INTRODUCTION:

The fungi (singular-fungus) are non green usually filameutous, branched, unicellular or multicellular, nucleated, spore bearing microorganisms surrounded by cell wall containing cellulose or chitin. The branch of Botany which deals with the study of fungi is called **Mycology**. The Italian botanist **Pier Antonio Micheli** is the founder of the Science of Mycology. He published his research work on fungi in a book **Nova Plantarum Genera** in 1729.

GENERAL CHARACTERS:

i) The fungi form a large diverse group of the plant kingdom.

ii) There are about 80,000 known species of fungi.

iii) The fungi are **cosmopolitan** in distribution.

iv) They occur growing on every habitat where moisture and organic materials are available.

v) They are achlorophyllous or non-green therefore they cannot prepare their own food material. Hence they are **heterotrophic** in nutrition.

vi) Most of the fungi grow on dead rotten or decaying organic material hence, they are called saprobes or **saprophytic** (Sapros = rotten + bios = life).

vii) Many fungi are parasites of plants and animals and cause many diseases.

viii) Some fungi grow symbiotically with algae or higher plants.

ix) Some fungi grow on our food material like breads, jams, pickles, fruits, vegetables and crop seeds etc.

x) The air also contains a large number of fungal spores.

xi) A very few fungi are aquatic.

xii) The plant body of fungi is a thallus.

xiii) Generally the fungal thallus is composed of a mass of many microscopic threads or filaments called the **hyphae** (singular hapha).

xiv) The hyphae are thin, transparent, tubular, coloured or hyline, unicellular or multicellular.

xv) The mass of hypae constituting the thallus of a fungus is called the **mycelium** (plural mycelia).

xvi) The fungal thallus without hyphae joining a chain of loosely arranged cells is the **pseudomycelium.**

xvii) In some fungi the hyphae grow together and form a thick, root like structure called the **rhizomorph** (rhoza = root, morphe = shape).

xviii) The hyphae may be septate or aseptate.

xix) The aseptate multinucleate hyphae are called **coenocytic** hyphae (Koinos = common, Kytos = a hollow vessel).

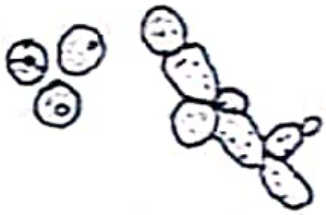
xx) The mycelium is monokaryotic or dikaryotic.

xxi) In monokaryotic mycelium, the cells of the haphae are uninucleate.

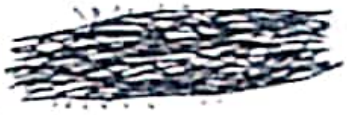
xxii) In dikaryotic mycelium, the cells of the haphae are binucleate.

xxiii) The mycelium of parasitic fungi is intercellular or intracellular.

xxiv) The intercellular mycelium produces certain knob like structures called the **Haustoria**



A : Pseudomycelium



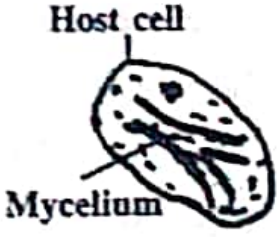
B : Rhizomorph

C : Coenocytic mycelium

D : Septate mycelium

E : Monokaryotic mycelium

F : Dikaryotic mycelium



G : Intracellular mycelium

(Sing. Haustorium) (Haustar = drinker).

xxv) The haustoria pennetrate the host cells and suck or drink the ready made food from the host cells. Hence they are also called as sucking organs.

xxvi) The fungal cells have cell wall which is made up of cellulose or a fungal cellulose chitin.

xxvii) The protoplasm of the cells contain the cell organelles like endoplasmic reticulum, mitochondria, ribosomes etc. in addition to the vacuoles and reserved food material in the form of glycogen, oil and fats.

xxviii) The fungi reproduce asexually and sexually.

xxix) The asexual reproduction takes place by the formation of spores. The asexual spores are also called as **conidia.**

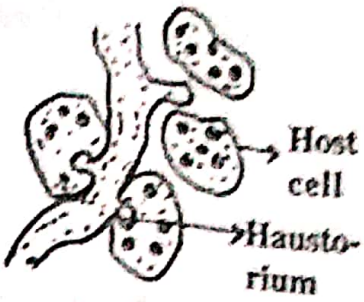
xxx) The sexual reproduction takes place by the formation of sex organs and it is of **oogamous** type.

xxxi) It involves plasmogamy, karyogamy and meiosis.

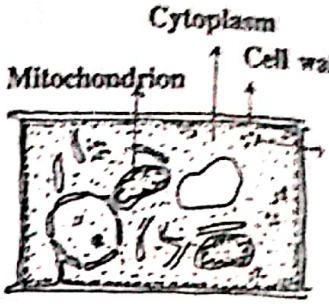
xxxii) The sexual reproduction also takes place by the **somatogamy** (fusion of two somatic or vegetative hyphae of opposite strain).

xxxiii) The sexual reproduction generally results into the formation of fruiting bodies.

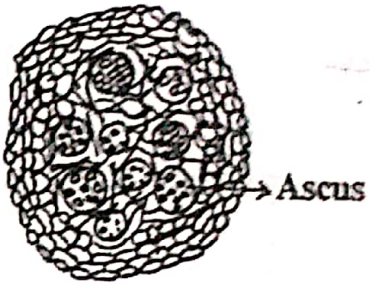
xxxiv) The closed fruiting body is called as cleistothecium, flask shaped fruiting body as perithecium and cup shaped fruiting body as apothecium.



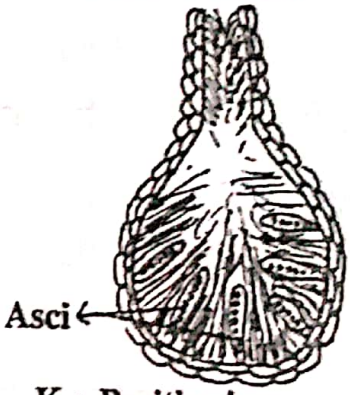
H : Intercellular mycelium



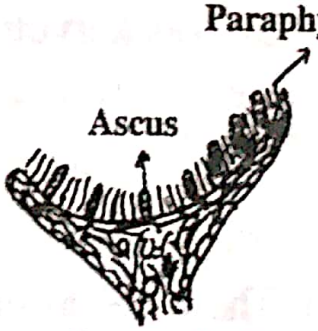
I : Fungal cell



J : Cleistothecium



K : Perithecium



L : Apothecium

Fig.3.1 (A-L). FUNGI: General Characters

CLASSIFICATION OF FUNGI:

(As per C.J. Alexopoulos and C.W. Mims, 1971)

Almost all the fungi are placed in a separate **Kingdom – Mycetae** or Fungi. The kingdom-Mycetae is divided into three divisions such as

i) Division – Gymnomycota.

ii) Division – Mastigomycota.

iii) Division – Amastigomycota.

Division – Gymnomycota:

The division – Gymnomycota is a group of prokaryotic fungi. The fungi of this division are slimy hence called **slime molds**. They show phagotrophic mode of nutrition like Amoeba. The thallus or plant body of these fungi is Amoeba like without cell wall called the plasmodium. They reproduce asexually only.

The division– Gymnomycota is divided into two sub divisions such as

i) Sub-division – Acrasiogymnomycotina.

ii) Sub-division – Plasmodiogymnomycotina.

The subdivision – Acrasiogymnomycotina has a single class – Acrasiomycetes. The sub-division – Plasmodiogymnomycotina has two classes such as Class – Protosteliomycetes and class – Myxomycetes.

Division – Mastigomycota:

It is a group of eukaryotic fungi. It is a group of lower fungi. The mycelium is coenocytic, branched and hyline. They reproduce asexually and sexually and produce indefinite number of spores. The reproductive cells are motile and flagellated.

The division – Mastigomycota is divided into two sub-divisions such as

i) Sub-division – Haplomastigomycotina.

ii) Sub-division – Diplomastigomycotina.

The sub-division – Haplomastigomycotina (reproductive cells

with single flagellum) is divided into three classes such as

i) Class – Chytridiomycetes.

ii) Class – Hypochytridiomycetes.

iii) Class – Plasmodiophoromycetes.

The sub-division – Diplomastigomycotina (reproductive cells with two flagella) has a single class i.e. the Class – Oomycetes (e.g. ***Albugo***).

Division – Amastigomycota:

It is a group of eukaryotic and higher fungi. The fungi of this division have septate, multicellular, filamentous, branched and coloured mycelium. They reproduce vegetatively by budding and fragmentation, asexually by conidia and sexually by sex organ. The reproductive cells are non motile and without flagella. It is divided into four sub-divisions such as

i) Sub-division – Zygomycotina.

ii) Sub-division – Ascomycotina.

iii) Sub-division – Basidiomycotina.

iv) Sub-division – Deuteromycotina.

The sub-division – Zygomycotina has two classes i.e. Class – Zygomycetes and Class – Trichomycetes.

The sub-division – Ascomycotina has a single class i.e. Class – Ascomycetes (the reproduction results into the formation of definite number of spores and the definite number is always eight) e.g. ***Eurotium***.

The sub-division – Basidiomycotina has a single class such as Class – Basidiomycetes (reproduction results into the formation of definite number of spores and the definite number is always four) e.g. ***Agaricus***.

The sub-division – Deuteromycotina has a single class i.e. Class – Deuteromycetes. (They reproduce asexually only. The sexual reproduction is totally absent hence this class is also called as Class – Fungi imperfecti). e.g. ***Cercospora***.

Ecology of Fungi:

- The fungi are most diversified in their habitat.
- They are found in almost all possible types of habitats.
- They are hetemtrophs and may be saprophytes, parasites or symbionts.
- Many species are found in the water and are called the aquatic fungi.
  eg. Phycomycetes.
- The epiphytic fungi are found upon algae & other plant in epiphytic state
- Some fungi are found on the dead organic material.
- Some species are sub-terranean and found under the surface of the earth.
- Many species are seen with naked eyes even from the distance.
  eg mushroom, morel, puff balls, bracket fungi, cup fungi, etc.
- Whereas on the other hand they are microscopic and may recognised with the microscope.
- The parasitic fungi are found on the host & cause various diseases & harm to the host plants.
- Some fungi are found in the alimentary canals of mammals & human beings where they cause various disorders.
- Some forms cause the skin disease.

- The fungi may be grouped into various ecological groups.
- Some ecological groups are as follows:

1) Soil fungi:
- The fungi present in the soil are the soil fungi.
- Along with the other microorganisms fungi are also associated with soil.

2) Dermatophytes:
- The fungi which cause disease of the skin of man, animal or both are called as dermatophytes.
- The important genera of these fungi belong to Fungi imperfecti (Deuteromycetes).
eg. Trichophyton, epidermophyton, Microsporum, etc.

3) Entomogenous fungi:
- The fungi associated with insects are known as entomogenous fungi.
eg. Entomophthora muscae present on the house fly.

4) Lignicolous Fungi:
- Lignin is quite resistant to the attack of fungi and other microorganisms.
- However, certain specific fungi are responsible for bringing out its degradation.
- The wood of trees is decayed by such fungi.
eg. Polystictus sanguineus causes the wood decay of sal tree.

5) Aquatic fungi:
- Several fungi present in water are called as aquatic fungi.
- several members of Chytridiales are found on algae & water molds.
- Most species of Monoblepharidales are aquatic.
- Though the members of aquatic fungi are found in all fungal groups yet most of them belong to lower fungi.

6) Coprophilous fungi:
(Gk. Kopros = dung : philein = to love)
- The fungi which grow on the dung of certain animals are called as the coprophilous fungi.
- The dung of herbivores has a large number of fungi out of which a few are exclusively coprophilous.
- On dung, fruiting bodies of lower as well as higher fungi are present.

7) Cellulose decomposing Fungi:
- Some fungi are found on cellulose rich material such as paper, cotton, etc.
- They may cause much damage to paper & textile industry.
- Some important cellulose decomposers are Stachybotrys atra, Chaetomium globosum

☆ Nutrition:

- The fungi are achlorophyllous plants, they cannot prepare their own food material like green plants.
- They are so simple in structure that they can not obtain inorganic food directly from soil, and therefore they are always dependent for their food on some dead organic material or living organisms.
- From the point of view of their nutrition the fungi are classified as follows -
  i) Saprophytes.
  ii) Parasites
  iii) Symbionts
  iv) Predacious fungi

- The fungi are always heterotrophic and never autotrophic.

i) Saprophytes:

- The fungi which obtain their food from dead organic materials are called as saprophytes.
- The saprophytic fungi live on dead organic materials produced by the decay of animal and plant tissues.
- They grow on dead organic matters such as rotten fruits, rotten vegetables, jams, jellies, plant debris, manures, moist bread and many other possible dead organic materials.

eg. Mucor, Rhizopus, Penicillium, Aspergillus, Agaricus, etc.

Some saprophytic fungi absorb their food from the substratum by ordinary vegetative hyphae which penetrate the substratum.

eg. Mucor

- Some other saprophytic fungi develop rhizoids which penetrate the substratum and absorb the food material.

eg. Rhizopus

ii) Parasites:

- The fungi which obtain their prepared food from dead living organic materials are called the saprophytes. Parasites.

- The living beings on which the fungi parasitize are called the hosts.
- The parasitic fungi absorb their food material from the living tissues of the hosts.
- Their mode of life is parasitic and the relation of host and parasite is called the parasitism.
- Such parasitic fungi are quite harmful to their hosts and cause many diseases.
- Many diseases of the important crops are caused by parasitic fungi.
  eg. Rusts, smuts, bunts, mildews, etc

a) Obligate parasite:

The parasites which survive on living hosts and only on living hosts are called the obligate parasites.

· Such parasites cannot be grown upon a organic media
eg. Puccinia, Peronospora, etc.

ii) Facultative saprophytes:
The parasitic fungi which usually live on living hosts and according to their need they adopt saprophytic mode of life for some time are called the facultative saprophytes.
eg. Taphrina deformans

iii) Facultative Parasites:
Some fungi are usually saprophytes but under certain conditions they parasitize some suitable host are called the facultative parasites.
eg. Fusarium, Pythium, etc.

· The parasitic fungi absorb their food from the hosts in different ways.
· The fungus having the mycelium outside the host is called the ectoparasite.
eg. Erysiphe
· The fungus having mycelium embedded in the host tissue is called as the endoparasite.
· In ectoparasite certain cushion like appressoria are developed from fungi on the surface of host.
· From each appressorium a peg-like structure is developed.
· It penetrates the host epidermal cell & give rise to a absorbing organ called the haustorium.

The haustoria may be small, rounded, button like, branched or unbranched

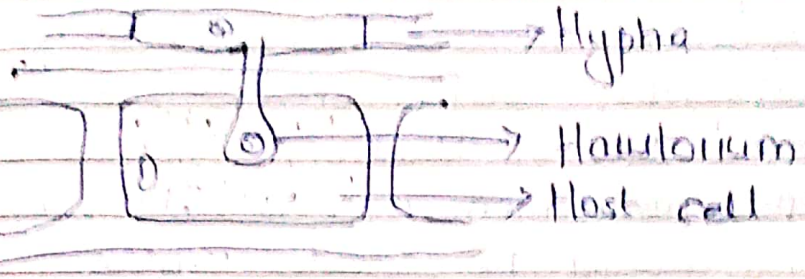


Fig: Haustoria.

iii) Symbionts

Some fungi grow in close association with other higher plants where they are mutually beneficial to each other. Such relationship is called the symbiosis and the participants the symbionts
eg. lichens and mycorrhiza.

- The lichens are the resultants of the symbiotic association of algae and fungi.
- Both live together and are beneficial to each other.
- The algal partner synthesizes the organic food and the fungal partner is responsible for the absorption of inorganic nutrients and water.
- In mycorrhiza some fungi are developed in the roots of higher plants.
- Here fungi absorb their food from the roots and in response are beneficial to the plants.
- The external mycorrhiza are confined to the outer region of roots whereas the internal mycorrhiza are found deeply in the root cells.

iv) Predacious Fungi:

- These are the animal trapping fungi.
- They have developed mechanism for the capturing small animals such as eelworms, rotifers or protozoa and use them as a food.
- The mechanism is that the fungi construct a ring around nematode which holds it and the hyphae sink haustoria into the body of the victim.

eg. Fungi of genera Arthrobotrys, Dactylella, Dactylaria etc.

- Some predacious fungi secrete a sticky substance on the surface of their hyphae to which small animal adheres.
- Haustorium like hyphae then grow into the body of the animal and absorb food.
- The animals ultimately die.

Reproduction:

- Fungi reproduce by means of vegetative, asexual and sexual methods.

1. Vegetative reproduction:

a. Fragmentation:

- 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 'Hyphal tip method' is commonly used for inoculation of fungi.

b. Budding:

- A small soft portion of the cell wall bulges out and a daughter nucleus migrates into it.
- The bud is pinched off by constriction at the point of origin of the bud.
- Sometimes the budding is so quick that a chain of cells is formed due to non-detachment of the daughter cells
eg. Saccharomyces.

c. Fission: It is characteristic of Bacteria

- In fungi, this occurs only in fission yeast.
- In fission the cell divides in transverse plane and forms two cells.

d. Sclerotia:

- The sclerotia are resistant and perennating bodies.

- They survive for many years.
- Each sclerotium is cushion-like structure of compact mycelium.
- They give rise to new mycelia on the approach of favourable conditions.

e. Rhizomorph:
- Rhizomorphs are rope like structures resistant to unfavourable conditions and give rise to new mycelia even after several years on the approach of favourable conditions.

2. Asexual Reproduction:
- Asexual reproduction takes place by means of spores.
- The spores are of diverse type and borne upon special structures called the sporophores.
- Usually the spores are uninucleate and nonmotile but multinucleate and motile spores are also found.
- The fungus producing more than one type of spores is called the pleomorphic or polymorphic fungus.
- The spores produced inside the sporangia are termed endogenous spores and the spores produced exogenously on the terminal ends of sporophores are called the exogenous spores.

a. Endogenous spores:
- The endogenous spores are produced within the special spore producing cell called sporangium.

. The sporophores which bear the sporangia on their apices are called the sporangiophores.
. The spores produced inside the sporangia are called the endospores
. They may be motile or non-motile

i) Zoospores:
. The motile spores are called the zoospores
. Zoospores are produced inside the zoosporangia.
. The protoplasm of the sporangium divides into uninucleate or multinucleate protoplasmic bits and each bit metamorphoses into a spore.
. Zoospores are uni or biflagellate.
. Each spore is without any cell wall, uninucleate and vacuolate.
. They can move with the help of their flagella.
. They are usually kidney-shaped and the flagella are inserted posteriorly or laterally on them.
eg. Albugo, Phytophthora, & pythium, etc.

ii) Aplanospores:
. The non-motile spores are called aplanospores.
. They are without flagella formed inside the sporangia.
. They may be uni or multinucleate.
. These spores lack vacuoles and possess two layered cell walls.
. The outer thick layer is exospore which is ornamented in many spores.
. The inner thin layer is endospore.
eg. Mucor, Rhizopus.

b) Exogenous spores:

- The spores produced externally are cal as exogenous spores or conidia.
- They are produced externally on the branched or unbranched conidiophores.
- The conidiophores may be septate or aseptate.
- The conidia are produced on sterigma singly or in chains.
- The conidia are diverse in their shape and size.
- They may be unicellular or multicellular, uninucleate or multinucleate.
- Different genera are recognized by the presence of various shaped and various coloured conidia.
- The conidia of Fungi Imperfecti are multicellular and variously shaped, whereas the conidia of Penicillium are smoky green coloured.
- In other type of exospores, the sporophores develop in groups and form the specialized structure called the pustules, pycnia, aecidia acervuli and sporodochia.

3. Sexual Reproduction:

- Large number of fungi reproduce sexually.
- The members of Deuteromycetes / Fungi Imperfecti lack sexual reproduction.
- Sexual reproduction takes place by formation of gametes.
- The gametes taking part in reproduction are usually formed in the cells of sacs called gametangia.

The most common methods of sexual reproduction are as follows.

1. Planogametic copulation:
- The type of sexual reproduction which involves the fusion of two naked gametes is known as planogametic copulation.
- The gametes are motile known as planogametes.
- They may be isogamous or anisogamous planogametes.

eg. Plasmodiophora, Synchytrium.

2. Gametangial contact:
- This method of reproduction is found in many lower fungi.
- In this method two gametangia of opposite sex come in contact and one or more gamete nuclei migrate from the male gametangium to the female gametangium.
- After the migration of the nuclei the antheridium eventually disintegrates but the oogonium continues its development in various ways. eg. Aspergillus, penicillium, Albugo, peronospora.

3. Gametangial copulation:
- In this method of sexual reproduction the fusion of the entire contents of two contacting compatible gametangia takes place.

eg. Mucor, Rhizopus, Entomophthora, etc.

4. Spermatization:

- The minute, uninucleate, spore like male structures are known as spermatia.
- They are produced in several ways.
- The spermatia are carried out by other agencies to the receptive hyphae of female gametangia, to which they become attached.
- A pore develops at the wall of contact & the contents of spermatium pass into the female gametangium through the receptive hypha.

eg. Neurospora (Class - Ascomycetes)

5. Somatogamy:

- The sex organs are not produced.
- The somatic cells take part in sexual fusion.

eg- Morchella.

Penicillium

Systematic Position:

Kingdom : Mycetae
Division : Amastigomycotina
Subdivision : Ascomycotina
Class : Ascomycetes
Order : Eurotiales
Family : Eurotiaceae
Genus : Penicillium

Occurrence:

- The penicillia are commonly known as the green or blue molds.
- They are cosmopolitan in their distribution.
- Usually Penicillium grows as a saprophyte on decaying fruits & vegetables.
- Usually fruits belonging to the family Rutaceae exhibit a bluish growth on them due to the blue coloured spore of Penicillium.
- Some species of Penicillium grow on the forest floors and a few of them grow on cultivated and manured ground.
- Some species cause fermentation in cheese and lend it characteristic aroma.
- Mycologists reported 140 species of genus Penicillium

- The mycelium is well developed and branched.
- It is composed of colourless, slender, tubular, branched and septate hyphae.
- The hyphae run in all directions on the substratum. It form a loose network of hyphae constituting the mycelium.
- Some hyphae grow into the interior of the substratum and rest spread on the surface.

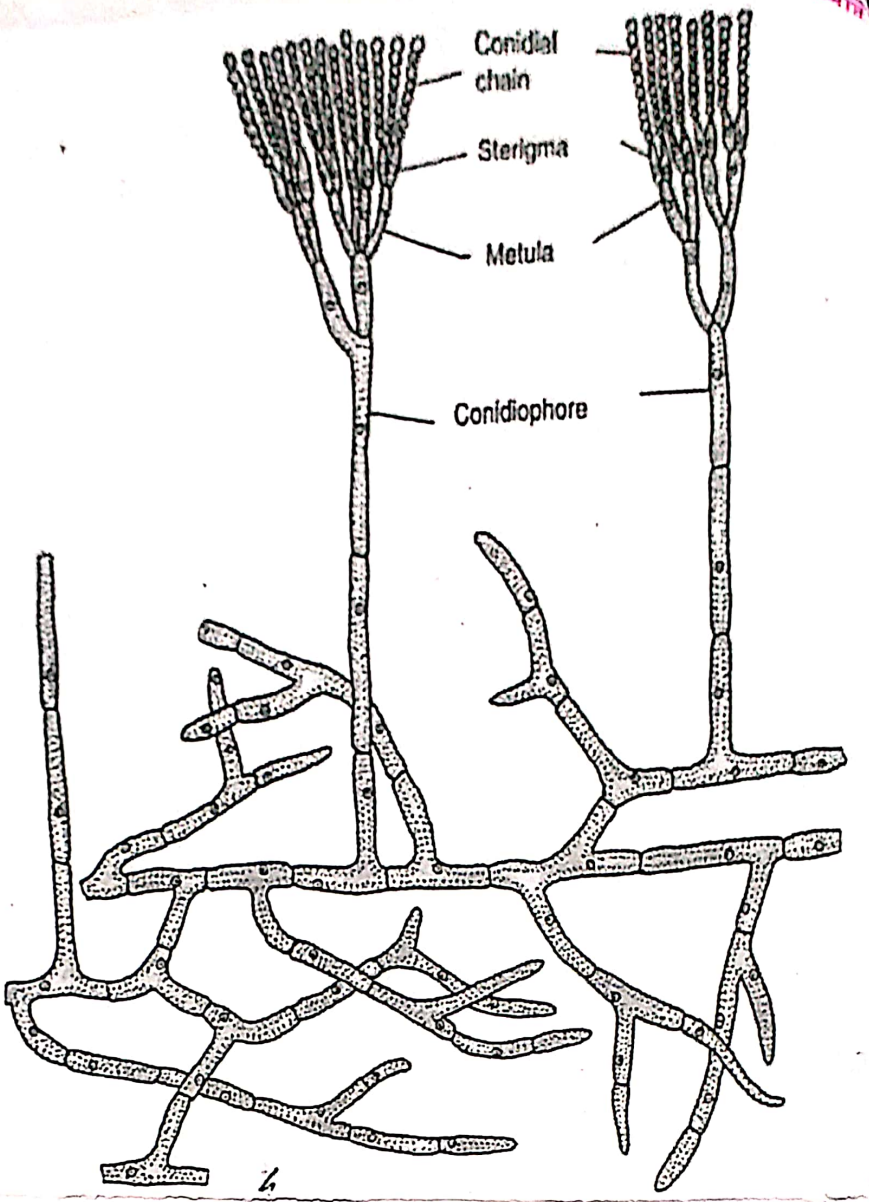


Fig: Part of the plant showing habit

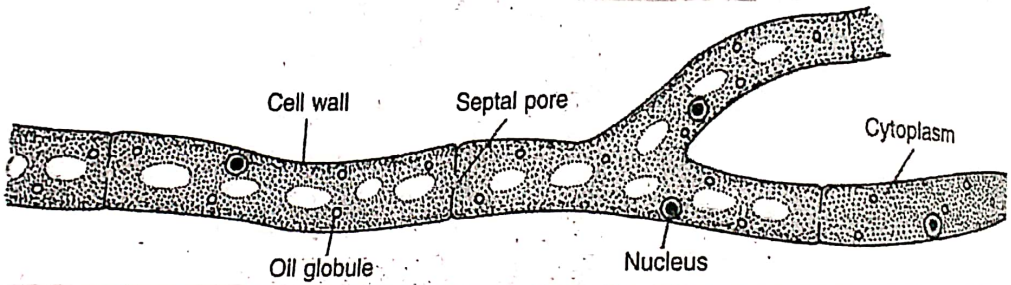


Fig: Portion of hypha enlarged

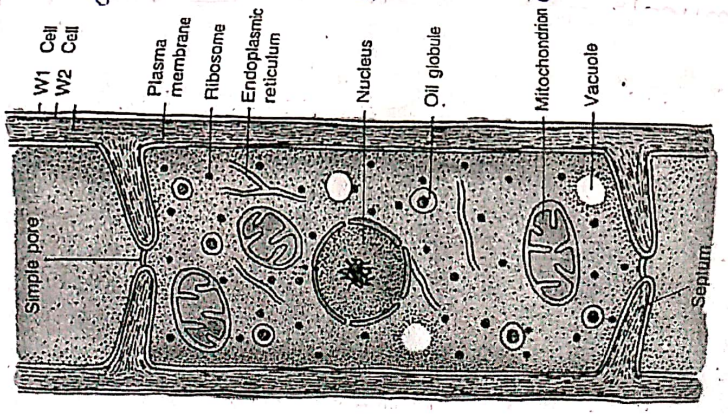


Fig: Structure of Cell

- The internal hyphae secrete enzyme and absorb food material from the substratum with the help of haustoria.
- The aerial hyphae receive nutrition from the haustorial hyphae and produce reproductive structure.
- The hyphae constituting the mycelium are septate and cells are short.
- The septa between the cells have a central pore.
- Through the pores the protoplasm flows from cell to cell.

Cell structure:

- The cells are short, thin and cell wall is microfibrillar in structure with the microfibrils running parallel to the surface.
- Penicillium notatum consist of 3 or 4 layers.
- The outermost layer (W_1) is made up of glucans.
The second layer (W_2) is composed of proteins.
The third layer (W_3) is formed of fibril material arranged parallel to the plasma membrane.
The fourth layer (W_4) is composed of pectic or hemicellulose material.
- The cytoplasm consist of mitochondria, ribosomes and endoplasmic reticulum.
- Cells may be uninucleate, binucleate or trinucleate (different in different species.
- The nuclear membrane has pores.
Oil globules may also be present as reserve food.
- During the vegetative phase, the mycelium is hyaline or pale. The colour appears when the fungus enters the reproductive phase.

Reproduction:

Penicillium reproduces both asexually & sexually.

- The asexual stage is dominant and constitutes the usual mode of reproduction.
- Sexual stage is rare.

Vegetative Reproduction:

i) Fragmentation:

The hyphae break up into short segments.

- Each segment / fragment grows by repeated division into a complete mycelium.

ii) Sclerotia:

In some species, the mycelium forms compact resting bodies, the sclerotia.

- They survive during unfavourable condition.
- On the onset of favourable condition sclerotium germinates to form a new mycelium.

Asexual Reproduction:

i) Sporulation:

It takes place by the formation of non-motile, asexual spores, conidia.

- Conidia are produced exogenously at the tip of long, erect, septate hyphae called the conidiophores.
- A conidiophore arises as an erect, tubular outgrowth from any cell of the mycelium.
- After some period of vegetative growth upright hyphae arise from the older portions of the mycelium.

. Each grows up in length vertically.
. After reaching certain height the septate conidiophore branches once or twice or even more times.
. These are termed as primary, secondary, or tertiary branches respectively.
. The ultimate branches bear tufts of flask shaped sterigmata or phialides are called as metulae.
. Conidia are formed from the tips of the sterigmata / phialides.
. They are borne in long, unbranched chain.

. The conidia are formed within the narrow tips of flask shaped phialides
. The conidium initial is formed by at the tubular tip of the phialide
. Phialide nucleus undergoes mitosis. One daughter nucleus remain in phialide and other migrates into a conidium initial.
. The conidium initial protoplast is then cut off from phialide protoplast by a thin perforated septum.
. The newly formed conidial protoplast secrete a wall around it distinct from the phialide wall and functions as the first conidium.
. The tip of phialide below the first conidium again elongates and swells. A second conidium is formed by repeating the process. Like this, one below the other, a long chain of conidia is formed.
. Being small, light and dry they are dispersed by air currents.
. They are ovoid, globose, elliptical or pyriform
. They are easily disseminated by wind.

- The conidial wall is differentiated in two layers, outer exine and inner intine.
- The exine is thick, smooth or spiny.
- The intine is thin.

- On falling on a suitable substratum & under suitable conditions the conidium absorbs moisture & swells.
- The swollen conidium germinates by putting out a germ tube.
- By further growth, septation & Branching mycelium is formed.

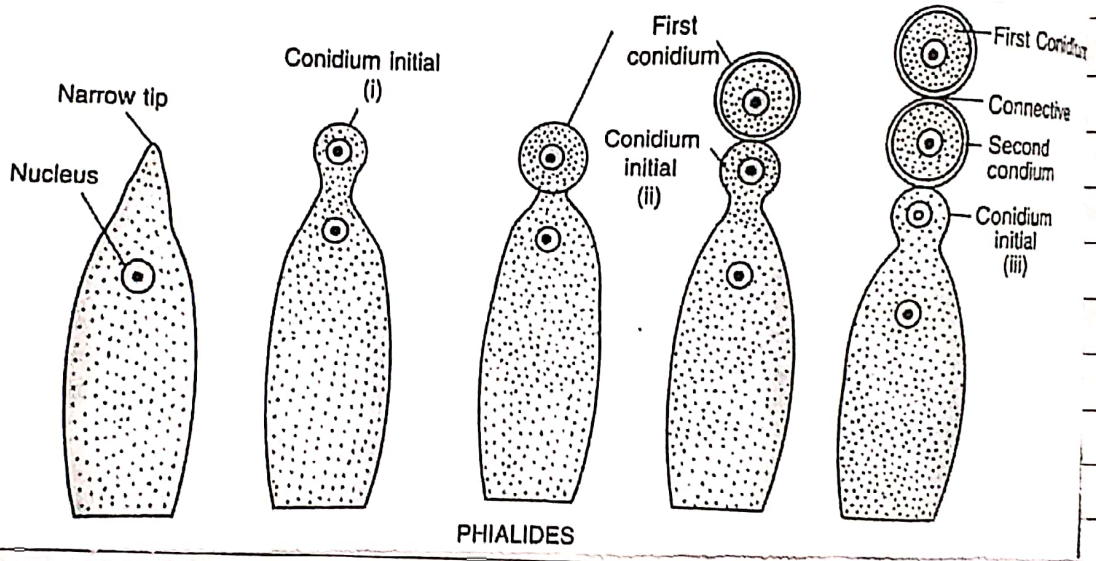


Fig: Stages showing development of conidia in chains.

Sexual Reproduction:

- The sexual reproduction takes place by formation of sex organs.
- The male sex organ is known as antheridia and female sex organ is known as ascogonia.
- The structure of sex organs varies from species to species.

a) Ascogonium:

- A mature ascogonium is a long, erect, multinucleate, unseptate, tubular structure.
- It arises as a lateral outgrowth from any cell of the vegetative mycelium
- When young the ascogonium is uninucleate. As it elongates the single nucleus within it divides and redivides to give rise to a definite number of daughter nuclei which is either 32 or 64.

b) Antheridium:

Meanwhile a slender uninucleate hyphal branch originates either from an adjacent cell of the same hypha which gives rise to the ascogonium or from a separate neighbouring hypha. It is antheridial branch.

- The distal end of the male branch becomes slightly inflated and is eventually cut off as an antheridium by septum.
- The antheridium is a short, terminal, club-shaped, uninucleate structure.

Plasmogamy:

The union of two protoplast is known as plasmogamy.

- The tip of the antheridium comes in contact with the ascogonium.
- At the point of contact, the double wall dissolves. Through the pore two protoplast come in contact, migration of male nucleus takes place in the ascogonium.
- The pairing of two nuclei takes place in ascogonium called as autogamy.
- Each pair is called as dikaryon.

· With the establishment of dikaryon, haplophase ends and the dikaryophase start in the life cycle.

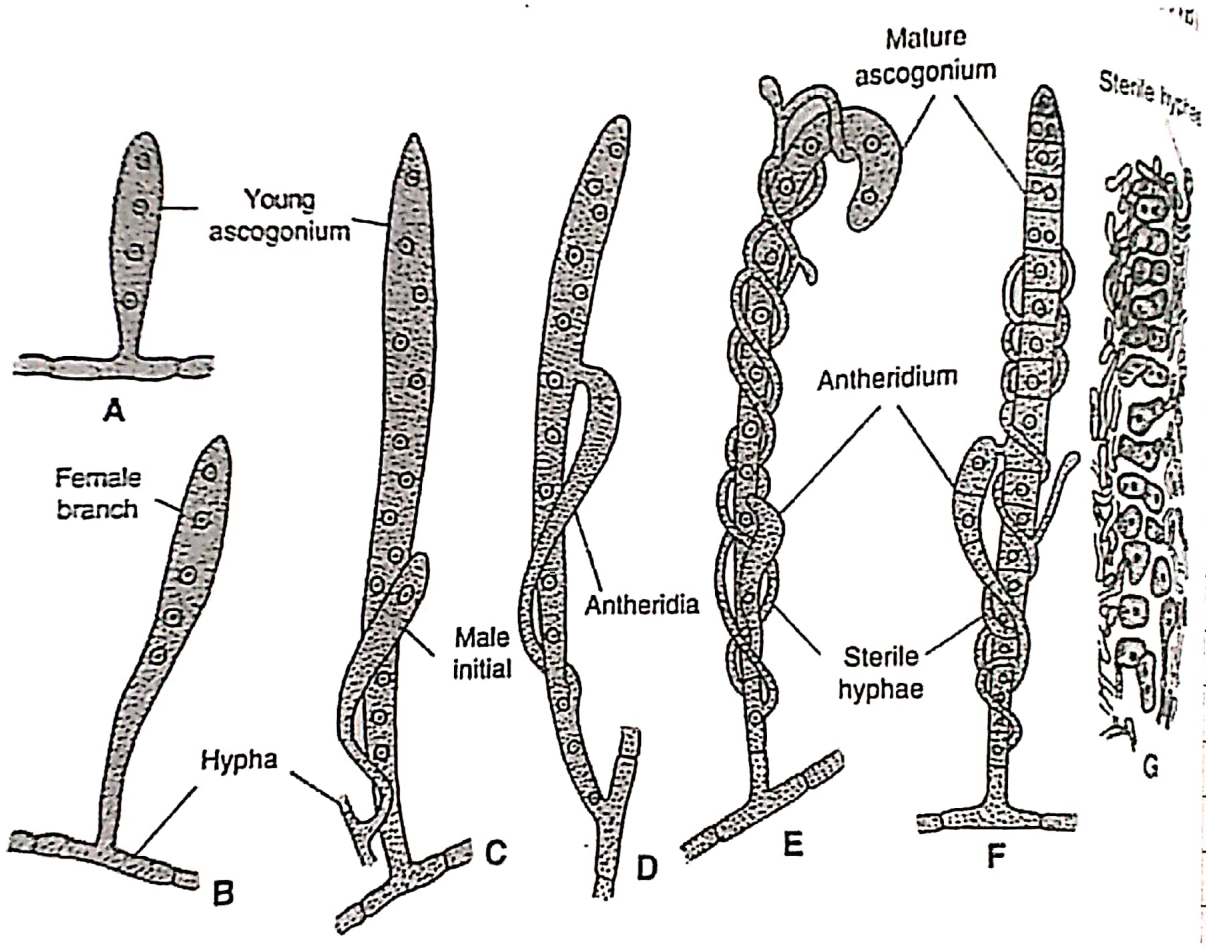


Fig: Stages in sexual reproduction

Post Plasmogamy or Autogamy changes:

i) Septation of Ascogonium:

- Plasmogamy or autogamy is followed by septation of the ascogonium
- Each segment has a pair of nuclei.
- Meanwhile entangled sterile hyphae grow up around the sexual apparatus and form an investment of loosely interwoven hyphae and gives protection to the structures developing within.

ii) Development of Ascogenous Hyphae:

- As a result of stimulus of plasmogamy or autogamy one or more lateral outgrowth arises from some of the binucleate segments situated in the middle of the septate ascogonium. Each outgrowth is called as ascogenous initial. It is binucleate
- Each ascogenous initial develops into a branched ascogenous hypha.

iii) Formation of Asci:

Asci in many species are developed directly from the binucleate cells towards the tips of the branches of the ascogenous hyphae.

1) Direct method of Ascus development:

- All the binucleate cells of the ascogenous hyphae are capable of directly developing into ascus mother cells.
- No croziers are formed

2) Indirect (crozier) method of ascus formation:

- In this case, the terminal binucleate cells of the ascogenous hyphae or their branches curl over to form a hook-like structure called the crozier.

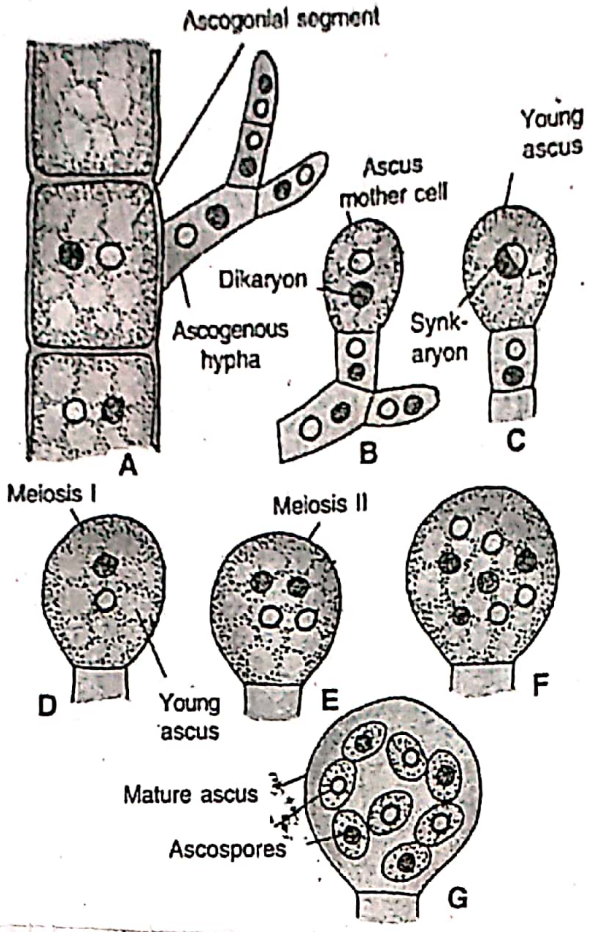


Fig: Direct method of Ascus development

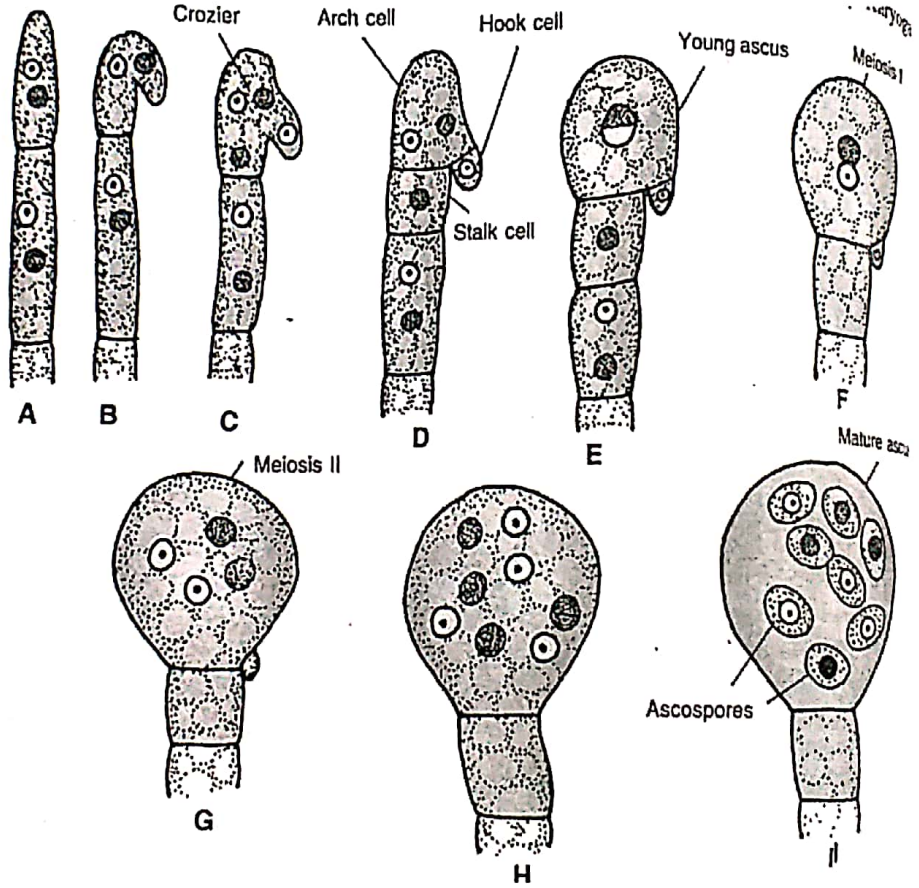


Fig: Indirect method of ascus development

The binucleate cell in both cases enlarges to function as the ascus mother cell.

- It is the last structure of the dikaryophase.
- The two nuclei in it eventually fuse. This is karyogamy.
- With karyogamy, the dikaryophase in the life cycle ends and the diplophase begins.

- The cell containing the fused diploid nucleus (Synkaryon) is the young ascus.
- It is the only diploid structure in the life cycle and thus represents the short-lived diplophase.

iii) Differentiation of Ascospores:

- The young ascus enlarges. Its diploid nucleus undergoes three successive divisions.
- First & second divisions constitute meiosis. The third is mitotic.
- The resultant 8 nuclei are thus haploid.
- A small amount of cytoplasm gathers around each daughter nucleus.
- The uninucleate protoplasts secrete their own walls and are converted into ascospore.
- Thus 8 ascospores are formed in each ascus which may be spherical or pear-shaped in appearance.

v) Formation of Ascocarp:

- A large number of sterile hyphae grow up around the sexual apparatus & form a hollow ball like structure called the peridium.
- It surrounds and protects the sexual apparatus. This is the ascocarp.

• This entire structure is spherical and no opening. Such a closed ascocarp is called the cleistothecium.

• At maturity the walls of the asci dissolve.
• The ascospores, float in the nourishing fluid formed by the degeneration of the inner layers of the peridium, walls of asci & the ascogenous hyphae.
• The ascospores absorb nutrition and mature.
• The mature ascospores are finally released by the decay of the other wall of the peridium.

• The liberated, uninucleate ascospores remain dormant when temperature and moisture conditions are low and air supply is restricted.
• On falling on a suitable substratum & under suitable conditions each ascospore germinates.
• It absorbs moisture & produces a germ tube.
• The germ tube by growth, septation & branching forms the mycelium.

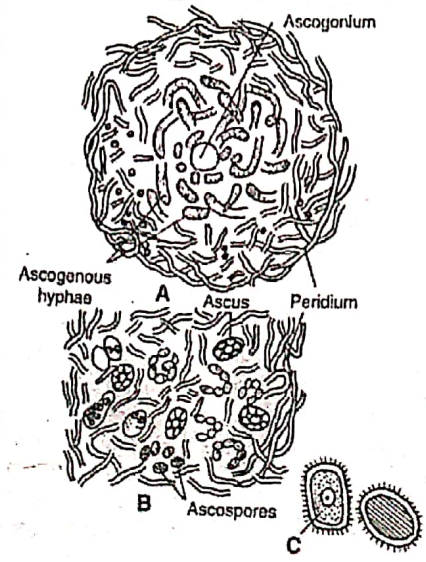


Fig: A: T.S. of young cleistothecium
B: Mature cleistothecium
C: Ascospore

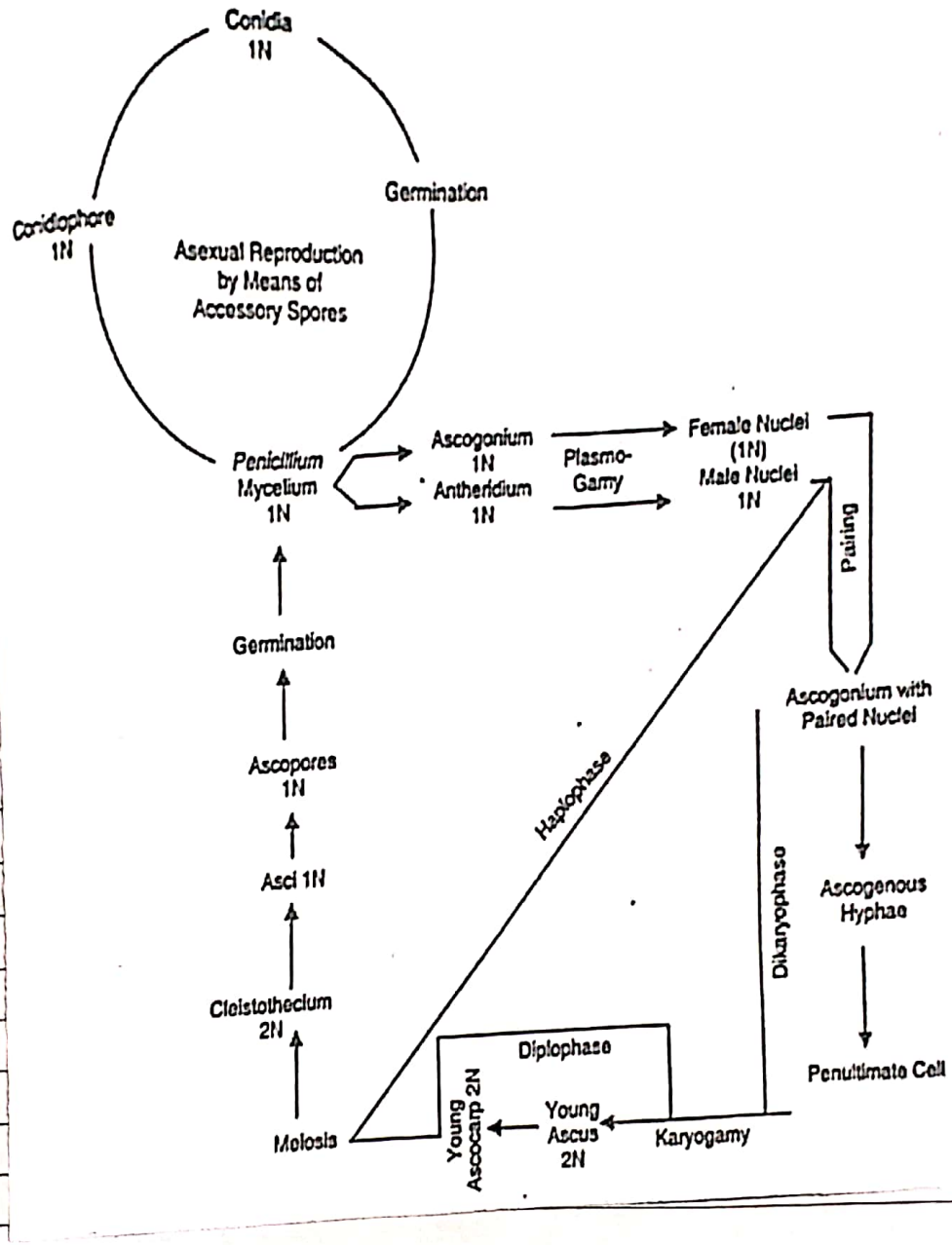


Fig: Graphic representation of the life cycle of penicillium sp.

Alternaria

Systematic Position:

Kingdom : Mycetae
Division : Amastigomycota
Subdivision : Deuteromycotina
Class : Deuteromycetes
Order : Moniliales
family : Dematiaceae
Genus : Alternaria

Occurrence:

- The genus Alternaria occurs universally.
- It has several species. Many of these are contaminants in laboratory media and on petri-dish culture.
- In nature the alternaria grow mostly as saprophytes on plant debris & dying plant parts.
- Several species are parasitic on plants.
- The important plant pathogens are -

1. Alternaria solani :
   It causes early blight of potato and other members of family solanaceae.

2. Alternaria brassicae & A. brassicicola :
   It cause leaf spot disease in crucifers such as mustard, cabbage, cauliflower.

3. Alternaria tenuis :
   It is causative agent of leaf blight of wheat seedlings.

* Mycelium:

- It is not large and extensive but is short, septate, branched, light brown but becoming darker with age.
- The colonies of Alternaria are woolly but more compact with the underside very dark coloured.
- In the parasitic species, the hyphae are intercellular at first, but later penetrate cells of the invaded tissue and thus become intracellular.
- The cells are usually multinucleate.

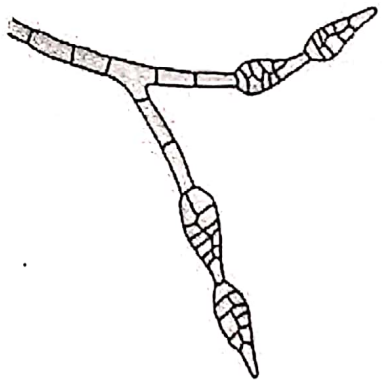


Fig. 16.9. *Alternaria* sp. Hyphae bearing multicellular muriform conidia.

Reproduction:

- Alternaria have no sexual or perfect stage.
- They multiply asexually by the method of sporulation.
- The characteristic asexual spores which are produced exogenously are the conidia.

- The conidia are produced at the tips of ordinary hyphae which are comparatively short and dark coloured.
- Special hyphae termed conidiophores are not recognisable.
- The conidia are large, dark coloured, several celled and beaked.
- The number of cells varies from 8-14 or even more.
- The septa dividing the conidia into cells are both transverse & vertical and their number is not fixed, it is affected by environmental conditions.
- Usually the conidia are borne end to end in chains of two or three.
- Occasionally they may occur singly at the tip of a hypha.

- Each conidium originates as a bud from the terminal cell of a hypha.
- The conidia are wind borne and thus invade laboratories where they contaminate cultures.
- The conidia germinate readily in the presence of moisture & suitable temperature by putting out a number of germ tubes.

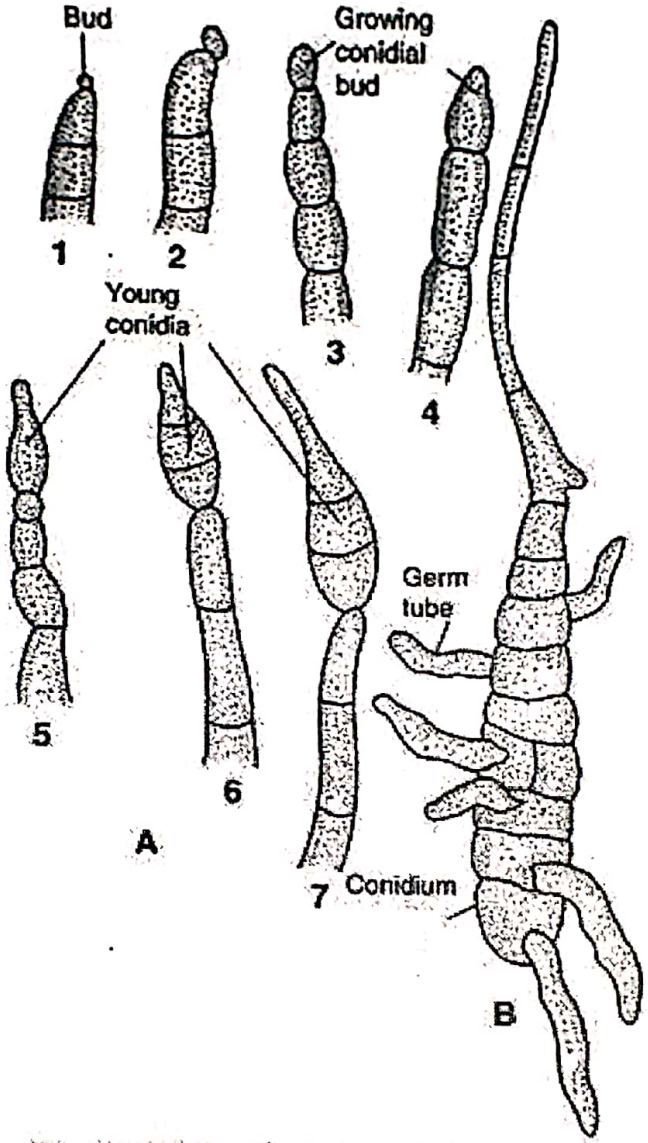


Fig. 16.10 (A-B). *Alternaria solani*. $A_{1,7}$, stages in the development of conidium; B, germinated conidium. (After Rands).

AGARICUS

SYSTEMATIC POSITION:

Division	–	Amastigomycota
Sub-division	–	Basidiomycotina
Class	–	Basidiomycetes
Order	–	Agaricales
Family	–	Agaricaceae
Genus	–	***Agaricus sp***

OCCURRENCE:

Agaricus is a very common **saprophytic** fungus. It occurs abundantly in rainy season on decaying logs of wood, bark of tree trunks and in damp soil rich in humus along the grasses. There are two types of *Agaricus* species. The edible species are called as the mushrooms and the non-edible species as the toad stools.

STRUCTURE OF MYCELIUM:

The mycelium of *Agaricus* is filamentous, branched, septate, multicellular and brown to black in colour. It is of two types i.e. monokaryotic mycelium and dikaryotic mycelium. The mycelium with uninucleate hyphal cells is called the monokaryotic mycelium. The monokaryotic mycelium may be of + or - strain. It is formed by the germination of haploid basidiospores. The dikaryotic mycelium is a mycelium with binucleate hyphal cells. The cells of the dikaryotic mycelium have two nuclei of opposite strain.

The cells of both the mycelia have double layered cell wall. The cell wall is made up of the fungal cellulose chitin. The protoplasm of the

cells contains cell organells like endoplasmic reticulum, ribosomes and mitochondria etc. in addition to the reserved food material in the form of glycogen granules, fats and oil.

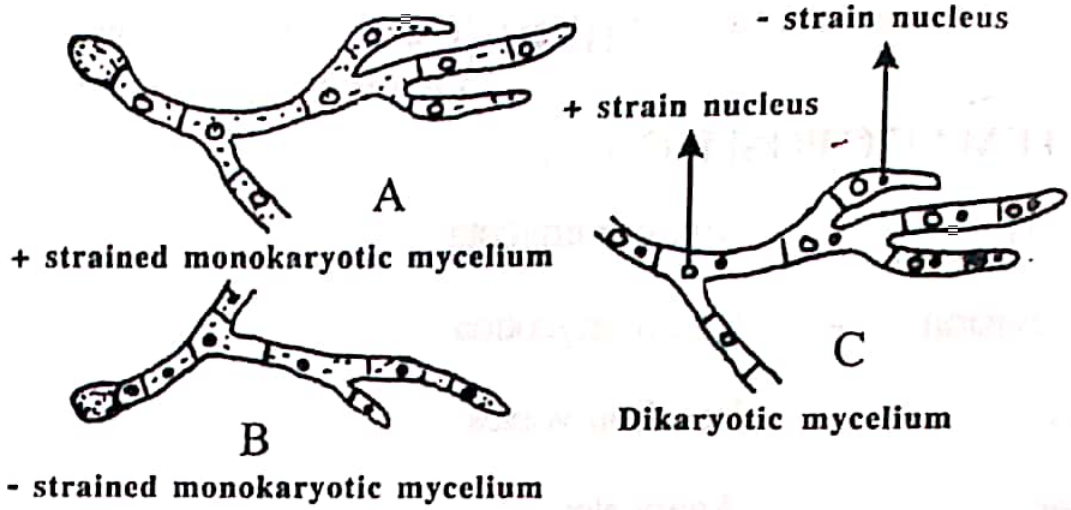


Fig. 4.1 (A-C). FUNGI: Agaricus – Mycelium.

REPRODUCTION:

Agaricus reproduces sexually only.

Sexual reproduction:

The sexual reproduction is of somatogamous type. The sex organs are totally absent in *Agaricus*. The somatic or vegetative, haploid, monokaryotic mycelia of opposite strains function as the sex organs. The sexual reproduction involves three different steps such as

i) Plasmogamy.

ii) Karyogamy.

iii) Reduction division or meiosis.

Plasmogamy:

During the process of plasmogamy the two haploid, somatic monokaryotic mycelia of opposite strain come in contact with each other and fuse. The wall of contact between the two fusing cells dissolves and mixing of protoplasm except nuclei takes place called the plasmogamy. The process of fusion of two somatic hyphae of opposite

strain is called somatogamy. The somatogamy takes place in soil. The plasmogamy results into the formation of a dikaryotic (binucleate) cell. The dikaryotic cell later on ramifies (gives rise to) into a dikaryotic mycelium.

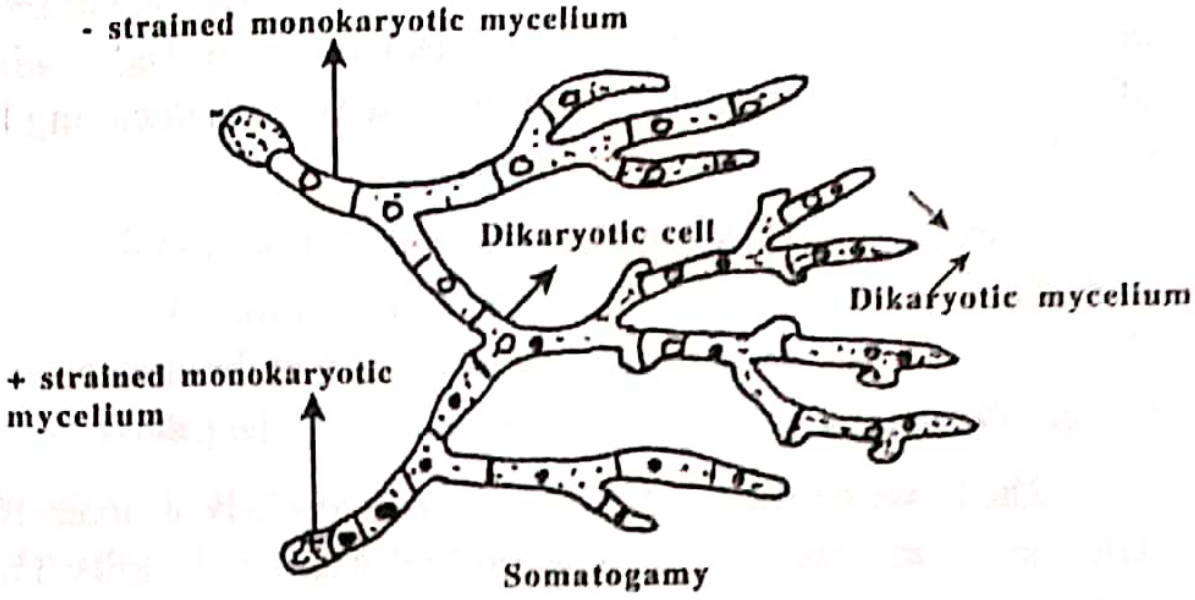


Fig. 4.2. FUNGI: Agaricus - Plasmogamy.

The dikaryotic hyphae grow in soil interwoven with each other and form a thick, twisted, white, root like structure called the rhizomorph. The rhizomorph is invisible in soil. It grows in all directions and forms a circular colony in the soil. It produces many umbrella like large, visible fruiting bodies called the basidiocarps. Some times the basidicocarps are developed at the tip of rhizomorphs in the circular colony. They grow and come above the ground in a

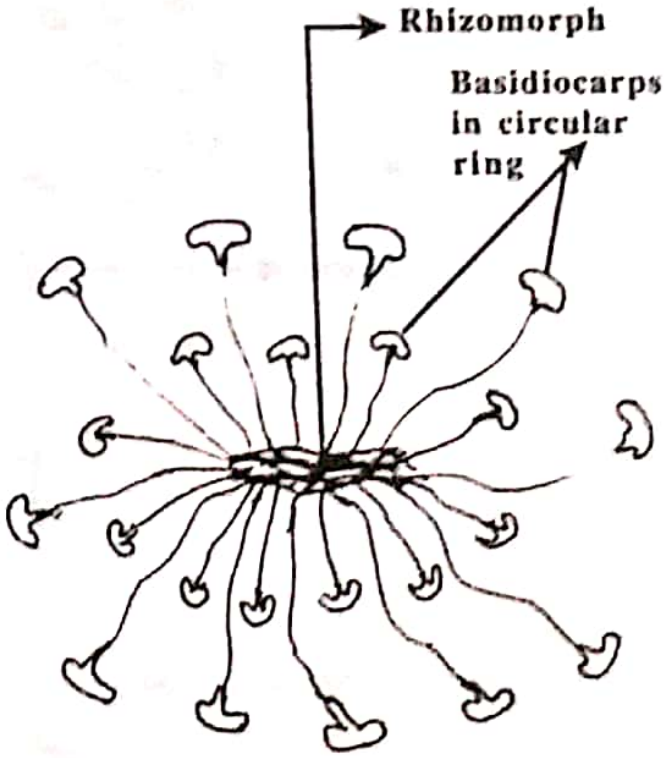


Fig. 4.3. FUNGI: Agaricus - Fairy ring.

circular ring called the **fairy ring**. There is an old superstition that the basidiocarps in a circular ring indicates the path of dancing fairies hence the ring of basidiocarps is called the **fairy ring**.

Structure of a basidiocarp:

Basidiocarp is a fruiting body of *Agaricus*. It is developed from the dikaryotic rhizomorph, hence is dikaryotic in nature. It is large visible, umbrella like structure. It is brown to black in colour. The basidiocarps of *Agaricus* are very common in rainy season on decaying logs of wood and along the grasses in damp places.

A mature basidiocarp is composed of a long, cylindrical, fleshy stalk and an umbrella like fleshy head. The stalk is known as **stipe**. The head is connected with the stipe by a thin membrane called veilum. The upper surface of the head is convex called the **pileus**.

The lower surface of the head is concave and bears many tubular, plate like structures like ribs of an umbrella called the **gills**. The gills are the main reproductive organs of *Agaricus*.

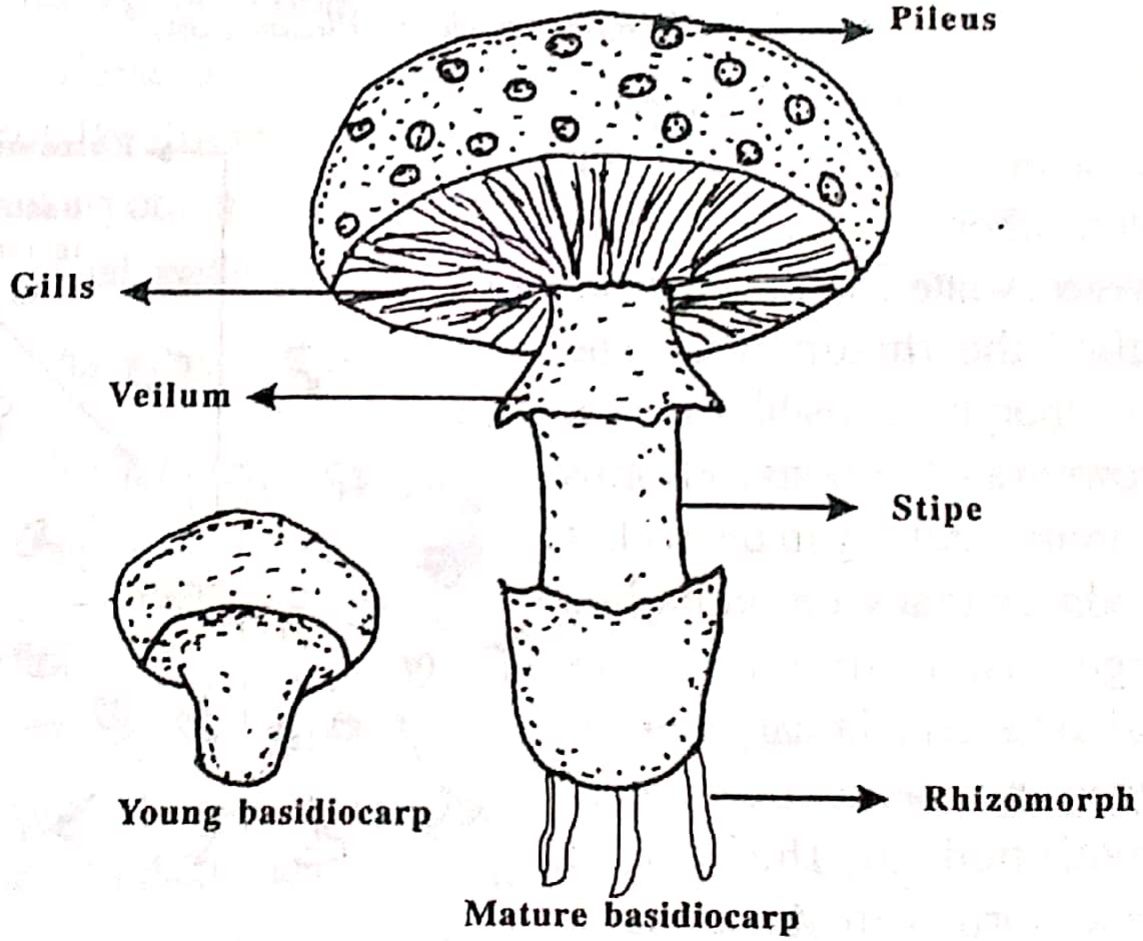


Fig. 4.4. FUNGI: Agaricus - Structure of basidiocarp.

Structure of gill:

The gills are long, tubular, plate like structures. They are present on the lower surface of the basidiocarp like ribs of an umbrella. A mature gill shows three different parts in V.S. (Vertical Section) such as

i) Trama.

ii) Sub hymenium.

iii) Hymenium.

Trama:

It is the central part of the gill. The dikaryotic mycelium in the centre interwoven freely and forms a mat like structure called the trama.

Subhymenium:

It is the middle part of the gill. The dikaryotic hyphae in the trama terminate and give rise to a single or double layer of small rounded or spherical cells on either side of the trama called the subhymenium.

Hymenium:

It is the outer most part of the gill. The rounded cells of the subhymenium give rise to a single layer of many club shaped cells called the **hymenium**. The hymenium layer contains two types of cells i.e. small, sterile, club shaped cells and large, fertile club shaped cells. The sterile cells are called paraphyses and fertile cells are called the basidia (singular basidium). The **paraphyses** and the **basidia** are intermingled with each other. The basidia are aseptate and dikaryotic.

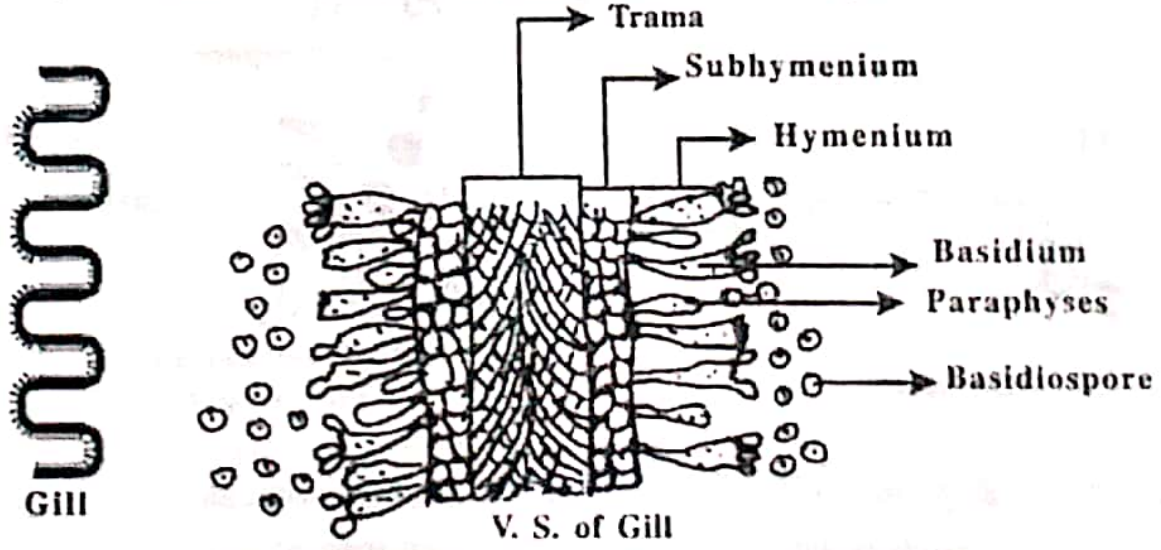


Fig. 4.5. FUNGI: Agaricus - Strucure of a gill (V.S.).

Karyogamy:

The karyogamy i.e. the fusion of two nuclei of opposite strain takes place in the basidium. The karyogamy results into the formation of a diploid nucleus in the basidium.

Reduction division (R.D.):

The karyogamy is followed by the reduction division of the diploid nucleus of synkaryon. The reduction division results into the formation of four, haploid daughter nuclei in the basidium. Now the four nucleated basidium gives rise to four projections at the apex called **sterigmata**. The haploid nuclei migrate into the sterigmata and organise into a single rounded structure at the tip of each sterigmata called the **basidiospore**. Thus four haploid basidiospores are formed exogeneously at the tip of each sterigmata. Out of four two basidiospores are of **+ strain** and two are of **- strain.**

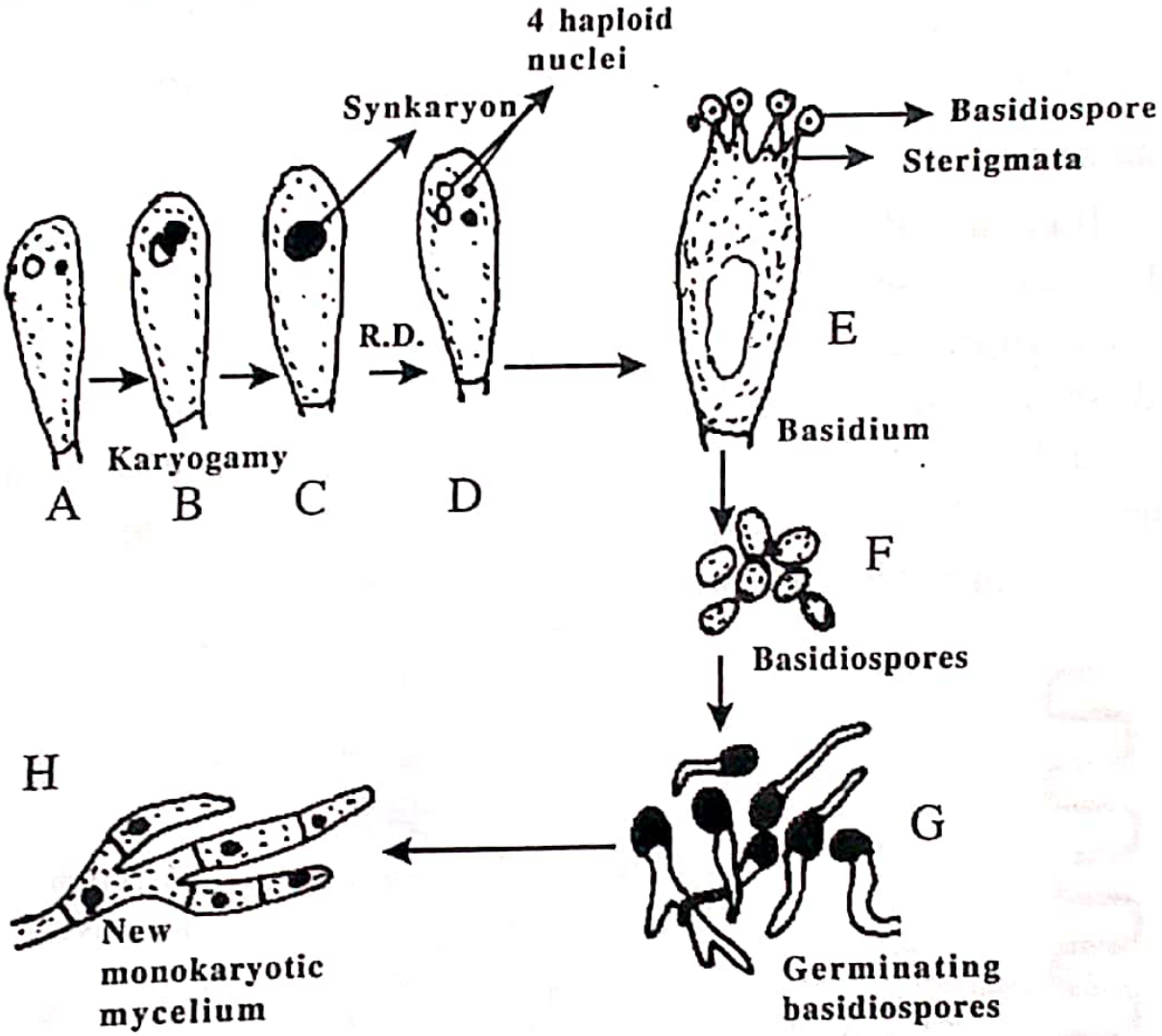


Fig.4.6 (A-H).FUNGI: Agaricus - Development, structure and germination of basidiospores.

GRAPHIC LIFE CYCLE OF *AGARICUS*:

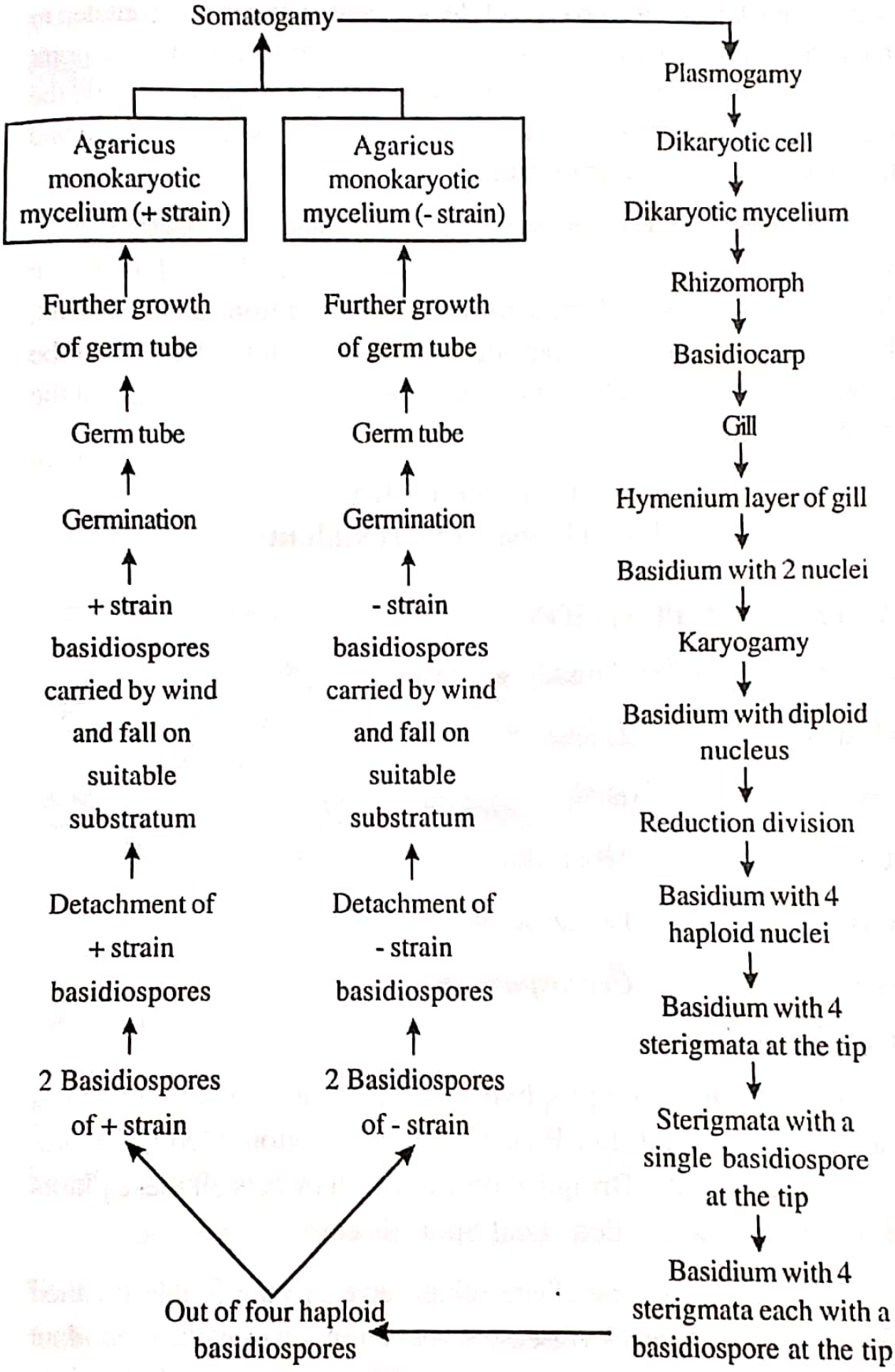


Fig. 4.7. FUNGI: Agaricus - Graphic life cycle.