CHAPTER - 02
BIOLOGICAL CLASSIFICATION

There is a vast diversity in the living world so it is very difficult to study each and every organism. So it is essential to group them in various categories based on their similarities and dissimilarities.

There are three main systems of classification - Artificial, Natural and Phylogenetic.

I. Artificial system of Classification

It is based on one or few morphological characters for grouping of organisms. Some have used habit and habitat for this purpose. Aristotle (350 BC) divided plants into herbs, shrubs and trees. He also divided animals into two groups - Enaima (with red blood) and Anaima (without red blood). Pliny the Elder (23 - 79 AD) used artificial system of classification for both plants and animals. Linnaeus also put forward an artificial system of plant classification on the basis of number of stamens.

II. Natural system of Classification

It is a system of classification which takes into consideration comparable study of a number of characters so as to bring out natural similarities and dissimilarities and hence natural relationships among the organisms. The system employs those characters which are relatively constant. They include morphological characters, anatomical characters, cytological characters, physiology, ontogeny or development, reproduction, cytochemistry and biochemistry, experimental taxonomy etc. The characteristics are helpful in bringing out maximum number of similarities in a group and comparable differences with other groups of organisms. A natural system for classification of seed plants was proposed by Benthem and Hooker (1862 - 1883)

III. Phylogenetic System of Classification

Classification based on evolutionary relationships of organisms is called phylogenetic system of classification. First phylogenetic system was proposed by Engler and Prantl (1887 - 1999)

Depending upon the type of system of classification, organisms are classified into two or three kingdoms, four kingdoms, five kingdoms and now into six kingdoms.

1. Two Kingdom Classification

In Linnaeus time a Two kingdom system of classification with **Plantae** and **Animalia.** Kingdoms was developed that included all plants and animals respectively. This system was mainly based on **presence or absence of cell wall.** This system did not distinguish between the eukaryotes and prokaryotes, unicellular and multicellular organisms and photosynthetic (green algae) and non-photosynthetic (fungi) organisms.

Classification of organisms into plants and animals was easily done and was easy done and was easy to understand, but , a large number of organisms did not fall into either category. Hence the two kingdom classification used for a long time was found inadequate.

Besides, morphology, a need was also felt for including other characteristics like cell structure, nature of cell wall, mode of nutrition, habitat, methods of reproduction, evolutionary relationships, etc. Classification systems for the living organisms have hence, undergone several changes over the time.

2. Three Kingdom Classification

Ernst Haeckel (1866) separated unicellular animals, algae and fungi from other organisms on the basis of lack of tissue differentiation. The new group was called kingdom Protista. Later on fungi and multicellular algae were taken out from the group so that kingdom protista came to have only unicellular organisms divided into three kingdoms - Plantae, Protista and Animalia.

3. Four Kingdom Classification

With the advent of electron microscope, it became clear that bacteria and related organisms have a different nuclear structure as compared to others. They are prokaryotes in contrast to others which have a true nucleus and are called Eukaryotes. **Copeland** (1956) created a separate kingdom for them - Monera. This divided the living world into four kingdoms - Monera, Protista, Plantae and Animalia. In this system, fungi continued to remain with the plants.

4. Five Kingdom Classification (From 1969 to 1990)

In order to develop phylogenetic classification, R.H. Whittaker (1969), an American taxonomist, divided all the organisms into five kingdoms. As the viruses are on the border line of living and non-living, they have been left out. He started kingdom fungi. Thus Whittaker's five kingdoms are Monera, Protista, Fungi, Plantae and Animalia.

5. Three Domain System (Six Kingdom Classification - 1990)

This system was introduced by Carl Woese, O.Kandler, M.L. Wheelis. He divided cellular life forms into three domains - **Archaea, Bacteria and Eukarya**. Woese argued, on the basis of differences in **16S rRNA genes**, that bacteria, archaea and eukaryotes each arose separately from an ancestor with poorly developed genetic, machinery, often called a **progenote.**

1. Domain Archaea : It contains a single kingdom.

(i) Kingdom Archaebacteria

2. Domain Bacteria :- There is a single kingdom

(ii) Kingdom Eubacteria

3. Domain Eukarya : It has four kingdoms

(iii) Kingdom Protista

(iv) Kingdom Fungi

(v) Kingdom Plantae

(vi) Kingdom Animalia

Five Kingdom Classification

The main criteria for classification used by Whittaker include :

(i) Cell structure [Prokaryote / Eukaryote]

(ii) Body organisation [Unicellular / Multicellular]

(iii) Mode of nutrition [Autotroph / Heterotroph]

(iv) Reproduction

(v) Phylogenetic relationships

Advantages of Five Kingdom Classification

1. Separation of prokaryotes in to a separate kingdom - Monera
2. Separation of unicellular eukaryotes into kingdom Protista - eg. Chlamydomonas, Chlorella
3. Separation of fungi into a separate kingdom
4. Here animal and plant kingdoms are more than they are in two kingdom classification
5. It has tried to bring out phylogenetic relationships even amongst the primitive forms
6. Placement of Euglena in kingdom Protista

Drawbacks of Five Kingdom Classification

1. Monera and Protista contain both walled and wall - less organisms, photosynthetic and non-photosynthetic organisms, unicellular, filamentous organisms.
2. Archaebacteria differ from other bacteria in structure, composition and physiology
3. Mycoplasmas are quite different from bacteria where they have been placed along with prokaryotes
4. Viruses have not been included in this system of classification.

CHARACTERISTICS OF THE FIVE KINGDOMS

Characters	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellular (Polysaccharide + amino acid)	Present in some	Present (without cellulose)	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multiceullar/ loose tissue	Tissue/ organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosynthetic and photosynthetic) and Heterotrophic (saprophyte/parasite)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic/ Saprophytic etc.)

KINGDOM MONERA

Monera is a kingdom of prokaryotes. It includes the most primitive forms of life. Being the earliest forms of life, monerans are adapted to all types of habitats. They are found everywhere (cosmopolitan in distribution). They occur in unicellular, colonial or filamentous forms.

There are two major groups - of monerans.

Archaebacteria and Eubacteria

Archaebacteria

They are primitive or first formed bacteria (ancient bacteria). They live in extreme environmental conditions like high acidity, high salt concentration etc. They survive in such conditions due to the specialised composition of their cell wall. Their cell wall is made up of a polysaccharide called **Pseudomurein**. The cell membranes are characterised by the presence of a monolayer of branched chain lipids.

Archaebacteria are of three major types - Thermoacidophiles, Halophiles, Methanogens.

1. Thermoacidophiles

They are temperature, acid loving bacteria. They are gram negative bacteria. They are facultative anaerobes. Basically they are chemosynthetic.

They often live in hot sulphur springs and can tolerate temperature as higher as 80^oC and pH as low as 2. eg. *Thermoplasma, Thermoproteus, Thermus aquaticus*

2. Halophiles

They are salt loving bacteria. They are gram negative and facultative anaerobes. They are chemoheterotrophs. They live in hyper saline lagoons, salt lakes, dead sea etc. They have reddish pigment called baceriorhodopsin in their membrane to trap sunlight and form ATP directly, under anaerobic conditions. This ATP is not used for the synthesis of food. eg. *Halobacterium* and *Halococcus*

3. Methonogens

They are methane producing bacteria. They are gram negative and obligate anaerobes. They are found in marshy habitat, swamps, sewage treatment plants and in the gut of several ruminant animals like cows and buffaloes. So the dung of these animals consist of these bacteria and can be used in biogas plant. eg. *Methanobacterium, methanococcus*

EUBACTERIA

They are true bacteria and cell wall is made up of peptidoglycan / Murein / Mucopeptide which is a combination of polysaccharides and aminoacids. Peptidoglycan is a rigid molecule and it is a heteropolysaccharide. It has long glycan strands which are made up of :

NAM $\rightarrow$ N-acetyl muramic acid

NAG $\rightarrow$ N-acetyl glucosamine

These glycan strands are interconnected by short peptide chains which have a few aminoacids.

Eubacteria are classified into two :

1. Bacteria **2. Cyanobacteria**

BACTERIA

Bacteria were first discovered by Leeuwenhoek in 1676. Ehrenberg coined the term 'bacteria'. Bacteria are of different size and shape. The average size of a bacterium is $3-5\mu m$.

Shapes of Bacteria

Bacteria are of 4 categories based on their shape. They are :

1. Coccus / cocci - spherical shaped 

2. Bacillus / Bacilli - Rod shaped 

3. Spirillum / Spirilli - Spiral shaped 

4. Vibrium / Vibrio - Comma shaped 

Classification of Bacteria based on the number and position of flagella

The various forms of flagellation are as follows :-

a) Atrichous - Flagella absent

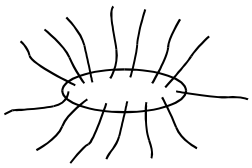
b) Monotrichous - A single flagellum occurs at or near one end of bacterium

c) Amphitrichous - A single flagellum at each of the two ends

d) Cephalotrichous - A group or tut of flagella is found only at one end

e) Lophotrichous - A tuft group of flagella occurs at each of the two ends or poles.

f) Peritrichous - A number of flagella are distributed all over the surface.



Bacteria have different life style. Though the bacterial structure is very simple, they are very complex in behaviour. Bacteria show the most extensive metabolic diversity, because some are anaerobes and others are aerobes, some are autotrophs others are heterotrophs. Different forms like nitrifying, denitrifying, ammonifying, nitrogen fixing etc. forms are there in bacterial community.

NUTRITION IN BACTERIA

Some bacteria are autotrophs, majority of others are heterotrophs.

AUTOTROPHIC BACTERIA

They can prepare their own food. They are of two types. Photoautotrophic bacteria and chemoautotrrophic bacteria.

Photoautotrophic bacteria

They can prepare their own food. They lack chlorophyll 'a'. So they are not taking water as reducing agent. So oxygen is not released in their photosynthesis. So their photosynthesis is Anoxygenic. They have photosynthetic pigments like bacteriochlorophyll and bacterioviridin.

Photoautotrophic bacteria can be classified into three.

Purple Sulphur Bacteria (Chromatium)

Green Sulphur Bacteria (Chlorobium)

Purple non sulphur bacteria. eg. *Rhodospirillum*

Chemoautotrophic Bacteria

They prepare their food using chemical energy. They oxidise various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production. They play a great role in recycling nutrients like nitrogen, phosphorous, iron and sulphur.

They are of different types :

1) Nitrifying bacteria eg. *Nitrosomonas, nitrobacter, nitrococcus*

2) Sulphur bacteria eg. *Beggiotoa, Thiobacillus, Thio-oxidans*

3) Methane bacteria eg. *Methanomonas*

4) Hydrogen bacteria eg. *Hydrogenomonas*

5) Iron bacteria eg. *Ferrobacillus, Ferro-oxidans*

Heterotrophic Bacteria

They depend upon other organisms for their food. They are the most abundant bacteria in nature. They are of different types :

Simple Saprophytes

Decomposer Saprophytes

Parasites

Symbionts

SIMPLE SAPROPHYTES

They live on organic matters like food-stuff and release digestive enzymes to the surroundings. These substances digest the complex organic molecules into simple organic and inorganic molecules. Then these are absorbed by them through general body surface.

eg. Lactobacillus or LAB / Lactic Acid Bacteria : which help in making curd from milk.

Bacteria which are used for the production of antibiotics.

DECOMPOSERS

Decomposers are the saprophytes which live on dead plant and animal bodies. They cause decaying and decomposing of dead bodies by breaking down complex organic compounds into simple organic and inorganic compounds.

eg. Ammonifying bacteria like ***Bacillus ramosus, Bacillus mycoiles, Bacillus valgaricus***

PARASITES

They are pathogenic bacteria which cause damage to humans like cholera - *Vibrio cholerae*, typhoid - *Salmonella typhi* / *S. typhimurium*, tetanus - *Clostridium tetani* etc.

Xanthomonas citri causes citrus canker in citrus fruits.

SYMBIONTS

eg. Rhizobium and roots of leguminous plants. Rhizobia are symbiotic nitrogen fixers.

E.coli [*Escherichia coli*] seen in human intestine. They help to absorb vitamin B-12 from our food and they synthesis vitamin B_{12}.

REPRODUCTION IN BACTERIA

Bacteria reproduce mainly by asexual method binary fission during favourable conditions. During unfavourable conditions bacteria from endospores.

True sexual reproduction is absent in bacteria 'so called' sexual reproduction methods are seen by adopting a primitive type of DNA transfer from one bacterium to another. The methods are :

1. Conjugation - Lederberg and Tatum discovered in 1946. Bacterial DNA is transfered from one to another through conjugation canal.

2. Transduction - Zinder & Lederberg (1952) - Transfer of DNA from one bacteria to another by virus.

3. Transformation - Griffith (1928)

CYANOBACTERIA

They are also known as blue-green algae because once they were included in plant kingdom along with algae. But as they were prokaryotes they were transferred into monera. So they are moneran algae. All of them are photoautotropic and aerobic. They have photosynthetic pigments chlorophyll a and phycocyanin (blue colour) which is a type of phycobilin. Their photosynthesis is oxygenic.

They occur as unicellular, colonial or filamentous forms. They can be marine or Freshwater forms. Some of them are terrestrial forms but they need moisture. They often form algal blooms in polluted water bodies.

Many of the cyanobacteria are nitrogen fixers ie, they convert atmospheric nitrogen into ammonia.

eg. ***Nostoc, Anabaena, Oscillatoria***

The colonies are generally surrounded by gelatinous sheath. In nostoc and anabaena nitrogen fixation occurs in specialised cells called heterocyst.

Heterocyst are large, pale yellow coloured thick walled cells, which contains nitrogenase enzyme which is needed for nitrogen fixation. *Nostoc* and anabaena can fix nitrogen freely and symbiotically. *Nostoc* has symbiotic association with coralloid roots of *Cycas*. *Anabaena* has symbiotic association with *Azolla*. So azolla can be used as bio fertilizer.

- *Nostoc* is called Moonspit, Fallenstar, star jelly
- ***Trichodesmium erythraceum*** $\rightarrow$ Red sea
- *Spirulina* is used as single cell protein [SCP]

MYCOPLASMA

They are otherwise called PPLO $\rightarrow$ pleuropneumonia like organism. They are the smallest living cell

or organism. They completely lack a cell wall. They are anaerobs. They were discovered by Nocard & Roux. They are :

- ♦ Witches broom in legumes
- ♦ Bunchy top of papaya
- ♦ Little leaf disease of brinjal
- ♦ Bovine pleuropneumonia in cattle

ACTINOMYCETES

They are filamentous bacteria. Once they were included in Fungi. Majority antibiotics are extracted from actinomycetes. Antibiotics like streptomycin, Aureomycin, Chloromycin, tetramycin, neomycin. Some cause disease in humans eg. *Mycobacterium tuberculae* causes tuberculosis, *M. leproae* causes leprosy, *Cornybacterium diphthereae* causes diptheria.

Ricketssios

1. It causes typhus fever, Rocky mountain spotted fever, Scrub fever.

KINGDOM PROTISTA

Protists are unicellular and eukaryotes. Boundaries of this kingdom are not well-defined. Unicellular fungi plants and animals are included in Protist. They are primary aquatic.

This kingdom forms a link with other kingdoms.

$\rightarrow$ Their cell contains a well defined nucleus and membrane bounded organelles.

$\rightarrow$ Some have flagella or cilia or pseudopodia as locomotary structures.

$\rightarrow$ They reproduce asexually and sexually. Sexual reproduction is by a process involving cell fusion and zygote formation.

Based on their mode of nutrition, kingdom Protista can be classified into three. They are:

1. Photosynthetic protists
2. Saprophytic protists
3. Protozoan protists

PHOTOSYNTHETIC PROTISTS

They are also called **Protistian algae**. Different forms are their in this group. The most common three types are:

1. Chrysophytes
2. Dinoflagellates
3. Euglenoids

These are unicellular algae and all of them are photosynthetic

Chrysophytes

This group include golden algae (Desmids) and Diatoms. They are found in fresh water as well as marine environment. They are microscopic and float passively in water currents. So they are called **Phytoplankton**.

Diatoms are golden-brown algae. Their body is covered by siliceous cell wall halves called frustules. The cell wall has two thin overlapping halfs which fit together as in a soap box. The larger frustule is called **epitheca** and smaller frustule is called **hypotheca**. The frustules are indestructurable. Diatoms have left behind large amount of cell wall deposits in their habitat. This accumulation over billions of years is referred to as “Diatomaceous earth”. Being gritty this soil is used in polishing, filtration of oils and syrups. It is used as insulation material in refrigerators and boilers. It is used as cleaning agent in

tooth paste. It is used to make sound proof room. Diatomaceous earth is also called Diatomite or Kiselgur.

Diatoms have photosynthetic pigments like chlorophyll 'a', chlorophyll 'c', carotenes, diatoxanthin etc. The reserve food is chrysolaminarin and Oil.

They multiply by binary fission. Repeated fission reduces the size of daughter cells. It is corrected by the development of **Rejuvenescent cells** [Auxospores]

Diatoms are the chief producers in the ocean

eg for diatoms

→ *Navicula*

→ *Triceratium*

→ *Pinnularia*

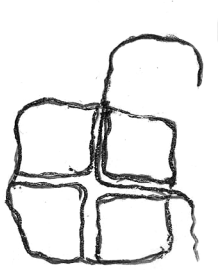
When diatoms where in plant kingdom they were included in the class Bacillariophyta.

Dinoflagellates [Pyrrophytes]

They are mostly marine. The photosynthetic pigments are chlorophyll 'a', chlorophyll 'c', fucoxanthin and other carotenoids. So they appear in different colours like yellow, green, brown, blue or red.

Reserve food is starch and oil. They have cellulosic cell wall which has stiff cellulose plates on the outer surface.

Most of them have two flagella. One lies longitudinally and projects out of the cell and the other flagellum lies transversely in furrow between the cell wall plates.



Red dinoflagellates are common. Very often they undergo rapid multiplication that thus make the sea appear red which is called **Red tide**

eg: *Gonyaulax, Gymnodinium*

At this time they release neurotoxins like Saxitoxin and Brevitoxin which kill marine animals like fishes.

Extra

→ Some dinoflagellates show bio-luminescence and are called fire algae. eg: *Noctiluca*

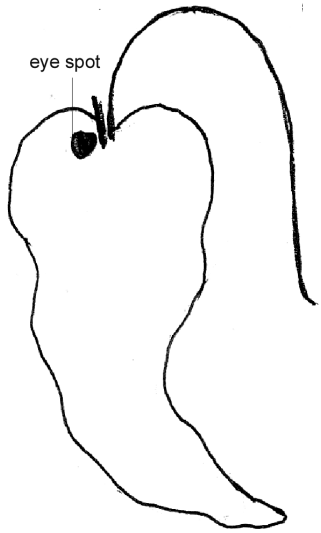
→ Dinoflagellates are only group of eukaryotes which lack histone proteins associated with DNA. So their nucleus is called **mesokaryon**.

Euglenoids

This group includes euglena and other related organisms. Majority of them are fresh water forms and found in stagnant water. They lack cell wall, instead of cell wall they have protein rich layer called **Pellicle** which makes their body flexible. They have two flagella- one short and one long. At the base of the flagella there is a photo receptor region called **Eyespot/Stigma**. Eye spot is made up of a red pigment called **Astaxantin**. Their nutrition is **Mixotropic** - they are photosynthetic in the presence of sunlight but when there is no sun light they behave as heterotrophs by predating on other smaller organisms i.e., holozoic. They have the photosynthetic pigments identical to those present in higher plants like chlorophyll 'a', chlorophyll 'b', xanthophyll, carotens. Contractile vacoules are there for

osmoregulation and excretion.

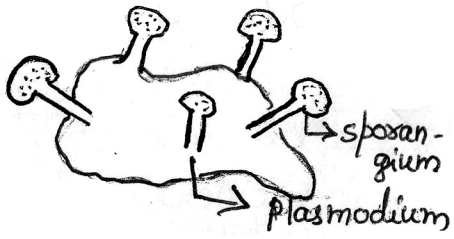
The reserve food is paramylum granules.



SAPROPHYTIC PROTISTS

Slime moulds

They were once included under fungi under the class Myxomycetes. Slime mould lack cell wall. So in favorable conditions the cells form an aggregation called plasmodium which may grow and spread over several feet. The body moves along decaying twigs and leaves engulfing small organic molecules. But they are basically saprophytes but can show holozoic nutrition.



During unfavorable conditions plasmodium differentiates and forms fruiting bodies called sporangia which bear spores. The spores posses true walls. They are extremely resistant and survive for many years even under adverse conditions. These spores are dispersed by air currents. Slime moulds are of two types:

Acellular eg: *Physarum, Physarella*

Cellular eg: *Dictyostelium*

PROTOZOAN PROTISTS

They were included under animal kingdom. They are believed to be primitive relatives of animals. The protozoans are heterotrophs and live as predators or parasites. Based on their locomotory structure they are classified into four:

1. Amoeboid protozoans
2. Flagellated protozoans
3. Ciliated protozoans

4. Sporozoans

Amoeboid Protozoan

These include amoeba and related organisms. They live in fresh water, sea water or moist soil. They move and capture their prey by putting out pseudopodia.

eg: *Amoeba*

Marine forms have silica shells on their surface. A parasitic form is ***Entamoeba histolytica*** - causing amoebiasis or amoebic dysentery in humans (spread through contaminated water)

Flagellated Protozoan [Zooflagellates]

They have flagella as the locomotary structure. The members of this group are either free-living or parasites. The parasitic form cause diseases in humans

eg: 1. African sleeping sickness- ***Trypanosoma gambiense***: while they are in the human blood they cause Gambia fever. While they are in the brain they cause sleeping sickness. They are transmitted by tse-tse fly [*Glossinia palpalis*]

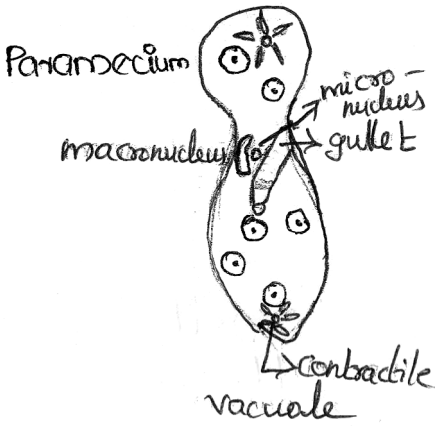
2. Kala azar- ***Leishmania donovani*** *:* It is transmitted by sand fly [*Phlebotomus argentipes]*

3. Symbiotic flagellated protozoan: *Trichonympha* and *Lophomonas* are symbiotic in intestine of termites and wood cockroaches.

Ciliated Protozoan

They have cilia as the locomotary structure. They are aquatic. They actively move through water because of presence of thousands of cilia. They have a cavity called gullet that opens to the outside of cell surface. The coordinated movement of rows of cilia causes the water laden with food to be steered into the gullet.

eg: Paramecium [first observed by Anton Van Laeewn hoek he called it as slipper animalcules]. Paramecium is binucleated- macronucleus and micronucleus [control the activity of cell][controls reproduction]. Contractive vacoule of or osmoregulation and excretion.



Sporozoans

They lack locomotary structures. They include diverse organisms that have an infectious spore like stage in their lifecycle. The most notorious one is ***Plasmodium vivax***- malarial parasite, which causes malaria in humans. Plasmodium is transmitted by female anopheles mosquito.

KINGDOM FUNGI

Study of fungi - mycology

Father of mycology -Pier Antonio Micheli

Father of Indian mycology - E.J. Butler

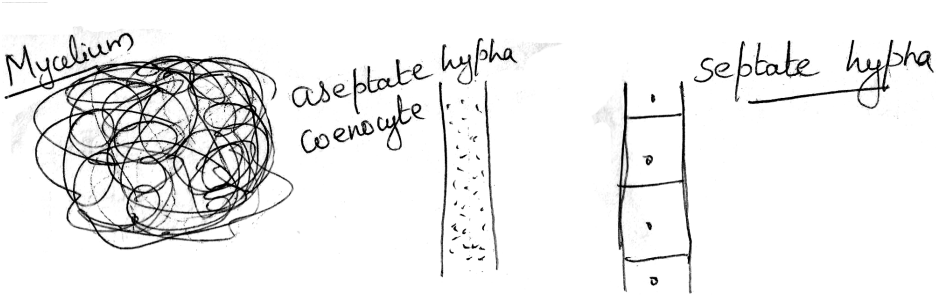
Father of modern mycology - Anton de Bary

Fungi are multicellular heterotrophs. Yeast is the exception. Yeast is the group of unicellular fungi.

Fungi show diversity in morphology and habitat. These are found in all habitats like soil, air, mouth, skin, hair, eyes on decaying matters etc. It shows in warm and humid places.

VEGETATIVE BODY

Vegetative body of fungi is filamentous except yeast. It consist of long slender thread like structures called hyphae. The network of hyphae is known as mycelium. Hyphae are of two types aseptate hyphae and septate hyphae. Aseptate hyphae lack cross walls or septa so they are continuous tubes filled with multinucleated cytoplasm and this condition is called coenocyte.



Aseptate hyphae is a primitive character of fungi septate hyphae have cross wall it is an advanced feature of fungi..

CELL WALL

Cell wall is made up chitin/ fungal cellulose. Chitin contain nitrogen containing polysacchride and it is the beta polymer of NAG [N-acetyl glucosamine]. In some cell wall is composed of cellulose. eg: Phytophthora, Pythium

NUTRITION

Fungi are strictly heterotrophic. Different types are

1. Simple saprophytes eg: Bread mould (Rhizopus).

2. Decomposers saprophytes eg: Mushroom.

3. Parasites eg: Ring worm in humans

4. Symbionts eg: eg: Lichens (association between fungi and algae), Mycorrhiza -association between fungi and roots of higher plants. Roots of the plants provide a shelter and food for fungi. Fungi absorb minerals and water from the soil. Mycorrhiza are of two types:

1) Ectomycorrhiza, 2) Endomycorrhiza. In ectomycorrhiza fungi are seen on the surface of roots. In endomycorrhiza fungi are seen within the roots. The most common type is VAM (Vesicular arbuscular mycorrhiza).

REPRODUCTION

Reproduction in fungi takes place mainly vegetatively and fragmentation, fission, budding are the most common type of vegetative reproduction methods.

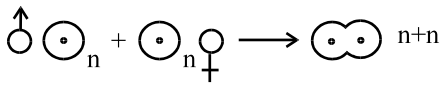
Asexual reproduction in fungi is by the production of asexual spores like conidia/conidiospores, Sporangiospores, zoospores etc.

SEXUAL REPRODUCTION

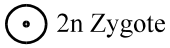
During unfavorable conditions fungi prefer sexual reproduction. Sexual reproduction is also by spore

formation. The sexual cycle involves three steps. They are :

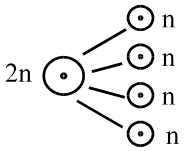
1) Plasmogamy : It is the fusion of protoplasm of gamates. Gamates can be motile or non-motile.



2) Karyogamy : It is the fusion of nuclei to form diploid zygote.



3) Zygotic meiosis : Zygote undergoes meiotic division to form haploid cells. These cells act as the sexual spores like Oospores, Ascospores and Basidiospores. These spores germinate and produce haploid hyphae.



In higher fungi like Ascomycetes and Basidiomycetes there is an interval of time between plasmogamy and karyogamy. This phase is called **Dikaryotic phase**.

Based on the morphology of mycelium, mode of spore formation and fruiting bodies, kingdom fungi is divided into 4 classes. They are:

1) Phycomycetes
2) Ascomycetes
3) Basidiomycetes
4) Deuteromycetes

PHYCOMYCETES (Algal Fungi / Conjugation Fungi)

They are found in aquatic habitats and on decaying wood, in moist and damp places or as obligate parasites on plants. Mycelium are **aseptate** and **coenocytic**.

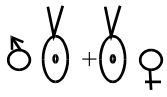
Reproduction- Vegetative reproduction by fragmentation.

Asexual reproduction is by the formation of asexual spores like Zoospores (motile) and Aplanospores (non-motile). These spores develop endogenously inside sporangia.

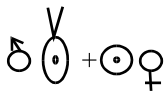
Sexual reproduction is of three types based on the nature of gametes. They are:

i) Isogamy : Male gamate and female gametes are similar. They can be motile or non-motile.

ii) Anisogamy : Male gamate is small and motile, female gamete is large and motile.



iii) Oogamy : Male gamate is small and motile, female gamate is larger and non-motile, then the female gamate is called edd or ovum.



After plasmogamy and karyogamy zygote is formed and this zygote is called **Zygospore**. Zygospore undergoes meiosis to form sexual spores called Oospores.

eg: Rhizopus (Bread mould)

Albugo - albugo is a parasite on mustard plants. It causes white rust on mustard leaves.

Pythium debaryanum - causes damping of seedlings.

Phytophthora infestans - Causes late blight of potato

Sclerospora - causes downy mildew of cereals.

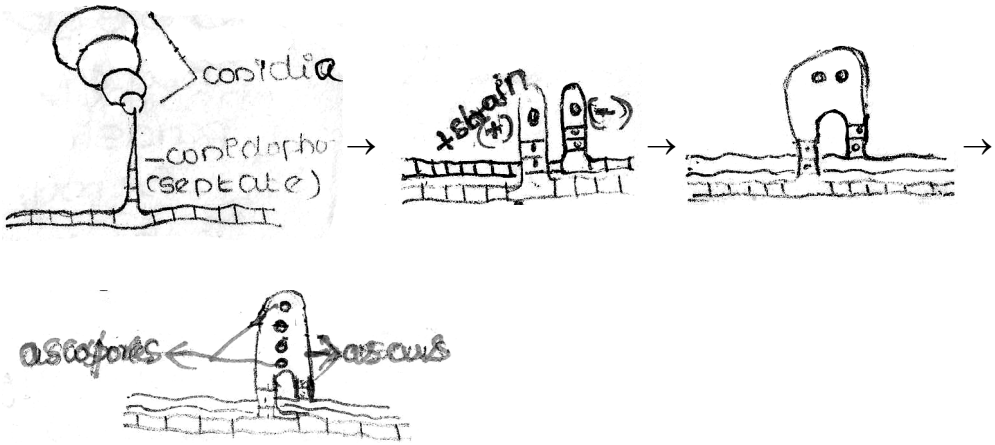
Saprolegnia - aquatic phycomycetes (saprophytes)

Mucor - grows on jams, horse dung. Terrestrial

ASCOMYCETES

Commonly called **Sac fungi**. Mycelium is multicellular septate, branched . Yeast is unicellular. They are saprophytic, decomposers, parasitic or coprophilous (growing on dung)

reproduction by fragmentation and asexually by the formation of asexual spores called conidospores or conidia. Conidia are produced exogenously at the tip of vertical hyphae called conidiophore.



Sexual reproduction is by the fusion of cells of opposite strain of hyphae. Here the vegetative cells of hyphae directly act as gamates. The plasmogamy of the gametes results in the formation of a sac- like structure called Ascus. After dikaryotic phase and karyogamy diploid zygote is formed. It undergoes zygotic meiosis to form 4-8 haploid sexual spores called ascospores. Hence the formation of ascospores is endogenous. ie., they are produced inside the ascus.

In higher ascomycetes numerous asci aggregate to form complex fruiting bodies called **ascocarp**. Ascocarp are of 4 types. They are:

1. Apothecium - cup shaped
2. Perithecium - flask shaped
3. Cleistothecium - closed
4. Hysterothecium - elongated with a slit.

eg: Yeast [*saccharomyces ceriviseae*/Bakers's yeast/Brewer's yeast].

Pencilium notatum [Green/blue mould]

Peziza - coprophilous

Aspergillus flavus - [weed of laboratory] - It produces a carcinogenic cancer causing) toxin called Aflatoxin.

Claviceps purpurea - It causes ergot disease in wheat and bajva. It is used for the production of a

halucinogen called LSD [Lysergic acid diethylamide]

Neurospora crassa [pink mould] - It is used extensively in biochemical and genetic work.

Gibberella fujikuroi

Edible ascomycetes

1. Morels - *Morchella*
2. Truffles - *Tuber aestivum*

BASIDIOMYCETES [Club fungi]

They grow in damp soil on logs and tree stumps and also as parasites.

The mycelium is branched and septate.

Vegetative reproduction by fragmentation. **No asexual reproduction**. Like ascomycetes here also there are **no sex organs**. Steps of sexual reproduction are same as that in ascomycetes. But here the spores are produced on club-shaped structure called basidia. Basidiospore are produced exogenously on basidium. In higher basidiomycetes numerous basidium aggregate to form basidiocarp. Hook shaped outgrowths or clamp connections are found on the side of septate of hyphae.

eg: Common edible mushroom [*Agaricus campestris*]

Amanita - the most poisonous mushroom. (Toad stool)

Polyporus [Bracket fungi]

Lycoperdon [Puff ball]

Rust [Puccinia]

Smut [Ustilago]

DEUTEROMYCETES [Fungi imperfecti]

This class is considered as artificial group because the vegetative or asexual phase of this fungi are only know. When the sexual forms of these fungi are discovered they were moved into classes they rightly belong to it. It is also possible that asexual and vegetative phase have been given a name and the sexual stage another. When the linkage were established the fungi where correctly identical and moved out of deuteromycetes and they were often moved to ascomycetes and basidiomycetes.

The deuteromycetes reproduce by **fragmentation** and asexual spores called **conidia**. Mycelium septate and branched. The members of this class are saprophytes or parasites. Majority of them are decomposers of litter (plant waste) and help in mineral recycling.

eg: Alternaria : causes early blight of potato and tomato

Colletotrichum falcatum : causes red rot of sugarcane

Trichoderma

Helmithosporium - Brown leaf spot disease of rice

Cercospora sps - Tikka disease of ground nut

Tinea rubrum : athlete foot disease in humans

Trichophyton - ring worm of beard

Microsporum - ring worm of scalp and body

KINGDOM PLANTAE

Plants are eukaryotic, photoautotrophs. Some members are partially or completely heterotrophs.

Examples for the insectivorous plants

Insectivorous plants are partial heterotrophs. They live in nitrogen deficient soil. So for nitrogen nutrition they trap insects, kill and digest them and absorb nitrogen compounds from the dead bodies of insects.

eg: Pitcher plant [Nepenthes]

Venus fly trap [Dinoea]

Sun dew plant [Drosera]

Bladder wort [Utricularia] -aquatic

Butter wort [Pinguicula]

Parasitic plants

Parasitic plants depend upon other plants for water, minerals and food. They produce haustoria or sucking roots for taking water and minerals from xylem and food from phloem.

- i) Stem parasite
  - Complete or total parasite : *Cuscuta*/Dodder plant/Amarbel
  - Partial parasite : *Loranthus, Visum* [Misletoe]
- ii) Root parasite
  - Total parasite : *Rafflesia, Orobanche, Balanophora*
  - Partial parasite : *Santalum, Striga*

Typical plant cell consist of chloroplast and cell wall is made up of cellulose.

Plant kingdom includes:

1) Algae

2) Bryophytes

3) Pteridophytes

4) Gymnosperms

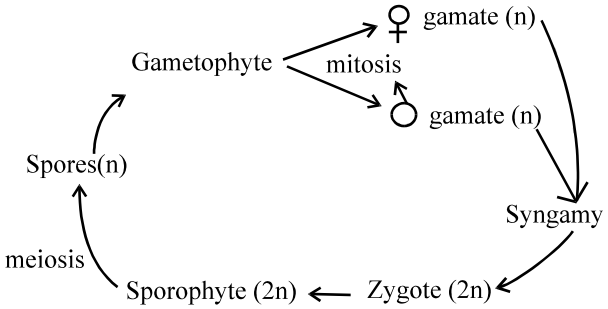
5) Angiosperm

Plants show a unique property called alternation of generation. The life cycle of plants consist of two distinct generation, They are;

i) A haploid generation called gametophyte (n)

ii) A diploid generation called sporophyte (2n)

Gametophyte produces gamate by mitosis and sporophyte produces spore by meiosis



KINGDOM ANIMALIA

Animals are heterotrophic, multicellular, eukaryotes which lack cell wall. They directly or indirectly depend on plants for food. They show holozoic nutrition by injection of food and digestion occurs in an internal cavity and store food as glycogen and fat.

They show a definite pattern of growth and adults have a definite shape and size. Higher animals show elaborate sensory and neuromotor mechanism. Most of them are capable of locomotion. Sexual reproduction is by copulation followed by embryological development. In many of the higher animals parental care is seen.

VIRUSES

Viruses are not truly living. They are characterised by having an inert crystalline structure outside the living cell. Then they are called **Viron**. Once they infect a living cell they take over the machinery of the host cell to replicate themselves and killing the host. Virus is considered as connecting link between living and non living being.

The term virus was given by Louis Pasteur. The term virus means "venom' or poisonous fluid. D.J Ivanowsky [1892] First discovered virus . He recognized certain causal organisms of tobacco mosaic disease. He found that these agents are smaller than bacteria and they can pass through bacteria filters.

M.W. Beijerineck [1898] demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants and he called the fungi as '**Contgium vivum fluidum***'* meaning infectious living fluid.

W.M Stanley [1935] first crystallized and isolated virus

STRUCTURE OF VIRUS

Viruses are obligate parasites. They have a protein coat and a genetic material. Genetic material could be either RNA or DNA. No virus contains both RNA and DNA. Thus a virus is a nucleoprotein and the genetic material is infectious.

In general viruses that infect plants have single stranded RNA [ssRNA]. Virus that infect animals have either single or double stranded DNA virus. Bacteriophages were discovered by Twort.

The protein coat of virus is called 'capsia' which is made up of small subunits called capsomeres are arranged in helical or polyhedral geometric forms.

Viruses cause diseases in humans like AIDS, Mumps, Small pox, herpes and influenza, common cold etc caused by Rhinovirus. In plants the symptoms of viral disease are mosaic formation; leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.

VIROIDS

In 1971, T.O Diener discovered viroids. Viroids are small than viruses but they lack the protein coat. Viroids are free RNAs. The RNA of the viroid is of low molecular weight. It causes potato spindle tuber disease.

PRIONS

These protineous, infectious particles discovered by Alper and the term was given by Prusiner. Prions cause scrapie in sheep and goats, mad cow disease or Bovine spongi form encephalopathy or Craeu'z feldt-Jacob disease, Kuru disease or the laughing death and alzhemer's disease.

LICHENS

Lichens are the symbiotic association between algae and fungi. The algae component is called Phycobiont and fungal component is called mycobiont. Algae are autotrophic and fungi are heterotrophic. Algae provides food to the fungi and fungi provide shelter and absorb mineral nutrients and water for algae.

The algae will be blue-green algae or unicellular green algae. The fungal partners will be members of ascomycetes. Lichens are very good pollution indicators i.e., they donot grow in polluted areas. They are highly sensitive to SO_2. Lichens are of three types.

1) Crustose - eg: *Graphis*

2) Foliose - eg:*Parmelia, Peltigera*

3) Fruticose - eg: *Cladonia* (Reindeer moss], *Usnea*, *Rocella tinctoria* [Litmus is extracted]

Reproduction of lichens is mainly by asexual bodies called **Soredia** and **Isidia.**

Sexual reproduction of lichens is performed only by fungal partner. It produces ascospores.