



VIVEKANANDA COLLEGE THAKURPUKUR

NAAC ACCREDITED GRADE—'A'

Subject: Botany

Topic: Classification of the biological world

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Classification and its significance

One of our basic instincts is to sort out or classify things into groups. **Classification** is the grouping of things together on the basis of features they have in common. The science of classification is called **Taxonomy**. According to some biologists, classifying things gives us a survival advantage. All biological organisms can be simply classified into prokaryotes and eukaryotes.

Histry of biological classification

Since the dawn of civilisation, there have been many attempts to classify living organisms. **Aristotle** (384 BC – 322 BC) was the earliest to attempt a scientific basis for classification. He used **simple morphological characters** to **classify plants** into **trees, shrubs** and **herbs**. He also divided **animals** into **two groups**, those **which had red blood** and **those that did not**. In **Linnaeus'** time a Two Kingdom system of classification with Plantae and Animalia kingdoms was developed that included all plants and animals respectively. After that, many scientists tried their own way to classify biological organisms. The sequence from the two-kingdom system by Linnaeus up to Cavalier-Smith's six-kingdom system is summarized below.

Name	Year	Type	Proposed members
Linnaeus	1735	2 kingdoms	Vegetabilia and Animalia
Haeckel	1866	3 kingdoms	Protista, Plantae and Animalia
Chatton	1925	2 empires	Prokaryota and Eukaryota
Copeland	1938	4 kingdoms	Monera, Protoctista, Plantae and Animalia
Whittaker	1969	5 kingdoms	Monera, Protista, Plantae, Fungi and Animalia
Woese et al.	1977	6 kingdoms	Eubacteria, Archaeobacteria, Protista, Plantae, Fungi and Animalia
Woese et al.	1990	3 domains	Bacteria, Archaea and Eucarya
Cavalier-Smith	1993	8 kingdoms	Eubacteria, Archaeobacteria, Archezoa, Protozoa, Chromista, Plantae, Fungi and Animalia
Cavalier-Smith	1998	6 kingdoms	Bacteria, Protozoa, Chromista, Plantae, Fungi and Animalia

In 1968, Murray proposed Procaryotae as a taxon 'at the highest level' and described it as 'a kingdom of microbes' Prokaryotae was characterized by the possession of nucleoplasm devoid of basic protein and not bounded from cytoplasm by a nuclear membrane. He suggested Eucaryotae as a possible taxon at the same level to include eukaryotic organisms including plants and animals.

The Five Kingdom classification by R. H. Whittaker (1969):

R. H. Whittaker in 1969, proposed the five kingdom classification of biological organisms. The main criteria for classification used by him include cell structure, thallus organisation, mode of nutrition, reproduction and phylogenetic relationships. The kingdoms defined by him were named **Monera**, **Protista**, **Fungi**, **Plantae** and **Animalia**.

The characters of the kingdoms are given below

Kingdom Monera

1. Procaryotic cells, lacking nuclear membranes, plastids, mitochondria, and advanced (9+2-strand) flagella
2. Solitary unicellular or colonial-unicellular organization (but in one group mycelial)
3. Predominant nutritive mode absorption, but some groups are photosynthetic or chemosynthetic
4. Reproduction primarily asexual by fission or budding; protosexual phenomena also occur
5. Motile by simple flagella or gliding, or nonmotile

Example: *Streptococcus* (bacteria), *Nostoc* (Blue-green algae) etc.

Kingdom Protista

1. Primarily unicellular or colonial-unicellular organisms (but simple multinucleate organisms or stages of life cycles occur in a number of groups), with eucaryotic cells (possessing nuclear membranes, mitochondria, and in many forms plastids (9+2)-strand flagella, and other organelles)
2. Nutritive modes diverse - photosynthesis, absorption, ingestion, and combinations of these

3. Reproductive cycles varied, but typically including both asexual division at the haploid level and true sexual processes with karyogamy and meiosis
4. Motile by advanced flagella or other means, or nonmotile

Example: *Euglena* (Euglenophyta), *Plasmodiophora* (Plasmodiophoromycota) etc.

Kingdom Plantae

1. Multicellular organisms with walled and frequently vacuolate eucaryotic cells and with photosynthetic pigments in plastids (together with closely related organisms which lack the pigments or are unicellular or syncytial)
2. Principal nutritive mode photosynthesis, but a number of lines have become absorptive.
3. Primarily nonmotile, living anchored to a substrate
4. Structural differentiation leading toward organs of photosynthesis, anchorage, and support, and in higher forms toward specialized photosynthetic, vascular, and covering tissues
5. Reproduction primarily sexual with cycles of alternating haploid and diploid generations, the former being progressively reduced toward the higher members of the kingdom.

Example: *Chara* (Charophyta), *Riccia* (Bryophyta), *Cycas* (Tracheophyta) etc.

Kingdom fungi

1. Primarily (excepting subkingdom Gymnomycota) multinucleate organisms with eucaryotic nuclei dispersed in a walled and often septate mycelial syncytium, plastids and photosynthetic pigments lacking
2. Nutrition absorptive. Somatic tissue differentiation absent or limited, reproductive tissue differentiation and life cycle elaboration marked in higher forms
3. Primarily nonmotile (but with protoplasmic flow in the mycelium), living embedded in a medium or food supply
4. Reproductive cycles typically including both sexual and asexual processes; mycelia mostly haploid in lower forms but dicaryotic in many higher forms.

Example: *Ascobolus* (Ascomycota), *Agaricus* (Basidiomycota) etc.

Kingdom Animalia

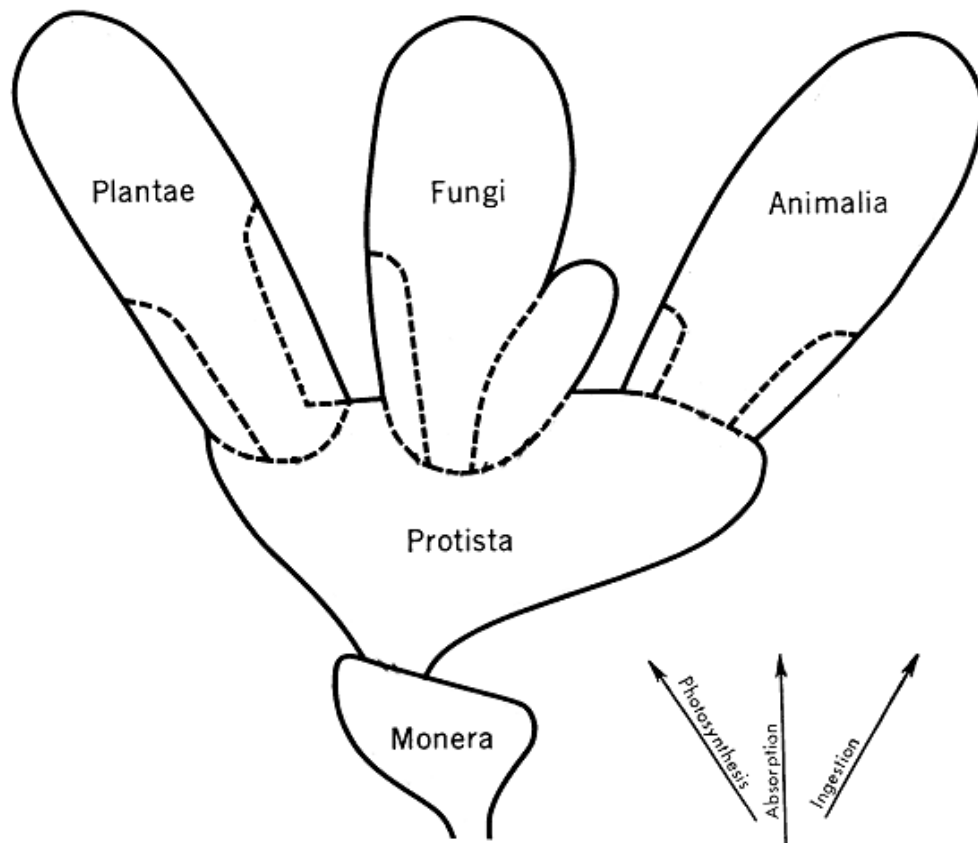
1. Multicellular organisms with wall-less eucaryotic cells lacking plastids and photosynthetic pigments
2. Nutrition primarily ingestive with digestion in an internal cavity, but some forms are absorptive and a number of groups lack an internal digestive cavity
3. Level of organization and tissue differentiation in higher forms far exceeding that of other kingdoms, with evolution of sensory-neuromotor systems and motility of the organism (or in sessile forms of its parts) based on contractile fibrils
4. Reproduction predominantly sexual, haploid stages other than the gametes almost lacking above the lowest phyla.

Example: *Hydra* (Cnidaria), *Homo* (Chordata) etc.

A comparative account of the five kingdoms

Characters	Five Kingdoms				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellulosic (Polysaccharide + amino acid)	Present in some	Present (mainly chitinous)	Present (cellulosic)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Unicellular; occasionally grouped	Unicellular, occasionally multicellular	Unicellular or Multicellular/ 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) Some are absorptive	Heterotrophic (Holozoic/ Saprophytic etc.)
Reproduction	Asexual, usually by binary fission	Mostly asexual, occasionally	both sexual and asexual, often with a complex life cycle	Both sexual and asexual	Primarily sexual

Evolutionary relationship among the five kingdoms



The figure shows the evolutionary relationships among the five kingdoms. There are three levels of organization—the prokaryotic (kingdom Monera), eucaryotic unicellular (kingdom Protista), and eucaryotic multicellular and multinucleate. On each level there is divergence in relation to three principal modes of nutrition—the photosynthetic, absorptive, and ingestive.

Merits and demerits of the Whittaker's system

Merits: This system of classification looks more scientific and natural because of the following considerations:

1. It is largely the most accepted system of modern classification mainly because of the phylogenetic placing of different groups of living organisms
2. Separation of prokaryotes into an independent kingdom is justifiable because they differ from all other organisms in their general organization.
3. Grouping of all unicellular eukaryotes under the kingdom Protista has solved many problems, particularly related to the position of organisms like *Euglena*.

4. Elevation of the group fungi to the status of a kingdom is justifiable since fungi totally differ from other primitive eukaryotes like algae and protozoans.
5. The kingdoms plantae and animalia are now more homogeneous groups than they were in the two kingdom classification as it shows the phylogeny of different life styles.
6. The five-kingdom classification gives a clear indication of cellular organization and modes of nutrition, the characters which appeared very early in the evolution of life.

Demerits: The five-kingdom classification has certain drawbacks also, particularly with reference to the lower forms of life. These are:

1. The kingdoms Monera and Protista include diverse, heterogeneous forms of life. In both the kingdoms there are photosynthetic (autotrophic) as well as non-photosynthetic (heterotrophic) organisms. Both the kingdoms include organisms which have cells with cell wall as well as without cell wall.
2. None of the three higher kingdoms include a single ancestor of all its forms.
3. Multicellular lines have originated from protistans several times.
4. Unicellular green algae like *Volvox* and *Chlamydomonas* have not been included under Protista because of their resemblance to other green algae.
5. Slime moulds differ totally from other members of Protista in their general organization.
6. Viruses have not been given proper place in this system of classification

Three Domain Concept of classification (Carl R. Woese 1978, 1990)

Carl R. Woese proposed the three domain classification of biological organisms on the basis of the ribosomal RNA sequence. Woese and Fox (1977) first showed that the Kingdom procaryotae is actually comprises of two phylogenetically different groups i.e. eubacteria and archaebacteria. Woese (1990) proposed that the highest level of taxon should be 'domain' instead of 'kingdom' and he along with other scientists classified biological organisms into three domains.

Domain Eukarya [Greek adjective εὖ (good); and Greek noun κάρυον (karyon) means nut or kernel)]:

1. Cells eukaryotic;
2. Cell membrane lipids predominantly glycerol fatty acyl diesters;
3. Ribosomes containing a eukaryotic type of rRNA

Domain Bacteria [Greek noun βακτήριον (Bacterium) means small rod or staff)]:

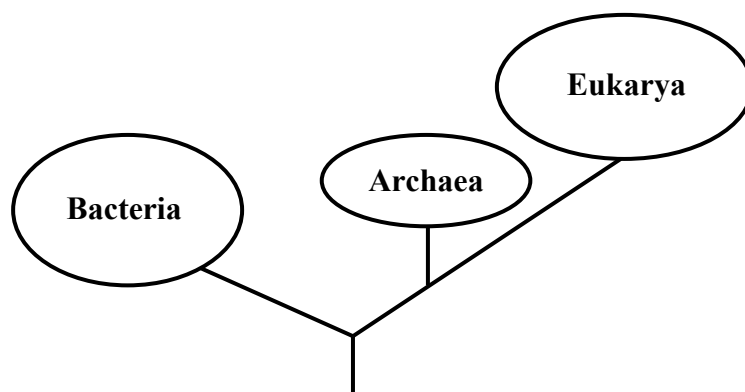
1. Cells prokaryotic;
2. Membrane lipids predominantly diacyl glycerol diesters;
3. Ribosomes containing a (eu)bacterial type of rRNA

Domain Archaea [Greek adjective αρχαίος (ancient or primitive)]:

1. Cells prokaryotic;
2. Membrane lipids predominantly isoprenoid glycerol diethers or diglycerol tetraethers;
3. Ribosomes containing an archaeal type of rRNA

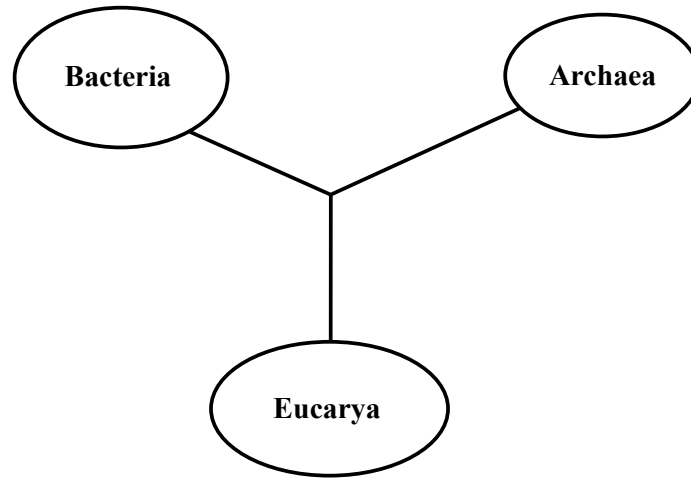
Relationship among the three domains

Phylogeny is the study of evolutionary relationships among different organisms. Woese have also drawn the phylogenetic relationship among the three domains. The phylogenetic tree shows that eubacteria is separated from the other two groups at the root of the tree. It shows that Archaeobacteria and eukaryotes specific (but distant) relatives. This may be surprising but many molecules of Archaea resemble more with eukaryotes than bacteria. One such example is rRNA.



Concept of Universal Phylogenetic Tree (Norman R. Pace 1997)

Norman R. Pace (1997) discussed the 'Universal Phylogenetic Tree'. He discussed that the evolutionary lineage Archaea is independent of both Eucarya and Bacteria.



Universal phylogenetic tree based on SSU rRNA sequences according to Pace (1997).

Difference between Prokaryotes and Eukaryotes

No.	Feature	Prokaryotes	Eukaryotes
1	Representative kingdom	Monera	Protista, Fungi, Animalia, Plantae
2	Cell size	Average diameter 0.5-10 μ m	10-100 μ m in diameter (1000-10000 times more volume of prokaryotic cells)
3	Form	Mainly unicellular (bacteria), sometimes trichomatous (cyanophycean algae)	Mainly multicellular or unicellular (majority of protists)
4	Evolutionary origin	3.5 thousand million years ago	1.2 thousand million years ago
5	Cell division	Mainly binary fission, no spindle formation	Mitosis, meiosis or both, spindles are formed
6	Genetic material	DNA is closed, circular and lies free in the cytoplasm (no true nucleus)	DNA is linear and contained in a nucleus

7	Organelles	Few organelles and none of them are surrounded by envelope (two membranes)	Many organelles and many of them are envelope-bound like nucleus, mitochondria, plastids Some organelles are single-membrane bound e.g. golgi apparatus, lysosomes, vacuoles, endoplasmic reticulum, microbodies
8	Ribosome	70S ribosome	80S ribosome
9	Cell wall	Rigid and contain polysachharides with amino acids; murein is the main strengthening compound	Cell walls of plants and fungi are rigid and contain polysachharides; cellulose and chitin are the main strengthening compound of plant and fungal cell walls, respectively
10	Flagella	Present only in bacteria (not found in cyanophycean algae) Simple, lacking microtubules, extracellular (not enclosed by cell surface membrane) 20nm (0.02µm) diameter	Complex, with '9+2' arrangement of microtubules; intracellular (surrounded by cell surface membrane) 200nm (0.2µm) diameter
11	Respiration	Respiration takes place in mesosomes in bacteria, except cytoplasmic membranes in cyanophycean algae	Aerobic respiration takes place in mitochondria
12	Photosynthesis	Photosynthesis takes place on membranes (membranes not stacked) in some photosynthetic bacteria including cyanobacteria	In photosynthetic organisms, photosynthesis takes place in chloroplasts containing membranes which are usually stacked into lamellae or grana
13	Nitrogen fixation	Some have the ability	None have the ability

Further reading:

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