**B.sc. Paper-I Notes**

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**DSC Latur**

Viruses have the following characteristics:

- All viruses have either DNA or RNA
- Viruses also have a protein coat which protects the DNA or RNA.
- Viruses cannot multiply outside a host cell
- Viruses are unable to create their own energy
- Viruses are not made of cells and they lack many of the cellular organelles found in other living organisms.

## Tobacco Mosaic Virus (TMV)

The virus, TMV, causes the disease Tobacco Mosaic which affects tobacco, tomato, other Solanaceous plants and upwards of 200 plant species

Tobacco mosaic virus also known as TMV is the most extensively studied virus in plants. It was Pathogen Description TMV is a viral plant pathogen and a member of a large group of viruses within the genus Tobamovirus.

Its particles are rigid rods only 300 nanometres long and 18nm wide, consisting of coat protein molecules stacked helically around a single strand of RNA, which is its genome.

Mode of Infection TMV enters plants through wounds. Damage to the plant cell membrane permits entry of infectious particles into the cytoplasm.

TMV 'hijacks' the hosts protein synthesis machinery to make viral proteins and TMV makes many copies of its RNA.

TMV spreads into neighbouring cells using its movement protein which modifies tiny channels, called plasmodesmata, which connect nearly all plant cells. The virus spreads from an initial infection site to all parts of the plant via the phloem, the plant's nutrient transport network.

It Was discovered by Iwanowski (1892) and obtained in pure state by Stanley (1935).

It has a helical symmetry. TMV is a cylindrical structure with a molecular weight of 40 million and dimension of 100 x 3000 A°. (10 x 300 nm).

**Structure of TMV:**

TMV is a simple rod-shaped helical virus consisting of centrally located single-stranded RNA enveloped by a protein coat.

The rod is considered to be 3,000 Å in length and about 180 Å in diameter.

The protein coat is technically called 'capsid'. R. Franklin estimated 2,130 sub-units, namely, capsomeres in a complete helical rod of TMV.

Each capsomere is a grape like structure containing about 158 amino acids in each capsomere.

There would be about 130 turns per rod of TMV. In this way every turn consists of 16 capsomeres.

The central core of the rod is about 40 Å in diameter.

The ssRNA is little more in length (about 3300 Å) slightly protruding from one end of the rod.

**Symptoms:**

The TMV virus/viruses attack is confirmed when on the younger leaves of tobacco plants, the veins may show a clear ring, which is later on followed by mottling. With the enlargement of leaves dark green spots of abnormal size appear and at later stage they transformed into crumpled blister areas which are irregular.On the other hand, the remaining portion of tissue becomes more chlorotic with the passage of time. Also, the growth of plant to many degrees remains stunted. The disease is characterized by mottling of leaves referred to as ‘mosaics’.This virus belongs to the genus Tobamovirus. It is a virus that infects many plants, especially plants of tobacco and plants of family Solanaceae.

It is a thermostable virus which means it can withstand up to 50 degree celsius temperature for 30 minutes. This virus has a very wide survival range. The 3’-terminus of the genome of this virus has tRNA (transfer ribonucleic acid) like appearance and 5’-terminus of the genome of this virus has a methylated nucleotide cap.

TMV virus can be used to engineer viral vectors. Viral vectors are the tools that are used in recombinant DNA technology in order to transfer the desired genetic material into the host cell. It is an ideal candidate to be incorporated into the battery electrodes. The incorporation of TMV into the battery electrodes increases the reactive surface area.

## Life-Cycle (Replication) of Tobacco Mosaic Virus (TMV):

Plant viruses like TMV penetrate and enter the host cells and their replication completes within such infected host cells. Inside the host cell, the protein coat dissociates and viral nucleic acid becomes free in the cell cytoplasm.

The capsid becoming free in the cell cytoplasm and the viral-RNA moves into the nucleus (possibly into the nucleolus).

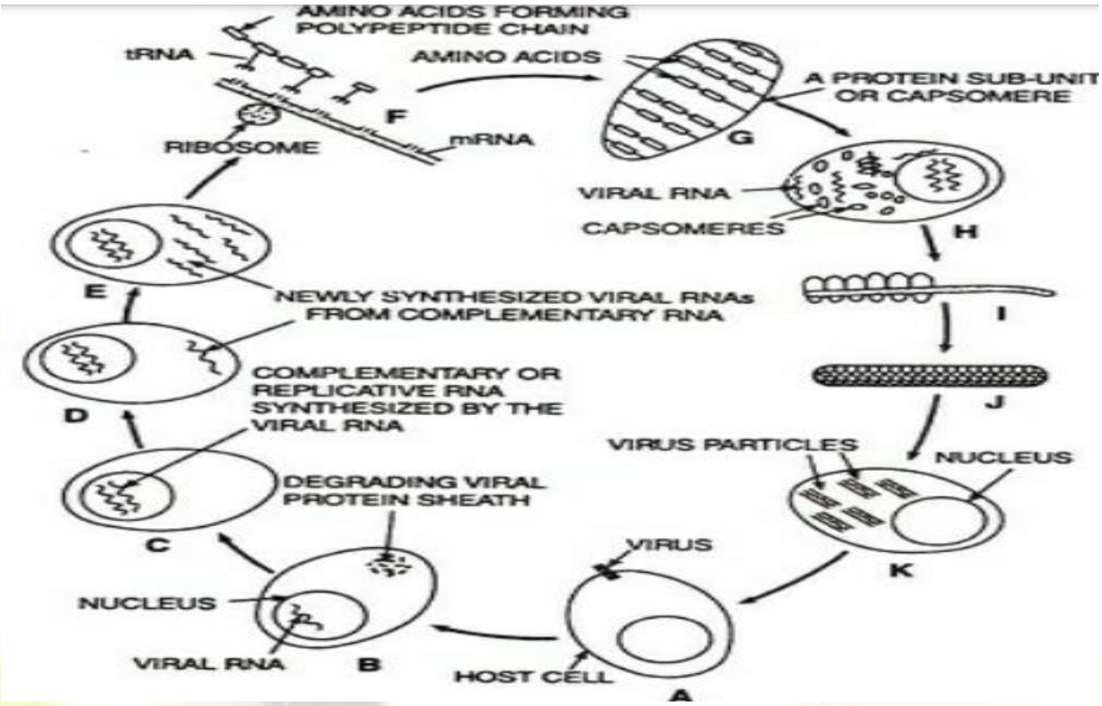
The viral-RNA first induces the formation of specific enzymes called 'RNA polymerases' . The single-stranded viral-RNA synthesizes an additional RNA strand called replicative RNA.

This RNA strand is complementary to the viral genome and serves as 'template' for producing new RNA single strands which is the copies of the parental viral-RNA.

The new viral-RNAs are released from the nucleus into the cytoplasm and serve as messenger-RNAs (mRNAs). Each mRNA, in cooperation with ribosomes and t-RNA of the host cell directs the synthesis of protein subunits.

After the desired protein sub-units (capsomeres) have been produced, the new viral nucleic acid is considered to organize the protein subunit around it resulting in the formation of complete virus particle, the virion.

No 'lysis' of the host cell, as seen in case of virulent bacteriophages, takes place. The host cells remain alive and viruses move from one cell to the other causing systemic infection. When transmitted by some means the viruses infect other healthy plants.




**Life Cycle of TMV**

**Yellow Vein Mosaic of Bhindi (Abelmochus esculentus)** Okra or Bhindi or Bhendi (*Abelmoschus esculentus* L. is regular vegetable grown in India and it belongs to genus *Abelmoschus* and its family is *Malvaceae*. It is also called as ladyfinger.

Yellow vein mosaic disease of Okra (Bhindi) is the commonest one of this vegetable in India and, most probably, is restricted to countries of South Asia. Kulkarni (1924) was the man who first reported this disease in our country and further studies were extended by Uppal et al. (1940).

Yellow vein mosaic of bhindi or vein clearing of bhindi is the most devastating disease in all the bhindi growing regions of India. The virus is, probably, small in size and spherical in shape but its morphology and ultra-structures are yet to be determined in detail. Begomo virus Hibiscus-1 are the causal organism and transmitted by white fly *Bemisia tabaci*.Genetic material of begomovirus is small sallite DNA beta component.

**Symptoms of Yellow Vein Mosaic Disease:**

The typical symptoms are vein-clearing and vein-chlorosis of leaves. First of all, the clearing of small veins starts at various points near the leaf margins and thereafter the vein-clearing develops into vein-chlorosis.(destruction of chloroplast)

In later stages the leaves show very conspicuous yellow network of veins and the veins thickened particularly towards the lower surface of leaves. Finally, the leaves become completely chlorotic leaving few green patches over the leaf surface.

The fruits developed on diseased plants are reduced in size, malformed, and yellowish-green in appearance.

**Disease Management:-**

Ammoniacal nitrogen has also positive advantage for viral infections so take care of ammoniacal nitrogen application.

Removing and destroying disease affected plants from crop fields to avoid secondary spread.

To destroy the host weeds such as croton and Crop rotation. Use seeds collected from disease free plants.

Use of disease resistent varieties such as Parbhani Kranti, Akra Anamika, Akra Abhay, Punjab-7 and Hybrid-6 .

Use of yellow sticky traps to monitor whiteflies and leaf hoppers (Empoasea devastans)population.

## Bacteria

**Bacterial cell Structure and Function**

Bacterial are unicellular prokaryotic organism. Bacterial cell have simpler internal structure. It lacks all membrane bound cell organelles such as mitochondria, lysosome, golgi, endoplasmic reticulum, chloroplast, peroxisome, glyoxysome, and true vacuole.

Bacteria also lacks true membrane bound nucleus and nucleolus. The bacterial nucleus is known as nucleoid. Ribosomes are present which are 70s types. They have (450s + 30 s subunits).

A typical bacterial cell have following structure.

**A. Structure Outside cell wall**

1. Capsule
2. Flagella
3. Pili

**Capsule:**

- Capsule is 0.2µm thick viscus layer outer layer to the cell wall.
- Capsule is 98% water and 2% polysaccharide or glycoprotein/ polypeptide or both.

- There are two types of capsule.
- Capsule is very delicate structure. It can be removed by vigorous washing.Capsule is most important virulence factor of bacteria.
- It helps in attachments as well as it prevent the cell from desiccation and drying.
- Capsule resist phagocytosis by WBCs

**2. Flagella:**

- It is 15-20 nm hair like helical structure emerges from cell wall.
- Flagella is not straight but is helical. It is composed of flagellin protein (globular protein) and known as H antigen.
- Flagella has three parts. Basal body, Hook and filament
- It helps motility of the bacteria

**3. Pili or fimbriae:**

- Pili are hollow filamentous and non-helical structure.
- They are numerous and shorter than flagella
- Pili is the characteristic feature of gram –ve bacteria.
- Pili is composed of pilin protein.
- Bacteria containing pili: *Shigella*, *Proteus*, *Salmonella* ,*E. coli*

**Function:**

- Attachment: pili helps the bacteria to attach the host cell surface. Most of the human pathogens of respiratory tract, urinary tract are attached with the help of pili.
- Pili (fimbrae) possess antigenic property

- Specialized function: some pili are modified for specialized function. Eg. Sex pilus (F-ve pili) help in transfer of DNA from donor to recipient cell during conjugation.
- F-ve pili also act as receptor for bacteriophage.

**7. Cell wall:**

- It is an important structure of a bacteria.
- It give shape to the organism.
- On the basis of cell wall composition, bacteria are classified into two major group ie. Gram Positive and gram negative.

**Gram positive cell wall**

Cell wall composition of gram positive bacteria is Peptidoglycan, Lipid and Teichoic acid

**Gram negative cell wall**

Cell wall composition of gram negative bacteria

Lipid ,Protein and Lipopopysaccharide (LPS)

**Peptidoglycan:**

- It consists of glycan backbone formed by repeated unit of NAG (n-acetyl Glucosamine) and NAM (N-acetyl muramic acid) and the glycan backbone is cross linked by peptide bond.
- Peptidoglycan layer is present in cell wall of both gram positive as well as gram negative bacteria. However, gram positive have thick layer of peptidoglycan.
- **Teichoic acid :-** Teichoic acid is water soluble polymer of glycerol or ribitol phosphate present in gram positive bacteria.

- It constitutes about 50% of dry weight of cell wall.
- It is the major surface antigen of gram positive bacteria

**8. Cell membrane:**

- Cell membrane is the inner layer that lies inside the cell wall and encloses the cytoplasm.
- It is also known as cytoplasmic membrane or plasma membrane.
- It is about 80nm thick.
- Cell membrane of bacteria is composed of phospholipid and proteins.

**Function:**

- It is selectively permeable as it allows to pass selective substances such as sugar, aminoacids across it.

**9. Nucleoid:-**

- Nucleus is the most important part of the cell.
- It controls and directs all the cellular activities and stores hereditary information of cell
- Bacterial nucleus is known as nucleoid; it lacks nuclear membrane, nuceloplasm and nucleolus.
- Bacterial DNA is naked (lacked histone protein)

**Function:**

- It contains and stores hereditary information of the cell.
- It controls all cell activities.

**10. Ribosome:**

- Bacterial ribosome is of 70s type.

- Ribosomes are rounded granules found freely floating in the cytoplasm
- Ribosomes are known as universal cell organelle because it is found in both bacterial cell and eukaryotic cell.
- Chemically the ribosomes are made up of nucleic acids (particularly RNA and proteins).

**Function:**

- It helps in protein synthesis

**11. Mesosome:**

- Mesosome is a spherical or round sac like structure found commonly in gram positive bacteria.
- Function: It is the site for respiration in bacterial cell

**12. Cytoplasm:**

- It is colorless, viscus fluid present inside cell membrane. And cytoplasm of bacteria does not show any streaming movement.
- All the cell organelles and inclusions are found floating in cytoplasmic fluid.
- It contains proteins, lipid, minerals, nucleic acids, glycogen, water etc.

**Function:**

- It helps to distribute water, oxygen as other substances throughout the cell.
- Literally, all the cellular content including nucleus, and other cell organelle are floating in cytoplasm.
- **Spores (endospore):**
- It was firstly discovered by John Tyndall in $19^{th}$ century. They are heat resistant can survive under $100^{0}$c temp. But can be destroyed by autoclave ($121^{o}$c).

- Spore is metabolically dormant structure produced during unfavourable condition by the process called sporulation.
- Sporulation occur during late log phase or early stationary phase
- Under favourable condition spores germinate to give vegetative cell.
- The endospore consists of **the bacterium's DNA and part of its cytoplasm, surrounded by a very tough outer coating**.
- Endospores can survive without nutrients. They are resistant to ultraviolet radiation, desiccation, high temperature, extreme freezing and chemical disinfectants.
- Gram positive (aerobic and anaerobic ) bacteria produces spores. But not archaebacteria.
- It **allows the bacterium to produce a dormant and highly resistant cell to preserve the cell's genetic material in times of extreme stress**. An endospore is called a resting structure **because it is a method of one cell "resting," or surviving**, as opposed to growing and reproducing.
- The protective endospore wall allows a bacterium to withstand adverse conditions in the environment.

## Reproduction in Bacteria :-

### Asexual Reproduction in Bacteria

**Binary Fission:** In binary fission, a single bacterial cell divides into two daughter cells. At first, the bacterial cell reaches critical mass in its form and cell components. The circular double-stranded DNA of the bacteria undergoes replication and new complementary strands are formed. These two strands of DNA are then moved to the different poles of the cell and a transverse septum then takes place and develops in the middle region of the cell which separates the two new daughter cells and thus binary fission I completed. It is a rapid process and takes minutes to complete.

**Conidia Formation:** The formation of conidia takes place in filamentous bacteria such as Streptomyces through the formation of a transverse septum at the apex of the filament. The part bearing the conidia is called the conidiophore and after it is detached from the mother cell, in a suitable substratum it germinates giving rise to new mycelium. This type of asexual reproduction is also called fragmentation.

**Budding:** In this method of reproduction, the bacterial cell develops a small swelling at one side which continuously increases in size. At the same time, the nucleus also undergoes division where one part with some cytoplasm enters the swelling and the other part remains with the mother cell. The outgrowth is called the bud and it eventually gets separated from the mother cell by a partition wall. This method of reproduction also comes under vegetative reproduction in bacteria. Example: Rhodomicrobium vannielii

Reproduction through endospore formation: Endospores in a bacterial cell are formed during stressful conditions such as desiccation and starvation.

They contain a central protoplast, and a core consisting of DNA, ribosomes, enzymes and the t-RNA, everything necessary for the formation of a new cell. Only one endospore is formed in one bacterial cell and on germination, it gives rise to a new bacterial cell.

**Transformation:**

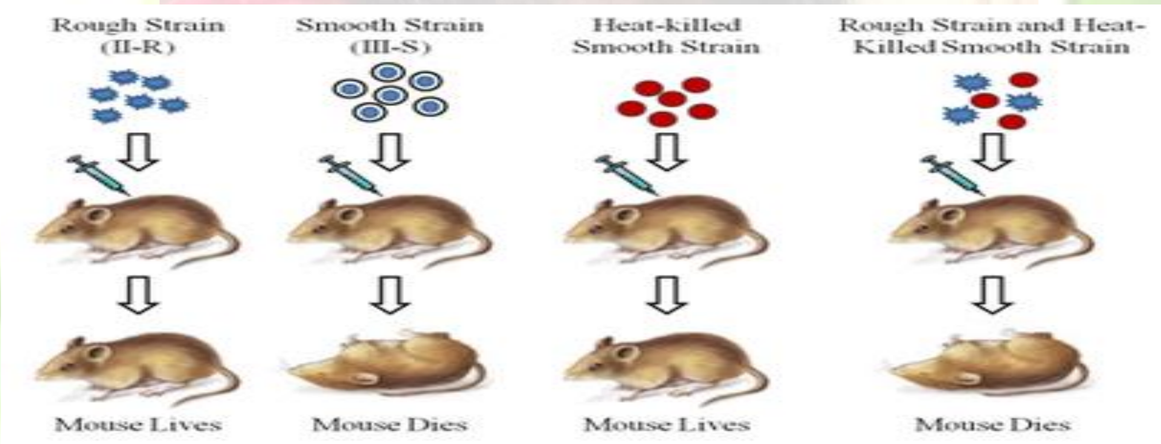
It is the absorption of DNA segment from the surrounding medium by a living bacterium.

The phenomenon of transformation was first recorded by Griffith (1928). Avery, Macleod and McCarty (1944) demonstrated that the transforming principle being DNA in the sequence of events in bacterial transformation.

In 1928, Frederick Griffith found that there are two strains of D. pneumoniae, one that forms smooth colonies protected by a capsule, and the other one that formed irregular or rough colonies without a capsule when grown on a suitable medium in petri dishes.

Receptivity for transformation is present for a brief period when the cells have reached the end period of active growth. At this time they develop specific receptor sites in the wall.

When injected into mice (A) only capsulated smooth cells (virulent) produced the disease, but not the non-virulent rough cells (B). On the other hand when the heat killed capsulated (virulent) smooth cells were mixed with non-virulent rough cells (D) and then were injected in the mice the disease was produced. This shows that some factors from the dead capsulated smooth cells, converted the living non-virulent rough cells into living smooth capsulated (virulent) cells,



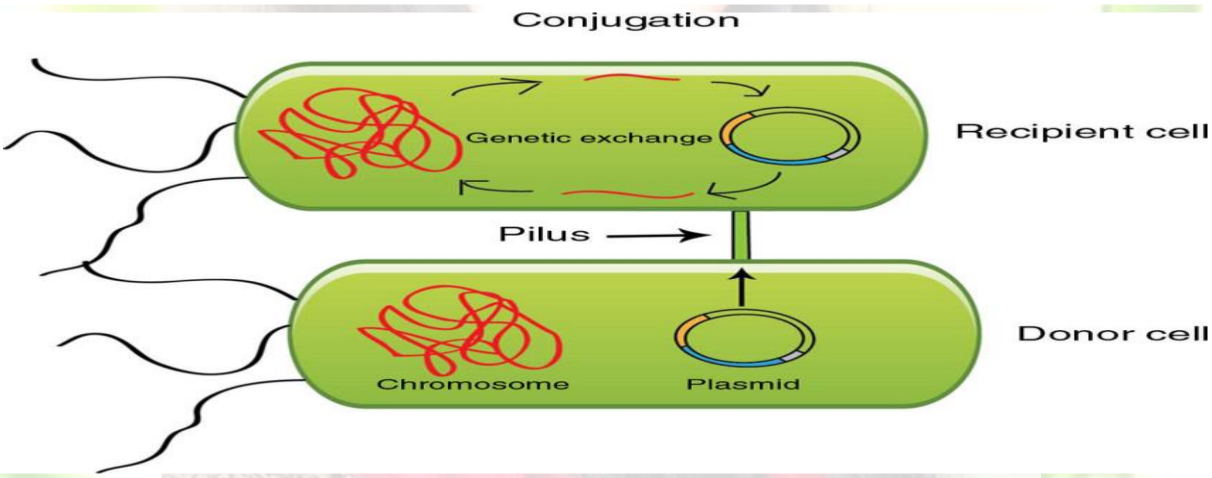

**Transduction:**

It is the transfer of foreign genes by means of viruses. Transduction was first discovered by Zinder and his teacher Lederberg (1952) in Salmonella typhimurium. The process also occurs in E. coli and a number of other hosts. A virus may pick up gene of the host in place of its own gene during its multiplication in the host cell.

**Conjuction:-**

Conjugation is the process by which one bacterium transfers genetic material to another through direct contact.

- During conjugation, one bacterium serves as the donor of the genetic material, and the other serves as the recipient. The donor bacterium carries a DNA sequence called the fertility factor, or F-factor. The $F^+$ (donor) cell produces the pilus, which is a structure that projects out of the cell and begins contact with an $F^-$ (recipient) cell.
- The sex pilus enables direct contact between the donor and the recipient cells.




**Gram staining :-**

**Economic Importance Of bacteria:-**

## General characteristic features of Fungi

**P. A. Micheli** known as father of mycology whereas E. J. Butler refer to as father of Indian mycology.

Majority of fungi are made up of thin, filamentous branched structures called hyphae.

A number of hyphae get interwoven to form mycelium.

The cell wall of fungi is made up of a polysaccharide called chitin (polymer of N-acetyl glucosamine).

The fungal mycelium is categorised into two types based on the presence or absence of septa .

In lower fungi the hypha is aseptate, multinucleate and is known as coenocytic mycelium (Example: Zygomycota *Albugo Mucor,rhizopus*).

In higher fungi a septum is present between the cells of the hyphae. Example: Ascomycetes,Basidiomycetes, Deturomycets classes.

Eg. *Fusarium,Aspergillus,Ustilago,Puccinia*

Kingdom fungi are multicellular eukaryotic organisms except for the yeast which is unicellular.

Xylem and Phloem are absent and there is no embryonic stage for fungi.

Yeasts are unicellular fungi that do not produce hyphae.

Optimum temperature of growth for most saprophytic fungi is 20-30°C while (30-37)°C for parasitic fungi.

Growth rate of fungi is slower than that of bacteria, it requires 4-5 days for complete growth.

Reproduction in fungi is both by sexual and asexual and vegetative.

They reproduce by means of spores.

Sexual spores are Oospores, Zygospores, Ascospores, Basidiospores, etc.

and Asexual spores are Sporangiospores, Aplanospores, Zoospores, Conidia,

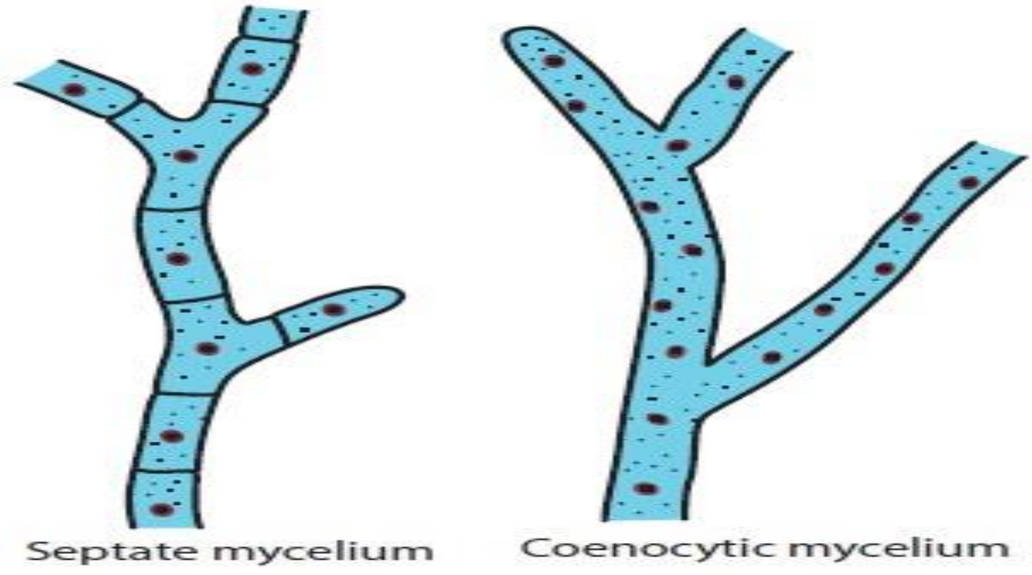



**Figure 1.19: Types of mycelium**

The mycelium is organised into loosely or compactly interwoven fungal tissues called **plectenchyma**.

It is further divided into two types **prosenchyma** and **pseudoparenchyma**.

In the former type the hyphae are arranged loosely but parallel to one another but latter hyphae are compactly arranged and loose their identity and forms mycelium.

In holocarpic forms the entire thallus is converted into reproductive structure whereas in Eucarpic some regions of the thallus are involved in the reproduction other regions remain vegetative.

The asexual phase of fungi is called **Anamorph** and the sexual phase is called **Teleomorph**. Fungi having both phases are called **Holomorph**.

**Asexual Reproduction**

1. Zoospores: They are flagellate structures produced in zoosporangia (Example: Chytrids)

2. Conidia: The spores produced on condiophores (Example*: Aspergillus*)

3. Oidia/Thallospores/Arthrospores: The hypha divide and develop in to spores called oidia (Example: *Erysiphe*).

4. Fission: The vegetative cell divide into two daughter cells. (Example: *Schizosaccharomyces*-yeast).

5. Budding: A small outgrowth is developed on parent cell, which gets detached and become independent. (Example: *Saccharomyces*-yeast*)*

6. Chlamydospore: Thick walled resting spores are called chlamydospores (Example: *Fusarium*).

**Sexual reproduction:-**

In fungi includes three steps 1. Fusion of two protoplasts (plasmogamy) 2. Fusion of nuclei (karyogamy) and 3. Production of haploid spores through meiosis.

1.Planogametic copulation: Fusion of motile gamete is called planogametic copulation. a. Isogamy – Fusion of morphologically and physiologicall similar gametes. (Example: *Synchytrium).* b. Anisogamy – Fusion of morphologically or physiologically dissimilar gametes (Example: *Allomyces*). c. Oogamy – Fusion of both morphologically and physiologically dissimilar gametes. (Example: *Monoblepharis*)

2. Gametangial contact: During sexual reproduction a contact is established between antheridium and Oogonium (Example: *Albugo*)

3. Gametangial copulation: Fusion of gametangia to form zygospore (Example: *Mucor, Rhizopus*).

5. Somatogamy: Fusion of two somatic cells of the hyphae (Example: *Agaricus*)

❖ Depending on the species and conditions both sexual and asexual spores may be produced.

❖ They are typically non-motile. ❖ Fungi exhibit the phenomenon of alteration of generation. They have both haploid and diploid stage.

Fungi is the plural of word fungus which is derived from the latin word fungour. Fungi are achlorophyllas, heterotrophic eukaryotic thallophytes.

**Alexopolus and Mims Classification(1979)**

According to Alexopoulos (1979), the fungi include nucleated spore bearing achlorophyllas organisms that generally reproduce sexually and whose filamentous branched somatic struture are typically surrounded by cell wall containing cellulose or chitin or both.

The branch of botany that deals with the fungi is called mycology and the scientist who is concern with the fungi is called a mycologist.

❖ Fungi are non-green in color with the capacity to live in all kinds of environments.

Lacking chlorophyll, the fungi are unable to synthesized their own organic food. They get it readymade sources either by living as parasites or saprophytes.

The fungal thallus which is termed as mycelium is not formed by the division and differentiation of the cells but composed of a false tissue called pseudoparanchyma.

Thus the unit of structure of a fungus thallus is not a cell but hyphae.

The cell or hyphae wall is composed of fungus cellulose or often called chitin. The reserve food invariably accumulated in the form of glycogen.

They generally have grown in dark and dim light.Fungi are cosmopolitan and occur in air, water soil and on plants and animals.

They prefer to grow in warm and humid places. Hence, we keep food in the refrigerator to prevent bacterial and fungal infestation.

The chemical composition of the cell wall is not the same in all fungi. Chitin is characteristically present in the cell walls of most fungi.

The chitin in fungal cell wall is not strictly identical with animal chitin, and the formula $(C_{22}H_{54}N_4O_{21})n$ has been suggested for the fungal chitin: It is a polymer of N-acetylglucosamine

Nucleus and mitochondria are found to connect with ER. Nucleus divides by intracellular mitosis called karyokinesis and where nuclear envelop remain intact during nuclear division and internal spindle develop. Reserve food is glycogen and oil.

**Ascospores:** An ascospore are produced inside an ascus during the optimal condition. This kind of spore is specific to fungi classified as ascomycetes

**NUTRITION :-** The fungi lack chlorophyll. Therefore, they cannot synthesiz their own food. Depending on from where and how they get nutrition, fungi are of following types:

a. Saprotrophs: They obtain food from dead and decaying organic matter. They secrete digesting enzymes to outside which digest the substratum and then absorb nutrients, e.g., Mucor, Agarious, Rhizopus etc.

b. Parasitic: They obtain food from living organisms. They may be facultative or obligate. Facultative parasites grow on a variety of tissues e.g., Ustilago.

The obiigate parasites growon only upon suitable host, e.g., downy mildews.

The parasitic fungi that grow on surface of host cells and absorb food through haustoria are called **ectoparasites** or ectophytic parasites (e.g., Mucor, Erisphae).

When parasitic fungi grow inside the host tissue are called endoparasites or endophytic parasites (e.g., Pythium, Puccinia).

c. Predacious: Some soil fungi develop ring-like noses to trap annelids, nematodes etc. e.g., Arthrobotrys, Zoophagus, Dactylella etc. Saprotrophs Parasitic fungi on ladybug Predacious fungi trap nematode

d. Symbiotic: They live in mutualistic relationship with another organism by which both are benefited. The two common examples are lichens and mycorrhiza.

Lichens :-shows symbiotic associations between fungi and algae. The fungal partner is a member of ascomycetes or basidiomycetes that provides water and nutrients, while the algal partner is a green alga or cyanobacteria that prepares food by photosynthesis.

Mycorrhizas: or mycorrhizae are the mutualistic symbiotic associations between soil fungi and the roots of most plant species. According to the carbohydrate theory ,the plants that grow in soils deficient in P and N, and high intensity light develop mycorrhizas.

The two most common types of mycorrhizas are the ectomycorrhizas (ECM) and the endomycorrhizas (also known as arbuscular mycorrhiza).

The two groups are differentiated by the fact that the hyphae of ectomycorrhizal fungi do not penetrate the cell wall of the plant's root cells, while the hyphae of arbuscular mycorrhizal fungi penetrate the cell wall.

## REPRODUCTION :-

In fungi reproduction may take place by three methods; vegetative, asexual and sexual.

❖ During asexual and sexual reproduction processes spores are the essential structures.

The spores formed after meiosis are called meiospores (e.g., ascospores, basidiospores and sporangiospores).

Those resulting from mitosis, called mitospores (e.g., mitospores, zoospores, aplanospores, conidia, uredospores).

The diploid body produced as a result of sexual fusion is known as zygote which in lower fungi is termed as resting spore, oospore or zygospore.

❖ In higher fungi, the zygote is represented by a diploid nucleus produced in a cell (ascus or basidium).

This diploid nucleus after undergoing meiosis results in the formation of haploid nuclei serving as centres for haploid sexual spores called ascospores and basidiospores.

### Vegetative reproduction:

In this type of reproduction, a part of mycelium separate and forms a new individual. The various methods of vegetative reproduction are:

a. Fragmentation: The hyphae break into small fragments. Each piece upon getting suitable conditions, germinates to form a new mycelium.

b. Fission: This method involves the splitting of cells into two daughter cells by the formation of a constriction followed by a cell wall formation.

c. Budding: A small bud formed from the parent cell which gradually increases in size and receives a part of nucleus. A cell wall is formed which separates the daughter cell from the parent cell. Fragmentation

d. Sclerotia: These are perennating bodies formed. by the compact masses of interwoven hyphae. Sclerotia under suitable conditions germinate to form new individuals e.g. Claviceps, Sclerotinia

## Asexual reproduction:

It commonly take place through spores, either motile or non-motile and form in a specialized part of mycelium.

The various types of spores are: a. Zoospores: These are commonly found in lower fungi e.g., Saprolegnia, Pythium etc.

They are naked spores, which after swarming, encyst, secrete a cell wall and germinate by germ tube into a thallus. They are equipped with one or two flagella.

Sporangiospore: The sporangiospores or aplanospores are nonmotile and lack flagella and are formed inside the sporangium e.g. Mucor, Rhizopus.

These spores may by uninucleate or multinucleate and possess two-layered cell wall.

**Conidia:** They are produced externally on branched or unbranched hyphal tips termed as conidiophores.

The conidia may be formed singly or in chains. The conidial chains may be basipetal ( Younger at base) or acropetal (Younger at top) in succession.

Conidia may be uninucleate or multinucleate.

**Oidia:** They are produced by fragmentation of hyphae from apex to base. Each cell thus formed rounds off and separates as a spore which under favourable circumstances germinates and forms the mycelium

**Sexual reproduction:**

It involves the formation and fusion of gametes. Sexual reproduction found in all groups of fungi except deuteromycetes or fungi imperfecti.

Sexual reproduction has three distinct phases i.e. plasmogamy (protoplasmic fusion), karyogamy (fusion of nuclei) and meiosis (reduction division of zygote). The various methods of sexual reproduction in fungi are as follows:

Isogamy: In this process fusing gametes are morphologically similar and motile but physiologically dissimilar. These gametes are produced by different parents, e.g. Synchytrium.

anisogamy and oogamy. Anisogamy consists of the fusion of two motile gametes where the male gamete is small and more active than the female gamete, e.g., Allomyces.

In oogamy the motile male gamete (antherozooid) fuses with the large, non-motile female gamete (egg or ovum) e.g., Synchytrium etc.

In the classification of kingdom fungi, the five major phyla are classified on the basis of their mode of sexual reproduction and also on the basis of molecular data.

Classification of Fungi by Ainsworth G. C. (1966, 71, 73):

He includes fungi along with slime molds under **the kingdom Mycota**. Based on the presence or absence of Plasmodium and pseudoplasmodium; the kingdom Mycota is further divided into two divisions: Myxomycota i.e., slime molds and Eumycota or true fungi.

He classified fungi on the basis of their reproductive structure.

He divided the kingdom Mycota into two divisions:

1. Myxomycota
2. Eumycota

These divisions are then divided into sub-divisions, then class, order, family and then genus.

## MYXOMYCOTA

- These include the slime moulds.
- They are the mass of free-living plasmodium. They do not possess a firm wall.
- It has class Myxomycetes. These are the true slime moulds

## EUMYCOTA

- They are the true fungi.

- The somatic body can be unicellular or multicellular filamentous.
- This division is further classified on the basis of spores.
- It is classified into five subdivisions:

1. Mastigomycotina
2. Zygomycotina
3. Ascomycotina
4. Basidiomycotina
5. Deuteromycotina

**MASTIGOMYCOTINA**

- They are motile cells. Zoospores are present. They possess the perfect state of oospore.
- This subdivision is divided into four classes:

1. Chytridiomycetes
2. Hypochytridiomycetes
3. Oomycetes
4. Plasmodiophoromycetes

Alexopolous and Mims proposed fungal classification in 1979. They place the fungi including the slime molds in the kingdom mycetae. They divide the kingdom mycetae into three divisions namely: Gymnomycota, Mastigomycota and Amastigomycota

**Division I Gymnomycota**

It includes phagotrophic organism devoid of cell walls.This division comprises two subdivisions.

These are Acrasiogymnomycotina and Plasmodiogynomycotina.

**Subdivision 1. Acrasiogymnomycotina**

It includes a single class Acrasiomycetes.

**Class 1. Acrasiomycetes**

**Subdivision 2. Plasmodiogymnomycotina**

It is divided into two classes:

**Class 1 Protosteliomycetes**

**Class 2 Myxomycetes**

**Division II Mastigomycota (With Flagella)**

Includes fungi with absorptive nutrition, unicellular or filamentous, mycelium coenocytic.

Fungi with centrioles and flagellate cells typically produced during the life cycle

nutrition typically absorptive and varying from unicellular that becomes converted into a sporangium,

asexual reproduction typically by zoospores .

**sexual reproduction by various means**

It comprises two sub divisions:

**Sub division 1 Haplomastigomycotina**

Includes fungi with uni-or, bi-flagellate zoospores.

**Class 1 Chytridiomycetes**– Fungi producing zoospores furnished with a single whiplash (plane)flagellum inserted at the posterior end.

**Class 2 Hyphochytridiomycetes-** Motile fungi cells with a single tinsel(with spike) flagellum inserted at the anterior end.

**Class 3 Plasmodiophoromycetes-** Parasitic fungi producing biflagellate motile cells with both the flagella of whiplash type inserted at the anterior end.

**Sub division 2. Diplomastigomycotima :**

Sexual reproduction ooagamous and asexually produced zoospores biflagellate.

It shows one class :- Class 1 **Oomycetes**

**Division III Amastigomycota**

Fungi with absorptive nutrition, motile cells lacking (No flagella) mycelium aseptate or septate.

This includes four sub divisions:

**Sub division 1 Zygomycotina**

Class 1 Zygomycetes – it includes six orders.

Class 2 Trichomycetes – it comprises five orders.

**Sub division 2 Ascomycotina**

Fungi usually with a septate mycelium producing haploid ascospores in sac like cells called asci.

Class 1 Ascomycetes-

**Sub division 3. Basidiomycotina**

Septate mycelium, produces basidiospores, exogenously on various types of basidia.

Class 1 Basidiomycetes:

Sub division 4. Deuteromycotina

It includes imperfect fungi in which sexual stage is unknown. It comprises a single form class.

Form Class Deuteromycetes

On the basis of the organisation of the vegetative thallus, the morphology of reproductive structures, the way of spores production and particular life cycle involved the kingdom mycota is classified into following divisions.

**Phycomycetes**

- It includes the simplest type of fungi. It is also called as Algae-Fungi because most of the characteristics of them are similar to algae like Vaucheria.
- They have simple thallus which is unicellular or coenocytic or aseptate filaments.

- They reproduce asexually by the formation of zoospores or non-motile spores.
- Sexual reproduction is isogamous or heterogamous which takes place by gametangial contact.
- The diploid phase is represented by zygote.
- Phycomycetes has been classified into subclasses: oomycetes and zygomycetes.

**Oomycetes**

- Oomycetes range from a primitive unicellular thallus to a profusely branched filamentous mycelium.
- Many members of them are terrestrial and obligate parasites.
- Asexually they reproduce by biflagellate zoospores.
- Sexual reproduction is oogamy that involves the fusion of male and female gametes to form oospore.
- Oospore undergoes meioses to produce haploid biflagellate zoospores.
- Example; Phytophthora infestans(causes late potato blight)

**Zygomycetes**

- The group is named zygomycetes because a diploid resting spore called the zygospore is formed during the life cycle.
- They are mostly saprophytic, some others are parasites on plants and animals.
- The vegetative body is mycelium which is well developed, profusely branched and coenocytic.
- They are non-motile sexual or asexual cells.
- The asexual reproduction takes place by sporangiospores, aplanospores or by conidia.
- Sexual reproduction occurs by conjugation of gametangia resulting in the formation of zygospore.
- Examples; Rhizopus, Mucor etc

**Ascomycetes**

- The species of ascomycetes are called the sac fungi because they produce sexual pores within the sac-like vascus.
- **General Characteristics**
- Ascomycetes are mostly terrestrial occurring as saprophytes or parasites.
- They have well-developed, branched, septate mycelium except yeast. Yeast is a unicellular fungus.
- Asexually they reproduce by non-motile spores, conidia, oidia or chlamydospores.
- Sexual reproduction takes place by the fusion of gametangia of opposite mating types.
- There is absence of motile cells.

Examples :-Saccharomyces cerevisiae, Penicillium, Aspergillus ,Morels,truffles etc.

**Basidiomycetes (Bracket Fungi)**

- The members of basidiomycetes are saprophytic or parasitic. The group is named basidiomycetes as they produce the basidiospores at the club-shaped basidium during sexual reproduction.
- Mycelium is highly developed, profusely branched and septate.
- The mycelia are differentiated into two mating types; (+ve) and (-ve).
- There are two kinds of mycelium; primary mycelium and secondary mycelium.
- Asexual reproduction takes place by fragmentation, budding, oidia, conidia or chlamydospore.
- The dikaryotic cell is formed during sexual reproduction.
- The absence of motile cell throughout the life cycle.
- Basidiomycetes are the most advanced fungi as their fructifications are often large and prominent.

- Examples;Aspergillus, Puccinia, Ustilago Puccinia etc.

**Deuteromycetes (The Imperfect Fungi)**

- Deuteromycetes compromises more than 17000 species of the diverse habits and habitats. It is considered as an artificial class of fungi.
- The fungi are saprophytes as well as parasites.Parasitic fungi cause serious diseases to plants, animals including human beings.
- Some of them are unicellular while others are multicellular.
- They reproduce asexually by conidia along with some other types of spores.
- The sexual reproduction is entirely absent.
- The asexual stage or imperfect stage in Deuteromycetes is well defined. But the sexual or perfect stage is absent in life cycle, therefore, they are called 'Fungi Imperfecti'.
- Example; Alternaria, Fusarium, Coletotrichum,Trichoderma, Helminthosporium etc.

**Classification of Fungi by Ainsworth G. C. (1966, 71, 73):**

Ainsworth G. C. (1966, 71, 73) proposed a more natural system of classification of fungi. This classification is based on morphology, especially of reproductive structure. He includes fungi along with slime molds under the kingdom Mycota.

**Based on the presence or absence of Plasmodium and pseudoplasmodium; the kingdom Mycota is further divided into two divisions:**

Myxomycota i.e., slime molds and Eumycota or true fungi. Divisions are subsequently divided into subdivision, class, subclass, order, family and then to genus. According to his classification, division ends in mycota, subdivision in mycotina, class in mycetes, subclass in mycetidae order in ales and family in aceae.

**A schematic outline of Ainsworth's (1973) classification is given:**

Kingdom: Mycota

**Important features:**

i. Free-living, parasitic or mutualistic symbionts, devoid of chlorophyll.

ii. Cell wall composition is very variable, majority contain chitin and glucan.

iii. Reserve food materials are oil, mannitol and glycogen.

iv. Except some unicellular members, majority are filamentous.

**A. Division. Myxomycota:**

Wall-less organisms possess either a Plasmodium (a mass of naked multinucleate protoplasm having amoeboid movement) or a pseudoplasmodium (an aggregation of separate amoeboid cells). Both are of slimy consistency, hence slime molds.

1. Class. Acrasiomycetes (cellular slime molds)

2. Class. Hydromyxomycetes (net slime molds)

3. Class. Myxomycetes (true slime molds)

4. Class. Plasmodiophoromycetes (endo- parasitic slime molds).

**B. Division Eumycota (True fungi, all with walls):**

a. Subdivision Mastigomycotina (motile cells – zoospores present, perfect state spore-oospore).

1. Class. Chitridiomycetes (unicellular, zoospore with single whiplash flagellum).

2. Class. Hyphochytridiomycetes (unicellular, zoospore with single tinsel flagellum).

3. Class. Oomycetes (aseptate mycelium, zoospores with two flagella).

b. Subdivision. Zygomycotina (mycelium aseptate, perfect state spore-zygospore).

Class. Zygomycetes (mycelium immersed in the host tissue).

2. Class. Trichomycetes (mycelium not immersed in the host tissue).

c. Subdivision. Ascomycotina (yeasts or septate mycelium, perfect state spore-ascospores formed in ascus, usually within ascocarp).

1. Class. Hemiascomycetes (no ascocarp, asci naked).

2. Class. Loculoascomycetes (fruit body an ascostroma, asci bitunicate i.e., 2-walled).

3. Class. Plectomycetes (fruit body cleistothecium, asci unitunicate i.e., 1-walled).

4. Class. Laboulbeniomycetes (fruit body perithecium, asci

unitunicate, exoparasite of arthopods).

5. Class. Pyrenomycetes (fruit body perithecium, asci unitunicate, not parasitic on arthopods.

6. Class. Discomycetes (fruit body apothecium, asci unitunicate).

d. Subdivision. Basidiomycotina (yeast or septate mycelium, perfect state spore – basidiospore formed on a basidium).

1. Class. Teliomycetes. Basidiocarp lacking, teliospores grouped in sori or scattered within the host tissue, parasitic on vascular plant.

2. Class. Hymenomycetes. Basidio- carp present. Hymenium is completely or partly exposed at maturity. Basidiospore ballistospores.

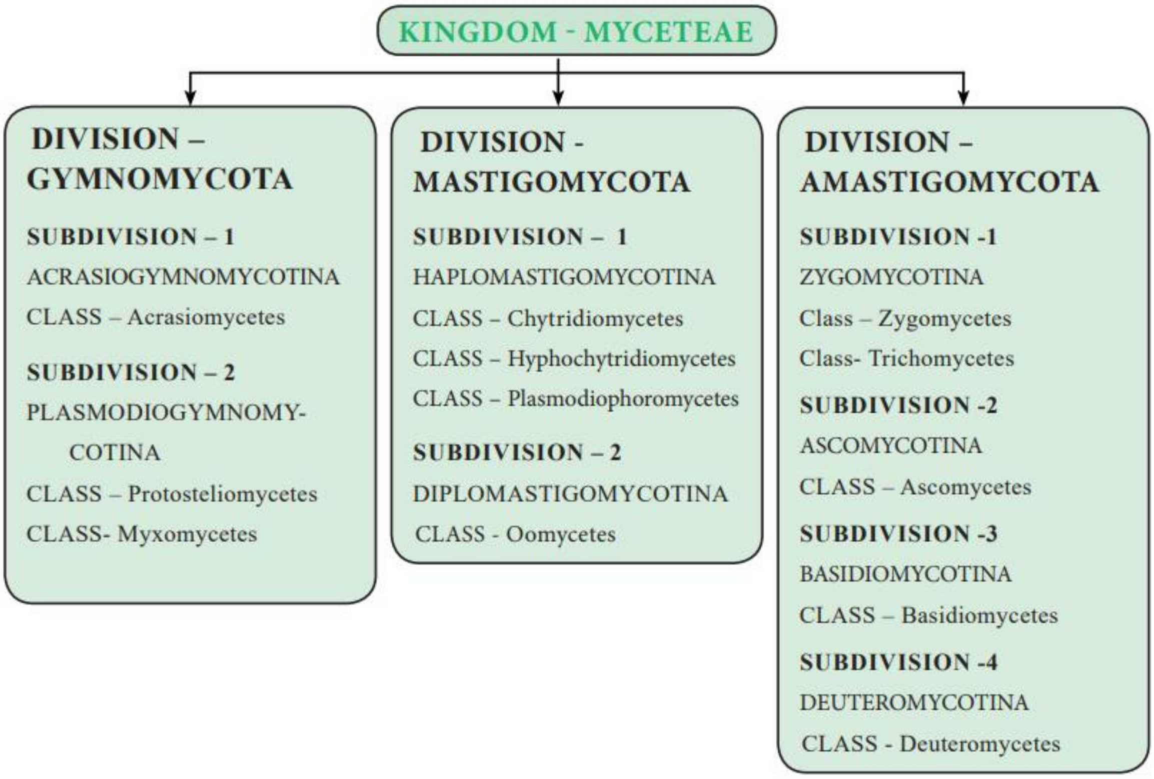
3. Class. Casteromycetes. Basidiocarp present. Hymenium enclosed in basidiocarp. Basidiospore not ballistospores.

(e) Subdivision. Deuteromycotina or Fungi imperfecti. Yeast or septate mycelium. Perfect state unknown.

1. Class. Blastomycetes. Budding (Yeast or Yeast like) cells with or without pseudomycelium. True mycelium lacking or not well-developed.

2. Class. Hyphomycetes. Mycelia sterile or bearing asexual spore directly or on conidiophore, in various aggregation.

3. Class. Coelomycetes. Mycelial; asexual spore formed in pycnidium or acervulus.




Economic importance of Fungi

Fungi provide delicious and nutritious food called mushrooms. They recycle the minerals by decomposing the litter thus adding fertility to the soil. Dairy industry is based on a single celled fungus called yeast. They deteriorate the timber. Fungi cause food poisoning due the production of toxins. The Beneficial and harmful activities of fungi are discussed below:

**eneficial activities**

**Food**

Mushrooms like *Lentinus edodes, Agaricus bisporus, Volvariella volvaceae* are consumed for their high nutritive value. Yeasts provide vitamin B and *Eremothe-cium ashbyii* is a rich source of Vitamin $B_{12}$.

**Medicine**

Fungi produce antibiotics which arrest the growth or destroy the bacteria. Some of the antibiotics produced by fungi include Penicillin (*Penicillium notatum*) Cephalosporins (*Acremonium chrysogenum*) Griseofulvin (*Penicillium griseofulvum*). Ergot alkaloids (Ergota-mine) produced by *Claviceps purpurea* is used as vasoconstrictors.

**Industries**

**Production of Organic acid:** For the commercial production of organic acids fungi are employed in the Industries. Some of the organic acids and fungi which help in the production of organic acids are: Citric acid and Gluconic acid – *Aspergillus niger*, Itaconic acid – *Aspergillus terreus*, Kojic acid – *Aspergillus oryzae*

**Bakery and Brewery**

Yeast(*Saccharomyces cerevisiae*) is used for fermentation of sugars to yield alcohol. Bakeries utilize yeast for the production of Bakery products like Bread, buns, rolls etc., *Penicillium roquefortii* and *Penicillium camemberti* were employed in cheese production.

**Production of enzymes**

*Aspergillus oryzae*, *Aspergillus niger* were employed in the production of enzymes like Amylase, Protease, Lactase etc.,' Rennet' which helps in the coagulation of milk in cheese manufacturing is derived from *Mucor* spp.

**Agriculture**

Mycorrhiza forming fungi like *Rhizoctonia*, *Phallus*, *Scleroderma* helps in absorption of water and minerals.

Fungi like *Beauveria bassiana*, *Metarhizium anisopliae* are used as Biopesticides to eradicate the pests of crops.

Gibberellin, produced by a fungus *Gibberella fujikuroi* induce the plant growth and is used as growth promoter.

## Harmful activities

Fungi like *Amanita phalloides* , *Amanita verna*, *Boletus satanus* are highly poisonous due to the production of Toxins. These fungi are commonly referred as **"Toad stools"**.

*Aspergillus* , *Rhizopus*, *Mucor* and *Penicilium* are involved in spoilage of food materials. *Aspergillus flavus* infest dried foods and produce carcinogenic toxin called aflatoxin.

Patulin, ochratoxin A are some of the toxins produced by fungi.

(a) Rust of wheat

(b) Anthracnose of beans

**Figure 1.25:** Fungal disease in plants.

| Table 1.11: Diseases caused by fungi | |
|---|---|
| **Name of the disease** | ***Causal organism*** |
| Plant diseases | |
| Blast of Paddy | *Magnaporthe grisea* |
| Red rot of sugarcane | *Colletotrichum falcatum* |
| Anthracnose of Beans | *Colletotrichum lindemuthianum* |
| White rust of crucifers | *Albugo candida* |
| Peach leaf curl | *Taphrina deformans* |
| Rust of wheat | *Puccinia graminis tritici* |
| Human diseases | |
| Athlete's foot | *Epidermophyton floccosum* |
| Candidiasis | *Candida albicans* |
| Coccidioidomycosis | *Coccidioides immitis* |
| Aspergillosis | *Aspergillus fumigatus* |

Penicillium

**is a genus of saprophytic (feeding on dead and decaying materials) fungi.**

**They are commonly known as blue or green mould.**

**They are economically important for the production of cheese, organic acids and antibiotics.**

**They play an important role as a decomposer in the ecosystem. Penicillium can be found at various places such as soil, air, on decaying food, etc. Penicillin is one of the most important antibiotics extracted from Penicillium sp.**

## Classification and Examples

***Penicillium*** is a genus under phylum **Ascomycota** or Ascomycetes. They are classified by the production of ascospores during sexual reproduction.

Penicillium means "painter's brush". They are named so, due to the presence of chains of conidia (produced asexually) appearing as a brush terminally on mycelia.

| | |
|---|---|
| Domain | Eukaryota |
| Kingdom | Fungi |
| Phylum | Ascomycota |
| Class | Eurotiomycetes |
| Order | Eurotiales |
| Family | Trichocomaceae |
| Genus | *Penicillium* |

common species of *Penicillium* include:

*Penicillium notatum*

*Penicillium chrysogenum*

*Penicillium camemberti*

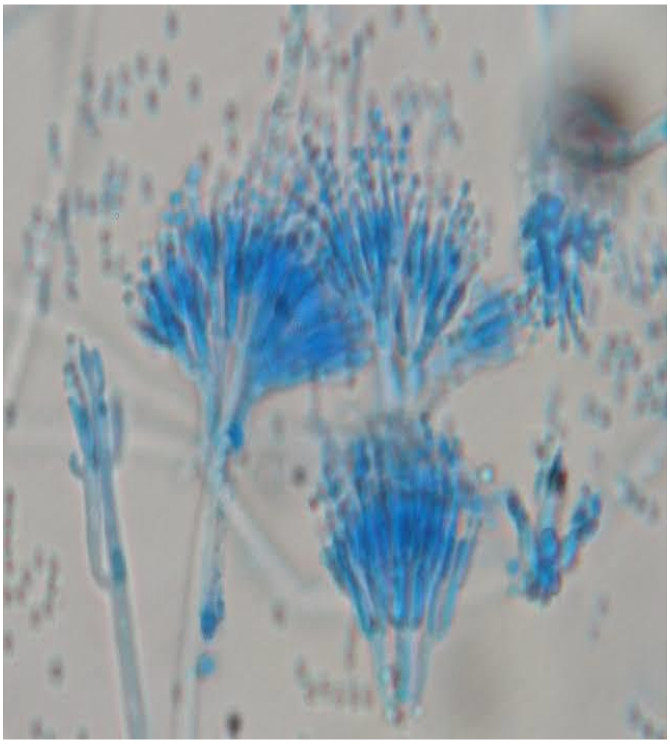
*Penicillium claviforme*

*Penicillium echinulatum*

*Penicillium glaucum*

*Penicillium roqueforti*

## Structure with Diagram



- he vegetative structure of Penicillium is a multicellular mycelium
- The mycelium is made up of highly branched, multinucleated and septate long thread-like filamentous structure known as hyphae
- The cell wall is made up of a glucose polysaccharide and chitin
- The cytoplasmic continuity is maintained through central pore, present in the septa.
- Conidiophores are present at the branch ending along with spherical conidiospores, which are asexual spores produced exogenously
- Conidia are produced in the basipetal succession, i.e. the youngest conidium is present at the base
- Conidia are produced from the specialised cells called phialide, present in the group and give a brush-like appearance to the fungus
- Ascospores are found in asci arranged in ascocarps, which are sexual spores produced endogenously

- Some of the mycelia grow deeper into the substratum to derive food.
- The food is stored in the form of oil globules

## Reproduction and Life Cycle

Penicillium reproduce by all the three processes, i.e. vegetative, asexual and sexual

**Vegetative reproduction** is by fragmentation and each of the fragments develops separately, making a complete mycelium

**Asexual reproduction** takes place in the special structures called **conidiophore.**

- Conidiophores may be unbranched or branched and differentiate into **metulae**
- Number of flask-shaped **phialide** cells develop at the end of each metulae, which form **conidia**
- **Phialide** cells divide mitotically forming a conidium. Phialide cells again divide pushing the first conidium towards outside and the second conidium is formed
- . This process repeats resulting in a chain of conidia, found in a basipetal succession
- The conidia may be blue, green or yellow in colour and oval or elliptical in shape
- Conidia get detached from the parent after maturation and dispersed by the wind
- They get attached to a suitable substratum and germinate
- Germination is by the germ tube formation. The nucleus divides mitotically multiple times. All the nuclei enter the germ tube and

followed by the elongation and formation of septa to give rise to a mature and branched mycelium

**Sexual reproduction** is by the formation of ascospores

- Some species of Penicillium are homothallic and some are heterothallic (male and female sex organs present on different thallus)
- The male and female sex organs are **antheridium** and **ascogonium** respectively
- One of the cells of the vegetative mycelium develops into ascogonium, which is unicellular having a single nucleus. The nucleus of ascogonium undergoes repeated division to produce 32 to 64 nuclei
- The developing antheridium branch coils around the ascogonium and the apical part of it is separated by septa forming a unicellular antheridium having a single nucleus
- After maturation, antheridium bends and touches the ascogonial wall and at the point of contact, cell wall dissolves and cytoplasm of both the cells get intermixed. The process is known as **plasmogamy**
- There occurs an intermediate **dikaryon phase**, which is a **dikaryotic stage** with 2 nuclei (n+n) present in the cell
- The ascogonium repeatedly divide by partition of the wall forming many binucleate cells arranged one above another
- The terminal dikaryotic cell swells up forming ascus mother cell
- **Karyogamy** (fusion of the two nuclei) occurs in the cell forming diploid cell (2n)
- The diploid zygote undergoes first meiosis and then mitosis to form 8 nuclei. Each accumulates some cytoplasm resulting in the formation of **8 ascospores**

- The ascospores are released by the dissolution of ascus wall and get attached to a suitable substratum
- The ascospores develop by forming a germ tube and mature into the branched mycelium

## Economic Importance

Penicillium species are very important economically. They produce many food products, organic acids, antibiotics and mycotoxins.

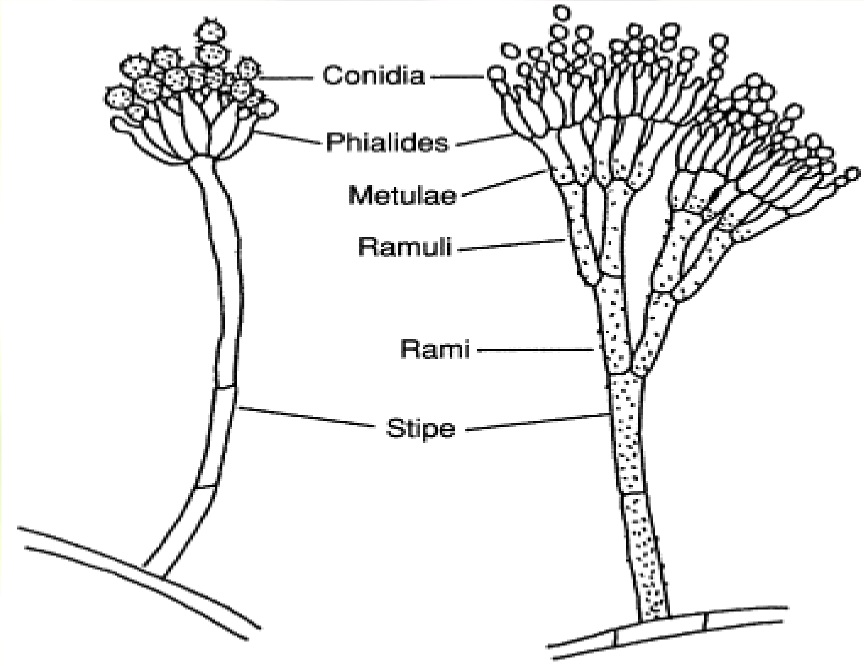
- **Cheese production-** many Penicillium species are used in the production of different kinds of cheese, e.g. blue cheese, *P. camemberti* forms Camembert and Brie cheese and *P. roqueforti* forms Roquefort cheese
- **Enzymes and Organic acid production-** many Penicillium species are used in the production of organic acids such as citric acid, gluconic acid, tartaric acid and enzymes like amylases, proteases, cellulase, lipase and pectinase
- **Antibiotic (Penicillin) production-** In 1929 **Alexander Fleming** isolated the antibiotic **Penicillin** from penicillium, which inhibited the growth of Gram-positive bacteria. Later **Florey and Chain** extracted and produced Penicillin from the moulds to treat soldiers of the World War II

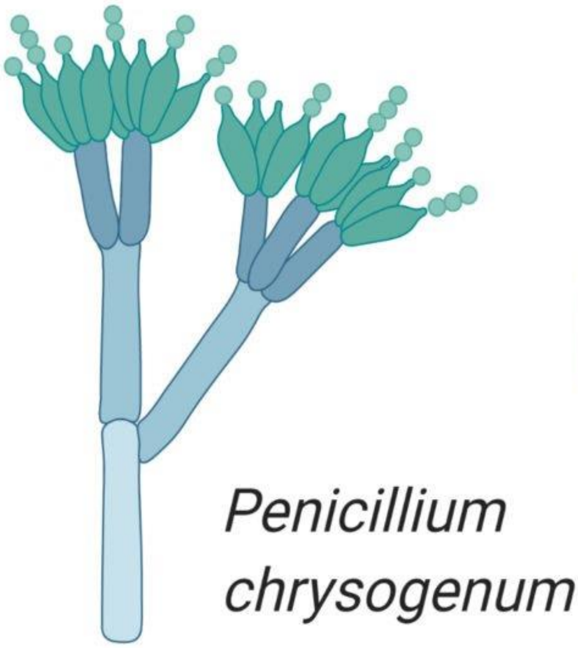
**Penicillin** is produced by *Penicillium chrysogenum* (earlier known as *Penicillium notatum*).

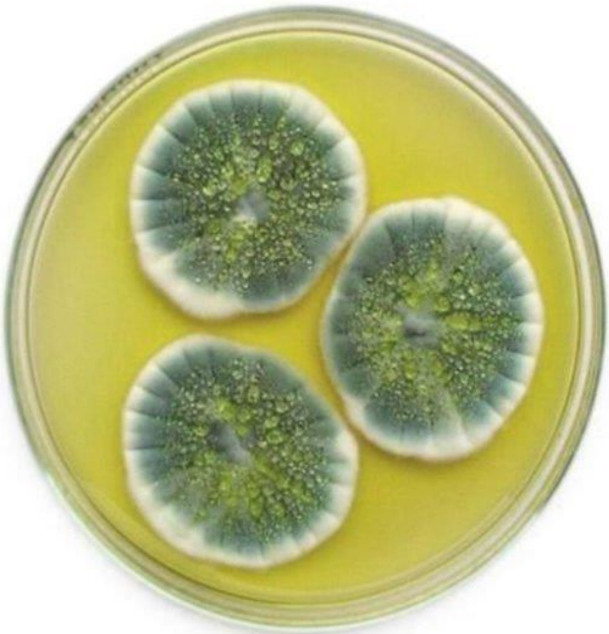
The naturally occurring penicillins are **Penicillin G (Benzylpenicillin),** which is given by intramuscular injection and **Penicillin V (Phenoxymethylpenicillin)** given orally to treat various infections.

Penicillin act by inhibiting enzymes responsible for the cell wall formation of bacteria and activating enzymes responsible for the breakdown of the protective wall of the bacteria.

- Penicillium species are also used in the production of antifungal drug and tumour suppressing compounds
- Penicillium species are also used in **mycoremediation**, i.e. bioremediation process using fungus to clean the environment due to their ability to breakdown xenobiotic compounds



## Alternaria

*Alternaria* spp are a group of Ascomycete fungi that are known for their saprophytic nature in decomposing soil and plants. They are ubiquitous, found in soil, air, and plants. They have a clinical impact as well as, it is a plant pathogen.

There are over 299 species of *Alternaria spp* with the most commonly known species including:

Some species are endophytic, living on plant parts such as seeds and fruits and can cause plant and fruit damage such as the mango rot. The clinical significance of some species in causing animal infections to include allergic (hypersensitivity) pneumonitis. *Alternaria alternata* is a causative agent of subcutaneous phaeohyphomycosis and mycotic keratitis. It is the most common species in this group of fungi.

There are over 299 species of *Alternaria spp* with the most commonly known species including:

- *A. alternariae*
- *A. botrytis*
- *A. leptinellae*
- *A. oudemansii*
- *A. Scirpinfestans*

Some species are endophytic, living on plant parts such as seeds and fruits and can cause plant and fruit damage such as the mango rot. The clinical significance of some species in causing animal infections to include allergic (hypersensitivity) pneumonitis. *Alternaria alternata* is a causative agent of subcutaneous phaeohyphomycosis and mycotic keratitis. It is the most common species in this group of fungi.

## Habitat of *Alternaria alternata*

- Alternaria species are saprophytic meaning that they thrive in decomposing materials and environments.
- They are also commonly found in organic materials and water or moisture areas.
- Some are endophytic, therefore they live in various plant parts such as seeds, and fruits.
- *Alternaria alternata* specifically lives in the soil as a saprophyte and decomposition organic matter.
- It is also found on plants where it caused plant diseases and can be transferred to animals through plants causing human and animal infections.

## Morphological and Cultural Features of *Alternaria alternata*

- In culture, *Alternaria alternata* grows as long chains with dark brown conidiophores.
- They thrive in environments with moisture and good nutrition, producing asexual spores known as conidiospores (conidia).
- The conidia grow on the conidiophores
- The spores are large and appear dark.
- They also have short beaks and fine long septate.

## Life Cycle of *Alternaria alternata*

- Dispersion of the conidiospores is by wind or by water, landing in a suitable environment such as plant parts like leaves, fruits, or seed.

- This enables the spore to start germinating when there is enough moisture and temperatures of 31-32°C.
- They develop into long chains that start producing spores from the tips of the hyphae, which is known as a conidiophore.
- The conidiophore is pale or dark brown, appearing as a straight elongated chain or has a flexuous appearance.
- The conidiophore produces brownish conidia with short beaks.
- The conidia that develop have a smooth surface.

## athogenesis of *Alternaria alternata*

### Pathogenesis in Human Host

- *Alternaria alternata* has been associated with causing cutaneous and subcutaneous infections, in individuals with an immunocompromised system, therefore it causes opportunistic infections
- Cutaneous infections are localized on the skin, forming skin lesions.
- Subcutaneous infections affect the underlying layers of the skin when the fungi gain entry into the skin causing manifestations on the skin surface.
- The infections may also affect other body parts including the sinus (rhinosinusitis), the nails (onychomycosis), and the cornea of the eye causing visual impairment (oculomycosis).
- *Alternaria alternata* also produces mycotoxins which cause mycotoxicosis, but it is rare but not uncommon.
- Mycotoxicosis effects on humans vary from mild to chronic infections but its effect is dependent on the host immunity.

### Pathogenesis in plants

In plants, *Alternaria alternata* causes infections such as Brown and Black spot on the leaves of plants and mycotoxicosis.

### Brown and blackspot

- It affects the leaves' plants when spores land of plant leaves and germinate on them.
- The manifestation begins on the edge of young leaves causing necrosis and chlorosis during plant development while utilizing the leaves'nutrients.
- The infection is characterized by lesions, which can also occur on the fruits of plants due to fungal growth and reproduction and fungal spread.
- On fruits such as mango, effects of mango rot are seen characterized by fungal penetration into the fruit lenticels and spread throughout the fruit.
- The infection is associated with fruit damage, darkening of the inner parts of the fruit.

**Mycotoxicosis in plants**

- *Alternaria alternata* is capable of producing secondary metabolites such as phytotoxins and mycotoxins which cause spoilage in plants.
- These elements cause toxicity that eventually causes disease.
- Infections that arise due to toxicosis include: Tomato black mold, olive black rot, citrus black/grey rot, black rot of apples and carrots

**Laboratory Diagnosis of *Alternaria alternata* infections**

**Specimen:** Plant Exudates, lesion biopsy, pus cells,

# ALGAE

## General characters of algae:-

Algae are Primitive, simplest, Prokaryotic/Eukaryotic, autotrophic and usually aquatic, thallophytes (that lack true roots, leaves and stem).

Algae are chlorophyll-bearing autotrophic thalloid plant body.

The multicellular complex thallus lack vascular tissue but it also show little differentiation of tissues.

The sex organs are generally unicellular but, when multicellular, all cells are fertile and in most cases the entire structure does not have any protection jacket.i.e. they lack sterile jacket cells around the reproductive cells.

The zygote undergoes further development either by mitosis or meiosis, but not through embryo formation.

## Occurrence of Algae: -

They mainly dwell in aquatic environments The algae are ubiquitous (present everywhere) in distribution,

They are found in fresh water as well as marine water, on soil, on rock, as epiphytes or parasites on plants and animals,

It also found in hot springs, in desert, on permanent snow-fields etc.. They are either free floating (plankton) or attached (benthos). On the basis of habitat, algae are of following types:

Plant body:

It is known as Thallus and they are avascular. The thallus show little differentiation of true tissues.

Even the complex thallus like found in brown algae lack vascular tissue and stomata.

The plant body may be unicellular motile (Chlamydomonas,), non -motile unicellular (Chlorella, diatoms), Motile colonial (Volvox), Nonmotile Colonial (Hydrodictyon), Filamentous unbranched (Spirogyra, Oedogonium), Filamentous branched (Stigeoclonium, Chara), siphonaceous (Caulerpa,Vaucheria) , psudoparanchymatous ( Ulva) and heterotichous ( Coleochaete spp., Batrachospermum). Their size ranges from a few micron to several metres.

**Food reserves:-**

Food reserves vary from group to group, e.g., starch (green algae), Laminarin & mannitol (brown algae), Floridean starch (red algae), Cyanophycean starch (Blue Green Algae), Paramylon (Euglenoids), Leucosin (diatoms) etc.

**Cell wall:** Cell wall of algal cell is cellulosic mostly. In cyanophyta mucopolypeptides are present in cell wall.

In diatoms it is silicified and made up of two halves. It is covered with mucilage and pectin in most of the algae.

In Xanthophyta pectic substance is more common.

In Phaeophyta cell wall contains alginic acid and fucinic acid.And In Rhodophyta the cell wall is made of non-cellulosic polysaccharides like xylans and galactans.

**Photosynthetic pigments:**

Algae have photosynthetic pigments for making their own food. Different pigments exist but Chlorophyll a is primary pigment and is present in all algae.

Besides, chlorophylls different Carotenes and Xanthophylls are also present. Algae classification based on presence of various pigment

Cyanophyta (Blue Green Algae): Chl a and no chl b, β carotene, xanthophylls, billiprotein like c-phycoerythrin and C-phycocyanin .

Chlorophyta (Green algae): Chlorophyll a + chlorophyll b, β carotene + ϒ Carotene + lycopene, xanthophylls like Neoxanthin, neo-fucoxanthin, oscillatoxanthin etc

Phaeophyta (brown algae): Chlorophyll a + Chlorophyll c, carotenes like β carotene, fucoxanthin is important xanthophyll. Rhodophyta (Red algae): Chlorophyll a+ Chlorophyll d, carotenes like β carotene + ∝ Carotene, xanthophylls like terraxanthin, neoxanthin etc., billiprotein like r-phycoerythrin and rphycocyanin.

Plants having distinct alternation of generations. Both gametophyte and sporophyte generations — when present in the life cycle are independent.

**Reproduction: -**

Algae reproduce either by vegetative, asexual or sexual method.

Vegetative reproduction: In this type, any vegetative part of the thallus develops into new individual. It does not involve any spore formation and there is no alternation of generations.

It is the most common method of reproduction in algae. Vegetative reproduction can take place by various methods in algae like- Fission, Fragmentation, Hormogonia Formation, Bulbils Formation, Adventitious Branch, Tuber, Amylum stars or Budding.

**Asexual reproduction:**

Asexual reproduction involves the formation of certain type of spores — either motile or non motile. It is a process of rejuvenation of the protoplast without any sexual fusion.

Each and every spore germinates into a new plant. In this method, there is no alternation of generations. The asexual spores can be- zoospore (motile), Aplanospores (non motile), Hypnospore (thick walled), Akinetes, Nannospores, Exospores, Tetraspores etc.

**Sexual reproduction:**

In algae the reproduction can be isogamous, anisogamous and oogamous and the life cycle can be simple or complex.

Sexual reproduction is completely absent in Cyanophyta. The reproduction is oogamous and life cycles are usually complex in Rhodophyta and Phaeophyta.

**Life cycles:** Algae show vari Life cycles: Algae show various types of life cycles like: haplontic (Oedogonium, Chlamydomanas, Chara), Diplontic (Bacillariophyta, Fucus, Sargassum), isomorphic Diplohaplontic (Ulvales, cladophorales), Heteromorphic diplohaplontic (Laminaria), Haplobiontic (Batrachospermum) and Diplobiontic (Polysiphonia)

## Classification

**F.E. Fritsch** proposed a classification for algae based on pigmentation, types of flagella, reserve food materials, thallus structure and reproduction.

He published his classification in the book "**The structure and reproduction of the Algae**"(1935).

He classified algae into 11 classes namely Chlorophyceae, Xanthophyceae, Chryso-phyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae uglenophyceae, Phaeophyceae, Rhodophy-ceae, Cyanophyceae.

## Class 1. Chlorophyceae ( Isokontae) :-

Generally algae are fresh water and chlorophyllous thallophytes.

Chlorophylla, b and carotenoides are present in chloroplasts.

The cell wall is made up of cellulose and pectose and food is synthesized in the form of starch. Motile spores and cilia are found.motile spores are zoospores ,which found in asexual reproduction.

Asexual reproduction also found by aplanospores and akinetis.

The sexual reproduction is isogamous, anisogamous and oogamous types.

Important genera are Chlamydomonas, Volvox,(unicellular and motile), Chlorella (unicellular and rich source of proteins,vitamins and antioxidant). Ulothrix, and Spirogyra (multicellular ,filamentous).

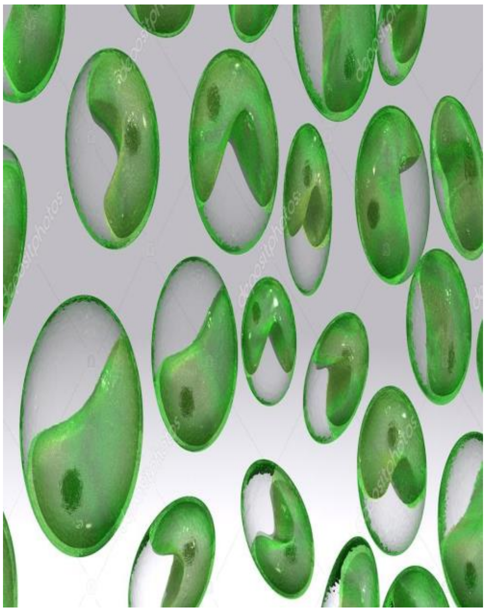


**Fig-1.Chlorella**

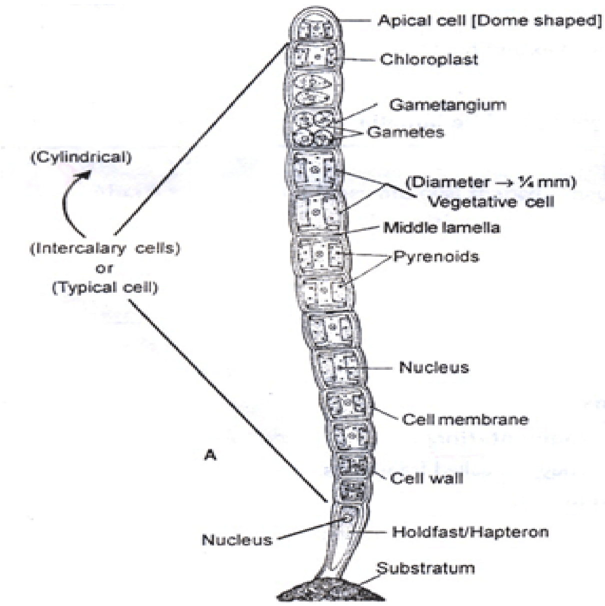
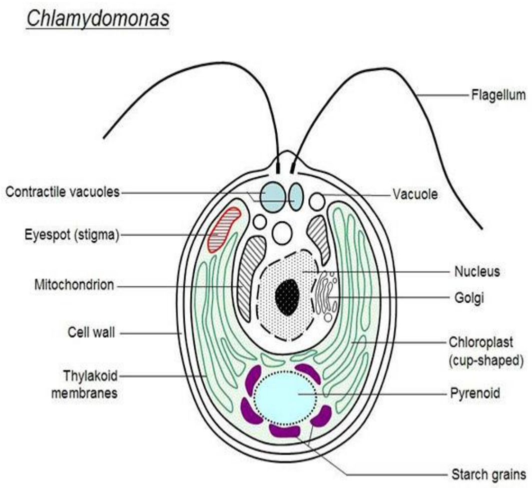



**Fig.2. Oedogonium**



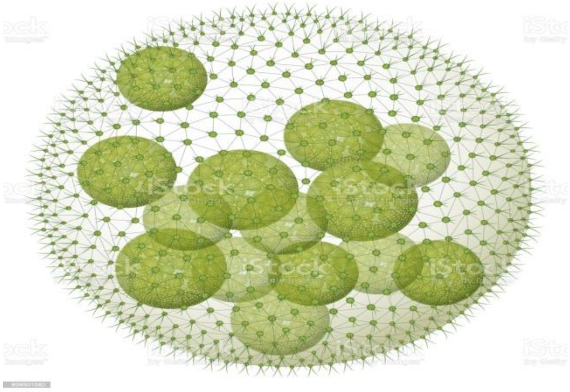



Fig.3. Chlamydomonas Fig.4. Volvox

**Class 2. Xanthophyceae (= Heterokontae)**

These are green-yellow in colour due to the presence of xanthophylls and beta carotene.

The pyrenoids are absent and food is in the form of fat.

Chlorophyll e is found in place of chlorophyll b.

The sexual reproduction occurs by fission of two gametes having cilia of different length. Important genera are Microspora, Vaucheria, Protosiphon.botrydium

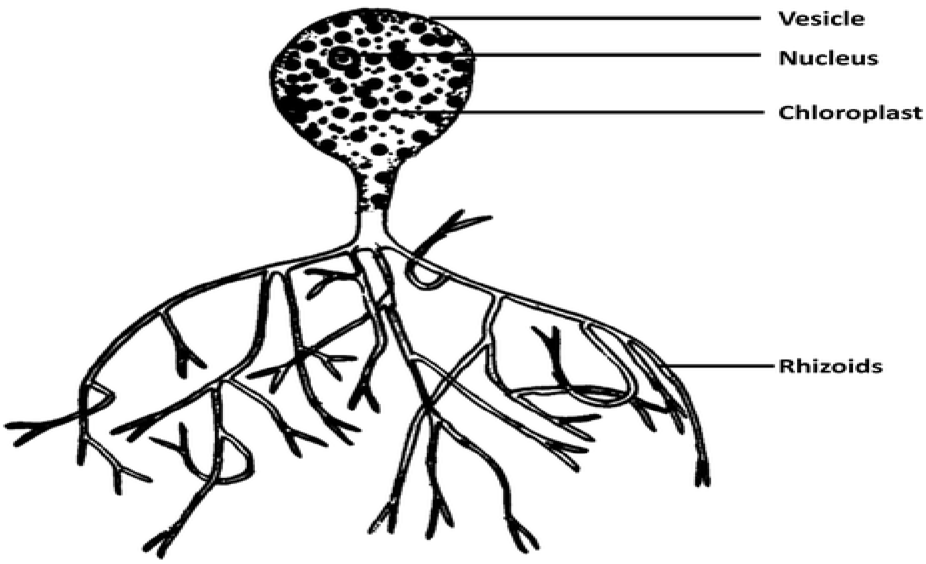


**Fig. Botrydium**

## Class 3. Chrysophyceae

In these organisms, besides chlorophyll, yellow-green pigments are present.ϖ Phycocyanin is the colouring material.ϖ Plants are unicellular, multicellular or colonial.ϖ The cell wall is present in the form of two overlapping halves and stored foodϖ is in the form of oil or insoluble carbohydrates, leuosin.

## Class 4. Bacillariophyceae ( diatoms)

These are yellow-green-brown or olive green in colour.Diatom in is the colouring material which is found in chloroplast. Pyrenoids are also present. These are unicellular and non- motile. Chlorophyll c is present in place of chlorophyll b. Important genera are Pinularia, Navicula, Fragilaria. e.g. Diatom.

## Class 5. Cryptophyceae:

These are red, green-blue, olive-green or green coloured algae. Each cell consists of two large chloroplasts in which pyrenoids are present. They occur in fresh water and sea. Important genera is Cryptomonas.

Pigment chl a,c, β - carotene, xanthophyll, phycocyanin and phycoerythrin but these are different from those of cyanophyceae -Reserve food starch ,pyrenoid present

- Mostly motile with unequal flagella - Sexual reproduction isogamous..

6..Dinophyceae- -Freshwater as well as marine and unicellular, motile biflagellate forms. -Pigments chlorophyll a and c, βcarotene, phycoerythrin, red peridinin -Reserve food starch and fat. -Sexual rep rare, when present isogamous.

7..Chloromonadineae- -Simple freshwater forms -Bright green due to an excess of chlorophylls and xanthophylls. - Reserve food fat -Rep by longitudinal division.

8.. Euglenineae- - Found in freshwater as well saline habitat - Unicellular motile forms with one or two flagella -Cell wall absent , pellicle present. -Pigments chl a and b -Rep by fission.

9..Phaeophyceae – -Mostly marine. Simplest thallus organization is heterotrichous filamantous thallus. Higher forms are large bulky parenchymatous thalli which may attain a length of several meters. -Chromatophores have chl a and c, β-carotene, fucoxanthin. - Reserve food laminarin and mannitol Motile rep structures with two laterally inserted flag. of unequal length and type - Sexual rep. -- isogamy to oogamy . - L.C. digenic with isomorphic or hetermorphic alternation of generations. or monogenic(diplontic) eg members of order fucales. e.g. Fctocarpus, Laminaria, Dictyota, Fucus, etc.

10..Rhodophyceae – -Majority are marine with a few exceptions. -Pigments are chl a, d, β- carotene, rPhycocyanin and r-phycoerythrin. -Reserve food is floridean starch. -Presence of pit connections common. Motile stages completely absent in the life cycle and the male gamete is known as spermatium. -Sexual rep oogamous, female sex organ – carpogonium and male sex organ spermatangium.The zygote never released from carpogonium. -Formation of a fruiting body – the carposporophyte ,as a result of postfertilisation changes. - Meiosis sporogenic and zygotic - L.C. trigenic. e.g. Batrachospermun, Polysiphonia, etc.

11..Myxophyceae – -Freshwater, terrestrial , epiphytic, endophytic and symbiotic. -Main pigments chl a, β-carotene, xanthophylls, c-phycocyanin and cphycoerythrin, allophycocyanin. -Reserve food glycogen, cyanophycean starch, metachromatin granules . -Conventional sexual rep absent.

## mycorrhizae

The associations between roots and fungi are called mycorrhizae. These symbiotic arrangements have been found in about 90% of all land plants, and have been around for approximately 400 million years.

Itadini (1842) was the first to recognise the possible beneficial role of fungal mycelia which mantle the root of higher plants, and this association is named as mycorrhiza (pl. mycorrhizae) i.e., the fungal root, by Frank (1885).

The mycorrhizal association is not available in Cruciferae, Chenopodiaceae and Resedaceae.Plant roots are hospitable sites for the fungi to anchor and produce their threads (hyphae).

The roots provide essential nutrients for the growth of the fungi. In return, the large mass of fungal hyphae acts as a virtual root system for the plants, increasing the amount of water and nutrients that the plant may obtain from the surrounding soil.

A plant that forms an association benefiting both the fungus and the plant is a "host." Large numbers of native desert plants are hosts to these fungi and would not survive without them.

Mycorrhizae are essential in areas where soils are deficient in water and certain nutrient conditions that are found in the desert.

Even when there is an ample amount of a nutrient, but it may not be readily accessible to the plant. A dramatically larger root system (or mycorrhizae) permits the plant to obtain additional moisture and nutrients.

This is particularly important in uptake of phosphorus, one of the major nutrients required by plants.

When mycorrhizae are present, plants are less susceptible to water stress. Not only do the fungal threads help to bring water and nutrition into the plant, but they also can store them for use when rainfall is sparse and temperatures are high.

When organic matter (compost) is added to improve a soil, mycorrhizae are important in making its nutrients available. The residual organic matter and the hyphae improve the structure of the soil. Recent research indicates that the fungi even help break down rock, increasing availability of the essential nutrients within, such as potassium, calcium, zinc and magnesium. Mycorrhizae also help the plant resist infection by other fungi and even bacteria. Mycorrhizae also help the plant resist infection by other fungi and even bacteria.

Mycorrhizae also help the plant resist infection by other fungi and even bacteria. There is a requirement for specific plant-fungus association, mycorrhizae can be important in reestablishing native species in areas where they have been lost.

**(1) Ectomycorrhizae:(Mungus, Rhiza- Roots)**

Ectomycorrhiza is commonly called “sheathing mycorrhiza”. They occur in 3% of all seed plants in forests of temperate regions, especially on pine, beech, spruce, birch etc.

The long roots show indefinite growth and their branches are the short roots that are thickened, forked and mycorrhizal.

They appear in various colours like white, brown, yellow, black etc., depending on the colour of the fungus.

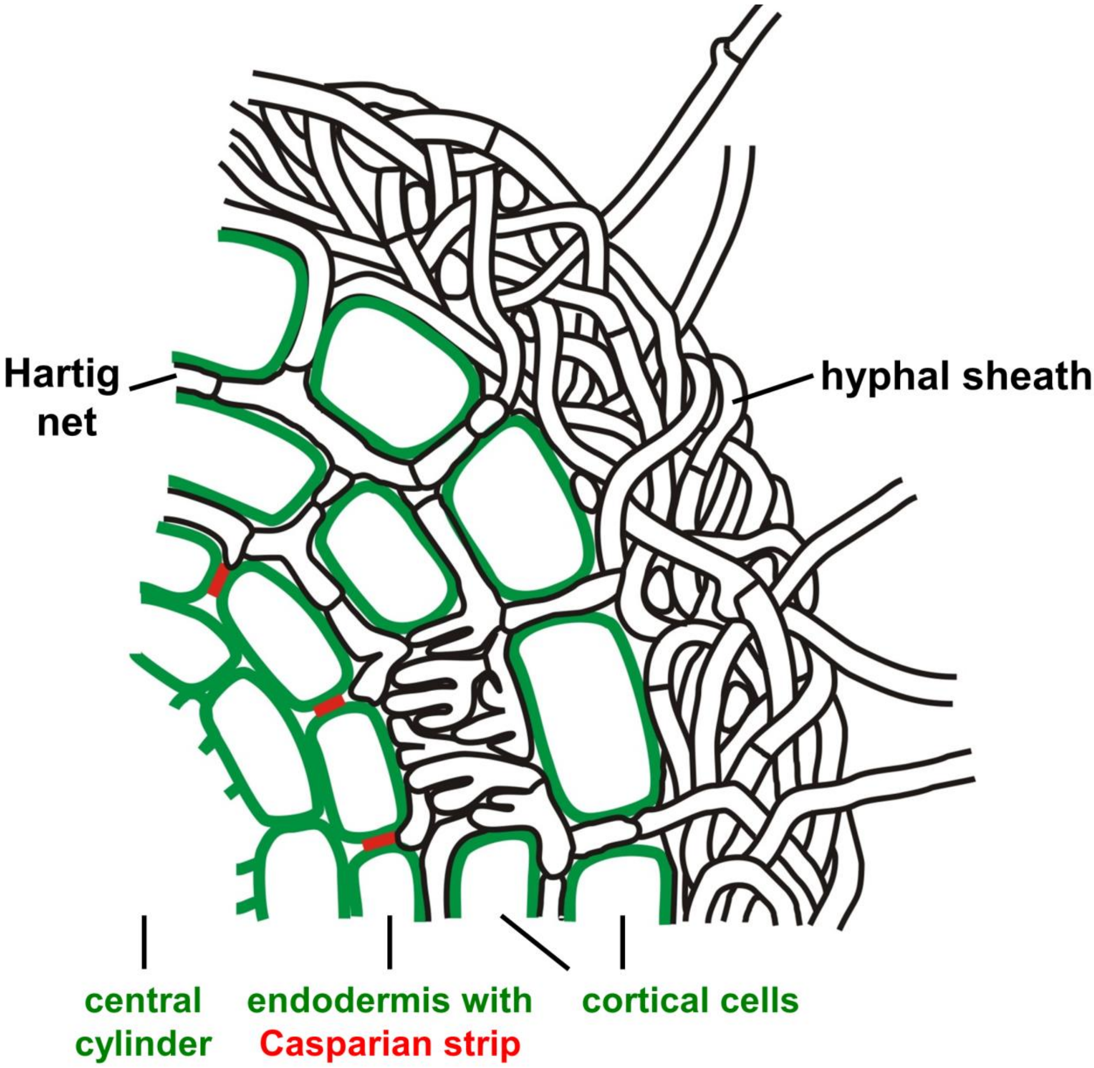
The fungus mantle enters the cortex region forming 'Hartig net', but never goes inside the endodermis or stele. They form a mantle of varying thickness.

Extensive multibranching increases water holding capacity of plants. Ectomycorrhiza is commonly called "sheathing mycorrhiza". They occur in 3% of all seed plants in forests of temperate regions, especially on pine, beech, spruce, birch etc.

Ectomycorrhizae increases tolerance to high temperature, high salinity, organic and inorganic soil toxicity and sometime protect from extreme acidic condition of sulphar and aluminium.

It enhance nutrient uptake of Phosphorus,Copper, Zinc through Hartig net.

It also play key role in Aforestation.Ectomycorrhizae  can culture on artificial media.




**Endomycorrhiza**

It is a type of endomycorrhizal association, where both vesicles and arbuscles are developed together.

VAM is by far the commonest of all mycorrhizae and has been reported in more than 90% of land plants.

They are found in bryophytes, pteridophytes, gymnosperm (except Pinaceae) and most of angiosperms, commonly in Leguminosae (Fabaceae), Rosaceae, Gramineae (Poaceae) and Palmae (Arecaceae).

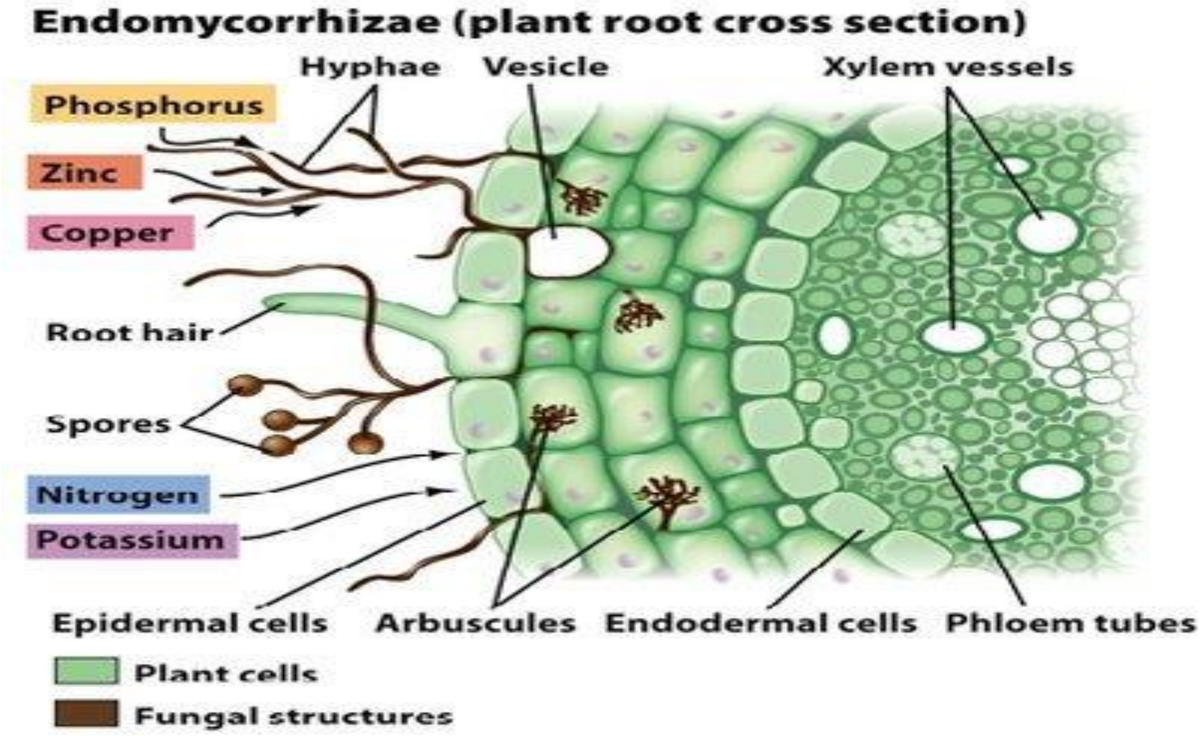
VAM is not found in Ericaceae and Orchidaceae, where other type of association is available. VAM has even been reported in Lower Devonian plant, Rhynia.

**T**he VAM is so named because of the presence of two characteristic structures i.e., vesicles and arbuscles.

The vesicles are thin or thick walled vesicular structures produced intra-cellularly and stored materials like polyphosphate and other minerals.

The arbuscles are repeated dichotomously branched haustoria which grow intracellularly .

The arbuscles live for four days and then get lysed releasing the stored food as oil droplets, mostly polyphosphate.




## <u>Lichens</u>

Defination :- Lichens are a small group of plants of composite nature, consisting of two dissimilar organisms, an alga-phycobiont (phycos — alga; bios — life) and a fungus-mycobiont (mykes — fungus; bios — life); living in a symbiotic association.

The algal partner manufactures the food through photosynthesis which probably diffuses out and is absorbed by the fungal partner.

**Characteristics of Lichens:**

1.Lichens are a group of plants of composite thalloid nature, formed by the association of algae and fungi.

2. The algal partner-produced carbohydrate through photosynthesis is utilised by both of them and the fungal partner serves the function of absorption and retention of water.

3. Based on the morphological structure of thalli, they are of three types crustose, foliose and fruticose.

4. Lichen reproduces by all the three means – vegetative, asexual, and sexual.

5.Vegetative reproduction: It takes place by fragmentation, decaying of older parts, by soredia and isidia. Asexual reproduction: By the formation of oidia.(oidia are fungal spores which can not survive under unfavourable condition.

6.Sexual reproduction: By the formation of ascospores or basidiospores. Only fungal component is involved in sexual reproduction. Ascospores are produced in Ascolichen and basidiospores produced by basidiolichen.

The male sex organ is flask-shaped spermogonium, produces unicellular spermatia.

The female sex organ is carpogonium (ascogonium), differentiates into basal coiled oogonium and elongated trichogyne.

The fruit body may be apothecial (discshaped) or perithecial (flask-shaped) type.

## Habit and Habitat of Lichens:

Lichens are found abundantly growing in various places like on rocks, walls, gravestones, on roofs, tree barks, soil, etc. Therefore, they are called the group of terrestrial organisms.

There is about 400 genera and 15,000 species of lichens, widely found in different regions of the world. The plant body is thalloid.

They grow luxuriantly in the forest areas with free or less pollution and with abundant moisture.

The growth of lichen is very slow. They do not grow in the highly polluted regions like Industrial areas, so they are known to be Pollution indicators.

**Depending on the growing region, the lichens are grouped as:**

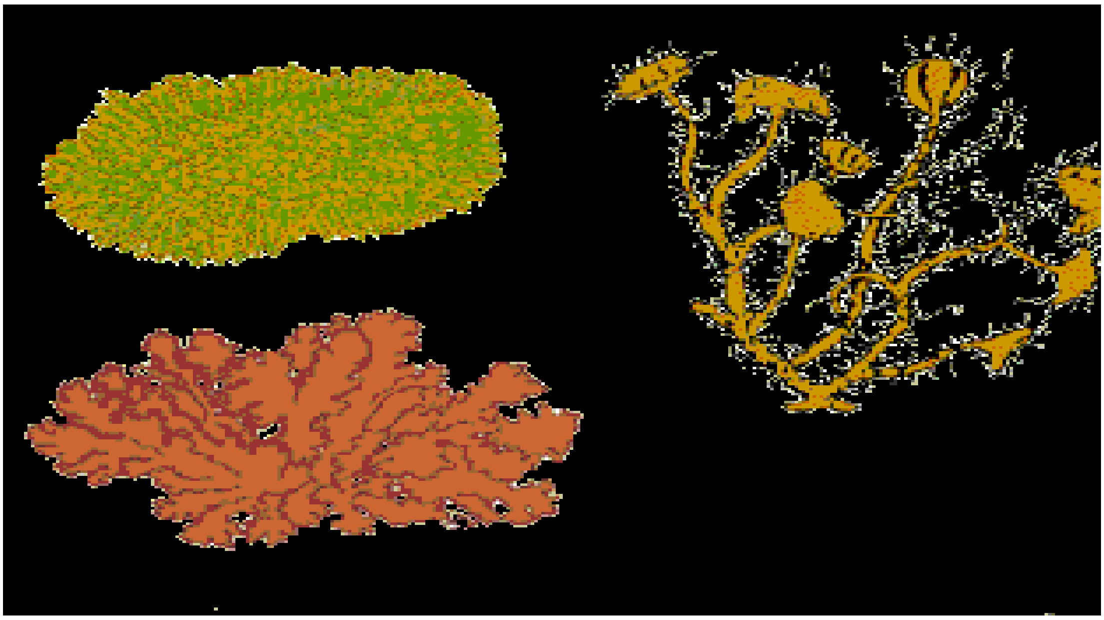
1. Lignicolous. These types of lichens grows on the woods.
2. Corticolous- These types of lichens grows on the bark of trees.
3. Saxicolous- These types of lichens live on stones or rocks.
4. Marine. These types of lichens are found growing on the siliceous rocks, near the shores of the sea.
5. Freshwater. These types of lichens are found growing on the hard siliceous rocks, especially around the freshwater.
6. Terricolous- These types of lichens are found growing on the soil, therefore also called the terrestrial lichens.

## A. External Structure of Thallus:

Based on the external morphology, general growth and nature of attachment, three main types or forms of lichens (crustose, foliose and fruticose) have been recognised.

### 1. Crustose Lichens

Crustose lichens are flat, thin and without any distinct lobes. They are usually found closely attached to stones, rocks, barks and the trunk of trees. They are either wholly or partially embedded in the substratum, e.g., Graphis, Lecanora, Strigula, Rhizocarpon, Verrucaria etc.are the best examples of crustose lichens.



**2. Foliose Lichens**

The foliose lichens are more attractive compared to other types of lichens.

They are flat shaped, broad, smooth and leaf-like structures, which often resemble crinkled and twisted leaves.

It holds a distinct upper and a lower surface. This type of lichens is generally found attached to rocks and twigs with the help of the rhizoid.

Cetraria, Parmelia, Physcia, Peltigera, Anaptychia, Hypogymnia, Xanthoria, Gyrophora, Collema, Chauduria etc. are a few examples of foliose lichens.

**4. Fruticose (Frutex, Shrub):**

These are shrubby lichens, where thalli are well developed, cylindrical branched, shrub-like either grow erect (Cladonia) or hang from the substratum (Usnea). They are attached to the substratum by a basal disc e.g., Cladonla, Usnea, Letharia, Alectonia etc.

**B. Internal Structure of Thallus:**

Based on the distribution of algal member inside the thallus, the lichens are divided into two types. Homoisomerous and Heteromerous.

**1. Homoisomerous:**

Here the fungal hyphae and the algal cells are more or less uniformly distributed throughout the thallus.

The algal members belong to Cyanophyta. This type of orientation is found in crustose lichens.

Both the partners intermingle and form thin outer protective layer e.g., Leptogium, Collema etc.

**2. Heteromerous:**

Here the thallus is differentiated into four distinct layers upper cortex, algal zone, medulla, and lower cortex.

The algal members are restricted in the algal zone only. This type of orientation is found in foliose and fruticose lichens . e.g., Physcia, Parmelia etc.

**The detailed internal structure Heteromerous Thallus :**

**(a) Upper Cortex:**

It is a thick, outermost protective covering, made up of compactly arranged interwoven fungal hyphae located at right angle to the surface of the fruit body.

Usually there is no intercellular space between the hyphae, but if present, these are filled with gelatinous substances.

**(b) Algal Zone:**

The algal zone occurs just below the upper cortex. The algal cells are entangled by the loosely interwoven fungal hyphae.

The common algal members may belong to Cyanophyta like Gloeocapsa (unicellular); Nostoc, Rivularia (filamentous) etc.

The Chlorophyta like Chlorella, Cystococcus, Pleurococcus etc also present in this zone.

This layer is either continuous or may break into patches and serve the function of photosynthesis.

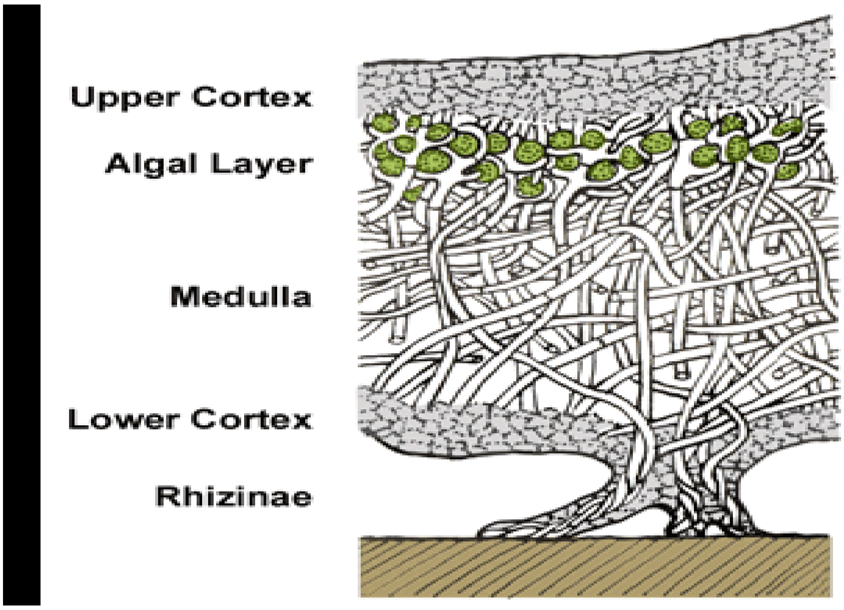
**c) Medulla:**

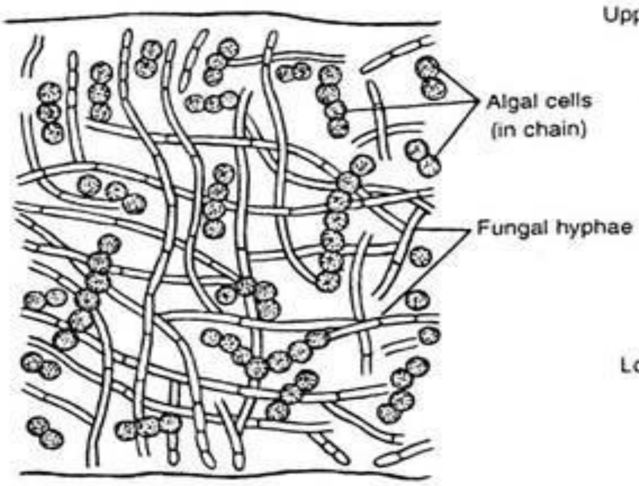
The medulla is situated just below the algal zone, comprised (consist) of loosely interwoven thick-walled fungal hyphae with large space between them.

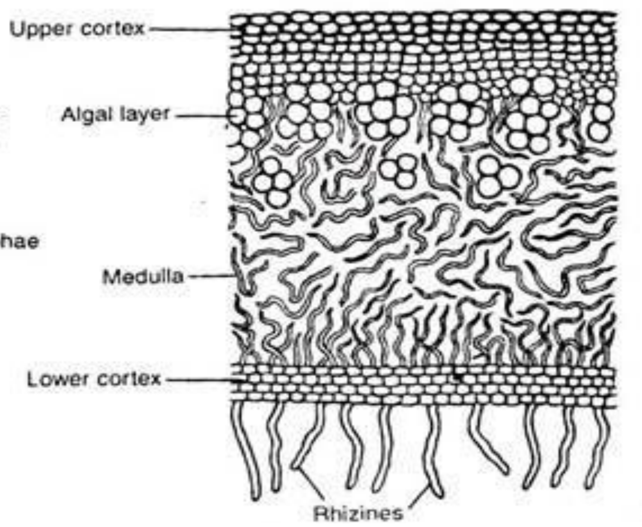
**d) Lower Cortex:**

It is the lowermost layer of the thallus. This layer is composed of compactly arranged hyphae, which may arrange perpendicular or parallel to the surface of the thallus.

Some of the hyphae in the lower surface may extend downwards and penetrate the substratum which help in anchorage, known as rhizines.




***<u>Economic importance of lichens</u>* :**

Lichens are used in varieties of ways. Some lichens are valuable source of food to wild animals like reindeer. Some lichens are fried and given to cattle as food and to some extent to human beings.

Some are used in medicines and other are for preparation of dyes. Litmus is prepared from certain lichens and some are also used in the preparations of cosmetics and perfumes.

Lichens growing on rocks disintegrate them to form soil, preparing the ground for mosses and subsequently for higher plants. Thus, they help in the succession of plant communities.

Lichens also plays an important role in the nitrogen cycle by fixing nitrogen from the atmosphere.

Based on the size of these lichens, Petrologists and Geologists are able to study and find the age and other features of rocks and their surfaces.

Lichens also serve as a Biodegradation, by the degradation of polyester, lead, copper, radionuclides and other pollutants, polluting the planet earth.

Apart from the pharmaceutical industries, lichens are widely used by various cosmetic industries and are also a natural medicine for various types of skin diseases and rashes.

Some species of lichens are used for degradation of pathogens and other environmental reservoirs, which causes certain dreadful infectious diseases both in plants, animals and also in humans.

They are also a great source of food for many aquatic organisms and are widely used as anti-infective agents in pharmaceutical industries to produce antibiotics, anti-mycobacterial, antiviral, anti-inflammatory products.