilar.

Eg. Allomyces macrogynus

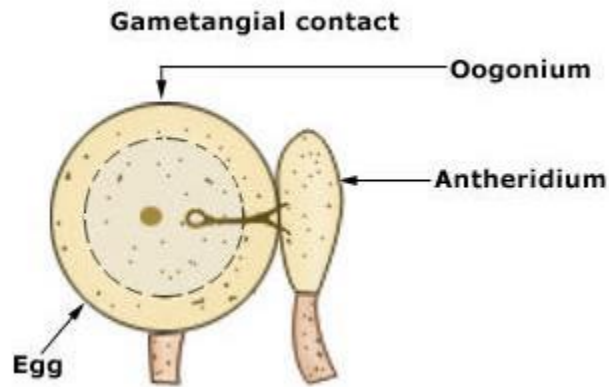
c. Heterogamy: If gametes are dissimilar, one motile, another is non motile.

Eg. Monoblepharis polymorpha.

2. Gametangial contact (gametangy / oogamy):

Male and female gametangia come in contact. At the place of contact, dissolution of wall occurs and a fertilization tube is formed. The contents of male gametangium migrate into female gametangium through a pore or fertilization tube developed at the point of contact. The gametangia do not lose their identity.

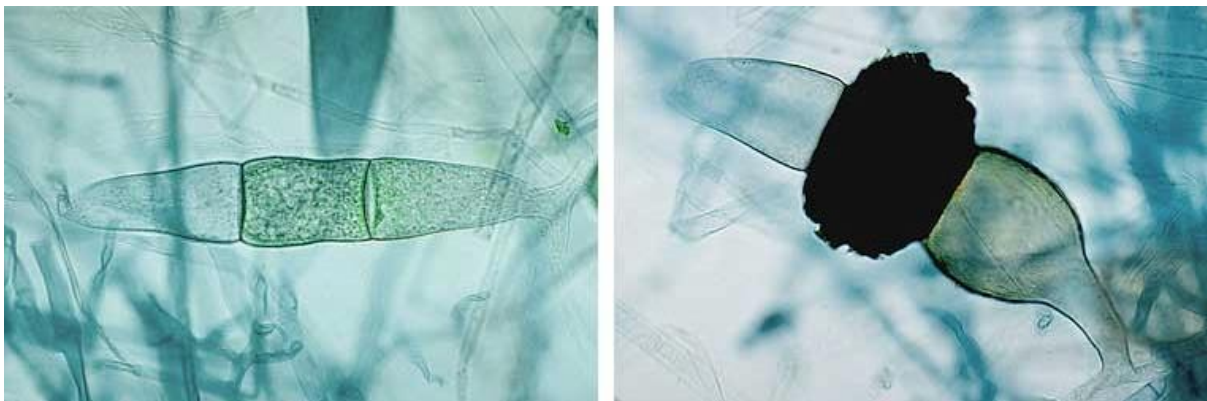
Eg. Pythium aphanidermatum.



3. Gametangial copulation (gametangiogamy):

The isogametangia come in contact, their intervening wall dissolves leading to fusion of entire contents of two contacting gametangia to form a single unit. Gametangia lose their identity. The protoplasts fuse and the unit increases in size.

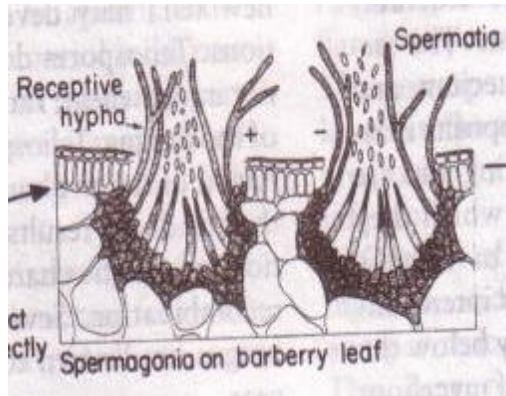
Eg. *Rhizopus stolonifer*.



4. Spermatization:

Minute, uninucleate male cells called as spermatia which are produced on spermatophores in a fruiting body (pycnium) are carried to female reproductive structures called receptive hyphae. Spermatia and receptive hyphae come in contact and contents of male spermatium migrate into female receptive hypha, thus making the cell binucleate. This process is called dikaryotization.

Eg. *Puccinia graminis tritici*



5.Somatogamy: Many higher fungi do not produce sex organs. In such cases somatogamy takes place. It is the union of 2 somatic hyphae or somatic cells representing opposite sexes to form sexual spores.

Eg. *Agaricus campestris*

Parasexual cycle / Parasexuality :

Parasexual cycle is a process in which plasmogamy, karyogamy and haploidisation (non meiotic process) takes place in a sequence but not at specified points in the life cycle of a fungus. It was first discovered in 1952 by Pontecorvo and Roper in *Aspergillus nidulans*, the imperfect stage of *Emericella nidulans*. It is of importance in heterokaryotic fungi (a fungi in which genetically different nuclei are associated in the same protoplast or mycelium). This is one of the methods of producing variability of fungal pathogens. In majority of Deuteromycotina, true sexual cycle is absent but derive many of the benefits of sexuality through this cycle.

Sexual fruiting bodies

a. Pycnium or spermatogonium (pl. pycnia; Gr. pycnos = concentrated) is a fruit body, which is similar to pycnidium and is formed in sexual cycle of rust fungi. Pycnia are produced from primary uninucleate mycelium growing in the tissues of the host. Pycnia may be flask-shaped, conical, flat and sprawling. The flask-shaped type is more typical, The mouth of the flask (called ostiole) is lined by a bunch of unbranched, tapering, pointed, orange coloured hairs called 'periphyses' (sing. periphysis; Gr. peri = around + physis = a being, a growth). The pycnial wall cells send many closely -packed, elongated, tapering, unbranched uninucleate sporogenous cells or spermatiphores (Gr. spermatation = little seed+ phoreus=bearer) in the cavity.

These spermatiphores give rise to a series of uninucleate spermatia (sing. spermatium Gr. spermatation=little seed) or pycnospores in a basipetal fashion. Pycnospore is a non-motile, uninucleate, unicellular spore-like male structure that empties its contents into a receptive female structure during plasmogamy. Pycnospores are variously regarded as gametes or gametangia. e.g. pycnium is produced by *Puccinia graminis tritici* in the alternate host, barberry (*Berberis vulgaris*).

b. Aecium **Aecium** (pl. **Aecia**; Gr. **aikia** = **injury**) is also formed during sexual cycle. Aecium is a shallow or deep cup-shaped structure produced in a leaf and located in the lower portion and break through the lower epidermis. The wall is known as ‘peridium’. In a young aecium that has not broken the host epidermis, the peridium surrounds the spore chain on all sides, forming a complete dome over them. When the aecium matures, the spore chains push through the roof of the peridium and the aeciospore are released. The torn peridium forms a lip-like structure around the aecial cup.

c. Ascocarps **Ascocarp** (Gr. **askos** = **sac**+ **karpos** =**fruit**) is a fruiting body that contains asci and ascospores. Ascomycetes fungi with few exceptions produce ascocarps. There are four categories ascocarps.

i. Cleistothecium: (pl. cleistothecia; Gr. kleistos = closed + theke = case)

Cleistothecium or cleistocarp is a closed ascocarp and has no ostiole. It is deep brown to black in colour, more or less spherical and often provided with appendages on its body, which serve as organs of anchorage and help in dissemination.

Cleistothecial appendages are of four types viz.

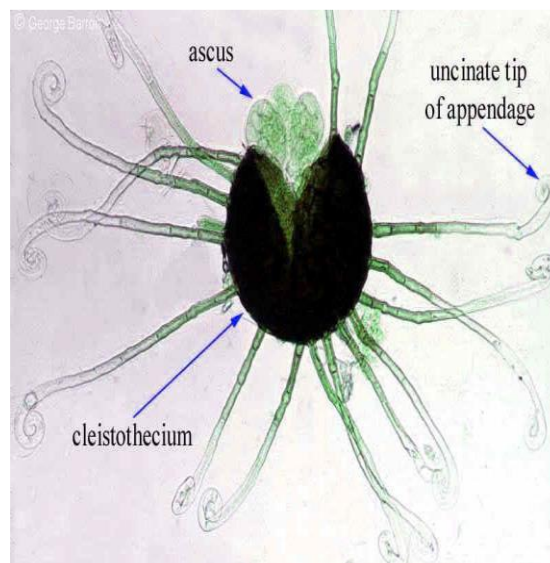
Myceloid appendages: Appendages resemble somatic hyphae in flaccidity and indefinite growth.

e.g. Erysiphe, Sphaerotheca and Leveillula.

Appendages are rigid, spear-like with a bulbous base and pointed tip. e.g. Phyllactinia.

Appendages are rigid with curved tips e.g. Uncinula, Pleochaeta.

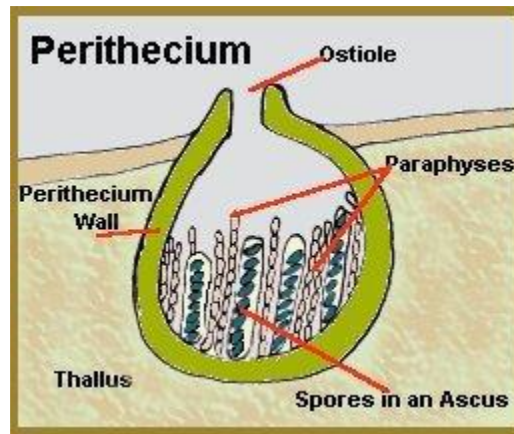
Appendages are rigid with dichotomously branched tips. e.g. Microsphaera, Podosphaera.



ii. Perithecium **Perithecium** (pl. **perithecia**, Gr. **peri** = **around** + **theke** = **a case**) is a flask-shaped ascocarp with a wall of its own. It is provided with a narrow ostiole and may possess

a short or a long neck through which the asci are released at maturity. The asci are intermingled with sterile filaments called paraphyses, which help the asci in with sterile filaments called paraphyses, which help the asci in nutrition and dispersal.

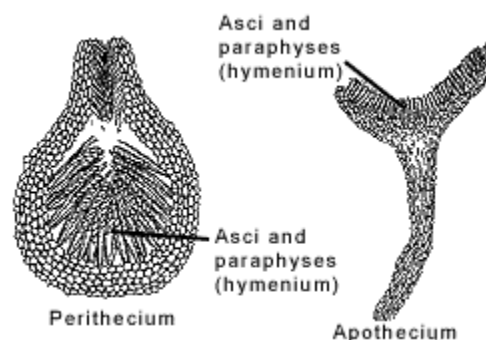
,Eg: Nectria, eratocystis, Podospora, Chaetomium, Xylaria, Ustulina, Rosellinia, Claviceps and Cordyceps.



iii. Apothecium Apothecium (pl. Apothecia; Gr. apotheke=store house) is an open ascocarp. It has a broad opening and is either cup or saucer shaped with asci arranged in a palisade layer within. It is usually fleshy or leathery in nature. An apothecium consists of three parts viz. hymenium, hypothecium and excipulum.

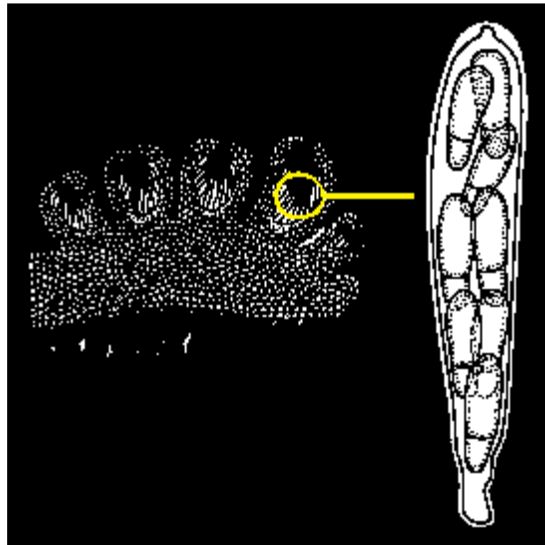
The hymenium is the layer of asci that lines the surface of hollow part of the disc, cup or saddle. The 'hypothecium'(pl. hypothecia; Gr. Hypo=under+ theke =a case) is a thin layer of interwoven hyphae, which is found immediately below the hymenium. The apothecium proper (i.e., the fleshy part of the ascocarp that supports the hypothecium and hymenium) is called excipulum (pl. excipula ; N.L. excipulum=receptacle)

Pyronema, Ascobolus, Peziza, Morchella, Sclerotinia etc



iv. Pseudothecium Pseudothecium or ascostroma (pl. ascostromata; Gr. askos = sac + stroma = mattress, cushion) like perithecium is a flask-shaped ascocarp provided with an ostiole through which the asci are discharged. . In pseudothecium asci are directly formed in a cavity (locule) within the stroma. The stroma itself thus forms the wall of the ascocarp

e.g. Cochliobolus, Pyrenophora, Ophiobolus, Pleospora, Leptosphaeria of the class Loculoascomycetes.



d. Basidiocarps **Basidiocarp (Gr. basidion=small base + karps = fruit)** is a fruiting body, which bears basidia and basidiospores. Basidia are borne on the under surface of fruit body. Basidia bear basidiospores exogenously usually on projections called sterigmata. Basidia are typically formed in definite layers called hymenium (pl. hymenia; Gr. hymen=membrane). Hymenium is composed of basidia and large sterile structures called cystidia (sing. cystidium; Gr. kystis =bladder + -idion = dimin. Suffix). They may vary in size from microscopic to a metre or more in dia. Most fungi in basidiomycotina except smuts (Ustilaginales) and rusts (Uredinales) form basidiocarps. They include mushrooms, (Agaricus, Pleurotus, Volvariella), shelf fungi, coral fungi.

Different types of sexual spores :

Sexual spores are formed after meiosis, hence also called meiospores. 1.Oospores
2.Zygosporos 3.Ascosporos 4.Basidiosporos

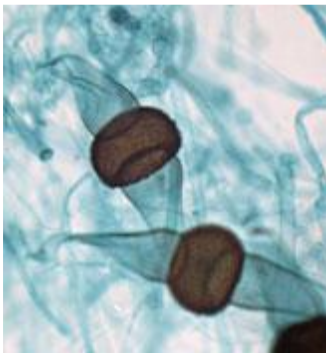
1.Oospore: A thick walled sexual resting spore produced by the union of two morphologically different gametangia



Eg. Pythium, Phytophthora, members of class Oomycetes.

2. Zygospore: A thick walled sexual resting spore produced by the fusion of two morphologically similar gametangia.

Eg. Rhizopus, members of sub-division Zygomycotina



3. Ascospore:

Sexual spore produced in a specialized sac like structure known as ascus. Generally 8 ascospores are formed. Eg. Erysiphe, members of sub-division Ascomycotina.



4. Basidiospore: Sexual spore produced on a club shaped structure known as basidium. Generally 4 basidiospores are formed. Eg. Puccinia, members of sub-division Basidiomycotina.