CHAPTER: 2

BIOLOGICAL

By Nishidha

CLASSIFICATION

Process by which anything is grouped into convenient categories based on some easily observable characters

ARTIFICIAL SYSTEM OF CLASSIFICATIONS

- Early system – used only gross superficial morphological characters such as habit, colour, number & shape of leaves, etc. Based mainly on vegetative characters
- The artificial system proposed by Linnaeus was based on number of stamens & carpels published in his book Genera Plantarum (1737). → Hence it's called sexual system of classification
- It was artificial b'coz – only few floral characters based. He divided plants into 24 classes – 23 – Flowering plants (Phanerogamia) & 24 (cryptogamia)
- Aristotle was the earliest to attempt a more scientific basis for classification – used simple morphological characters → Plants (Trees, Shrubs, Herbs) Animals (Enaima (RBC), Anaima (no RBC))
- Aristotle – 'Historia Animalium' (First book of zoology)
- Also wrote Scala Naturae • Theophrastus – 480 plants in "Historia Plantarum"
- Also artificial classification → eq to vegetative & sexual (1st book of Botany)

NATURAL SYSTEM OF CLASSIFICATION

- based on natural affinities among the organisms & consider not only the external features, but also internal – ultra-structure, anatomy, embryology & phytochemistry • Based on morphology & affinities • Modern day classification employs anatomical & physiological traits • large no. of traits considered.
- Natural system of classification for Flowering Plants – George Bentham & Joseph Dalton Hooker, in 3 volumes of Genera Plantarum. → used by most of herbaria of the world. • Bentham & Hooker described 202 families
- They divided plant kingdom into 2 subkingdom – Cryptogamia (seedless) & Phanerogamia (seeded plants) → into 3 classes. • Compositae – belongs to inferae of gamopetalae. • Sub-class monochlamydae includes 8 series in which 8th series is Ordines Anomali (Families having Plants with anomalous characters). ↓ includes few orders – couldn't placed in classification
- Demerits: Gymnosperms are placed b/w dicots & monocots only bcoz convenience rather than affinities

PHYLOGENETIC SYSTEM OF CLASSIFICATION

- At present it is acceptable – based on evolutionary relationships. • This assumes – organisms belonging to the same taxa have a common ancestor.
- Phylogenetic system is based on evolution, order & ancestry, based on common evolutionary descent.
- In classification of plants, the term cladistics refers to phylogenetic classification. • cladistics is classification which is based on both evolutionary & genetic relationships. • First phylogenetic system was proposed by Engler & Prantl in monograph 'Die Natürlichen Pflanzen Familien'. Engler & Prantl classification:

Phanerogamia → Gymnospermae; Angiospermae → Monocotyledonae; Dicotyledonae → Gamopetalae; Polypetalae

- John Hutchinson (1959) proposed phylogenetic system in his book 'Families of Flowering Plants' into two volumes. Hutchinson classification was revised in 1995.

Angiospermae → Dicotyledonae → Lignosae; Herbaceae → Calyciflorae; Corolliferae; Glumiflorae
Angiospermae → Monocotyledonae → Glumiflorae

- Takhtajan also proposed phylogenetic system in his book 'A system of Phylogeny of Flowering plants' & 'Flora Armenica'
- According to Takhtajan 'Taxonomy without phylogeny may be likened to bones without flesh'. • According to Engler & Prantl 'classification of monocots were primitive than dicots'

PLANT KINGDOM

Subkingdom: Cryptogamia; Phanerogamia
Classes: Dicotyledonae; Gymnospermae; Monocotyledonae
Subclasses: Polypetalae; Gamopetalae; Monochlamydae
Series: Thalamiflorae (→ Cruciferae, → Malvaceae); Disciflorae (→ Anacardiaceae); Calyciflorae (→ Leguminosae, → Cucurbitaceae)
Inferae (→ Compositae); Heteromerae; Bicarpellatae

KINGDOMS OF LIFE

TWO KINGDOM CLASSIFICATION

- Linnaeus • 2 Kingdoms – Plantae & Animalia • Used till very recently (Before 1969). • Drawback – Didn't distinguish unicellular organisms from multicellular, prokaryotic from eukaryotic & photosynthetic from non-photosynthetic.

Exceptions:
- chlamydomonas – unicellular green algae. Plant features: cell wall present, made of hydroxy Proline (AA) & glycoprotein. Animal features: neuromotor sensory apparatus.
- Euglena – Plant F: Photosynthetic, saprophytic / holozoic. Animal F: cell wall ×, Pellicle present.
- slime mould – Plant F: Spores have cell wall made of cellulose. Animal F: non chlorophyllous, non photosynthetic

FOUR KINGDOM CLASSIFICATION

- Proposed by Copeland (1956)
- Created a separate kingdom 'Monera' (Mycota) for Prokaryotes.

THREE KINGDOM CLASSIFICATION

- by Ernst Haeckel (1866)
- Third Kingdom was Protista

FIVE KINGDOM CLASSIFICATION

- By R.H Whittaker (1969)
- New kingdom 'Fungi'
- Based on phylogenetic relationships. He used 5 criteria for 5 kingdom classification:
1. Reproduction
2. Cell structure
3. Phylogenetic relationships
4. Mode of nutrition
5. Thallus organisation

SIX KINGDOM CLASSIFICATION (3-DOMAINS OF LIFE)

- by Carl Woese (1990)
- Based on the sequence of subunit rRNA genes

3 Domains:
1. Domain Archea
2. Domain Bacteria
3. Domain Eukarya → 4 Eukaryotic kingdoms

- He believed that they originated from common ancestor called progenote

CLASSIFICATION

FIVE KINGDOMS

CHARACTERS	MONERA	PROTISTA	FUNGI	PLANTAE	ANIMALIA
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	non cellulosic (Polysaccharide + AA)	Present in some	Present (without cellulose)	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	cellular	cellular	Multicellular / loose tissue	Tissue/organ	Tissue/organ/organ system
Mode of nutrition	Autotrophic (chemosynthetic & photosynthetic) & Heterotrophic (saprophytic/parasitic)	Autotrophic (Photosynthetic) & Heterotroph c	Heterotrophic (saprophytic/Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic/saprophytic).

KINGDOM MONERA

- Monera is a Kingdom of Prokaryotes.
- Bacteria are the sole members
- On the basis of rRNA genes monera has 2 major groups - Archaebacteria & Eubacteria

ARCHAEBACTERIA

- oldest living beings. most primitive bacteria / monerans. They are special bacteria b'coz they live in some of the most harsh habitats.
- Halophiles & methanogens are obligate anaerobes while thermoacidophiles are facultative anaerobes.
- Archae bacteria differ from other in having a diff cell wall structure or cell membrane • Thermococcus, methanogens are archaebacteria - contain protein homologous to eukaryotic core histones.

HALOPHILES : live in extremely salty areas. Halobacterium found in dead sea & great salt lake can not live in less than 3 M NaCl conc • They grow in conc. salt soln due to accumulation of KCl.

THERMOACIDOPHILES : Bacteria living in hot springs / deep sea water. eg : Thermococcus.

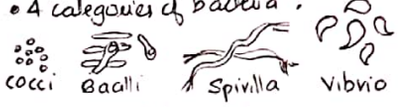
METHANOGENS : Bacteria living in marshy areas and produce methane gas. methanogens are present in the gut of several ruminant animals such as cows & buffaloes & are responsible for the production of biogas (methane) from dung of these animals. eg : methanobacterium, Methanococcus.

EUBACTERIA

- True bacteria • characterised by the presence of a rigid cell wall and if motile, a flagellum.

BACTERIA

- most abundant microorganisms, most adaptive & versatile.
- Diplostreptococcus pneumoniae is smallest bacterium. • Bacteria were 1st discovered by Leeuwenhoek • Term bacteria by Ehrenburg • 'Germ theory of disease' given by Louis Pasteur.
- Father of bacteriology - Antonyan Leeuwenhoek (Holland / Netherland)
- Bacteria also live in extreme habitats such as hot springs, deserts, snow & deep oceans where very few other life forms can survive. • many are parasites.
- 4 categories of bacteria :



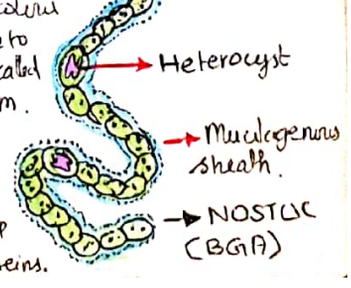
- cocci - smallest in size
- Salmonella → rod-shaped bacterium which is gas forming & causes food poisoning.
- chain of rod shaped bacteria is streptobacillus & chains of spherical bacteria is called streptococcus.
- Staphylococcus have grape or bunch like irregular colony
- Vibrio cholerae is comma shaped bacteria.

CYANOBACTERIA (BGA = BLUE GREEN ALGAE)

- Cyanobacteria is modern name of myxophyceae or myxobacteria or cyanophyceae or cyanophyta.
- Cyanobacteria are gram negative, unicellular, colonial or filamentous.
- They may be freshwater, marine or terrestrial algae • The colonies are generally surrounded by gelatinous/mucilagenous sheath. • Colony with mucilaginous sheath → filament & without sheath → trichome.
- The ability of BGA to change their body colour according to diff wavelength of light → Gaidukov's phenomenon or chromatic adaptation.
- cell wall of BGA have peptidoglycan.
- have chlorophyll a similar to green plants, also have phycocyanin & phycoerythrin which are present in bacteria • They are photosynthetic autotrophs. • In BGA photosynthesis occurs in chromatophores or membranous lamellae. • Cyanobacteria / Nostoc / Anabaena / Oscillatoria perform oxygenic photosynthesis
- Reserve food material - Cyanophycean granule or α-granule / cyanophycean starch (similar to glycogen)
- Reproduce by vegetative & asexual methods

(BGA)

- Asexual rep - hormogonia - multicellular fragment of BGA capable of growth into new plant.
- Unicellular, reproduce asexually → fission eg Spirullina
- Flagella absent but move by gliding
- Nostoc & Anabaena fix atmospheric nitrogen in specialised cells called heterocysts - contain nitrogenase.
- Spirullina → great nutritional value as a good source of SCP & vit B12. • Red colour of red sea (Red bloom) is due to a red colour cyanobacteria called Trichodesmium erythraeum.
- During rain - land slippery due to growth of BGA
- many BGA occur in thermal springs / hot water springs. Temp tolerance of these algae have been attributed to homopolar bonds in their proteins.



MYCOPLASMA

→ are called PPLO. They are unicellular prokaryotic organisms that completely lack a cell wall, so they are without any specific shape (pleomorphic). • outermost - cell membrane • The plasmalemma is rich in cholesterol • Smallest living cells known that are capable of growth, division & reproduction. They can survive without oxygen. • They are gram (-) & heterotrophic. • They have elementary bodies which help in reproduction. • Resistant to insensitive to penicillin that act on cell wall but killed by the tetracycline, chloramphenicol & streptomycin that act on metabolic pathways. • Many mycoplasma are pathogen to animals & plants. In plants they causes little leaf disease of Brinjal, Potato purple top, witches broom of Potato. • mycoplasma can cause abortion.

MORE ABOUT BACTERIA

FLAGELLAR ARRANGEMENT

- Atrichous → Flagella absent
- → Monotrichous
- → Lophotrichous (2 or more) (both sides)
- → Amphitrichous
- → Peritrichous (all around body)

Gram staining developed by Hans Christian Gram in 1884 (Denmark)

GRAM STAINING

Bacteria
↓ stained with crystal violet
All bacteria will be stained bluish or bluish purple or violet
↓ 0.5% I_2 solution
Stain will be fixed due to formation of a complex of crystal violet and I_2 (mordant)
↓ Destaining is done with acetone or 95% ethyl alcohol

- Strain doesn't come out → Gram +ve
- Strain come out → Gram -ve

BACTERIAL CELL STRUCTURE

1. Glycocalyx : most external (Present / absent) • 2 types - slime layer, capsule.
   • Slime layer - loosely arranged, made of Dextrin, dextran, levan. helps in attachment to substrate, prevents from dehydration. • capsule - compactly arranged, composed of D glutamic acid with polysaccharide, responsible for pathogenicity, mainly in gram -ve bacteria.
2. cell wall - provide shape & prevents from bursting out.
3. cell membrane - made of lipids, protein, carbohydrates mainly composed of lipoprotein. • contains enzymes of ETS & succinate dehydrogenase of Krebs cycle.
4. Mesosome - Extension of cell membrane • Analogous to mitochondria.
5. NUCLEOID 6. PLASMIDS
7. CYTOPLASM - granular due to 70S ribosome. Polysome bound. 8. FLAGELLA : Feature of gram -ve. 3 parts - basal body, filament & hook (middle)

REPRODUCTION

- Asexual
  - Binary Fission
  - Endospore formation
- Genetic recombination
  - Conjugation
  - Transformation
  - Transduction

Transfer of genetic material from 1 to other bacteria via conjugation tube. - Lederberg & Tatum

Transfer of free genetic material from 1 bacteria to another. cell can pick DNA from solution - Griffith

Transfer of genetic material from 1 bacteria to another via bacteriophage. - Zinder & Lederberg

- In bacteria, cell division is amitotic. • mitotic apparatus is absent. • Shorter generation time of E. coli as compared to eukaryotes is due to large surface area / volume ratio.
- Endospores are thick walled spores formed in unfavourable conditions in clostridium & bacilli type of bacteria
- Pilli involved in sexual reproduction

MODE OF NUTRITION

1. Photosynthetic autotrophs : eg. Cyanobacteria (BGA)
2. Chemosynthetic autotroph - These oxidize inorganic substances such as nitrates, nitrites & ammonia for ATP production. eg : Nitrifying bacteria, iron bacteria, sulfur bacteria, etc.
3. Decomposer heterotroph - Most important in recycling of nutrients.
4. Pathogenic heterotroph - These causes diseases in human (typhoid, cholera, tetanus, TB, etc), animals & plants (citrus canker, etc).

[Nishidha]

KINGDOM PROTISTA

- All single celled eukaryotes
- highly heterogenous group b'coz the boundries of this kingdom are not well defined
- Mostly aquatic.
- Reproduction : Asexual & sexual (cell fusion & zygote formation is involved).

EUGLENOIDS

- Euglena like unicellular flagellates which possesses a protein rich layer called pellicle, instead of cell wall.
- Pellicle makes their body flexible
- mostly fresh water organisms found in stagnant water. • have 2 flagella - a short & a long. Flagellation of Euglena or Astasia is stichonemahc - Flagella having small hair like structures (mastigonemes). • They have ch-a, ch-b & carotenoids (carotene & xanthophylls) • mode of nutrition : photosynthetic. They can predate on smaller organisms in absence of light (heterotroph) • connecting link b/w plants & animals - • In Euglena reserve food is paramylum bodies or paramylon.

SLIME MOULDS (Myxomycetes)

- Saprophytic protists without cell wall.
- Spores possess true walls. • Habitat : Decaying twigs & leaves • During favourable conditions, they form an aggregation called plasmodium which may grow & spread over several feet.
- Thalloid multinucleate body of slime mould is called plasmodium. • During unfavourable condition it differentiates & forms fruiting bodies bearing spores at their tips. • Spore producing body of slime mould is called sporangium or fruiting body. They are extremely resistant & survive for many years.

CHRYSOPHYTES

Belong to division bacillariophyta & class bacillariophyceae

• It includes diatoms & desmids (golden algae) • Cosmarium is unicellular non-motile desmid. • Habitat : Aquatic (Fresh water or marine) & plankton (Passively floating) • lack flagella except in the reproductive stages. • microscopic • Diatoms stay floats on water surface due to light weight stored lipids. • Phytoplanktons acts as direct or indirect food for all marine creatures.

DINOFLAGELLATES

• class : dinophyceae • appear yellow, green, brown, blue or red depending on the main pigment present in their cells. They are mostly marine & photosynthetic. • contain chl-a, chl-c & unique xanthophyll pigment. • As the name indicates most of the dino flagellates have 2 flagella. One lies longitudinally & other transversely (heterokontae) in furrow b/w the wall plates. • very often, red dinoflagellates (Gonyaulax) undergo such rapid multiplication that they make the sea appear red, called red tides. • Toxins (saxitoxin) released by such large numbers may even kill other marine animals such as fishes. • Other example of dinoflagellates is Ceratium & Noctiluca

DIATOMS

: cell wall (siliceous) form two thin overlapping shells which fit together as in soap box. The walls are embedded with silica & thus the walls are indestructible • The diatoms are left behind large amount of cell wall deposits in their habitat. This accumulation over billions of years is called diatomaceous earth or diatomite or Kieselguhr. • Diatoms are chief producers in oceans • commercial use : Polishing and filtration of oils and syrups. • Reserve food is leucosin (Polysaccharide) & oil.

PROTOZOANS

• actually acellular • All heterotrophs & live as predators or parasites. BGA live endosymbiotically inside protozoan, called cyanellae. • They are believed to be primitive relatives of animals. • Protozoans are classified on the basis of locomotory organs.

- Amoeboid protozoans : Locomotory organ is Pseudopodia. Features : Present in fresh water or sea water or moist soil. Marine forms may have silica shells
  eg : Amoeba (Free living) Entamoeba (Parasitic)
- Flagellated protozoans : Flagella, Free living (aquatic) or parasitic. Eg : Trypanosoma (Dreaw - African sleeping sickness)
- Ciliated protozoans : Cilia, Aquatic - numerous cilia are present over the body - food is drawn by steering action of cilia present in gullet of cell.
  Eg : Paramoecium.
- Sporozoans : Locomotory organ is absent.
  • These possess spore like infectious stage.
  Eg : Plasmodium (Malarial Parasite)

KINGDOM FUNGI

- Study of fungi – mycology
- Father of mycology – Micheli
- Father of Indian mycology – Butler
- Fungi are cosmopolitan & prefer to grow on warm & humid places.

General informations about kingdom fungi

- Members are filamentous & multicellular (except yeast) • All heterotrophic (mostly saprotrophic). Few may be parasitic. • 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 septae or cross walls in their hyphae.
- The cell walls of fungi are compound of chitin $(C_{22}H_{54}N_4O_{21})_n$ and polysaccharides. • Cell wall of both bacteria & fungi have **N-acetylglucosamine**.
- In fungi food is stored in the form of glycogen & oil. • Fungi may live as symbiont – **In lichens** (with algae) or as **mycorrhiza** (with roots of higher plants)

REPRODUCTION

- **Vegetative**
  - Fragmentation
  - Fission
  - budding
- **Asexual**
  - Spores
    - Conidia
    - zoospores
    - Sporangiospores
- **Sexual**
  - Oospores, ascospores or basidiospores. (Produced in fruiting bodies or cups)

Sexual cycle involves 3 steps:

1. Plasmogamy (fusion of protoplasm)
2. Karyogamy (fusion of nuclei)
3. Zygotic meiosis resulting in haploid spores.

NUTRITION

: Fungi don't have chlorophyll hence cannot manufacture their food. They show 3 types of heterotrophic nutrition: → Saprophytic, → Parasitic, → Symbiotic

- Fungi which absorb soluble organic matter from dead substrate → **Saprophytes**
  - Obligate saprophyte : obtain food only from dead & decaying organic matter. eg: Rhizopus nigricans
  - Facultative parasite : They are normally saprophytic but in the absence of dead organic matter they become parasitic. eg: Rhizopus stolonifer.
- Those that depend on living plants & animals are called **parasites**
  - Obligate parasite: They fail to survive in absence of host. eg: Albugo candida
  - Facultative saprophyte : They are normally parasitic but in the absence of host they become saprophytic. eg: Helminthosporium oryzae.
- The parasitic fungi take their nutrition from the host with the help of **haustoria**

CLASSIFICATION OF FUNGI

Features	Phycomycetes	Ascomycetes	Basidiomycetes	Deuteromycetes
Common name	Algal fungi	Sac fungi	Mushrooms / Puffballs / bracket fungi	Fungi imperfecti
Mycelium	Aseptate & coenocytic	Branched & septate	Branched & septate	Branched & septate
Asexual reproduction	zoospores / aplanospores (Endogenously produced in sporangium)	Conidia (Exogenously Produced)	Usually absent	Conidia (Exogenously Produced)
sexual reproduction	Oospores	Ascospores (Endogenously Produced)	Basidospores (Exogenously Produced)	–
Dikaryotic stage (n+n) in sexual cycle	Absent	Present	Present	Absent
Other feature	Aquatic / decaying logs / obligate parasites on plants	Saprophytic / decomposers / coprophilous (enduring) / Parasitic	In soil / decaying logs / Parasites on Plants as rusts & smuts. commonly reproduce by fragmentation. Sex organs absent.	only asexual/ vegetative stage known. Sexual stage is absent. saprophytic / Parasitic
Examples:	Rhizopus (bread mould), Albugo (Parasitic fungi on mustard), Mucor	Neurospora (used in genetics), Claviceps, Aspergillus, Yeast, Penicillium. Edible → Morels & truffles	Agaricus (mushroom) Puccinia (rust fungus) Ustilago (smut fungus)	Colletotrichum Alternaria, Trichoderma

VIRUS

- Term coined by **Louis Pasteur** (Father of microbiology) • Acellular organisms obligate parasites • No place in 5 kingdom classification • Connecting link b/w living & non living. Virus means poison or venom – **D.J. Ivanowsky** : Virus are causative agents of tobacco mosaic disease (discovery of virus). – **M.W. Beijerinh (1898)** : Demonstrated infectious nature of plant sap obtained from infected part of tobacco plant. He also gave the term : Contagium vivum fluidum (living infectious fluid) to it. **W.M. Stanley (1935)**: Crystallization of virus. Also showed that these crystals were made of Protein. • They destroy the host.
- **Genetic material** : Either double stranded DNA or double stranded RNA or single stranded DNA or single stranded RNA.
- **chemical nature** : nucleoprotein. Genetic material - nucleic acid & the Protein coat is capsid.
- **Human viral diseases** : Flu, Influenza, AIDS, Mumps, small pox, herpes, etc.
- Plants are also infected by virus & produce symptoms like mosaic Pattern formation, leaf curling, leaf rolling, yellowing & vein curling, drafting & stunted growth, etc.

VIROIDS

• Term by T.O. Diener → discovered Potato spindle disease is caused by a new infectious agent which was smaller than virus. It was found to be free RNA late & given the term Viroid.
• Low molecular weight.

PRIONS

• Discovered by Prusiner.
• They are infectious protein causes – Animal diseases
• Mainly attack on nervous system. • also known as 'slow virus' Prions causes:
• Scrapie disease of sheep / goat
• MAD cow disease
• Alzeimer disease in man
• Creutzfeldt disease in man.
• KURU (laughing death in natives)

LICHENS

• It is a symbiotic association (mutualism) b/w algae & fungi.
• Dual hypothesis for lichens was given by **Schwendener**
• Algal component or **phycobiont** – It is autotrophic & provides food for fungi. • Fungal component or **mycobiont** – It is heterotrophic. It provides shelter & also absorb water & minerals for algae. • **Ecological importance** : Lichens also act as good pollution indicators (Cladonia, Usnea). They do not grow in Polluted areas