

Biological Classification

- * Earlier man classified living organisms based on his needs for Food, Clothing and Shelter.
- * **Aristotle** was the first person to classify organisms scientifically based on morphological characters. He classified plants into **Herbs, Shrubs and Trees**. He also classified animals into two groups as animals **with Red blood** and without **Red blood**.

Two Kingdom Classification

- * It was given by **Linnaeus**. It has **Plant** and **Animal Kingdoms**. This classification had been in use till recent years.
- * It was easy to understand and easy to classify organisms.
- * He placed organisms **with cell wall** in Plant kingdom and **without cell wall** in Animal Kingdom.
- * He placed Bacteria, Algae, Fungi, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms in Plant kingdom because of presence of cell wall.

Demerits:

1. This classification is based on only one character i.e. presence or absence of cell wall.
 2. Several organisms do not fall into either of these categories because they exhibit both plant and animal characters. Ex: Euglena lacks cell wall but carries out photosynthesis like plants and heterotrophic like animals.
 3. This system does not separate Prokaryotes and Eukaryotes. Bacteria and Blue Green Algae are prokaryotes placed along with Eukaryotes of plants.
 4. There is no separation of autotrophs and heterotrophs. Fungi, which are heterotrophs, are placed along with autotrophic plants like angiosperms and algae.
 5. Unicellular and multicellular organisms are placed together. Plant kingdom has unicellulars like Chlamydomonas and multicellulars like angiosperms together. Similarly animal kingdom has unicellular protozoans and multicellular phyla like Chordata together.
 6. Unicellular Chlamydomonas and Multicellular Spirogyra are placed in Algae.
 7. Though fungi have differences with other plants in showing heterotrophic nutrition and Chitinous cell wall they are not separated but kept along with the plants. Other plants of the kingdom have cellulosic cell wall and show autotrophism.
- * Due to the above demerits, a need was felt to include the characters like cell structure, Nature or cell wall, Mode of nutrition, Habitat, Reproduction methods, evolutionary relationships for classification besides morphological characters.
 - * In the successive classification systems, though both plant and animal kingdoms are retained, the groups included in these kingdoms have been changed because the criteria considered for classification have been changed from time to time.
 - * The number and nature of other kingdoms have been understood differently by different scientists over time.

Five Kingdom Classification

- * It was given by Whittaker. The kingdoms are Monera, Protista, Fungi, Plantae and Animalia.
- * Kingdom Monera includes all Prokaryotes. These have all types of nutritions.
- * Kingdom Protista has unicellular organisms. These show both autotrophism and heterotrophism.
- * Kingdom Plantae has Multicellular autotrophic photosynthetic organisms
- * Kingdom Fungi has only fungi which have chitinous cell wall and heterotrophic nutrition.
- * Kingdom Animalia has multicellular animals.

The following table gives comparative account of the five kingdoms.

Characters	Five Kingdoms				
	Monera	Protista	Plantae	Fungi	Animalia
1. Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
2. Nuclear envelope	Absent	Present	Present	Present	Present
3. Cell Wall	Present or absent. If present non-cellulosic made of Mureins are Pseudomureins	Present or absent. If present it is usually cellulosic	Present and Cellulosic	Present and usually Chitinous	Absent
4. Body organization	Unicellular	Unicellular	Multicellular with tissues and organs	Multicellular/ loose tissues	Multicellular with tissues, organs and organ systems.
5. Mode of Nutrition	Photoautotrophic Chemoautotrophic Photoheterotrophic Chemoheterotrophic(Parasitic, Saprophytic)	Autotrophic, Heterotrophic	Photoautotrophic	Heterotrophic and non-photosynthetic	Heterotrophic

Kingdom Monera

- * The taxon Monera was proposed by **Haeckel** as Phylum of Protista but raised to kingdom rank by **Chatton**. Monera has the following features.
 1. These are usually unicellular or mycelial (Actinomycetes).
 2. Cells are prokaryotic because nuclear membrane is absent. Nucleus is called as nucleoid.
 3. Membrane bound organelles like plastids, mitochondria, lysosomes are absent. But 70S ribosomes are present.
 4. True vacuoles are absent but Gas vacuole may be present.
 5. Reserve food is glycogen, volutin granules, poly-Betahydroxy butyrate etc.
 6. Histone proteins are usually absent but archaea have histones.
 7. Flagella do not show 9 + 2 structure.
 8. Nutrition is predominantly absorptive and heterotrophic but some show photosynthetic and chemoautotrophic nutrition.
 9. Reproduction takes place by Binary fission or budding. Sexual reproduction is absent but show genetic recombination by primitive type of sexual process like transformation, conjugation and transduction.

10. These are usually non-motile or move by flagella and gliding.
 11. These are microscopic and usually 1 to few microns in size.
 12. Cell wall is present. Absent in Mycoplasmas. It is made of Mureins or Pseudomureins but not cellulosic.
 13. They show much diversity in metabolism
- * Monerans include Archaea, Eubacteria, Cyanobacteria, Actinomycetes, Mycoplasmas etc.

Archaeobacteria

- * These are Monerans which can tolerate extreme conditions such as high acidic conditions (Acidophiles E.g. *Sulpholobus*), high temperature (thermophiles – *Methanopyruskandleri*), high salt concentrations (Halophiles - *Halobacterium*), oxygen lacking conditions (Methanogens - *Methanobacterium*). Methanogens are present in oxygen lacking conditions like marshes and rumen of cattle and release methane from organic matter. They are termed as Extremophiles. They exhibit the following characters.
1. They have Surface layer known as S-layer with glycoproteins or proteins. It is in the form of monolayer and has hexagonal protein or glycoprotein structures and resists the bacteria from low pH and lytic enzymes.
 2. Cell wall lacks mureins but Pseudomureins are present in the cell wall having L-amino acids as tetrapeptides, N-acetyl glucosamine and N-acetyl Talosamine Uronic acid in β 1,3 linkage. Hence lysozyme cannot attack this cell wall. NAT is associated with L-amino acids such as Glutamic acid, Alanine, Lysine and Glutamic acid. Thermoplasma is Cell wall less
 3. Cell membrane has L-Glycerol in phospholipids and the fatty acid chain is linked to the Glycerol by Ether bonding and the fatty acid chain has branched isoprene units having 5C. This imparts high resistance to archaens. The lipids are tetraether lipids in thermoplasma which can tolerate high temperatures
 4. The chromosome is circular with double stranded DNA associated with histone proteins.
 5. Ribosomes are of 70S type and sensitive to Diphtheria toxin which inactivates eEF₂ on ribosome and inhibits protein synthesis (similarity with eukaryotes).
 6. The first amino acid involved in protein synthesis is Methionine like in Eukaryotes
 7. Its tRNA lacks Thymine
 8. They do not have pathogenic nature.
 9. Chlorophyll based photosynthesis is absent.

Eubacteria

- * These are most abundantly present Monerans and first discovered by Leeuwenhoek.
- * They are ubiquitous. They live as free living, symbiotic, parasitic and saprophytic organisms. Some are anaerobes and others are aerobes. Some of them occur in extreme habitats such as hot springs, Ice Mountains, deserts, deep oceans etc.
- * They basically occur in four different shapes i.e. Cocci, Bacilli, Vibrios and Spirillae. Some are pleomorphic and some are filamentous.

- * Some Eubacteria have a continuous polysaccharide covering around the cell wall known as Glycocalyx. It may be loose sheath known as slime layer or compact and closely investing structure called Capsule which is meant for attaching to the rocks in aquatic environment or host cell.
- * Cell wall has peptidoglycan or mureins. It has polymer of NAG and NAM linked by β 1-4 glycosidic bond. The NAM is associated with an oligopeptide.
- * Gram +ve bacteria have Teichoic acid in its cell wall.
- * Cell membrane has globular finger like infoldings consisting of vesicles, tubules, lamellae known as mesosomes which help in DNA replication, Septum formation, respiration etc.
- * Cells may be Trichous or Atrichous. If trichous flagella may be one or more than one. Flagellum does not show 9 + 2 structure but made of proteins called as Flagellin.
- * The genetic material is double stranded circular DNA not associated with histones and not covered by nuclear membrane. It is called as Nucleoid or incipient nucleus.
- * In some strains of bacteria extrachromosomal DNA rings ranging 1 to 100 per cell known as Plasmids or Episomes are present. These have genes for Fertility, Antibiotic resistance, toxins and pathogenesis.
- * Membrane bound organelles are absent. Photosynthetic bacteria have chlorophyll containing Chlorobium vesicles associated with cell membrane or lamella like invaginations of cell membrane with pigments involved in photosynthesis.
- * Protoplasm has 70S ribosomes occurring singly or as polysomes or attached to cell membrane.
- * These bacteria show most extensive metabolic diversity. Some bacteria are Photoautotrophic (Chlorobium), some are Photoheterotrophic (Rhodospirillum), some are Chemoautotrophic (Nitrifying bacteria) and still others are Chemoheterotrophs as symbionts, parasites and saprophytes. Bdellovibriobacteriovorous is parasitic on other harmful bacteria. Chemosynthetic bacteria oxidise inorganic substances and the liberated energy is used for ATP production. These play a role in recycling of materials.
- * Most of the heterotrophs are saprophytes. Some saprophytes help in the formation of curd from milk (Lactic acid bacteria). Some bacteria like Bacillus produce antibiotics. Parasitic bacteria cause diseases in man, animals and plants.
- * Cholera is caused by Vibrio cholera, Tetanus by Clostridium tetani, Typhoid by Salmonellatyphi.
- * Citrus canker is caused by Xanthomonas axonopodis pv. Citri.
- * In favourable conditions, bacteria reproduce by binary fission once in 18-20 minutes.
- * In unfavorable conditions it reproduces by Endospore formation.
- * They reproduce by a type of primitive sexual process called Conjugation or Transformation and Transduction.

Cyanobacteria

- * These are also called as Blue-Green algae.
- * These are mainly present in Paddy fields.
- * These are photosynthetic autotrophs similar to green plants and release oxygen in photosynthesis. These have Chlorophyll a which is needed for oxygen evolution in photosynthesis.
- * These are unicellular (Chroococcum), colonial (Microcystis) or filamentous (Spirulina, Nostoc, Anabaena). These are aquatic or terrestrial.
- * These are most primitive organisms showing oxygenic photosynthesis.
- * Filament or trichome or colony or cell is covered by mucilaginous sheath. Hence these are also called as Myxomycetes.
- * Protoplasm is divided into central colorless centropiasm with chromatin material and peripheral pigmented chromoplasm.
- * Filaments have specialized colorless cells meant for nitrogen fixation called **Heterocysts** (Nostoc, Anabaena).
- * They asexually reproduce by Hormogonia or thick walled Akinetes.
- * Flagella are absent. They do not reproduce sexually.
- * The red color of red sea is due to a phycobilin known as Phycoerythrin in the BGA known as *Trichodesmium erythrum*.

Mycoplasmas

- * These were discovered by Nocard and Roux. The term Mycoplasma was first used by Frank. These are previously known as **PleuroPneumoniaLikeOrganisms**.
- * These belong to class Mollicutes of Monera.
- * They lack cell wall.
- * These are non-motile. Some may show gliding motility.
- * These do not have definite shape. These are pleomorphic.
- * Colonies of these organisms show **Fried egg** like appearance on culture plates.
- * These are penicillin resistant and sensitive to detergents.
- * They measure 0.3 to 0.8 μ in size.
- * These are usually facultative anaerobes and some are obligate anaerobes.
- * They require sterols for their growth. Sterol is present in their membrane.
- * They do not show complete TCA cycle.
- * *Mycoplasma genitalium* causes urethritis in man. Phytoplasma causes witches broom in plants. Mycoplasma mycoides causes Pleuropneumonia in Cattle.

Actinomycetes

- * These are filamentous Monerans.
- * Filaments are branched.
- * These are mainly present in the soil. They live as Decomposers and form humus. Their activity gives characteristic odour to soil after rain.
- * These are Gram +ve aerobic bacteria.
- * They reproduce asexually by conidiospores and sporangiospores.
- * These are non-flagellate. Spores may be flagellate.
- * These form radiating colonies in cultures.
- * Cell wall has Mycolic acid (*Mycobacterium*).
- * *Mycobacterium tuberculosis* causes Tuberculosis, *Mycobacterium leprae* causes Leprosy, *Corynebacterium diphtheria* causes Diphtheria. *Nocardia madurae* causes Madura foot disease.
- * Species of *Streptomyces* produce several antibiotics Like Streptomycin, Cycloheximide (*Streptomyces griseus*), Chloramphenicol (*S. venezuelae*), Neomycin (*Streptomyces fradiae*), Amphotericin (*S. nodosus*), Oxytetracylin (*S. rimosus*), and Kanamycin etc.

Kingdom Protista

- * This kingdom was created by **Haeckel** and consists of Photosynthetic protists, Slime moulds and Protozoans.
- * These are first Eukaryotes evolved about 1000 million years ago. From these three kingdoms i.e. Plantae, Fungi and Animalia have evolved.

Characters

1. These are usually aquatic and form the dominant part of Planktonic organisms. It has Phytoplankton and Zooplankton. Phytoplankton carry out 80% of global photosynthesis.
2. These are unicellular or colonial.
3. These are first Eukaryotes. These have nuclear envelope and membrane bound organelles, cytoskeleton, Centrosomes, vacuoles etc.
4. Motile cells have Cilia or Flagella which show 9 + 2 structure. In some locomotion takes place with the help of pseudopodia, contractions and mucilage secretion.
5. Chromosome has Linear DNA associated with histone proteins. (Histones are absent in Dinoflagellates – Mesokaryotes).
6. Cells may be uninucleate or binucleate or multinucleate.
7. Both 80S and 70S ribosomes are present.
8. Cytoplasm shows movements.
9. Cell wall, if present contains Cellulose or Pectic layer surrounded by Siliceous walls.
10. They show Photosynthetic (dinoflagellates, Chrysophytes), Ingestive (Protozoans), Saprophytic (Slime moulds) and Parasitic mode of nutrition. Some live symbiotically in the gut of animals. Chemoautotrophism is absent.
11. Reserve food is Starch, Glycogen, Chrysolaminarin, Paramylon, Oil etc.

12. Asexual reproduction is common. It occurs by budding, Binary fission, multiple fission, Plasmotomy, Spores, Cyst formation etc.
13. Sexual reproduction is present. Sex organs do not have jacket. Karyogamy and meiosis is present. Meiosis is zygotic or gametic. Embryo is absent.
14. Mitotic apparatus is formed during cell division.

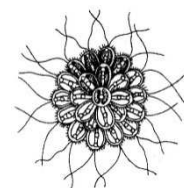
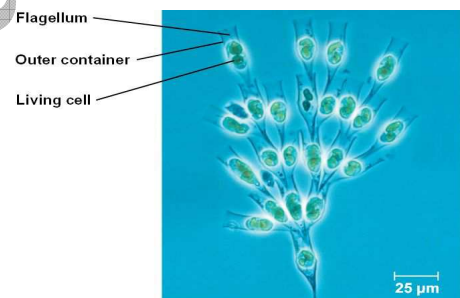
It has various groups such as Chrysophytes, Dinoflagellates, Euglenoids, Slime moulds and Protozoans.

Chrysophytes

It includes both Golden algae and Diatoms.

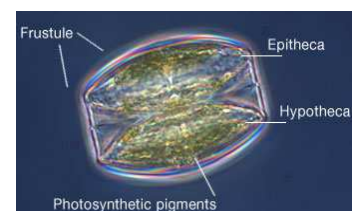
Golden algae

- * Chrysophytes, or **golden algae**, are common microscopic Chromists in fresh water. Some species are colorless, but the vast majority is photosynthetic.
- * they are primary source of food for zooplankton. They are not considered truly autotrophic by some biologists because nearly all chrysophytes become **facultatively heterotrophic** in the absence of adequate light, or in the presence of plentiful dissolved food. When this occurs, the chrysoplast atrophies and the alga may turn predator, feeding on **bacteria** or **diatoms**.
- * Most of them free-swimming and unicellular, but there are filamentous and colonial forms. Other chrysophytes may spend part of their life as amoeboid cells.
- * The individual cells may surrounded by vase-shaped **loricae**, composed of chitin fibrils and other polysaccharides as in *Dinobryon*.
- * The colonies grow as branched or unbranched chains. A spherical colonial form, *Synura*, has its surface covered by silica scales. Species which produce siliceous coverings may have bristles or scales with quite complex structure.
- * Most of the freshwater Chrysoomonads secrete **resting cysts** of silica.
- * The fossils of chrysophytes, like those of Diatoms, are often used as paleoecological indicators to reconstruct ancient environments.

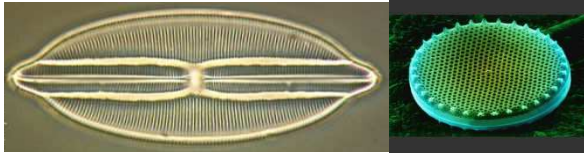


Diatoms

- * These are golden brown autotrophic protists commonly called as **Diamonds of the living world**.
- * These are fresh water as well as marine water protists.
- * These are microscopic and planktonic and float passively in water currents.
- * Most of them are photosynthetic
- * These are unicellular forms. Colonies and incipient filaments are also found (*Melosira*).



- * The cell wall has inner pectic layer which completely surrounds the protoplast and an outer silicious cell wall known as **Frustule** has two halves arranged like soap box. The upper larger halve is known as **Epitheca** and inner smaller one has **Hypotheca**. Cell wall has a longitudinal cleft known as raphe is present in gliding diatoms.
- * Cell shows bilateral (*Naviluca*) or centric symmetry (*Melosira*).



- * Cell has a central vacuole in which the diploid nucleus is suspended by cytoplasmic threads.
- * Chromatophores are one to many and present in the peripheral cytoplasm. These are discoid and have few isolated lamellae with or without pyrenoids that lack starch. They have chlorophyll **a** and **c**, Lutein, Fucoxanthin and β -carotene.
- * Reserve food is usually oil stored in the cytoplasm nearer to the chromatophore. **Volutin** globules and polysaccharide **Leucosin** is are also present.
- * These multiply by Binary fission. Each daughter cell has one parental silica halve and the new one is formed later. The size of the cells gradually decreases in successive generations as **Hypotheca** of parental cell behaves as **Epitheca** of daughter cell. When the cell size decreases to critical size, the cell forms rejuvenating spores called as Auxospores.
- * Sexual reproduction occurs in those diatom cells where there is reduction in size to a critical level. Two smaller cells come closer, contact with each other and their protoplast nuclei undergo meiosis and two haploid nuclei in each protoplast degenerate and the remaining two nuclei are involved in formation of two gametes. One of the gametes of each cell degenerates and the other one fuses with the gamete of opposing cell to form larger diploid zygote. It later enlarges, secretes a silicious cell wall to behave as vegetative cell. Gametic union is physiologically anisogamous or anisogamous. The zygote escapes from the frustule, elongates and formed as **Auxospore**. It secretes a pecticsilicious layer known as **Perizonium**. New frustule is secreted inside the perizonium and the reconstructed diatom cell is of normal size.
- * Piled up silicious cell wall in the ocean is called as **Diatomite** or **Kieselghur**. It is used in industrial filtration for clearing oils, in tooth pastes, Night visibility paints, insulater in refrigerators and as a source of Sodium silicate.

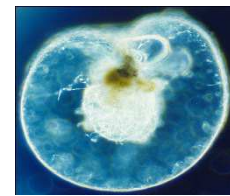
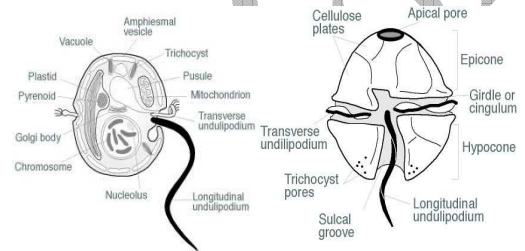
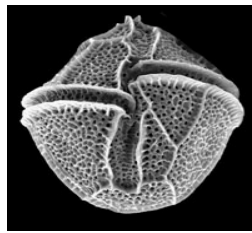
Dinoflagellates

- * These are mainly marine and photosynthetic. Some are freshwater forms. Some are symbionts (*Zooxanthella*) in otherprotists and invertebrates.
- * They are **Gloden brown**, Green, Yellow Blue and Red.
- * Cells are covered by sculptured plates of *cellulose* collectively called as **Theca**.
- * A smooth flagellum is present in the posterior longitudinal groove called as **Sulcus**. The transverse flagellum has fine attachment threads lies in transverse groovecalled as

Cingulum or **Annulus**. Since these flagella are present perpendicularly, Dinoflagellates show whirling movements and hence called as **Whirling Whips**.

- * Nucleus has **mesokaryon** structure. It has condensed chromosomes even in interphase which lacks histones but attached to nuclear envelope. Chromosomes are acentric.
- * Cell has chromatophores with **Chlorophyll a, c**, abundant fucoxanthin
- * Reserve food is **Starch** and Oil.
- * Cell has a non-contractile vacuole called as **Pusule**
- * Cell division is by **Dinmitosis** in which nuclear membrane persists. Spindle is not formed.
- * Some species show **Bioluminescence** e.g. *Noctiluca* (ghost fire, Fire of the sea)

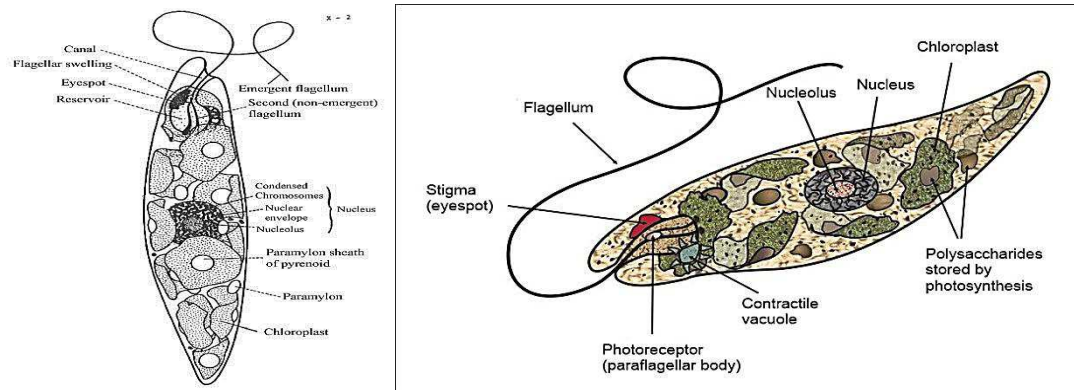
- * *Gonyaulax* is a red colored dinoflagellate which multiplies in great numbers in nutrient rich conditions and makes the sea appear red – **Red tide** in Mediterranean sea. It also releases neurotoxins that kill the fishes.



Euglenoids

- * Most of them grow in stagnant freshwater bodies.
- * These are unicellular flagellate protists
- * These are fusiform with relatively rounded anterior and pointed posterior.
- * They lack a cell wall but have a protein rich pellicle supported by microtubules.
- * The anterior part of the body has an invagination consisting of Cytostome, Cytopharynx and reservoir.
- * Deep in the reservoir one short and one elongated flagella are attached to cell membrane.
- * On the surface of reservoir an eyespot or stigma made of carotenoids is present. It filters the light falling on light detecting structure called as Paraflagellar body allowing only certain wavelength of light reaching it.
- * It has several chloroplasts with three unit membranes. Each chloroplast has a paramylumstarch storing structure called as pyrenoid. Chloroplast has chlorophyll a and b and resembles the chloroplasts of higher plants and green algae.
- * Nearer to the reservoir there is a contractile vacuole which helps in expelling excess water through the reservoir.
- * The cell is uninucleate with a distinct nucleolus and chromosomes are n highly condensed state.
- * It reproduces asexually by longitudinal or transverse binary fission and by Palmelloid stage (In unfavourable conditions, it withdraws its flagella, divides repeatedly by binary fission and each cell secretes a thick wall and all the cells are embedded in common mucilage matrix and resembles a green alga called as *Palmella*).
- * Sexual reproduction is not reported.

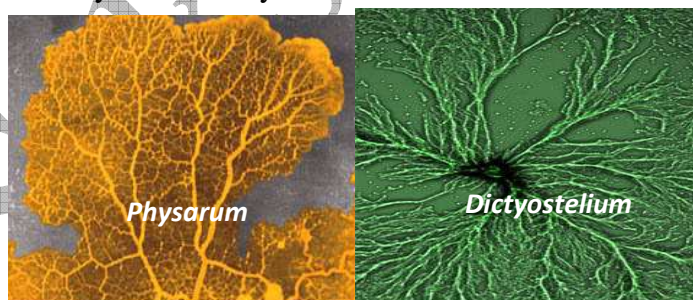
- * It shows photoautotrophic nutrition in the presence of light and heterotrophic nutrition in the absence of light by predateding other organisms



Slime Moulds

- * These are saprophytic or Consumer-Decomposer protists.
- * These are mainly present in damp shady places rich in organic matter like twigs, fallen leaves, logs and humus.
- * These lack chlorophyll and heterotrophs (Saprophytes, Phagotrophs).
- * Body of the organism has mass of protoplasm with cell membrane. If it is uninucleate, it is called as Myxamoeba (Cellular slime moulds) and multinucleate (Acellular slime moulds) one is called as Plasmodium. Myxamoebae may fuse and form multinucleate structure called as Pseudoplasmodium. It can grow up to several feet.
- * They show amoeboid movement by forming pseudopodia and engulf the organic matter like leaves.
- * Asexual reproduction takes place by binary fission, Plasmotomy, Spores, Cysts and Sclerotia. Spores have Cellulosic cell wall and resist unfavourable conditions for years.
- * Sexual reproduction is isogamous or anisogamous.
- * Meiosis is zygotic in cellular slime moulds and Gametic in Acellular slime moulds.

Ex: Physarum, Dictyostelium



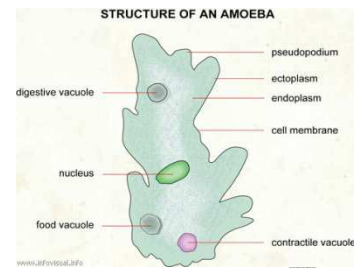
Protozoan Protists

- * These are heterotrophs and live as predators or parasites.
- * These are believed as ancestors of animals.
- * They lack cell wall. Protoplasm is surrounded by plasma membrane.
- * Glycogen is reserve food material.

These are of four types. They are

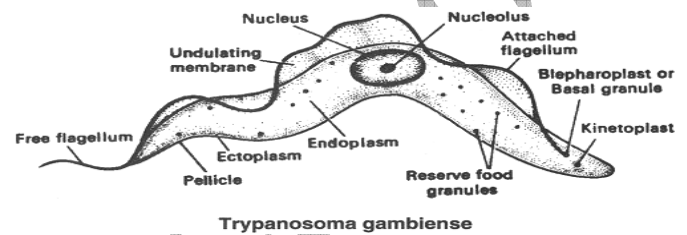
1. Amoeboid Protozoans

- * They live in moist places, freshwater and marine waters.
- * These are free living or parasites.
- * They form pseudopodia which help in movement and capturing food materials as in *Amoeba*
- * Marine forms have Silica shells on their surface.
- * *Entamoeba* is a parasite.



2. Flagellated Protozoans

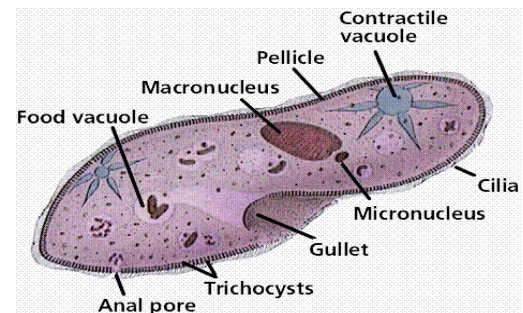
- * These have elongated coiled locomotory structures arising from protoplasm known as Flagella.
- * These are either free living or parasites.
- * Parasitic forms cause diseases like Sleeping sickness (*Trypanosoma*).



3. Ciliated Protozoans

- * These are aquatic and have thousands of short locomotory structures called as Cilia.
- * Cell has Gullet which is opened outside the cell.
- * Ciliary movement helps in steering the food into Gullet.

Ex: *Paramecium*



4. Sporozoans

- * These are diverse organisms.
- * These have infectious spore like stage in their life cycle
- * They cause dreaded diseases like malaria (*Plasmodium*)



3. Kingdom Fungi

- * Fungi are heterotrophic organisms. They live as saprophytes, parasites, symbionts (Lichens, Mycorrhizae).
- * They occur in all sorts of habitats such as water, soil, air, in the bodies of plants and animals where little moisture and warm conditions are present. Some grow on bread as molds (*Rhizopus*), some cause rot in oranges (*Alternaria*), wheat rust (*Puccinia*), white rust or spots of mustard (*Albugo*). Yeasts are used in bread and beer making. *Penicillium* used in antibiotics production. Some fungi like mushrooms are edible. Toadstools are poisonous.
- * They do not have plastids and photosynthetic pigments.
- * Yeasts are unicellular. Remaining fungi have filament like body. The filament is known as hypha. Hyphae are branched and together known as mycelium. Mycelium is aseptate and coenocytic (*Rhizopus*) or septate monokaryotic or dikaryotic (*Puccinia*, *Penicillium*).
- * Cell wall is made of chitin.
- * Reserve food materials are glycogen and oil.
- * Vegetative reproduction takes place by fragmentation, budding and fission.
- * Asexual reproduction takes place by aplanospore (sporangiospore) or zoospore and conidia formation.
- * Sexual reproduction takes place by Oospore (Thick walled sexual spore formed by the fusion of antheridium and archegonium), Ascospore and Basidiospore formation.
- * Sexual fruiting bodies are present. These are ascocarps and basidiocarps.
- * Sexual process is Gametogamy (Isogamy, anisogamy, Physiological anisogamy, Oogamy) or Gametangial union or Somatogamy.
- * In most of them the monokaryotic haploid gametes are cells fuse and form a dikaryotic cell by the union of only cytoplasm. The dikaryotic cell divides and forms a dikaryotic mycelium. In some cells the two nuclei of the cell fuse and form diploid cells. These diploid cells undergo meiosis and form meiospores which germinate and form an haploid mycelium.

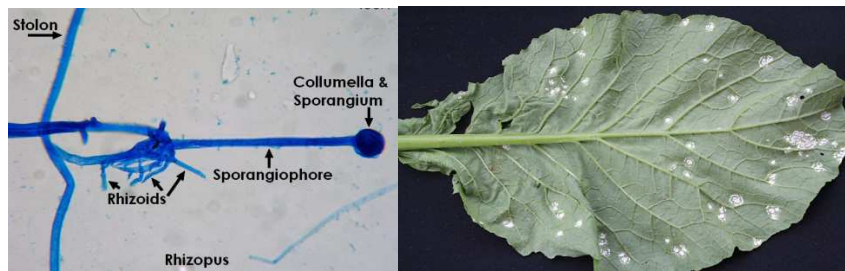
Kingdom fungi divided into four classes called as Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes on the basis of nature of mycelium, type of fruiting bodies and formation of spores.

1. Phycomycetes

- * These are commonly called as **Algae like Fungi**.
- * They occur in aquatic habitats, moist decaying wood and as obligate parasites on plants.
- * Mycelium is branched filamentous and aseptate. It is coenocytic.
- * Asexual reproduction takes place by endogenously formed aplanospores and zoospores in sporangia.
- * Sexual reproduction is isogamous, anisogamous or oogamous. It results in zygosporangium formation. Gametangial union is also present.

- * Sexual fruiting bodies are absent.

Ex: *Rhizopus* (Bread mold), *Mucor*, *Albugo* (parasitic on mustard and causes white rust).



2. Ascomycetes

- * These are commonly called as Sac fungi.
- * These are unicellular (*Saccharomyces*) and majority of them are multicellular (*Penicillium*).
- * Mycelium is branched filamentous, septate. Cells are monokaryotic or dikaryotic.
- * They live as saprophytes, parasites; decomposers and Coprophilous (grow on dung).
- * They reproduce asexually by conidia formation formed on special hyphae called as conidiophores. Conidia form mycelia upon germination.
- * Sexual reproduction takes place by gametangial contact. The male sex organ is antheridium and the female is called as **Ascogonium**. Male nuclei migrate into female gametangium and form dikaryotic cell. This dikaryotic cell divided and forms dikaryotic mycelium. This mycelial hyphae are called as ascogenous hyphae. These form fruiting bodies called as **Ascocarps**. Ascocarp has **asci**. The two nuclei of each ascus fuse and form diploid nucleus. This nucleus undergoes reduction division and forms haploid nuclei. These nuclei accumulate cytoplasm around them and develop into haploid ascospores which on germination develop into monokaryotic mycelium. Globose closed ascocarp is called as **Cleistothecium** (*Penicillium*), flask shaped ascocarp with apical opening is called as **Perithecium** (*Aspergillus*, *Claviceps*) and cup shaped is called as **Apothecium** (*Peziza*).
- * **Morels** (*Morchella*) and **Truffles** (*Tuber*) are edible.



3. Basidiomycetes

- * These are commonly called as Club fungi. These are mushrooms, toadstools, bracket fungi and puff balls.
- * They grow on moist organic rich soils, moist logs and trunks of trees and as parasites (rusts and smuts) in plants.
- * Mycelium is branched filamentous and septate. Mycelium is monokaryotic and dikaryotic. Dikaryotic mycelium has dolipore septa. And Clamp connections.
- * Vegetative reproduction takes place by fragmentation.
- * Asexual reproduction is usually absent.
- * Sex organs are absent. Sexual reproduction takes place by somatogamy between the cells of opposite strains of monokaryotic mycelia. It results in formation of dikaryotic cell and later dikaryotic mycelium. It gives rise basidium. In the basidium karyogamy takes place. The diploid nucleus undergoes meiosis and later Basidiospores are formed exogenously on the basidium.
- * The fruiting body is called as Basidiocarp.

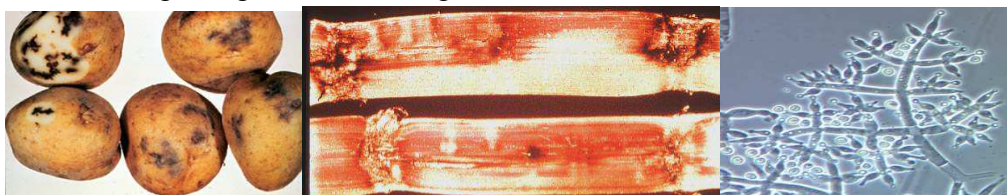
Ex: *Agaricus*, *Ustilago* (Smut fungus) *Puccinia* (rust fungus), *Polyporus* (Bracket fungus) *Lycoperdon* (Puff ball).



4. Deuteromycetes

- * These are commonly called as **Fungi Imperfecti** as they do not have sexual stage. When the sexual stage is discovered, they are mostly transferred to the actual classes. Sometimes the asexual stage is given one name and placed in Deuteromycetes and sexual stage is given other name and placed in other class.
- * Mycelium is branched filamentous and septate.
- * They reproduce asexually by conidia spore formation.
- * Some are saprophytic and some are parasites. Several are decomposers of litter and help in recycling of minerals.

Ex: *Alternaria* (Early blight of Potato), *Colletotrichum* (Red rot), *Trichoderma* (Used as biocontrol agent against other fungi)



4. Kingdom Plantae

- * These are chlorophyll containing multicellular organisms with cellulosic cell walls. These are usually Photoautotrophs.
- * Reserve food is starch.
- * They show absorptive mode of nutrition.
- * Insectivorous plants like Bladderwort and Venus Fly trap are partial heterotrophs.
- * *Cuscuta* is a parasite.
- * It has Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.

5. Kingdom Animalia

- * It has multicellular organisms without cell wall.
- * Reserve food is glycogen or fat.
- * They depend either directly or indirectly on plants for food.
- * Mode of nutrition is holozoic
- * Food is digested in internal cavity
- * They follow definite growth pattern.
- * Sensory and neuromotor mechanisms are seen.
- * Most of them show locomotion.
- * Sexual reproduction is due to copulation between male and female and embryonal development.

Six Kingdom classification

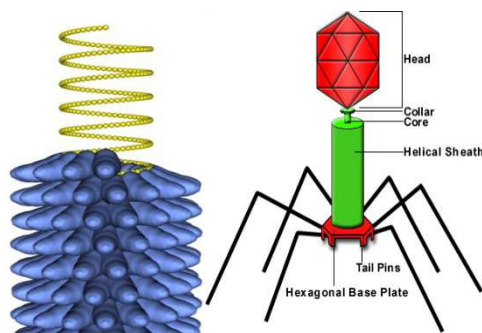
- * It was given by Carl Woese.
- * He used 16S rRNA of smaller subunit of 70S ribosome as marker to understand the evolutionary relationships.
- * He classified living world into 3 domains Bacteria, Archaea and Eukarya.
- * Domain Bacteria has kingdom Bacteria, Domain Archaea has Archaeobacteria, and Domain Eukarya has Protista, Fungi, Plantae and Animalia.
- * Bacteria, Archaea and Eukaryotes are believed to be originated from common ancestor Progenote.
- * This classification shows that archae are more related to eukaryotes than bacteria.



Viruses, Viroids, Prions and Lichens

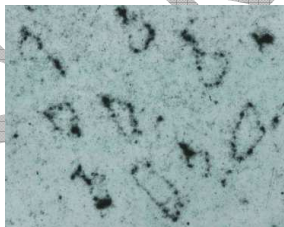
Viruses

- * The term Virus was given by Pasteur which means poison.
- * These are obligate parasites.
- * They have not given any place in the classification because they have acellular structure and inert crystal like when present outside the host. When present in the host they replicate and weaken the host and sometimes eventually kill the host.
- * They have nucleic acid and protein. The protein coat that encloses the nucleic acid is called as Capsid.
- * The nucleic acid is infectious. It is either RNA or DNA but both are not present in the same Virus.
- * Tobacco Mosaic Virus (TMV), Human Immunodeficiency Virus (HIV) are RNA containing Viruses.
- * Viruses that infect bacteria are called as Bacteriophages. These have DNA as genetic material.



Viroids

- * These are infectious nucleic acid particles discovered by Raymer and Diener. They discovered the Viroid that caused Spindle Tuber disease in Potato. Cadang-Cadang in Coconut is also caused by Viroid



- * Since protein coat is absent it is called as Viroid.
- * It has circular single stranded RNA with low molecular weight. DNA viroids are not discovered.

Prions

- * These are infectious protein particles. These were discovered by **Stanley Prusiner**.
- * These cause **Scrapie** disease of Sheep and **Madcow** disease of Cow and **Creutzfeldt–Jakob disease (CJD)** and **Kuru** in humans.



Lichens

- * Lichens are Algal-Fungal symbiotic associations.
- * Algal component is called as Phycobiont. The phycobiont prepares food for the fungus.
- * The fungal component is called as Mycobiont and it provides shelter and absorbs mineral nutrients and water for its Phycobiont.
- * These are indicators of Air pollution and do not grow in polluted areas.

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