THE LIVING WORLD

INTRODUCTION

- Biology is the science of life forms and living processes.
- The living organisms interact with one another as well as with their physical and chemical environment.
- The term biology was introduced by G. R. Treviranus and Lamarck (1802).
- The living organisms occur almost in every habitat on earth.
- All living beings share certain unified and basic characteristics. These include organisation, energy utilization, regulation or homeostasis, growth, development, reproduction and adaptation.

LIFE

Living organisms show a great biodiversity and are classified into different kingdoms-Monera, Protista, Fungi, Plantae and Animalia. All of these share the following properties -

- They have definite organisation.
- They always have cellular nature so are either unicellular (e.g., Amoeba, Paramecium etc.) or multicellular (e.g., Hydra, man etc.).
- They show coordination between different parts of body to maintain homeostasis (constant internal environment) inside the body.
- They have the ability of movements and locomotion.
- They show metabolic functions in the presence of energy.
- They have the ability of growth and development.
- They have specific receptors (e.g., sense organs to receive external and internal stimuli) and specific effectors (e.g., muscles and glands to give specific response).
- They have regulatory mechanisms (e.g., nervous system and hormones in animals, and only hormones in plants) to maintain homeostasis inside the body.
- They show adaptations to their environment to increase their chances of survival.
- They show variations which help in speciation and evolution.
- They have capacity to reproduce for continuity of their race.
- They have definite life span (period from birth to death).
- They undergo ageing after adulthood and then natural death.

BUILDING BLOCKS OF LIFE AND THEIR FUNCTION

- Living organism is formed of many types of inorganic as well as organic biomolecules.
- Inorganic compounds include water, minerals etc. and are always micro-biomolecules (small sized, low molecular weight, readily soluble in water and diffusible) while organic molecules may be micro (e.g., monosugars, amino acids etc.) or macro-biomolecules (large sized, high molecular weight, insoluble or slightly soluble and non-diffusible e.g., proteins, fats, nucleic acids, etc.). These both types of biomolecules play important roles in metabolism.
- **Role of Water** : Water forms 70-90% of the cellular pool. It forms 65% (about two-thirds) of human body. It is formed of H and O in the ratio of 2:1. 95% of water is found in free state and 5% in combined form in the cell. Water helps in sustaining the life processes.
- **Role of Oxygen** : Oxygen is mainly utilized in aerobic respiration of the nutrients inside the mitochondria to produce energy-rich ATP molecules, so it is essential for life. In the absence of oxygen, only 5% of energy available is released.

- Role of Carbohydrates : Carbohydrates are organic compounds formed of C, H and O generally in the ratio
of 1:2:1. These are commonly called saccharides (Gk. saccharon = sugar). Carbohydrates are the main storage molecules and most organisms use carbohydrates, as an important fuel, by breaking these bonds and releasing energy to sustain life.
- **Role of Proteins** : Proteins are polymeric compounds formed by interlinking of amino acids (monomers) by peptide bonds. Out of about 100 types of amino acids, only 20 types
of amino acids are of biological importance, so are called Magic-20. Proteins play a vital role in the formation of structures in living organisms. Like carbohydrate and fat, protein can be broken down with the release of energy. Protein is not stored as such in the body and it is only used as a substantial source of energy in condition of starvation.
- **Role of lipids** : Lipids comprise a major group of insoluble hydrocarbons having many functions. These are polymers of alcohols (e.g., glycerol) and fatty acids interlinked by ester bonds.

Complex lipids such as true fats are important organic molecules that are used to provide energy.
- **Role of Nucleic acid** : These are polymers of nucleotides interlinked by phosphodiester bonds called polynucleotides. Each nucleotide is formed of 3 components: a pentose sugar (e.g., ribose in RNA and deoxyribose in DNA), a phosphate group and an inorganic nitrogen-base (a purine or a pyrimidine). DNA acts as genetic material in most organisms and controls the synthesis of structural and functional proteins. RNA also act as genetic material in all plant viruses e.g., TMV and helps in protein synthesis.

SYSTEMATICS

- The term "Systematics" was proposed by **Linnaeus** in 1735.
- It includes description of external morphological characters of plants or living organisms. E.g., morphological characters of root, stem, leaves, flowers.
- This description is used to know inter-relationship among plants or living organisms.
- The term systematics, taxonomy and classification are after held as synonyms but technically they carry different meanings.
- **New systematics** or **Neo systematics** or **Biosystematics** is a new branch. Its name was given by Julian Huxley (1940).
- New systematics includes description of all the characters (internal) including morphological characters (external) of plants or living organisms. E.g., anatomical characters and cytological characters. It is used to know the inter-relationship among living organisms.
- **Carolus Linnaeus** is called father of taxonomy.
- **H. Santapau** is called the father of Indian taxonomy.
- Taxonomy is of 3 types - α, β and ω :
  - In **α (alpha) taxonomy**, only morphological characters are used for identification and classification of plants.
  - **β (Beta) taxonomy** involves genetical, anatomical, cytological, palynological, physiological and other characters.
  - Analysis and synthesis of all information and types of data to develop classification system based on phylogenetic relationship is called omega taxonomy.
- **Identification** is to determine the exact place or position of an organism in the set plan of classification. It is carried out with the help of taxonomic keys.
- **Classification** is the placing of an organism or a group of organisms in category according to a particular system and in conformity with a nomenclature system.
- New systematics is mainly based on evolutionary as well as genetic relationship (experimental taxonomy) as compared to morphological characters.
- **Cytotaxonomy** : The use of cytological characters of plants in classification or in solving taxonomic problems is called cytotaxonomy. Cytological characters constitute an important aid to plant taxonomy, especially in determining affinities at the generic and intrageneric levels.

- **Chemotaxonomy** : The use of chemical compounds present in plants for classification or in solving taxonomic problems is called chemotaxonomy or chemical taxonomy. It is based on the chemical constitution of plants. The basic chemical compounds used in chemotaxonomy are alkaloids, carotenoids, tannins, polysaccharides, nucleic acids, fatty acids, amino acids, aromatic compounds etc.
- **Karyotaxonomy** : It is based on the characters of nucleus and chromosomes. Pattern of chromosomal bands (dark bands and light bands) is most specific character for classification of organisms.
- Taxonomy is the study of principles and procedures of identification, nomenclature and classification of organisms.

NOMENCLATURE

- **Nomenclature** is giving distinct scientific names to various structures including living organisms for their identification.
- The names are of two types - **vernacular** (common name) and **scientific names**.
- The vernacular names are based on some peculiarity of the organisms, e.g., Kandali (a plant having spines).
- Scientific names are distinct and specific, they have particular spellings which are not changed.

TYPES OF NOMENCLATURE

Three types of nomenclature are polynomial, binomial and trinomial.

POLYNOMIAL SYSTEM

According to this system, name of any plant consists of many words.
For e.g., Caryophyllum saxatilis folis gramineus umbellatus corymbia which means Caryophyllum growing on rocks, having grass like leaves and umbellate corymb flowers.

BINOMIAL SYSTEM

- **Carolus Linnaeus** used this nomenclature system for the first time and proposed scientific name of all the plants and animals. He is the founder of binomial system.
- Linnaeus proposed scientific name of plants in his book "Species plantarum".
- In binomial nomenclature, each scientific name has 2 components - **generic name (genus)** and **specific name (species)**. E.g., Solanum tuberosum (potato), Mangifera indica (mango)
- The name indicates relationship of a species with others present in the same genus.

TRINOMIAL SYSTEM

- This system was proposed by Huxley and Stricklandt.
- According to this system, name of any plant or species is composed of three names-
  - Generic name
  - Specific name
  - Subspecific name (Name of variety)
- When members of any species have large variations then trinomial system is used. On the basis of dissimilarities, this species is classified into sub-species.

Eg. Brassica oleracea var. botrytis (Cauliflower)
Brassica oleracea var. capitata (Cabbage)
Brassica oleracea var. caulorapa (Knol-Khol)

ICBN - INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE

- Collection of rules regarding scientific - nomenclature of plants is known as ICBN.

- ICBN was firstly proposed by Sprague, Hitchcock, Green (1930).
- ICBN was first accepted in 1961.

MAIN RULES OF ICBN

- According to binomial system name of any species consists of two names.

E.g., Solanum tuberosum (Potato)
↓ ↓
Generic name Specific name

- In plant nomenclature (ICBN), tautonyms are not valid i.e. generic name and specific name should not be same in plants *E.g., Mangifera mangifera*

But tautonyms are valid for animal nomenclature (ICZN-International Code of Zoological Nomenclature)
E.g., Naja naja (Indian cobra), Rattus rattus (Rat)

- Length of generic name or specific name should not be less than 3 letters and not more than 12 letters *E.g., Mangifera indica*.

Exception : Riccia pathankot ensis - More than 12 letters

- First letter of generic name should be in capital letter and first letter of specific name should be in small letter, *E.g., Mangifera indica.*
- When written with free hand or typed, then generic name and specific name should be separately underlined. But during printing, name should be italicized.
- Name of scientist (who proposed nomenclature) should be written in short after the specific name

E.g., Mangifera indica Lin.

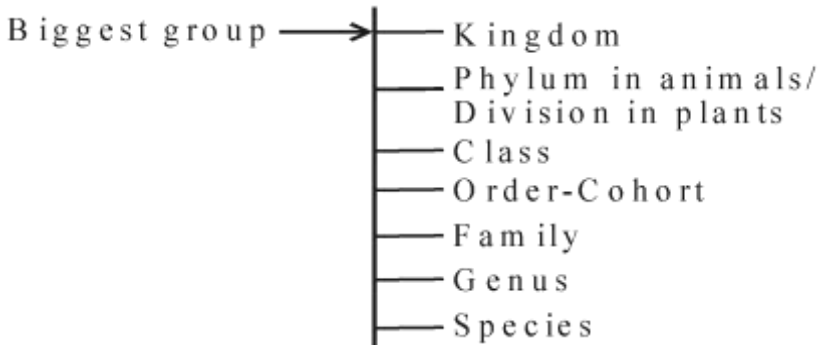
- Name of scientist should be neither underlined nor written in italics, but written in roman letters (simple alphabets).
- If any scientist has proposed wrong name then his name should be written in bracket and the scientist who corrected the name should be written after the bracket.

E.g., Tsuga canadensis (Lin.) Salisbury
Notes:- Linnaeus named this plant as Pinus canadensis.

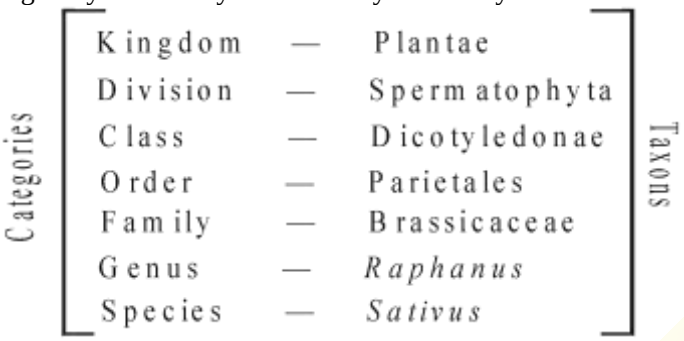
- The ICBN recognises several kinds or types, depending on the way in which a type of specimen is selected.
- Type specimen (Herbarium Sheet) of newly discovered plant should be placed in herbarium (Dry garden).
- Standard size of herbarium sheet is 11.5 × 16.5 inches.
- Type specimen (herbarium sheet) are of different types
  - **Holotype** : Herbarium sheet on which the first description of plant is based.
  - **Lectotype** : In case of holotype is lost, second herbarium sheet prepared from the original plant is called lectotype.
  - **Neotype** : In case holotype and original plant is lost then herbarium sheet prepared from some other plant of same species is called neotype.
  - **Syntype** : In case holotype and original plant is lost then many herbarium sheet prepared from many plants of same species is called syntype.
  - **Isotype** : It is duplicate of holotype. In presence of holotype a second herbarium sheet prepared from the original plant is called isotype.
  - **Paratype** : Additional herbarium sheet used in the first description of plant is called paratype. It is prepared from some other plant of same species having some variations.

TAXONOMIC CATEGORIES

There are 7 main taxonomic categories. They are obligate categories i.e., they are strictly used at the time of any plant classification.



There are some extra categories, like sub division, sub order, sub family, tribe, sub tribe,. etc. They are not regularly used. They are used only when they are needed.



- The sequence of arrangement of taxonomic categories in a descending order during the classification of an organisms is called taxonomic hierarchy.
- Kingdom is the highest and species is the lowest category in this hierarchy.
- Plant groups or animal groups included in categories are called taxon.
- **Suffix for taxa (Taxon)**

Division – phyta
Sub division – phytina
Class – opsida, phyceae, ae
Order – ales
Sub-order – ineae
Family – aceae
Sub family – oideae
Tribe – eae
Sub tribe – inae

Notes: There is no suffix for Genus, Species and Kingdom.

SPECIES

Species is the smallest taxonomic category. It is the basic unit of classification.
John Ray proposed the term and concept of species (1942).

BIOLOGICAL CONCEPT OF SPECIES

- Mayr proposed the biological concept of species.
- According to Mayr "all the members that can interbreed among themselves and can produce fertile offsprings are the members of same species"
- But this definition of Mayr was incomplete because this definition is applicable to sexually reproducing living beings. There are many organisms that have only asexual mode of reproduction.

E.g., Bacteria, Mycoplasma.

- The main character in determination of any species is interbreeding. But this character is not used in taxonomy. In taxonomy, the determination of species is based on other characters.

E.g., mainly morphological characters.

STATIC CONCEPT OF SPECIES

- The static concept of species was proposed by Linnaeus.
- According to Linnaeus "species is unchangeable" i.e. there is no change in the character of species. The species of present day are same as they were in past and they will remains same in future.

DYNAMIC CONCEPT OF SPECIES

- This concept was proposed by "Lamarck".
- According to this concept, "species is always changeable". Changes always occur in the characters of species from one generation to next generation. And these changes are known as "**evolution**".

TYPOLOGICAL CONCEPT

- This concept was proposed by "Aristotle" and "Plato".
- According to this concept, "there is a definite type or pattern of characters in each species of every living organisms and all the members of species show maximum resemblance with this pattern". (Typological concept is based on single individual of species).

Biotype : Members of same species inhabiting similar environment and having some genetic variations are known as biotypes. Variations found in these members are permanent. These members cannot interbreed among themselves.
E.g., Cauliflower, cabbage, knol-khol are three biotypes of one species.

Ecotypes : Members of same species inhabiting different environment and having some genetic variations are known as ecotypes. Variations are permanent. These members can interbreed among themselves but due to geographical barrier they cannot interbreed.
E.g., Crow (Corvus splendens) found in different regions are ecotype of one species.

Ecads or Ecophenes : Members of same species having some non genetic variations due to environment is called Ecads. These variations are temporary.
Definition related to species

Allopatric species : Those species that are found in different geographical regions and have geographical barriers between them are known as allopatric species. Geographical barriers are hills, oceans, himalayan mountains.

Sympatric species : The species found in similar geographical regions are sympatric species.

GENUS

- Genus is an assembly of related species which involved from a common ancestor and have certain common characters called correlated characters.

- Potato, tomato and brinjal are three different species but all belong to the genus Solanum. Lion (Panthera leo), leopard (P. pardus) and tiger (P. tigris) with several common features, are all species of the genus Panthera. This genus differs from another genus Felis which includes cats.

FAMILY

- Family, has a group of related genera with still less number of similarities as compared to genus and species.
- Families are characterized on the basis of both vegetative and reproductive features of plant species.
- Three different genera Solanum, Petunia and Datura are placed in the family Solanaceae. Among animals for example, genus Panthera, comprising lion, tiger, leopard is put along with genus, Felis (cats) in the family Felidae.

ORDER

- Order being a higher category, is the assemblage of families which exhibit a few similar characters. The similar characters are less in number as compared to different genera included in a family.
- Plant families like Convolvulaceae, solanaceae are included in the order polemoniales mainly based on the floral characters.
- The animal order, Carnivora, includes families like Felidae and Cancidae.

CLASS

- A class is a subdivision within a phylum made of one or more related orders.
- Order Primata comprising monkey, gorilla and gibbon is placed in class Mammalia along with order Carnivora that includes animals like tiger, cat and dog. Class Mammalia has other orders also.

PHYLUM

Classes comprising animals like fishes, amphibians, reptiles, birds along with mammals constitute the next higher category called phylum. All these based on the common features like presence of notochord and dorsal hollow neural system, are included in phylum Chordata. In case of plants, classes with a few similar characters are assigned to a higher category called **Division**.

KINGDOM

All animals belonging to various phyla are assigned to the highest category called **Kingdom Animalia**. The **Kingdom Plantae**, on the other hand, is distinct, and comprises all plants from various divisions.

Table : Organisms with their Taxonomic Categories

Common Name	Biological Name	Genus	Family	Order	Class	Phylum/Division
Man	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda
Mango	*Mangifera indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	Angiospermae

TAXONOMIC AIDS

- Taxonomic works involves studies both in field and in laboratory.
- The correct identification is a primary task for any plant, animal or organisms to be classified.
- Biologists use herbarium, botanical garden, museums, zoological parks and keys in taxonomic studies.
- **Herbarium** is a collection of plants parts that usually have been dried, pressed and preserved on sheets.
- **Botanical gardens** are the collections of living plants maintained for reference.
- **Museums** have collection of preserved plants and animal specimens for the study and reference.
- The **keys** are based on the contrasting characters generally in a pair called **couplet**. It represents the choice made between two opposite options. This results in acceptance of only one and rejection of the other. Each statement in the key is called a **lead**. Separate taxonomic keys are required for each taxonomic category such as family, genus and species for identification purposes. Keys are generally analytical in nature.

Major Botanical Gardens, Herbaria and Research Institute

- Oldest botanical garden is "Padua Botanical Garden" Italy (Established -1545).
- Largest Botanical garden in the world is Royal Botanical Garden, Kew, Surrey, England, established by William Aiton, 1759.
- Largest herbarium of the world is "Museum of Natural History" - Paris - with a collection of 8880000 specimens.
- Largest Botanical Garden of Asia is Indian Botanical Garden, Shibpur, Kolkata. Established by Robert Kyd, 1786.
  - Largest herbarium of Asia is Central National Herbarium located in Indian Botanical Garden, with a collection of 25 lakh specimens.
  - Indian Botanical Garden is famous due to the presence of "Great Banyan Tree" in its campus.
  - In campus of Indian Botanical Garden Botanical Survey of India (BSI) is present which is established by William Rouxburgh 1890. Botanical Survey in India is done by BSI.
- National Botanical Garden, Lucknow. National Botanical Research Institute (NBRI) is located in National Botanical Garden.
- Forest Botanical Garden, Dehradun.

Forest Research Institute (FRI)is located in Forest Botanical Garden.

- Lloyd Botanical Garden - Darjeeling.
- CDRI - Central Drug Research Institute - Lucknow
- CAZRI - Central Arid Zone Research Institute - Jodhpur
- CIMAP - Central Institute of Medicinal and Aromatic Plants - Lucknow
- IARI - Indian Agriculture Research Inst. (Pusa Inst.) - New Delhi
- Birbal Sahni Institute of Paleobotany (National Institute of Paleobotany) - Lucknow.

BRANCHES OF BIOLOGY

- Anatomy - Study of internal structure
- Phycology or Algology - Study of Algae
- Agrostology - Study of grass
- Anthology - Study of flowers
- Agronomy - Study of crops plants.
- Biochemistry - Study of organic substances, found in living organisms.
- Biophysics - Study of importance in metabolic reactions of different physical theories

- Bacteriology - Study of bacteria
- Bryology - Study of bryophytes
- Bio-metrics - Study related to different biotic reactions and their results.
- Biotechnology - Study of isolation of protoplasm and their culture
- Cytology - Study of structure and functions of cell
- Dendrology - Study of tree.
- Dendrochronology - Study of age of trees
- Embryology - Study of gametes formation, fertilization and formation of embryo
- Ecology - Study of inter-relations between living organism and their atmosphere
- Evolution - Study of different development process of living organism
- Economic botany - Study of plants of economic importance
- Exobiology - Study of presence of possible organism on other planet
- Euphenics - Study of control of heredity disease
- Floriculture - Study of culture of ornamental flowers
- Forestry - Study of forests
- Genetics - Study of heredity and variations
- Gymnology - Study of Gymnosperm
- Genetic engineering - Study of manipulation of genes for human welfare.
- Histology - Study of structure of tissues .
- Horticulture - Study of culture of garden plant, fruits and vegetables
- Karyology - Study of nucleus
- Morphology - Study of external characters of plants
- Mycology - Study of fungi
- Microbiology - Study of microorganisms
- Molecular Biology - Study of nucleic acid (DNA and RNA)
- Oncology - Study of cancer
- Physiology - Study of various organ within organisms.
- Paleobotany - Study of fossil plants
- Pedology - Study of soil

CONTRIBUTIONS AND CONTRIBUTORS

Contributions - Contributors

- Cell theory - Schleiden and Schwann
- Central Dogma of Molecular genetics (Name) - Crick
- Chromosomal Theory of Linkage - Morgan and Castle
- Chromosomal Theory of inheritance - Sutton and Boveri
- Cohesion Theory of Ascent of Sap - Dixon and Jolly
- Double fertilization of Angiosperms - Nawaschin and Guingard
- Gene Theory (Linkage of genes) - Morgan
- Germplasm Theory - Weismann
- Germ Theory of disease - L. Pasteur
- Induced fit Hypothesis of enzyme - Koshland
- Mutation Theory - Hugo de Vries
- Omnis cellula e cellula - R. Virchow
- One gene-one enzyme theory - Beadle and Tatum

- Operon Concept of Gene action - Jacob and Monod
- Organic evolution - Darwin and Wallace
- 'Protoplasm is the physical basis of life' (Book) - Huxley
- Theory of Acquired Characters - Lamarck
- Theory of Natural Selection - Charles Darwin

INVENTIONS AND DISCOVERIES

Inventions and discoveries - Contributors

- ATP - Karl Lohmann (1929)
- Blood groups A, B and O - K. Landsteiner (1900)
- Blood group AB - de Castello and Sturli (1902)
- C_3 pathway of plants - Melvin Calvin
- C_4 pathway of plants - Hatch and Slack
- Chargaff's rule of DNA base composition - Erwin Chargaff
- First test tube baby - Edwards and Steptoe
- First vaccination - Edward Jenner
- Heterothallism in fungi - A. F. Blakeslee
- Insecticidal properties of DDT - Dr. Paul Muller (1939)
- Jumping genes (transposons) - Mc. Clintock
- Patau's syndrome - K. Patau
- Penicillin - A. Fleming (1920)
- Photophosphorylation in chloroplast - Arnon
- TMV virus (discovery) - D. J. Ivanowski
- Vitamin - Kazimierz Funk (1911)

CONNECTING AND MISSING LINKS OF BIOLOGICAL WORLD

Link - Between the groups

- Actinomycetes - Bacteria and Fungi
- Archaeopteryx - Birds and Reptiles
- Balanoglossus - Chordates and non-chordates
- Chimaera (rat or rabbit fish) - Bony and Cartilaginous fishes
- Club moss - Bryophytes and Pteridophytes
- Cycas - Pteridophytes and Gymnosperms
- Gnetum - Gymnosperms and Angiosperms
- Neopilina - Annelida and Mollusca
- Ornithorhynchus (Duck billed Platypus) - Reptiles and Mammals
- Peripatus (Walking worm) - Annelida and Arthropoda
- Protopterus (Lungfish) - Pisces and Amphibia
- Rickettsia - Virus and Bacteria
- Virus - Living and nonliving

COMMON ABBREVIATIONS IN BIOLOGY

- ABA - Abscisic acid
- ACTH - Adrenocorticotropic Hormone

- ADH - Antidiuretic Hormone
- AIDS - Acquired Immuno Deficiency Syndrome
- ATP - Adenosine triphosphate
- ATPase - Adenosine triphosphatase
- BMR - Basal Metabolic Rate
- BOD - Biological Oxygen Demand
- 2,4-D - 2, 4-Dichlorophenoxy acetic acid
- DDT - Dichloro diphenyl trichloroethane
- DLC - Differential Leucocyte Count
- ECG - Electrocardiogram
- EDTA - Ethylenediamine tetra acetic acid
- ELISA - Enzyme-Linked Immunosorbent Assay
- FAD - Flavin adenine dinucleotide
- FADH - Reduced Flavin adenine dinucleotide
- FMN - Flavin mononucleotide
- GDP - Guanosine diphosphate
- HIV - Human Immunodeficiency Virus
- IAA - Indole Acetic Acid
- LH - Luteinizing Hormone
- NAA - Naphthalene Acetic Acid
- NADP - Nicotinamide adenine dinucleotide phosphate
- NOR - Nucleolar organising region
- P_{680} - Reaction centre of Photosystem II
- P_{700} - Reaction centre of Photosystem I
- PEP - Phosphoenolpyruvate
- RBC - Red blood corpuscles
- RuBP (RuDP) - Ribulose bisphosphate
- RuBisCO - Ribulose bisphosphate carboxylase oxygenase
- TMV - Tobacco mosaic virus
- WBC - White blood corpuscles
- ICBaN - International Code of Bacteriological Nomenclature.
- ICVN - International Code of Viral Nomenclature
- ICNCP - International Code of Nomenclature for Cultivated Plants.

TALLEST, SMALLEST, LONGEST, LARGEST

TALLEST

- Angiosperm - Eucalyptus (Australian species, 114m)
- Animal - Giraffe (Giraffa camelopardalis)
- Gymnosperm - Sequoia sempervirens (111.25 m)
- Monocot plant - Date palm (Phoenix dactylifera)

SMALLEST/SHORTEST

- Angiospermic flower - Wolffia (1.1mm)
- Angiospermic plant - Lemna (Duckweed)

- Ape - Gibbon
- Bird - Hummingbird of Cuba (Helenae)
- Cell - Pleuro Pneumonia like Organisms (PPLO)
- Cell of vertebrate - Squamous epithelium
- Gymnosperm - Zamia pygmaea
- Number of chromosome in animals - Ascaris (2)
- Number of chromosome in plant - Haplopappus gracilis (2n = 4)
- Pollen grain - Orchid
- Pteridophyta - Azolla

LONGEST

- Bone of man - Femur
- Cell - Neuron
- Creeper (Plant) - Elephant creeper (Entada pursaetha)
- Leaf - Raphia vinifera (30-50 ft)

LARGEST/BIGGEST/HEAVIEST

- Alga - Macrocystis macrocarpa (Brown alga, Kelp 60 m)
- Amphibian - Cryptobranchus
- Antherozoid - Cycas circinalis
- Archegonium - Bryophyte (Moss)
- Biome (richest in terms of plant species) - Tropical rainforest
- Bird sanctuary - Bharatpur
- Class (of plantae) - Angiosperms
- Coral reef in world - Great barrier reef of North East Coast of Australia (2×10^3 kms.)
- Exocrine gland - Liver
- Flower - Rafflesia arnoldii
- Largest Forest area in India - Madhya Pradesh
- Number of Animal chromosomes - Aulacantha (Radiolarian; 2n=1600)
- Number of Plant chromosomes - Ophioglossum (pteridophyte, Adler's tongue, 2n=1262)
- Plant cell - Acetabularia (green alga)
- Pollen grain in Angiosperms - Mirabilis
- Primate - Gorilla
- Phylum (of Animals) - Arthropoda

IMPORTANT DATES

- Anti Leprosy Day - 30th January
- Blood Donation Day - 1st October
- Doctor's Day - 1st July
- Human Rights Day - 10th December (To commemorate the death of Alfred Nobel)
- International Day of Biodiversity - 29th December
- International Thalassaemia day & World - 8th May
- Red. Cross Day - 8th May
- Kisan Divas (National Farmer's Day) - 23rd December
- National Pollution Prevention Day - 2nd December

- Van Mahotsava (Festival of Tree Plantation) - 1st week of February and July
- Vigyan Divas (National Science day) - 28 February
- World AIDS day - 1st December
- World Conservation Day - 3rd December
- World Earth day - 22nd April
- World Environment Day - 5th June
- World Forest Day - 21st March
- World Health Day - 7th April
- World Literacy Day - 8th September
- World Ozone Day - 16th September
- World Population Day - 11th July
- World Wildlife Week - 1st Monday of October

HUMAN BODY

- Largest artery - Abdominal aorta
- Largest bone - Femur
- Largest heterocrine organ - Alimentary canal
- Largest endocrine gland - Thyroid
- Largest gland - Liver
- Largest salivary gland - Parotid gland
- Largest vein - Inferior Vena cava
- Least regenerative capacity - Brain
- Longest cell in the body - Neuron
- Longest cranial nerve - Vagus
- Longest nerve of the body - Sciatic
- Muscles : Number - 639

Smallest muscle - Stapedius
Largest muscle - Gluteus maximus
Longest muscle - Sartorius

- Number of cranial nerves - 12 pairs
- Number of spinal nerves - 31 pairs
- Smallest cranial nerve - Abducens
- Smallest bone - Stapes (2.6 – 3.4 mm)
- Smallest endocrine gland - Pituitary
- Speed of Sneezing - 60-100 miles/hour
- Spinal cord : Weight - 35g. Length - 42-45 cm

BIOLOGICAL CLASSIFICATION

INTRODUCTION

- Identification of differences among organisms and placing them into groups that reflect their most significant features and relationship is called **biological classification**.
- The purpose of biological classification is to organise the vast number of known plants into categories that could be studied easily.
- Organisms have been classified from different points of view at different times.
- Biological classification was first proposed by **Aristotle** who used simple morphological characters to classify plants and animals.

ARTIFICIAL CLASSIFICATION

In this type of classification, plants are classified on the basis of one or two morphological characters i.e. overall morphology is not considered.

- Artificial system of classification was adopted by **Pliny the Elder** for animals on the basis of habitat, e.g. land, air and water.
- Classification proposed by **Linnaeus** is artificial.
- Linnaeus classified plant kingdom into 24 classes on the basis of only two characters-stamens and style in his book '*Genera Planatarium*'.

NATURAL CLASSIFICATION

- In this type, plants are classified on the basis of their complete morphology. In it, the classification of whole plant is included (like stem, root, leaves, flowers etc). Maximum characters are taken as base in this classification.
- The first natural system of plant classification was proposed by **Schimper** (1879) followed by **Eichler** (1833).
- Natural classification is believed to be the best classification because it represents the natural similarities and dissimilarities of plants i.e. it represents the inter-relationship among plants.
- In this classification, the plants belonging to the same group show many similarities, while in artificial classification, the plants belonging to the same group show only, one or two similar characters. They have many dissimilarities.
- Natural classification is of two types - **natural formal** and **natural phylogenetic**.
  - In Natural formal classification, the phylogeny of the plant is not considered i.e. only the morphology of the plant is considered.
  - In Natural phylogenetic classification, both morphology and phylogeny are considered. In phylogenetic classification, the plants are arranged on the basis of their evolution.
- Lamarck : Proposed the term "Phylogeny".
- Ernest Haeckel : Gave the concept of phylogeny.
- Charles Darwin : Gave broad explanation of phylogeny in his book.
- Genealogy → Sequence of evolution
- Genealogy of plant kingdom : Thallophyta → Bryophyta → Pteridophyta → Gymnosperm → Angiosperm (Most advanced plants)

ADANSONIAN SYSTEM OR PHENETIC CLASSIFICATION OR NUMERICAL CLASSIFICATION

- It is proposed by "**Sokel and Sneath**". Plants are classified on the basis of numbers of similarities and dissimilarities.
- In this, importance to single character is not given, all characters have the same importance. While, in natural classification, floral (reproductive) characters have more importance than vegetative (root, stem and leaves) characters.

HISTORY OF TAXONOMY

ARISTOTLE & THEOPHRASTUS (370 - 285 B.C.)
Aristotle : He is the father of biology and zoology.
Theophrastus : He is known as the father of ancient plant taxonomy and father of botany.

- Both Theophrastus & Aristotle are Greek political philosophers.
- Theophrastus wrote many books on plants. Few of them are as follows :
  - Historia plantarum
  - Causes of plants
  - Enquiry into plants
- Theophrastus gave names and descriptions of 480 plants in his book Historia plantarum.
- Theophrastus proposes the first classification of plant kingdom. He classified plant kingdom into four groups on the basis of growth habit like trees, shrubs, under shrubs, herbs. It is an artificial classification. He proposed the term annual, biennial and perennials.

CAROLUS LINNAEUS (1707 - 1778)

- He is known as the father of taxonomy, father of plant taxonomy and father of animal taxonomy.
- Linnaeus gave the two kingdom system of classification. He grouped plants and animals into kingdom plantae and kingdom animalia respectively. Linnaeus wrote many books. Some important books are:
  - Hortus uplandicus - First book
  - Flora lapponica
  - Philosophia botanica
  - Critica botanica
  - Systema naturae (1737)
  - Genera plantarum
  - Species plantarum - last book (1753)
- In "Philosophia botanica," Linnaeus gave the principles of nomenclature.
- In "Systema naturae," Linnaeus gave the scientific names of animals. In this book, he gave the detailed description of the animal kingdom. He also gave the outline classification of plant kingdom in this book.
- In "Genera plantarum," Linnaeus gave the detailed description of plant kingdom.
- The main basis of Linnaeus classification was the "sex organs". Therefore, this classification is also known as "Sexual classification".
- In "Species plantarum," he gave the scientific names of plants. (He gave the description of 6000 plant species).

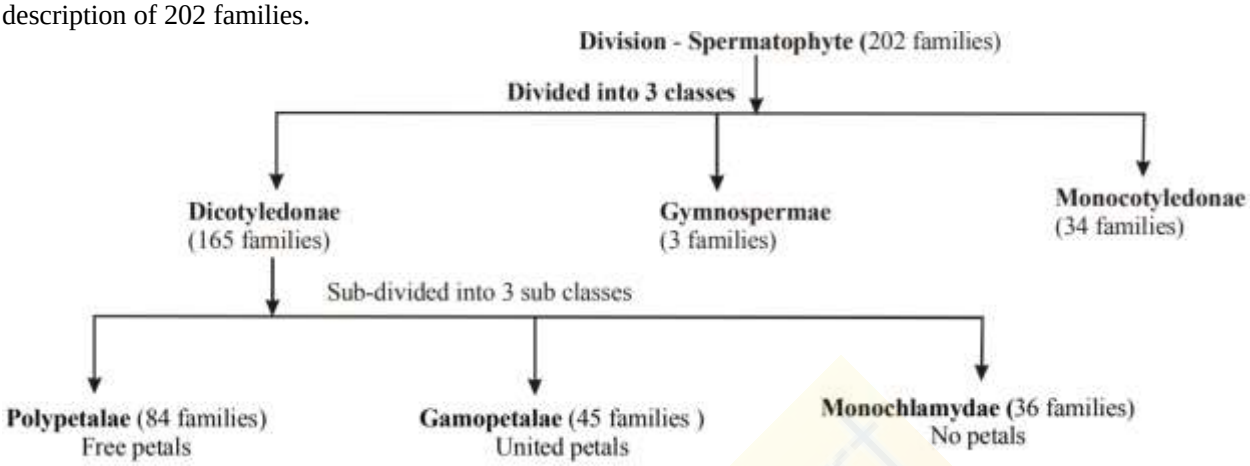
A.P. DE CANDOLLE

- He wrote the book - "Theories Elementaire de la botanique".
- He was the first to propose the significance of vascular tissue in taxonomy. On this basis of vascular tissue, he classified plants into two groups –
  - Cellular plants (Non - vascular plants) - This group includes thallophyta and bryophyta.

- Vascular plants - This group includes pteridophyta, gymnosperms and angiosperms.

GEORGE BENTHAM (1800 -1884) AND JOSEPH DALTON HOOKER (1817 -1911)

They wrote the book "Genera plantarum" (1862 - 1883). In this book, Bentham and Hooker gave the biggest and natural classification of spermatophyta i.e. plants with seeds. In Genera plantarum, there is description of 202 families.



Flow chart 2.1 : Classification of spermatophyta by Bentham and Hooker

Merits of Bentham and Hooker classification

- The classification of Bentham and Hooker was natural formal.
- The classification of Bentham and Hooker was mainly based on the floral characters. This was very appreciable because floral characters are more stable than vegetative characters.
- It is the simplest classification. Therefore, the arrangement of all plants in the botanical gardens and herbarium of the world is based on it. Although it is not the best classification but yet the arrangement of plants in botanical gardens and herbarium is based on it, because it is the simpler one. The main reason for its simplicity is that this classification is based on actual observations.

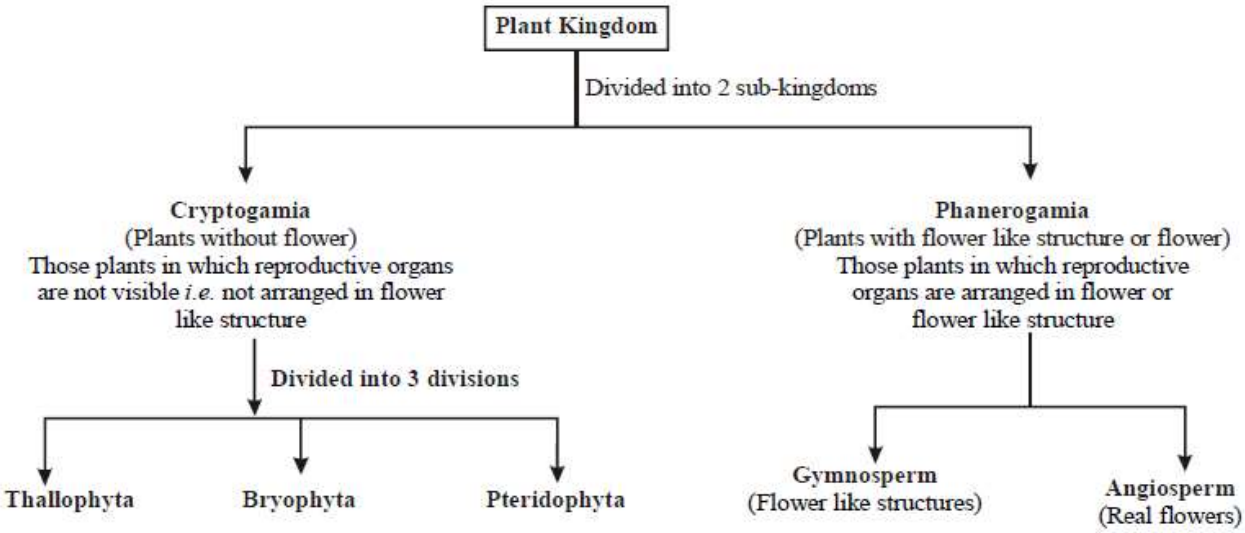
Demerits of Bentham and Hooker

In this classification, the phylogeny of plants is not considered because in it gymnosperms are placed in between dicots and monocots. The sequence of evolution is as follows –

Phylogeny = Gymnosperm → Dicots → Monocots

A. W. EICHLER

- Eichler gave the first phylogenetic classification of plant kingdom.
- Eichler classified plant kingdom into two sub-kingdoms- cryptogamia and phanerogamia
- The classification of Eichler is very little phylogenetic.



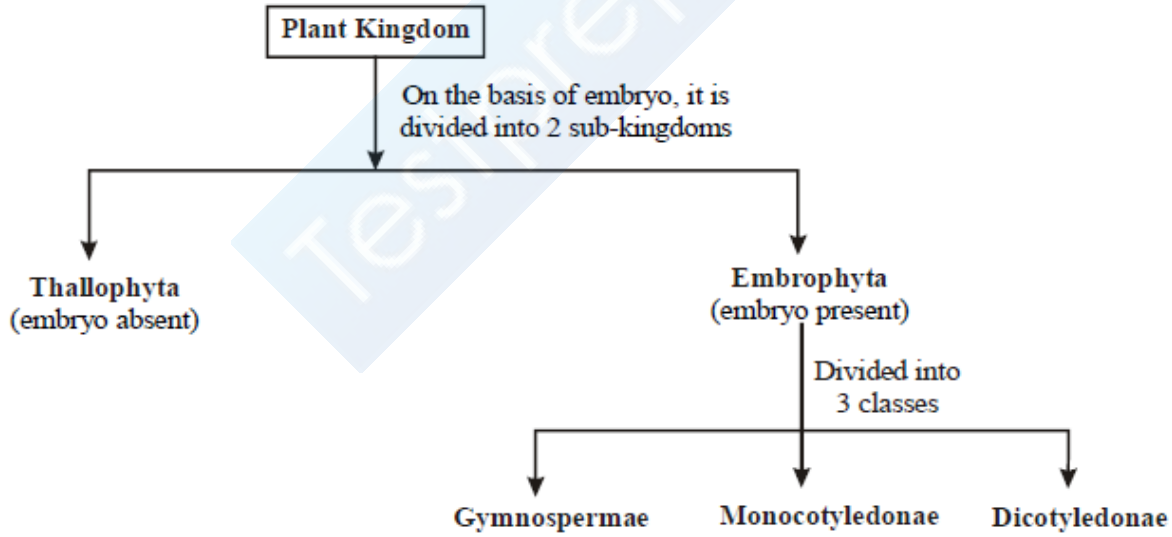
Flow chart 2.2 : Classification of plant kingdom (by Eichler)

- In this way, Eichler classified plant kingdom into five divisions and arranged them in the order of evolution (Phylogeny).

Thallophyta → Bryophyta → Pteridophyta → Gymnosperm → Angiosperm

ENGLER (1844 - 1930) AND PRANTL (1849 - 1893)

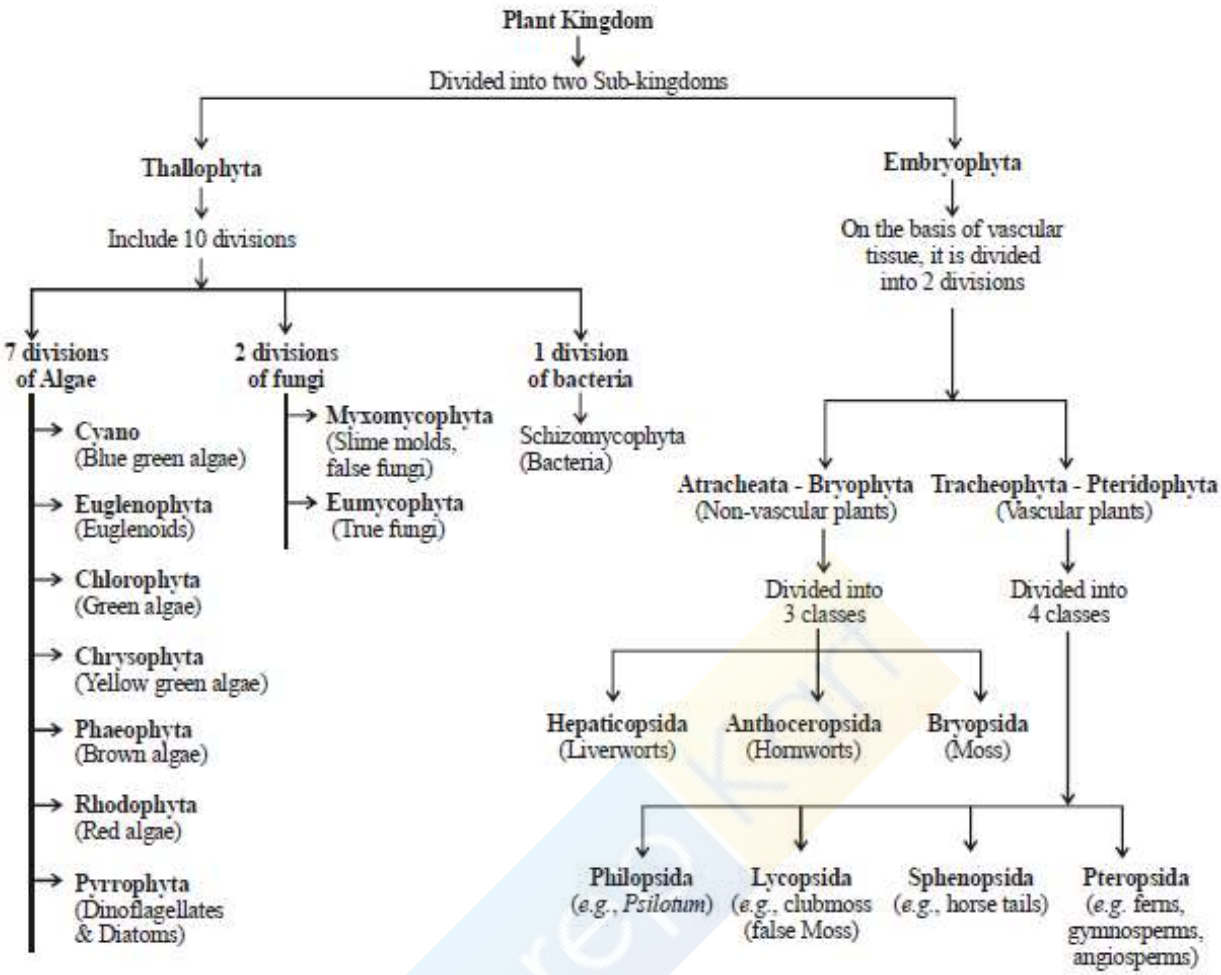
- Book - "Die Naturlichen Pflanzen Familien" is written by Engler & Prantl.
- He gave the **phylogenetic classification of plant kingdom**. This classification was more phylogenetic as compared to Eichler's classification.



Flow chart 2.3 : Plant classification by Engler and Prantl

OSWALD TIPPO

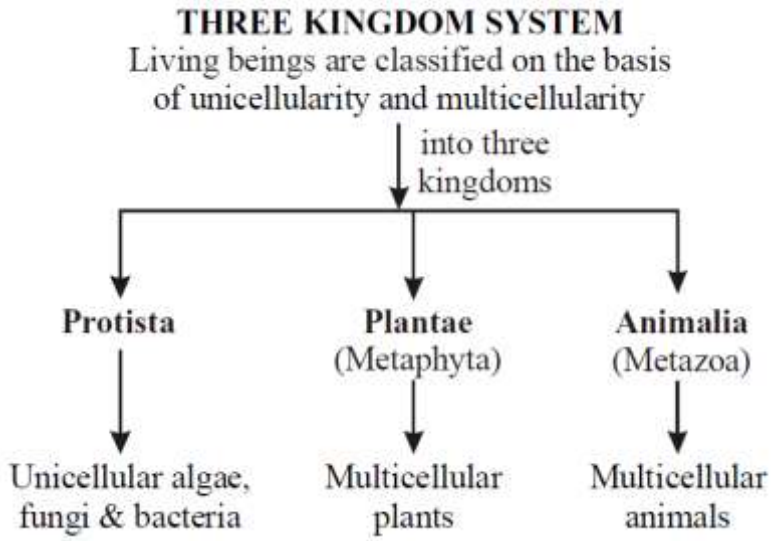
He proposed the biggest phylogenetic classification of plant kingdom.
This classification is the complete classification of plant kingdom (Refer flowchart 2.4).



Flow chart 2.4 : Classification of Plant Kingdom by Oswald Tippo

HAECKEL

- Haeckel gave the three kingdoms (Protista, Plantae, Animalia) system of classification (1866).
- Haeckel established the kingdom Protista.
- The term 'Protista' was given by C. Cuvier.
- Haeckel grouped those living organisms in Protista which did not have tissues.
- Kingdom Protista includes prokaryotes, protozoa, porifera, algae and fungi.
- This system of classification was not accepted because it includes both prokaryotic & eukaryotic chlorophyllous and non chlorophyllous organisms together.



Flow chart 2.5 : Three kingdom system of classification by Haeckel

COPELAND (1956)

He gave the four kingdom system of classification.

- **Mycota** : Dougherty and Allen gave the name "Monera" to Mycota of Copeland. All the prokaryotes are grouped in Monera. E.g., bacteria, mycoplasma, blue green algae.
- **Protista or Prototista** : Copeland grouped those eukaryotes in protista, which are visually different than normal plants and animals. Eg, brown algae, red algae, fungi, protozoa
- **Plantae or Metaphyta** : Remaining all eukaryotic plants are grouped into this kingdom.
- **Animalia or Metazoa** : Remaining all eukaryotic animals are grouped into this kingdom.

R.H. WHITTAKER (1969)

- He gave the five kingdom system of classification.
- The five kingdom classification of Whittaker was based on 3 main characters –
  - **Complexity of cell** : Cell is prokaryote or eukaryote , on this basis, Kingdom Monera is formed and all the prokaryotes are grouped into it.
  - **Complexity of organism** : Organism is unicellular or multicellular. On this basis Kingdom Protista was formed, and all the unicellular eukaryotes were grouped into it.
  - **Nutrition** : Organism is autotrophic or heterotrophic. On this basis Kingdom Mycota, Plantae and Animalia were formed. Except fungi (heterotrophic), all the plants are autotrophs. Therefore, fungi is separated from plants and placed in Kingdom Mycota. And remaining all the autotrophic plants are placed in Kingdom Plantae. Since all the animals are heterotrophs, therefore they are placed in the fifth kingdom i.e. kingdom Animalia.

THE FIVE KINGDOMS

1. **Monera** : It includes all the prokaryotes (Eubacteria, Actinomycetes, blue green algae, Mycoplasma) and Akaryote (virus).
2. **Protista** : It includes all the unicellular eukaryotes (Protozoans, Dinoflagellates, Diatoms, Euglenoids, Slime molds).
3. **Mycota** : It includes true fungi.
4. **Plantae** : It includes multicellular eukaryotic plants (Algae, Bryophyte, Pteridophyte, Gymnosperm and Angiosperm).
5. **Animalia** : It includes multicellular animals.

Characteristics of five kingdoms

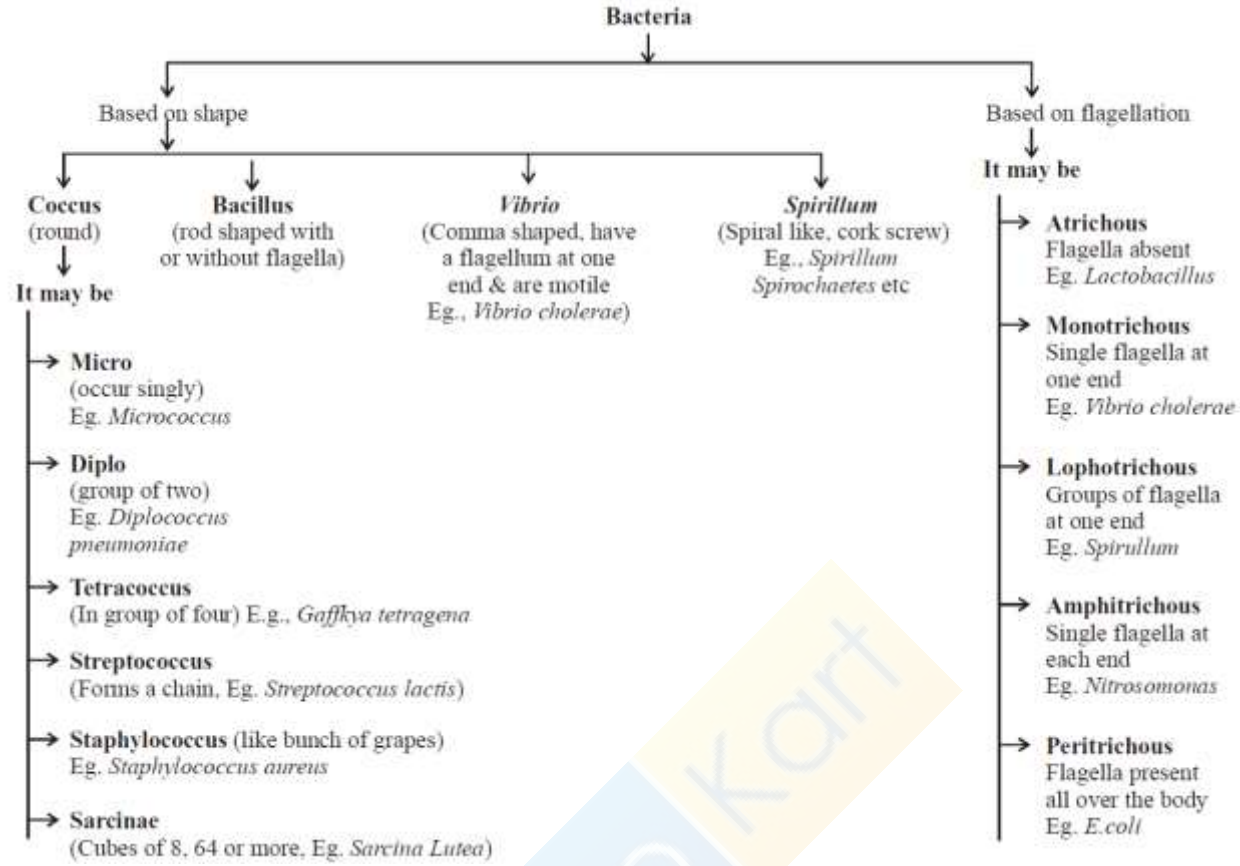
Characters	Five Kingdoms				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non-cellulosic (Polysaccharide + amino acid)	Present in some	Present (without cellulose)	Present (with cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multiceullar/ loose tissue	Tissue/organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosynthetic and photosynthetic) and Heterotrophic (saprophytic/ parasitic)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic / Saprophytic etc.)
Mode of reproduction	Conjugation	Gamete fusion & conjugation	Fertilization	Fertilization	Fertilization

KINGDOM MONERA

- Monera (Monos - single) includes prokaryotes.
- They are typically unicellular organisms (but one group is mycelial).
- The genetic material is naked circular DNA, not enclosed by a nuclear envelope.
- Ribosomes and simple chromatophores are the only subcellular organelles in the cytoplasm. The ribosomes are 70S. Mitochondria, plastids, golgi apparatus, lysosomes, endoplasmic reticulum, centrosome, etc. are lacking.
- Sap vacuoles do not occur. Instead, gas vacuole may be present.
- The predominant mode of nutrition is absorptive but some groups are photosynthetic (holophytic) and chemosynthetic.
- The organisms are non-motile or move by beating of simple flagella or by gliding.
- Flagella, if present, are composed of many intertwined chains of a protein **flagellin**. They are not enclosed by any membrane and grow at the tip.
- Moneran cells are microscopic (1 to few microns in length).
- Most organisms bear a rigid cell wall (peptidoglycan).
- Reproduction is primarily asexual by binary fission or budding. Mitotic apparatus is not formed during cell division.
- It includes bacteria, actinomycetes, mycoplasma and cyanobacteria.

BACTERIA

- Bacteria are the smallest free living organisms which are mostly unicellular.
- Bacteria was discovered by Leeuwenhoek in pond water and in tartar scraped from teeth.
- Compared to many other organisms, bacteria as a group shows the most extensive metabolic diversity. Some of the bacteria are autotrophic, i.e., they synthesize their own food from inorganic substrates. They may be photosynthetic autotrophic or chemosynthetic autotrophic. The vast majority of bacteria are heterotrophs, i.e., they do not synthesise their own food but depend on other organisms or on dead organic matter for food.
- Bacteria are grouped under four categories based on their shape: the spherical **Coccus**, the rod-shaped **Bacillus**, the comma-shaped **Vibrio** and the spiral **Spirillum**.



Flow chart 2.6 : Types of bacteria based on shape & flagellation

STRUCTURE OF BACTERIAL CELL

- **CAPSULE** : In a large number of bacteria, a slimy capsule is present outside the cell wall. It is composed of polysaccharides and the nitrogenous substances (amino acids) are also present in addition. This slime layer becomes thick called **capsule**. The bacteria, which form a capsule, are called **capsulated** or **virulent bacteria**. The capsule is usually found in parasitic forms, e.g., Bacillus anthracis, Diplococcus pneumoniae, Mycobacterium tuberculosis.

- **CELL WALL** : All bacterial cells are covered by a strong, rigid cell wall. Therefore, they are classified under plants. Inner to the capsule, cell wall is present. It is made up of polysaccharides, proteins and lipids.

In the cell wall of bacteria, there are two important sugar derivatives i.e., **NAG** and **NAM** (N-acetylglucosamine and N-acetyl muramic acid) and besides L or D-alanine, D-glutamic acid and diaminopimelic acid are also found.

- **PLASMA MEMBRANE** : Each bacterial cell has plasma membrane situated just internal to the cell wall. It is a thin, elastic and differentially or selectively permeable membrane. It is composed of large amounts of phospholipids, proteins and some amounts of polysaccharides but lacks sterols. It is characterized by possessing respiratory enzymes.

- **CYTOPLASM** : The cytoplasm is a complex aqueous fluid or semi fluid ground substance (matrix) consisting of carbohydrates, soluble proteins, enzymes, coenzymes, vitamins, lipids, mineral salts and nucleic acids. The organic matter is in the colloidal state.

The cytoplasm is granular due to the presence of a large number of ribosomes. Ribosomes in bacteria are found in the form of polyribosome. Membranous organelles such as mitochondria, endoplasmic reticulum, golgi bodies, lysosomes and vacuoles are absent. In some photosynthetic bacteria, the plasma membrane

gives rise to large vesicular thylakoids which are rich in bacteriochlorophylls and proteins.

- **NUCLEOID** : It is also known as genophore, naked nucleus, incipient nucleus. There is nuclear material DNA which is double helical and circular. It is surrounded by some typical protein (polyamine) but not histone proteins. Histones (basic proteins) are altogether absent in bacteria.

- **PLASMID** : In addition to the normal DNA chromosomes, many bacteria (e.g., E.coli) have extra chromosomal genetic elements or DNA. These elements are called plasmids. Plasmids are small circular double stranded DNA molecules. The plasmid DNA replicates independently maintaining independent identity and may carry some important genes. Plasmid term was given by Lederberg (1952). Some plasmids are integrating into the bacterial DNA chromosome called episomes.

There are 3 types of plasmids :

- **F-factor or fertility factor** : It is responsible for transfer of genetic material.
- **R-factor or resistance factor** : It provides resistance against drugs.
- **Colicinogenic factor** : It produces colicines which kill other bacteria.

- **FLAGELLA** : These are fine, thread-like, protoplasmic appendages which extend through the cell wall and the slime layer of the flagellated bacterial cells. These help bacteria to swim about in the liquid medium.

Bacterial flagella are the most primitive of all motile organs. Each is composed of a single thin fibril as against the 9+2 fibrillar structure of eukaryotic cells. The flagellum is composed entirely of flagellin protein.

- **PILI OR FIMBRIAE** : Besides flagella, some tiny or small hair-like outgrowths are present on bacterial cell surface. These are called pili and are made up of pilin protein. They measure about 0.5 – 2 μm in length and 3 – 5μm in diameter. Fimbriae take part in attachment like holding the bacteria to solid surfaces.

Some sex pili act as conjugation canals through which DNA of one cell passes into the other cell.

STAINING OF BACTERIA

- **SIMPLE STAINING** : The coloration of bacteria by applying a single solution of stain to a fixed smear is termed simple staining. The cells usually stain uniformly.

- **GRAM STAINING** : This technique was introduced by Hans Christian Gram in 1884. It is a specific technique which is used to classify bacteria into two groups Gram +ve and Gram –ve. The bacteria are stained with weakly alkaline solution of crystal violet. The stained slide of bacteria is then treated with 0.5 percent iodine solution. This is followed by washing with water or acetone or 95% ethyl alcohol. The bacteria which **retain the purple stain are called as Gram +ve**. Those which become **decolourised and appear in red colour are called Gram –ve**. In general, the wall of Gram +ve bacteria have simpler nature as compared to Gram –ve bacteria. E.coli is a Gram –ve bacteria. Gram negative bacterium can be seen with other stain safranin.

Gram positive bacteria : E.g., Pneumococcus, Streptococcus, Staphylococcus, Bacillus, Clostridium, Mycobacterium, Streptomyces.

Gram negative bacteria : E.g., Salmonella, Pseudomonas, Escherichia, Haemophilus, Helicobacter, Vibrio, Rhizobium.

NUTRITION IN BACTERIA

- On the basis of mode of nutrition, bacteria are grouped into two broad categories - **autotrophic** and **heterotrophic** bacteria.

- ***Autotrophic bacteria*** are able to synthesize their own food from inorganic substances, as green plants do. Their carbon is derived from carbon dioxide. The hydrogen needed to reduce carbon to organic form comes from sources such as atmospheric H_2, H_2S or NH_3.
- ***Heterotrophic bacteria*** can not synthesize their own organic food. They are dependent on external organic materials and require atleast one organic compound as a source of carbon for their growth and energy.
- Heterotrophic bacteria are of three types - **parasites**, **saprophytic** and **symbionts**.
- ***Parasitic bacteria*** live in contact with other living beings for obtaining nourishment or special organic compounds required for growth.
- ***Saprophytic bacteria*** are living bacteria which obtain food from organic remains, e.g., animal excreta, fallen leaves, vegetables, etc.
- ***Symbiotic bacteria*** live in mutually beneficial association with other organisms. Eg., E.coli.

ARCHAEBACTERIA

- These bacteria are special since they live in some of the most harsh habitats such as extreme salty areas (**halophiles**), hot springs (**thermoacidophiles**) and marshy areas (**methanogens**).
- Archaebacteria differ from other bacteria in having a different cell wall structure and this feature is responsible for their survival in extreme conditions.
- In halophiles, a purple pigmented membrane containing bacteriorhodopsin is developed in sunlight, which utilizes light energy for metabolic activities, e.g., Halobacterium and Halococcus.
- Thermoacidophiles are aerobic bacteria and have the capacity to oxidize sulphur to H_2SO_4 at high temperature and high acidity, e.g., Sulfobolus and Thermoplasma.
- Methanogens are present in the guts of several ruminant animals such as cows and buffaloes and they are responsible for the production of methane (biogas) from the dung of these animals.

EUBACTERIA (TRUE BACTERIA)

- These are characterized by the presence of a rigid cell wall, and if motile, a flagellum.
- The **cyanobacteria** (also referred to as blue-green algae) have chlorophyll a similar to green plants and are photosynthetic autotrophs.
- Cyanobacteria reproduce asexually by fission and fragmentation. Sexual reproduction is totally absent.
- The cyanobacteria are unicellular, colonial or filamentous, marine or terrestrial algae. The colonies are generally surrounded by gelatinous sheath. They often form blooms in polluted water bodies. Some of these organisms can fix atmospheric nitrogen in specialized cells called **heterocysts**, e.g., Nostoc and Anabaena.

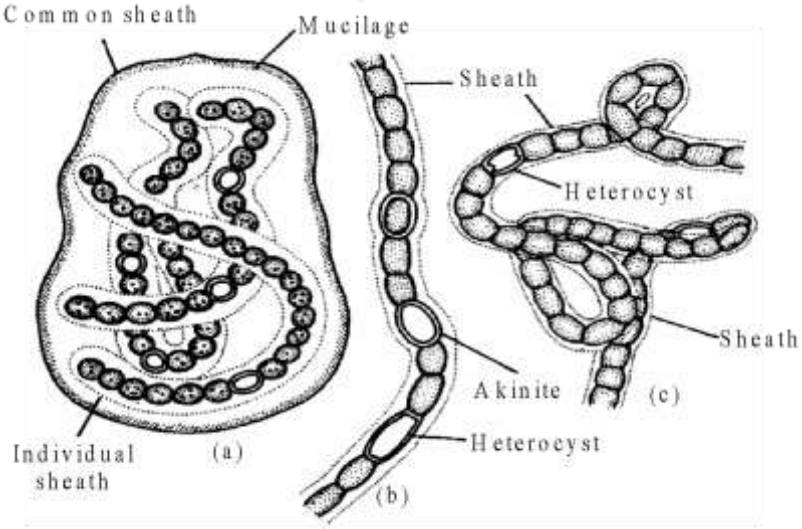


Fig. : Nostoc

- **Chemosynthetic autotrophic bacteria** oxidize 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.
- **Heterotrophic bacteria** are most abundant in nature. The majority are important decomposers. Many of them have a significant impact on human affairs. They are helpful in making curd from milk, production of antibiotics, fixing nitrogen in legume roots, etc. Some are pathogens causing damage to human beings, crops, farm animals and pets. Cholera, typhoid, tetanus, citrus canker are well known diseases caused by different bacteria.
- Bacteria reproduce mainly by fission. Sometimes, under unfavourable conditions, they produce spores. They also reproduce by a sort of sexual reproduction by adopting a primitive type of DNA transfer from one bacterium to the other.

MYCOPLASMA

- Mycoplasmas are organisms that completely lack a cell wall. These are the smallest living cells known and can survive without oxygen. Many Mycoplasma are pathogenic in animals and plants.
- Unit membrane is made up of lipoprotein. The genetic material is a single, linear, double stranded molecule of DNA, without a nuclear envelope.
- Mycoplasma hominis causes pleuropneumonia, inflammation of genitals and endocarditis, etc. Mycoplasma pneumoniae causes PAP (primary atypical pneumonia), haemorrhagic, laryngitis, etc. Mycoplasma fermentatus and M. hominis cause infertility in man, otitis media (inflammation of the middle ear).
- Mycoplasma mycoides causes pneumonia in cattle. Mycoplasma bovigenitalum causes inflammation of genitals in animals. Mycoplasma agalactiae causes agalactia of sheep and goat.
- Common mycoplasmal diseases of plants are : Bunchy top of papaya, witches' broom of legumes, yellow dwarf of tobacco, stripe disease of sugarcane, little leaf of brinjal, clover phyllody, big bud of tomato etc.

KINGDOM PROTISTA

- All single-celled eukaryotes are placed under Protista, but the boundaries of this kingdom are not well defined.
- Members of protista are primarily aquatic. This kingdom forms a link with the others dealing with plants, animals and fungi. Being eukaryotes, the protistan cell body contains a well defined nucleus and other membrane-bound organelles. Some have flagella or cilia.
- Protists reproduce asexually and sexually by a process involving cell fusion and zygote formation. It may be photosynthetic, holotropic, saprotrophic, parasitic and symbionts. Some have mixotrophic nutrition (holotropic + saprobic). The photosynthetic, floating protists are collectively called **phytoplankton**. The free-floating, holozoic protozoans are collectively termed **zooplankton**.
- Unicellular protists have been broadly divided into three major groups :
  - **Photosynthetic protists** : e.g., dinoflagellates, diatoms, euglenoids.
  - **Consumer protists** : e.g., slime moulds or myxomycetes.
  - **Protozoan protists** : e.g., zooflagellata, sarcodina, sporozoa, ciliata.

CHRYSOPHYTES

- This group includes diatoms and golden algae (desmids).
- They are found in fresh water as well as in marine environments. They are microscopic and float passively in water currents (plankton).
- The reserve food material is oil and a polysaccharide-chrysolaminarin (or leucosin).
- In diatoms, the cell walls form two thin overlapping shells, which fit together as in a soap box. The walls are embedded with silica and thus, the walls are indestructible. Thus, diatoms have left behind

large amounts 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. Diatoms are the chief ‘producers’ in the oceans.

DINOFLAGELLATES

- These organisms are mostly marine and photosynthetic.
- They appear yellow, green, brown, blue or red depending on the main pigments present in their cells. The cell wall has stiff cellulose plates on the outer surface.
- Most of them have two flagella; one lies longitudinally and the other transversely in a furrow between the wall plates. Very often, red dinoflagellates (Example: Gonyaulax) undergo such rapid multiplication that they make the sea appear red (red tides). Toxins released by such large numbers may even kill other marine animals such as fishes.
- The reserve food material is starch in fresh water forms and oil in marine forms.
- Dinoflagellates reproduce asexually through cell division or by the formation of zoospores and cysts.
- If sexual reproduction occurs, it is **isogamous** or **anisogamous**. Two cells conjugate by a conjugation canal where the two amoeboid gametes fuse to form a diploid zygote. Life cycle involves zygotic meiosis (e.g., Ceratium, Gymnodinium etc.) or gametic meiosis (e.g., Noctiluca).

EUGLENOIDS

- Majority of them are freshwater organisms found in stagnant water.
- These protists are devoid of cellulose cell wall. The body is covered by thin and flexible pellicle.
- They have two flagella, a short and a long one. Though they are photosynthetic in the presence of sunlight, when deprived of sunlight they behave like heterotrophs by predating on other smaller organisms. Interestingly, the pigments of euglenoids are identical to those present in higher plants. Example: Euglena.
- The two flagella join with each other at a swelling called paraflagellar body. An orange-red coloured eyespot or stigma is located at the base of flagellum attached to the membrane of the reservoir at the level of paraflagellar body. They contain red pigment astaxanthin. Both paraflagellar body and eye spot act as photoreceptors and direct the organism towards the optimum light.
- Sexual reproduction has not yet been definitely proved. Under favourable conditions, euglenoids multiply by longitudinal binary fission.
- Euglena is a connecting link between animals and plants.

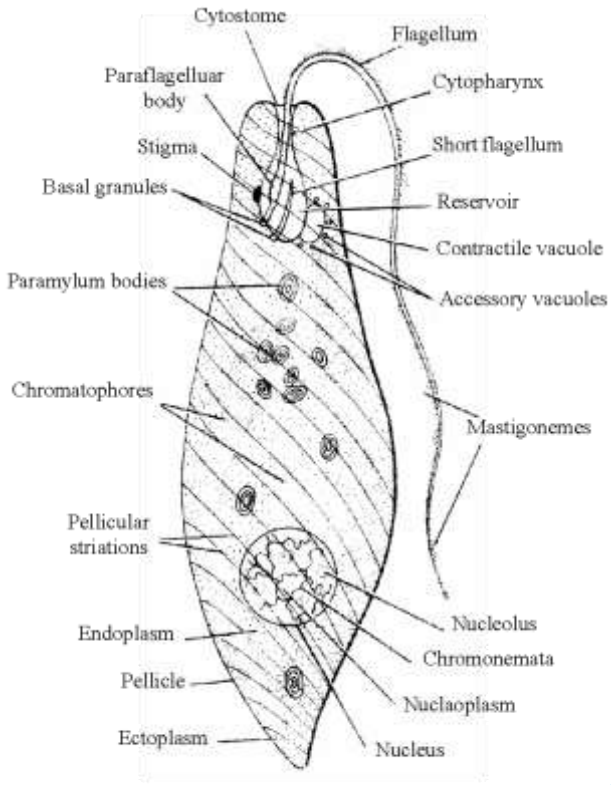


Fig : Euglena

Fig. : Euglena

SLIME MOULDS

- Slime moulds are **saprophytic protists**. The body moves along decaying twigs and leaves engulfing organic material.
- Under suitable conditions, they form an aggregation called Plasmodium which may grow and spread over several feet. During unfavourable conditions, the Plasmodium differentiates and forms fruiting bodies bearing spores at their tips. The spores possess true walls. They are extremely resistant and survive for many years, even under adverse conditions. The spores are dispersed by air currents.
- Slime moulds are of two types : acellular and cellular

ACELLULAR (PLASMODIAL) SLIME MOULDS

- Acellular slime moulds commonly grow as slimy masses on damp places rich in dead and decaying organic matter.
- The somatic phase is diploid and consists of a free living organic matter with multinucleated protoplasm called plasmodium.
- The Plasmodium slowly streams or glides over decaying organic matter putting out blunt finger like pseudopodia showing amoeboid movement.
- They also absorb dissolved organic substances from the substratum showing saprotrophic nutrition.
- Under unfavourable conditions, the plasmodium contracts and gets surrounded by thick horny wall. It is called sclerotium.
- Each plasmodium reproduces asexually by the formation of several, small, sessile or stalked, brightly coloured sporangia.
- The multinucleated protoplasm of sporangium is cleaved to produce a large number of small uninucleate spores.

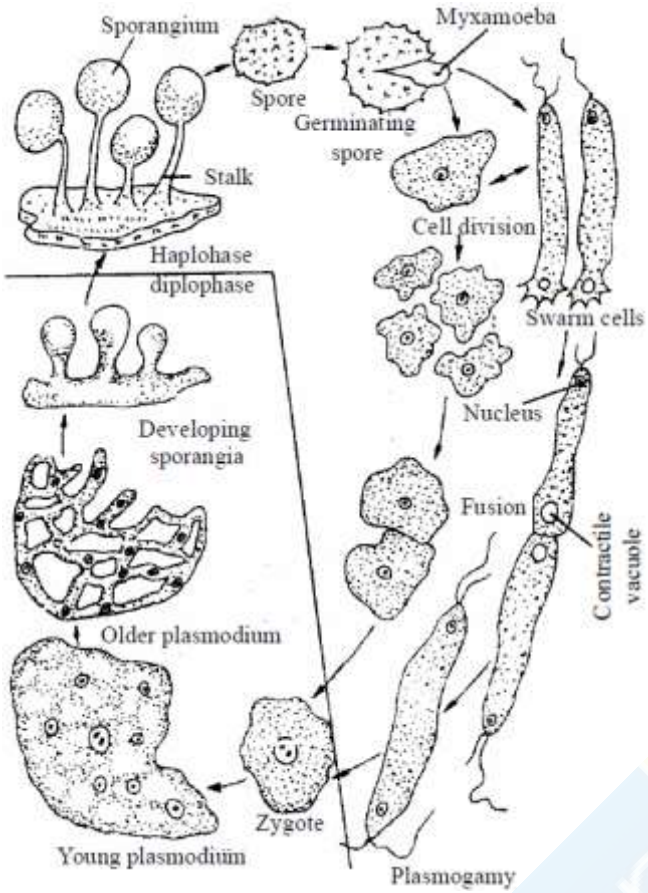


Fig. : Life cycle of Acellular Slime mould (e.g., Physarum)

CELLULAR SLIME MOULDS

- The cellular slime moulds occurs in the form of haploid uninucleated, naked (without cell wall) cell covered by plasma membrane. These cells are called myxamoebae or swarm cells.
- The myxamoebae move freely with the help of amoeboid movement and phagotrophic or holozoic nutrition.
- They grow and divide to form a large population of individuals.
- Under unfavourable conditions, a myxamoebae secrete a rigid cellulose wall to form the microcyst. Microcyst formation is a means of perennation.

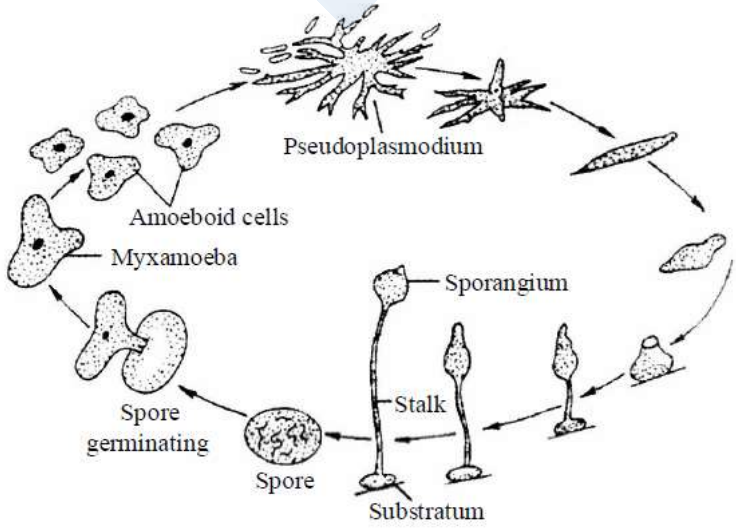


Fig. : Life cycle of cellular slime mould

PROTOZOANS

- Protozoa is the 3rd largest phylum. It is one celled body performed all the biological activities like multicellular animals. So they are termed as "acellular" organism, proposed by Dobell.
- Protozoans were first studied by Leeuwenhoek and the name protozoa was coined by Goldfuss.
- Study of protozoans is known as **Protozoology**.
- Protozoa are world wide, cosmopolitan mostly microscopic, aquatic, terrestrial , free living (Amoeba) or parasitic (Plasmodium), solitary or colonial (Proterospongia).
- Body level of organisation of protozoans is protoplasmic level. It consists of uninucleate or multinucleate protoplasm mostly naked or some have body bounded by delicate membrane or a firm pellicle; test, lorica or shell. In few groups of protozoa $CaCO_3$ & silica shell's exoskeleton is found. E.g. Radiolarian group & foraminifera group.
- Number of nuclei vary from one to many. Few show nuclear dimorphism, e.g. Paramecium. Body performs all necessary biological activity so in them subcellular-physiological division of labour is found.
- Locomotion is by means of
  - Finger-like Pseudopodia, e.g. Amoeba.
  - Whip like Flagella, e.g. Euglena.
  - Hairy cilia, e.g. Paramecium
  - By contraction
  - No motion
- Nutrition of protozoans are mainly **holozoic** (Amoeba), **mixotrophic** (Euglena), **parasitic**, **saprozoic** (Plasmodium) and digestion is intracellular which take place in food vacuole.
- Respiration and excretion take place by exchange of gases through body surface. Some excretion may occur through contractile vacuole.

Nitrogenous waste is ammonia. Some freshwater protozoans get rid of excess water through 'contractile vacuole known as osmoregulation. Amoeba has one and Paramecium has two vacuoles.

- Reproduction takes place by asexual & sexual method
  - **Asexual reproduction** by Binary fission (Amoeba), Transverse fission (Paramecium), Longitudinal fission (Trypansoma, Euglena), Multiple fission (Plasmodium), Budding (Amoeba)
  - **Sexual reproduction** by syngamy (Plasmodium) and conjugation (Paramecium). Some also form cysts which help in unfavourable condition for reproduction of an organism. They do not have natural death because in unicellular animals there is no division of somatoplasm & germplasm so these are considered as immortal.

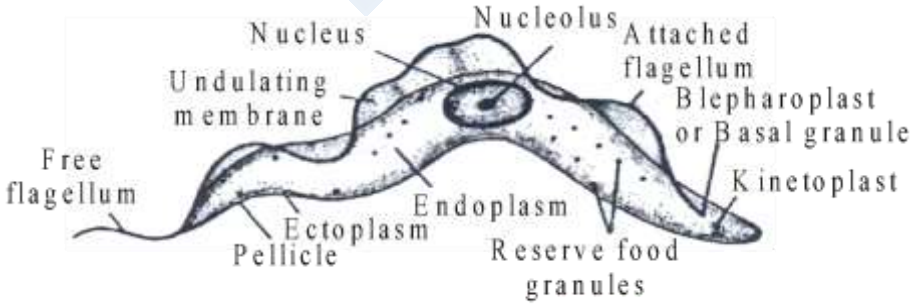


Fig. : *Trypanosoma gambiense*

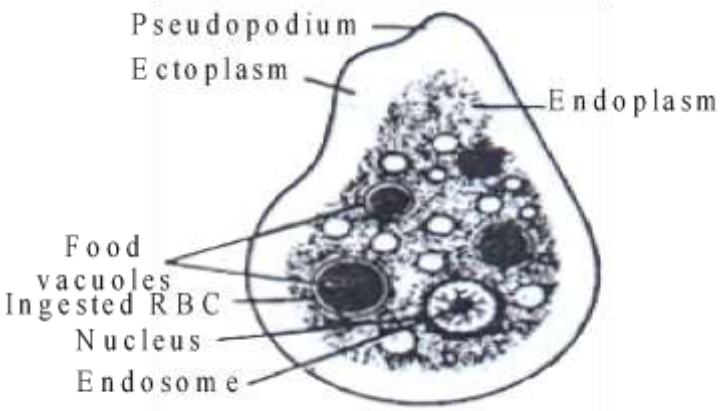


Fig. : Trophozoite of *Entamoeba histolytica*

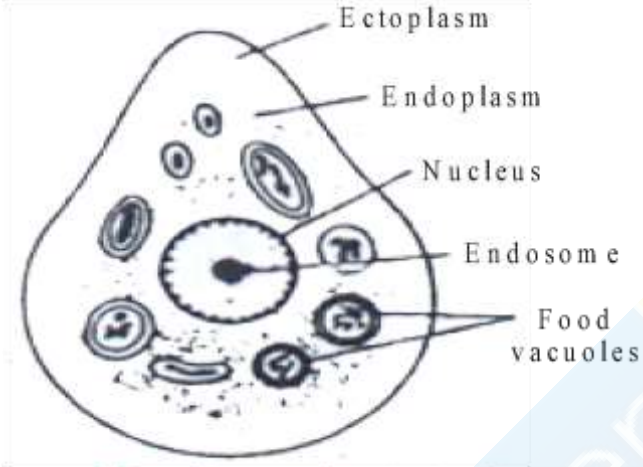


Fig. : *Entamoeba gingivalis*

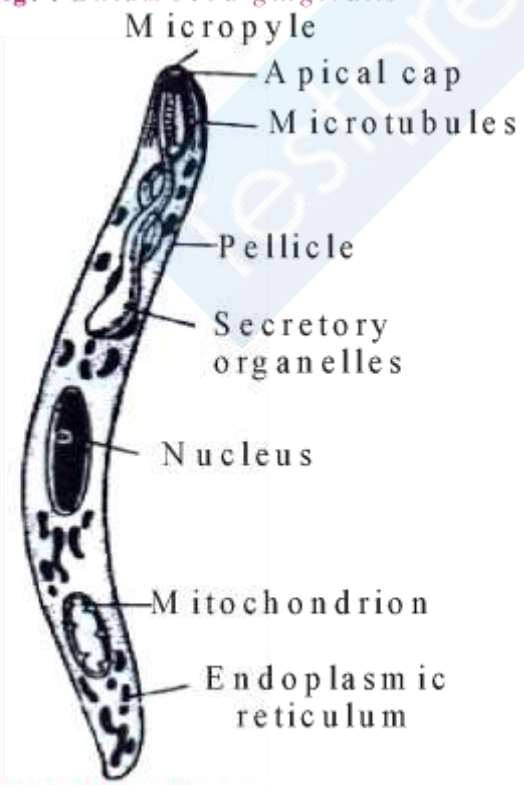


Fig. : Ultra structure of a Sporozoite of *Plasmodium*

- Protozoa are divided into four major groups on the basis of locomotory organelles.

- Amoeboid protozoans
- Flagellated protozoans
- Ciliated protozoans
- Sporozoans

AMOEBOID PROTOZOANS

- These organisms live in freshwater, sea water or moist soil. They move and capture their prey by putting out pseudopodia (false feet) as in Amoeba. Marine forms have silica shells on their surface. Some of them such as Entamoeba are parasites.
- Amoeba belongs to the class sarcodina or rhizopoda of the phylum protozoa.
- The most common species is Amoeba proteus. Proteus is the name of the mythical sea god who could change shape.
- Body is covered by plasmalemma. It is a trilaminar and selectively permeable membrane. Plasmalemma is excretory, ammonia diffuses out through it. It is also respiratory as diffusion of oxygen and carbon dioxide takes place through it.
- Pseudopodia are found in Amoeba and leucocyte of higher animals.
- Locomotion of Amoeba is known as amoeboid movement.
- Digestion in Amoeba is intracellular. Amoeba secretes digestive enzymes for hydrolysing starch, protein, fat etc.
- Food vacuole of Amoeba is analogous to the alimentary canal of an animal or gastrovascular cavity of Hydra. The contents of food vacuole in Amoeba first becomes acidic and alkaline.
- Amoeba responds to environmental conditions. Response to the stimuli is called taxis. Different taxis are **thermotaxis** (temperature), **phototaxis** (light), **thigmotaxis** (touch), **chemotaxis** (chemicals), **galvanotaxis** (electric current), **geotaxis** (gravity) and **rheotaxis** (water current).

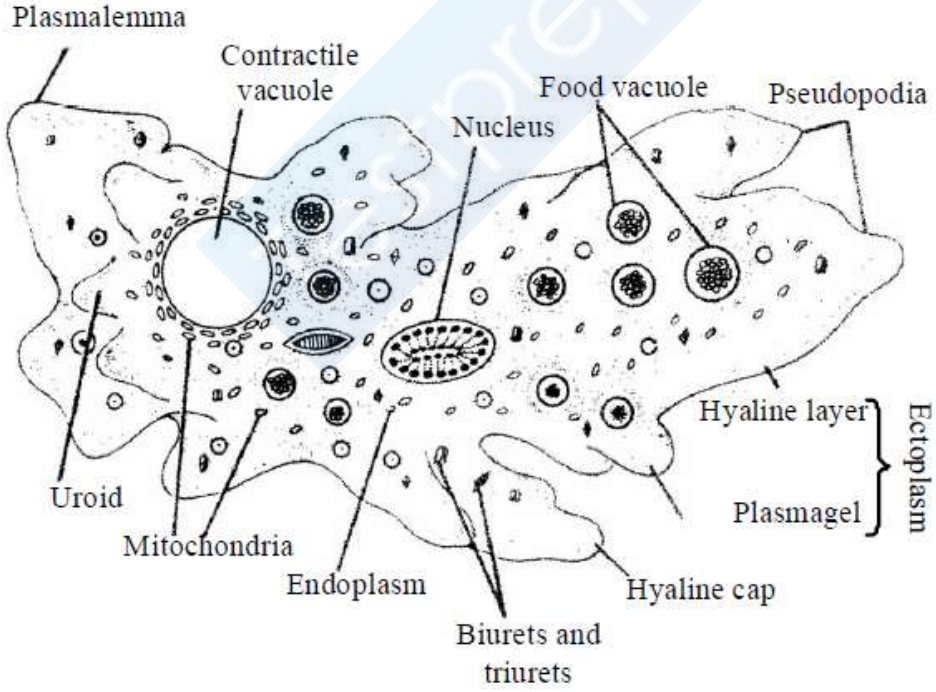


Fig. : Amoeba

FLAGELLATED PROTOZOANS

- The members of this group are either free-living or parasitic. They have flagella.

- Trypanosoma gambiense is the parasitic zooflagellate which causes one of the deadliest ailments in human beings called **African sleeping sickness** or **Trypanosomiasis**. It was discovered by Frode in 1901.
- Trypanosoma is usually found in the blood of vertebrates, finally invading cerebrospinal fluid.
- Trypanosoma reproduces asexually by longitudinal binary fission. It does not form cysts.
- Trypanosoma is an endoparasite, blood parasite, extracellular parasite.
- Trypanosoma is digenetic, that is, it completes its life cycle in two hosts. The primary or principal or definite host is man and the intermediate or secondary host or vector is the insect, tse-tse fly or bug.

CILIATED PROTOZOANS

- These are aquatic, actively moving organisms because of the presence of thousands of cilia. Example: Paramecium.
- Paramecium is commonly called as 'Slipper animalcule'. Body is distinguished into an oral or ventral surface and an aboral or dorsal surface.
- Body is covered with a thin, firm, flexible membrane called pellicle. Entire body surface is covered by numerous cilia, the locomotory organelles.
- Digestion in Paramecium is intracellular. Food vacuole constantly moves along a definite course (cyclosis) within streaming endoplasm. Food vacuole is digested in the cell body in acidic to alkaline media. Egestion of undigested food takes place through cytopyge or cytoproct, a temporary formed anus.
- Paramecium reproduces by transverse binary fission and nuclear reorganisation. Binary fission occurs during favourable conditions. In this process, macronucleus divides amitotically and micronucleus mitotically.

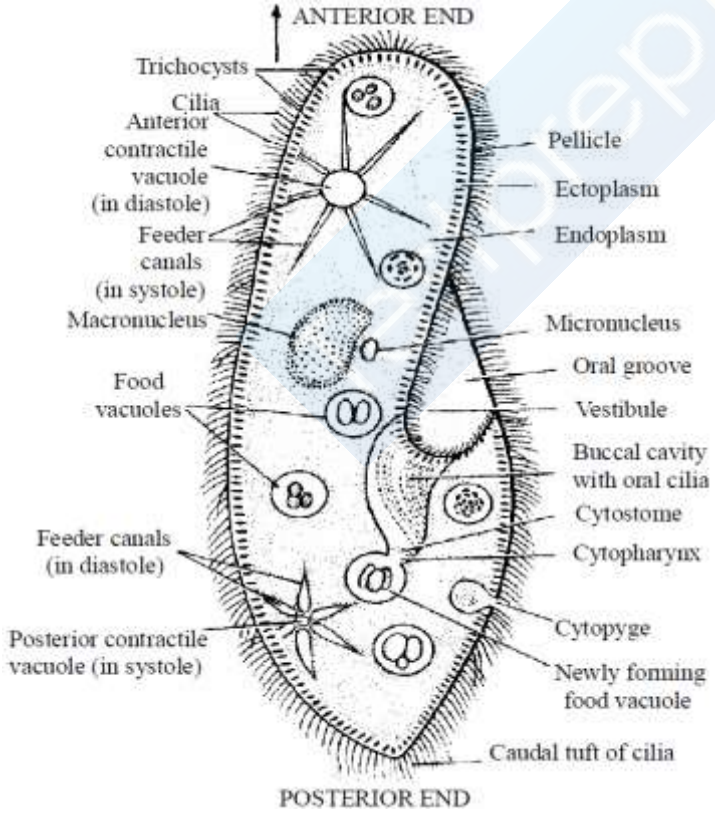


Fig. : Paramecium

SPOROZOANS

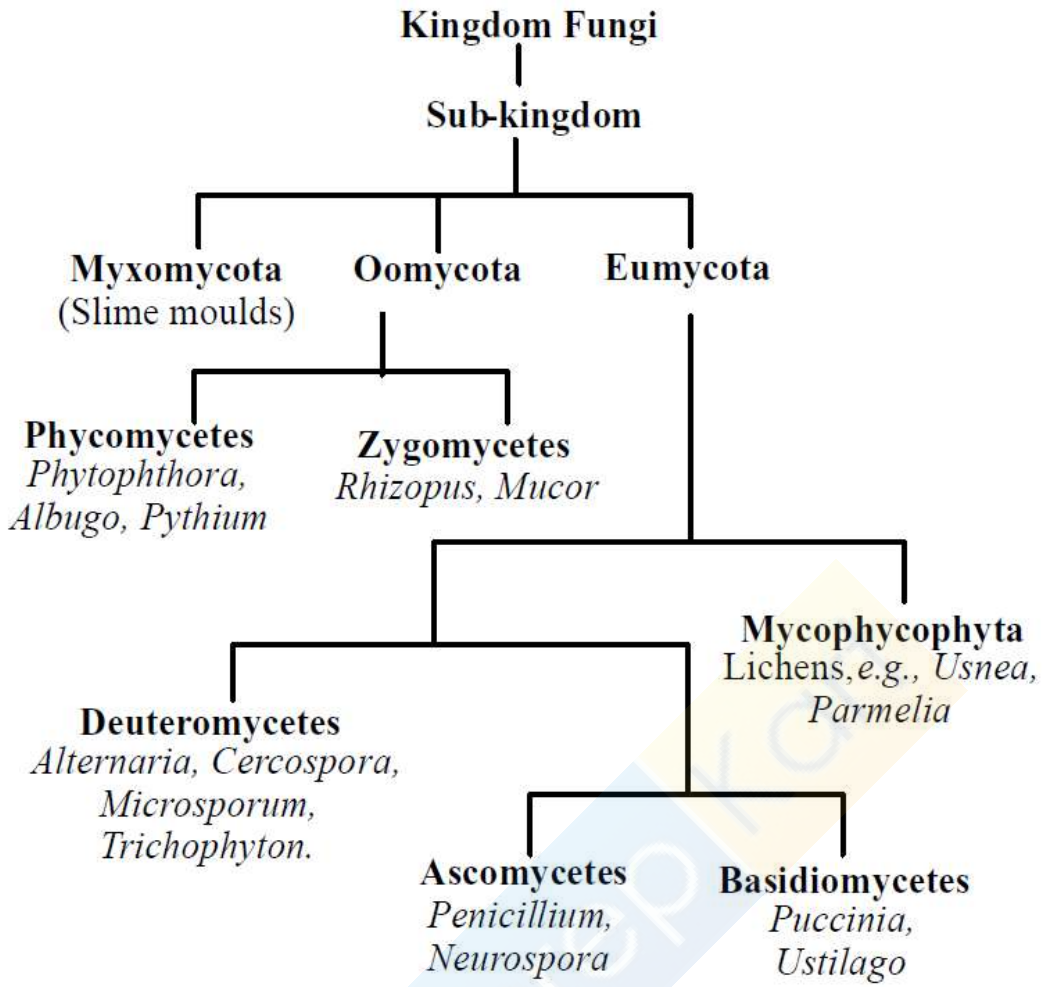
- These are spore forming parasitic protists which lack locomotory structure and contractile vacuoles. The body is covered by a pellicle or cuticle.

The most notorious is Plasmodium (malarial parasite) which causes malaria having a staggering effect on human population.

- Laveran (1880) discovered that malaria is caused by a protozoan parasite, Plasmodium vivax. Sir Ronald Ross (1896) was the first to observe oocytes of Plasmodium in female Anopheles.
- In the life cycle of Plasmodium, two important phases are present.
  - **Endogenous or Asexual phase** : passes in man.
  - **Exogenous or Sexual phase** : passes in female Anopheles mosquito.

KINGDOM FUNGI

- The fungi are a group of eukaryotic microorganisms that lack chlorophyll, are unable to synthesize their own food and are therefore heterotrophic.
- The branch of science that deals with the study of fungi is called **Mycology**.
- Fungi possess all eukaryotic organelles and reserve food particles (glycogen, lipids etc.)
- With the exception of yeasts which are unicellular, fungi are filamentous. Their bodies consist of long, slender thread-like structures called **hyphae**. The network of hyphae is known as **mycelium**. Some hyphae are continuous tubes filled with multinucleated cytoplasm – these are called coenocytic hyphae. Others have septate or cross walls in their hyphae.
- The cell walls of fungi are composed of chitin and cellulose. While, chitin is a polymer of N-acetyl glucosamine, cellulose is a polymer of D-glucose.
- Those fungi that depend on living plants and animals are called parasites. They can also live as symbionts – in association with algae as lichens and with roots of higher plants as **mycorrhiza**.
- Fungi possess true nucleus having definite nuclear envelope. The nuclear envelope persists during nuclear division.
- The fungi reproduce by all the three methods - vegetative, asexual and sexual.
- Reproduction in fungi can take place by vegetative means – fragmentation, fission and budding.
- **Asexual reproduction** is by spores called conidia or sporangiospores or zoospores, and **sexual reproduction** is by oospores, ascospores and basidiospores. The various spores are produced in distinct structures called fruiting bodies.
- The sexual cycle involves the following three steps:
  - Fusion of protoplasms between two motile or non-motile gametes called **plasmogamy**.
  - Fusion of two nuclei called **karyogamy**.
  - Meiosis in the zygote resulting in haploid spores.
- When a fungus reproduces sexually, two haploid hyphae of compatible mating types come together and fuse. In some fungi, the fusion of two haploid cells immediately results in diploid cells (2n). However, in other fungi (ascomycetes and basidiomycetes), an intervening dikaryotic stage (n + n i.e. two nuclei per cell) occurs; such a condition is called a **dikaryon** and the phase is called **dikaryophase of fungus**. Later, the parental nuclei fuse and the cells become diploid. The fungi form fruiting bodies in which reduction division occurs, leading to the formation of haploid spores.
- The classification of fungi based on the characteristics of the life cycle involved like nature of somatic phase, kinds of asexual spores, kinds of sporangia, nature of the life cycle and presence or absence of perfect or sexual stage.



Flow chart 2.7 : Classification of Fungi

PHYCOMYCETES

- Phycomycetes are algae like fungi.
- Members of phycomycetes are found in aquatic habitats and on decaying wood in moist and damp places or as obligate parasites on plants. The mycelium is aseptate and coenocytic.
- Two types of flagella are present in phycomycetes, these are whiplash and tinsel type.
- Asexual reproduction takes place by zoospores (motile) or by aplanospores (non-motile). These spores are endogeneously produced in sporangium. Zygospores are formed by fusion of two gametes. These gametes are similar in morphology (isogamous) or dissimilar (anisogamous or oogamous). Examples : Mucor , Rhizopus and Albugo (the parasitic fungi on mustard).
- **Rhizopus / Mucor** - They are cosmopolitan and saprophytic fungus, living on dead organic matter. Rhizopus stolonifer occur very frequently on moist bread, hence commonly called black bread mold.
- Mucor is called dung mold. Both are called black mold or pin mold because of black coloured pin head like sporangia. Besides, it appears in the form of white cottony growth on moist fresh organic matter, jams, jellies, cheese, pickles, etc.
- These reproduce by vegetative, asexual and sexual methods.
  - **Vegetative reproduction** takes place by fragmentation. If stolon breaks accidentally into small segments, each part grows into a new mycelium.
  - **Asexual reproduction** occurs by three types of non-motile mitospores, that is sporangiospores, chlamydospores and oidia.

- **Sexual reproduction** takes place by conjugation between two multinucleate but single celled gametangia. The gametes are isogamous and non-motile.

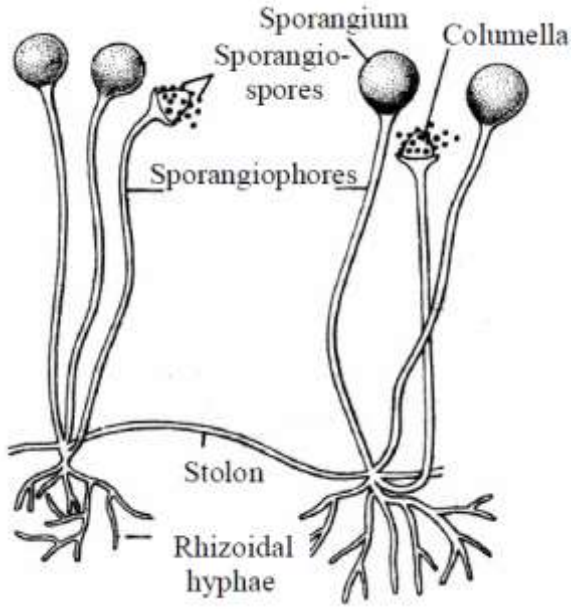


Fig. : Rhizopus

ECONOMIC IMPORTANCE

- **Spoilage of food** : Exposed bread and other food particles are spoiled by Rhizopus and Mucor species.
- **Soft rot** : Rhizopus species attack sweet potato, apple and strawberry producing soft rot or leak disease. Germinating maize grains are also attacked.
- **Mucormycosis** : Mucor pusillus and M. ramosissimus may attack internal human organs, including lungs, alimentary canal and nervous system.
- **Fermented foods** : Tempeh (a solid food from soyabean) and sufu (Chinese cheese) are prepared with the help of Rhizopus and Mucor respectively.
- **Chemicals** : Citric acid prepared by Mucor from molasses, fumaric acid and cortisone by Rhizopus stolonifer, lactic acid by R. stolonifer and R.nodosus and alcohol by R. oryzae and M. javanicus.
- **Antibiotic** : Ramysin is produced by Mucor ramannianus.
- **Wastewater treatment** : Growth of Mucor arrhizus removes heavy metal contamination of water.

ALBUGO

- Albugo is an obligate parasite and grows in the intercellular spaces of host tissues.
- It is parasitic mainly on the members of families cruciferae, compositae, amaranthaceae and convolvulaceae. The disease caused by this fungus is known as **white rust** or **white blisters**.
- The most common and well known species is Albugo candida which attacks the members of the mustard family (Cruciferae). It is commonly found on Capsella bursa pastoris (Shepherd's purse) and occasionally on radish, mustard, cabbage, cauliflower, etc. The reserve food is oil and glycogen.

ASCOMYCETES

- These are unicellular as well as multicellular fungi. In the latter, mycelium is septate.
- The asexual spores formed in chains are called conidia. These detach from the parent and form new mycelia.
- The asexual spores are conidia produced exogenously on the special mycelium called conidiophores. Conidia on germination produce mycelium. Sexual spores are called ascospores which are

produced endogenously in sac like asci (singular ascus). These asci are arranged in different types of fruiting bodies called ascocarps.

- Some examples are Aspergillus, Claviceps and Neurospora. Neurospora is used extensively in biochemical and genetic work. It is known as Drosophila of plant kingdom. Many members like morels and buffles are edible and are considered delicacies.
- **Yeast** was first described by Antony Von Leeuwenhoek in 1680. Yeast are non-mycelial or unicellular, small and either spherical or oval in shape.
- Under favourable conditions, yeast grow rapidly and form false mycelium or **pseudomycelium**. Individual cells are colourless but the colonies may appear white, red, brown, creamy or yellow.
- The single cell of yeast is about 10 μm in diameter. It is enclosed in a delicate membrane which is not made up of fungal cellulose but is a mixture of two polysaccharides known as mannan and glycogen.
- Yeast reproduces by **vegetative** or **asexual** and **sexual** methods.
- Yeast reproduce vegetatively either by budding or by fission.
- **Sexual reproduction** in yeasts takes place during unfavourable conditions, particularly when there is less amount of food.

The sex organs are not formed in yeasts and the sexual fusion occurs between the two haploid vegetative cells or two ascospores which behave as gametes. The two fusing gametes are haploid and may be isogamous or anisogamous. Such kind of sexual reproduction is called **gametic copulation**. It is the best example of **hologamy** i.e., the entire vegetative thallus is transformed into reproductive body. The sexual fusion leads to the formation of diploid zygote. The zygote behaves as an ascus and forms 4 – 8 haploid ascospores. These liberate and function as vegetative cells.

ECONOMIC IMPORTANCE

- **Useful activities**
  - Baking industry : Yeast are used in the manufacture of bread. Kneaded flour is mixed with yeast and allowed to ferment. Yeast convert starch into sugars and sugar into CO_2 and alcohol with the help of enzyme zymase. CO_2 is released when effervescence takes place due to which bread becomes spongy and gets swollen and is of light weight.
  - Brewing industry : Brewer's yeast or Beer yeast is Saccharomyces cerevisiae and wine yeast is Saccharomyces ellipsoideus. These perform alcoholic fermentation.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Zymase}]{\text{Yeast}} \underset{\text{Ethyl alcohol}}{C_2H_5OH} + 2CO_2$$

  - Food yeast : Yeast from brewing industry is harvested and used as food yeast. It is rich in protein and vitamin-B (Riboflavin).
- **Harmful activities**
  - Fermentation of fruits and fruit juices by yeast cells makes their taste unpleasant.
  - Parasitic species of yeast like Nematospora causes diseases in tomato, cotton and bean.
  - Parasitic yeast cause diseases in human beings (e.g., cryptococcosis, blastomycosis and torulosis)

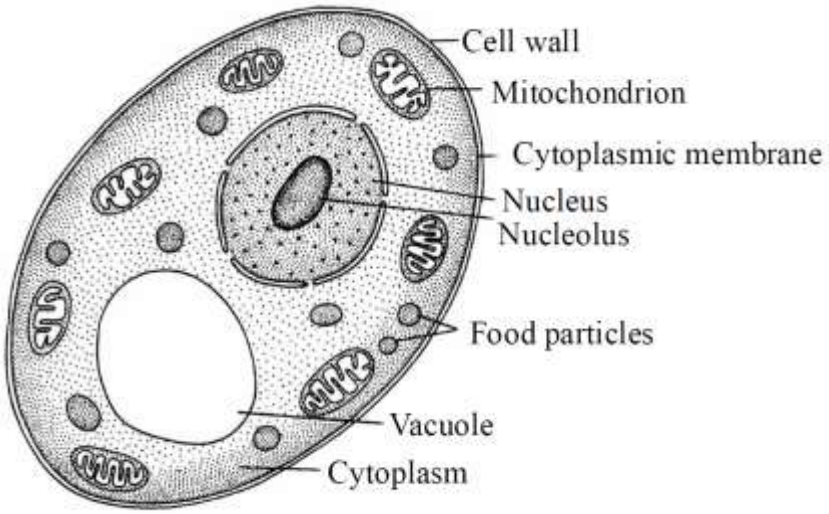


Fig. : Yeast Cell

BASIDIOMYCETES

- Basidiomycetes are commonly known as club fungi.
- It resembles the ascomycetes in having a septate mycelium and production of non-motile spores.
- Commonly known forms of basidiomycetes are mushrooms, bracket fungi or puffballs. They grow in soil, on logs and tree stumps and in living plant bodies as parasites, e.g., rusts and smuts. The mycelium is branched and septate.
- The asexual spores are generally not found, but vegetative reproduction by fragmentation is common. The sex organs are absent, but plasmogamy is brought about by fusion of two vegetative or somatic cells of different strains or genotypes. The resultant structure is dikaryotic which ultimately gives rise to basidium. Karyogamy and meiosis takes place in the basidium producing four basidiospores. The basidiospores are exogenously produced on the basidium. The basidia are arranged in fruiting bodies called basidiocarps.
- The dikaryotic cells divide by **clamp connections**. A lateral pouch or clamp like outgrowth arises which projects downward like a hook. The two nuclei now undergo conjugate division in such a way that-one spindle lies parallel to the long axis of the cell and the other somewhat obliquely. As a result, one daughter nucleus enters into the clamp.
- Some common members are Agaricus (mushroom), Ustilago (smut) and Puccinia (rust fungus).

DEUTEROMYCETES

- It is commonly known as **imperfect fungi** because only the asexual or vegetative phases of these fungi are known.
- The deuteromycetes reproduce only by asexual spores known as conidia. The mycelium is septate and branched. Some members are saprophytes or parasites while a large number of them are decomposers of litter and help in mineral cycling.
- Examples : Alternaria, Colletotrichum, Trichoderma, Fusarium, Helminthosporium oryzae, Cercospora personata.

SOME COMMON NAMES OF FUNGI

- Myxomycetes - Slime fungi or slime or mycocetozoa
- Eumycetes - True fungi
- Phycomycetes - Algal fungi or aquatic fungi
- Ascomycetes - Sac fungi
- Basidiomycetes - Club fungi (e.g. Saprolegnia)

- Allomyces - Water molds or aquatic fungi (e.g. Blastocladiella)
- Pythium - Damping off fungus
- Mucor - Black or Bread mold
- Mucor mucedo - Dung mold
- M. Stolonifer - Bread mold
- Penicillium - Green or blue mold
- Pezzia - Cup fungi
- Polyporus - Pore fungi
- Morchella - Morel or sponge mushroom
- Agaricus campestris - Common edible mushroom
- Poisonous mushroom - Toadstool
- Coprinus comatus - Inky cap mushroom
- Synchytrium - Chytrid
- Aspergillus - Conidial fungus
- Neurospora - Red bread mold or Bakery mold or Genetical fungus or Drosophila of plant kingdom
- Puccina - Rust fungus
- Ustilago - Smut fungus
- Lycoperdon - Puffball or Earth star
- Cyathus, Nidula - Bird's nest fungi
- Nidularia - Fairy purse
- Pernospora - Downy mildew
- Aspergillus niger - Black mold or weed of laboratory
- Saccharomcyes crevisiae - Yeast of commerce
- Marasimus oreaders - Fairy rings fungi
- Yeast - SCP, sprouting fungi, sugar fungi
- Mucor stolonifer - Bread mold
- Claviceps - Ergot fungi
- Marchella - Edible sac fungi
- Auricularia - Jelly fungi
- Dictyophora - Stinkhorn fungi duplicate
- Fomes - Shelf fungi
- Clavicornona - Coral fungi
- Armillariella mellea - Honey mushroom
- Psilocybe geastrum - Hallucinogenic fungi
- Astraeus - Earth stars
- Labryrinthula - Net slime molds
- Rhizopus - Conjugation fungi

SOME IMPORTANT ANTIBIOTICS

	Antibiotic	Fungi
1.	Penicillin B	*Penicillium notatum*
2.	Notatin or Panetin	*P. notatum*
3.	Penicillin	*P. chrysogenum*
4.	Gresioflavin	*P. genseni*
5.	Citrinin	*P. citrinum*
6.	Flavisin	*Aspergillus flavus*

KINGDOM PLANTAE

- Kingdom plantae includes all eukaryotic chlorophyll-containing organisms commonly called plants.
- Cells are surrounded by cell wall and contain cellulose.
- Reserve food is starch in green algae and embryophytes, floridean starch in red algae and laminarian in brown algae.
- Growth occurs due to the presence of definite growing points or cells. In higher forms, growing areas are called meristems.
- A multicellular embryo is formed during development from the zygote. Life cycle consists of alternating haploid gametophyte and diploid sporophyte generation. This phenomenon is called alternation of generations.
- August Wilhelm Eichler (1883), a Vinnese botanist, divided plant kingdom into two sub-kingdoms mainly on the basis of presence or absence of seeds.
  - **Cryptogamae** are lower plants in which sex organs are hidden and seeds and flowers are absent. It includes **thallophytes**, **bryophytes**, **pteridophytes**.
  - **Phanerogamae** are higher plants in which sex organs are evident; seeds present. It includes gymnosperms and angiosperms.
- In modern system of classification like Whittaker (1969), fungi, lichens and bacteria are excluded from this group and are placed in separate kingdoms.

KINGDOM ANIMALIA

- This kingdom is characterized by heterotrophic eukaryotic organisms that are multicellular and their cells lack cell walls.
- Animals have heterotrophic mode of nutrition.
- They require oxygen for aerobic respiration.
- Animals are able to make rapid responses to external stimuli as a result of the activity of nerve cells, muscle or contractile tissue or both.
- Animal life cycle includes stages of embryonic development. Mitotic cell divisions (cleavage) transform the animal zygote into a multicellular embryo.
- **Anaemia** are animals without red blood, e.g., sponges, cnidaria, mollusca, arthropoda, echinodermata, etc.
- **Enaima** are animals with red blood, e.g., vertebrates.
- **Vivipara** are those animals which give birth to young ones, e.g., man, dogs, cows, etc.
- **Ovipara** are those animals which lay eggs, e.g., frogs, toads, lizards, snakes, birds, etc.
- **Anamniotes** are vertebrates without embryonic membranes e.g., fishes, amphibians.
- **Amniotes** are vertebrates with embryonic membranes (chorion, amnion, allantois, yolk sac) e.g., reptiles, birds, mammals.
- **Acraniata or protochordata** are chordates without cranium (brain box). It includes urochordata and cephalochordata.
- **Chordates** are animals with notochord, dorsal tubular nerve cord, paired pharyngeal gill slits. All urochordates, cephalochordates and vertebrates are called chordates.
- **Craniata or vertebrates** are chordates with cranium. It includes cyclostomes, pisces, amphibians, reptiles, birds and mammals.
- **Non-chordates** are animals without a notochord (a rod like elastic structure which supports the body). Phylum porifera to phylum hemichordata are called non-chordates.
- **Invertebrates** are animals without vertebral column (backbone). All the non-chordates, urochordates and cephalochordates are collectively called invertebrates.

VIRUSES, VIROIDS AND LICHENS

- The term 'virus' has been derived from Latin, which means poison or venom or viscous fluid. They remain inactive outside a living host but become active inside the host and multiply in it.
- **D.J. Ivanowsky** (1892) recognised certain microbes as causal organism of the mosaic disease of tobacco. These were found to be smaller than bacteria because they passed through bacteria-proof filters.
- **M.W. Beijerinek** (1898) demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants and called the fluid as Contagium vivum fluidum (infectious living fluid).
- **W.M. Stanley** (1935) showed that viruses could be crystallised and crystals consist largely of proteins. They are inert outside their specific host cell.
- In addition to proteins, viruses also contain genetic material, that could be either RNA or DNA.
- A virus is a nucleoprotein and the genetic material is infectious. In general, viruses that infect plants have single stranded RNA and viruses that infect animals have either single or double stranded RNA or double stranded DNA.
- Bacterial viruses or bacteriophages (viruses that infect bacteria) are usually double stranded DNA viruses and contain lysozyme enzyme.

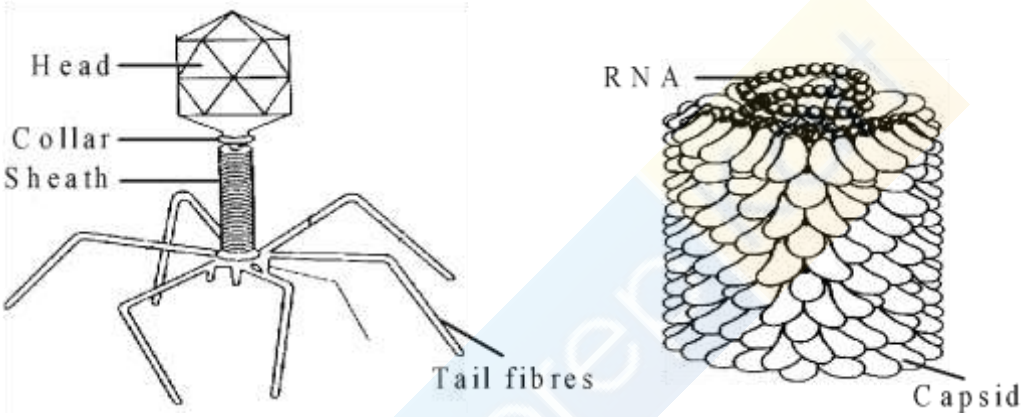


Fig. : (a) Bacteriophage; (b) Tobacco Mosaic Virus (TMV)

- The protein coat called a capsid made of small subunits called capsomeres, protects the nucleic acid. These capsomeres arranged in helical or polyhedral geometric forms possess antigenic properties.
- Viruses cause diseases like mumps, smallpox, herpes and influenza. AIDS in humans is also caused by a virus. In plants, the symptoms can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.
- In 1971, T.O. Diener discovered very simple smallest infectious agents called Viroids. They consist of RNA and capsid is lacking. The RNA of the viroid was of low molecular weight. They cause persistent infections.
- A lichen is structurally organised entity consisting of the permanent association of a fungus and an alga. The algal component is known as phycobiont and fungal component as mycobiont, which are autotrophic and heterotrophic, respectively.
- Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner.
- Lichens reproduce both by asexual and sexual methods.
- Lichens are very sensitive to SO_2 and grow only in SO_2 free atmosphere.

Table : Diseases and their causal organisms

Human diseases		
	Disease	**Causal organism**
1.	Paratyphoid	*Salmonella paratyphi*
2.	Gastroenteritis	*Salmonella* sp. and *Escherichia coli*
3.	Dysentery	*Shiegella dysenteriae, S. sonnei, S. boydii*
4.	Influenza	*Haemophilus influenzae*
5.	Pneumonia	*Diplococcus pneumoniae*
6.	Typhoid	*Salmonella typhosa*
7.	Cholera	*Vibrio cholerae*
8.	Plague (Black death)	*Pasteurella pestis*
9.	Gonorrhoea	*Neisseria gonorrhoeae*
10.	Diarrhoea	*Bacillus coli*
11.	Gangarin	*Clostridium perfringens*
12.	Whooping cough	*Haemophilus pertussis*
13.	Tetanus (lockjaw)	*Clostridium tetani*

Plant diseases		
	Disease	**Casual organism**
1.	Wilt of maize	*Xanthomonas stewartii*
2.	Ring rot of potato	*Corynebacterium.*
3.	Canker of tomato	*Corynebacterium michiganense*
4.	Leaf spot of Lady's finger	*Xanthomonas esculenti*
5.	Hairy rot of apple	*Agrobacterium rhizogenes*
6.	Soft rot of potato	*Pseudomonas solanacearum*
7.	Citrus canker	*Xanthomonas citri*
8.	Bacterial blight of paddy	*Xanthomonas oryzae*
9.	Potato wilt	*Pseudomonas solanacearum*
10.	Fire blight of apple and peach	*Erwinia amylovora*
11.	Crown gall of sugar beet	*Agrobacterium tumefaciens*
12.	Black rot of cabbage	*Xanthomonas compestris*