Classification of living organisms

1. Taxonomy

Taxonomy is the branch of biology that deals with the study of identification, classification, description and nomenclature of living organisms. The word taxonomy is derived from two Greek words (Taxis means arrangement and Nomos means laws). The word 'taxonomy' was first coined by Augustin-Pyramus de Candolle.

Classification

Plants are arranged into different groups and categories on the basis of similarities and differences. It is called classification. There are four types of classification.

1. Artificial system of classification
2. Natural system of classification
3. Phylogenetic system of classification
4. Modern system of classification

1. Artificial system of classification

This is the earliest system of classification in plants. Plants are classified on the basis of one or few morphological characters. The most famous artificial system of classification is Linnaeus classification which was proposed by Carolus Linnaeus in his book Species plantarum.

2. Natural system of classification

In this system, plants are classified on the basis of several characters. Bentham and Hooker's classification is an example of natural system of classification. This system of classification is based on morphological and reproductive characters of the seeded plants. Bentham and Hooker published their natural system of classification in their book named General Plantarum in three volumes. This classification is widely used in many herbaria and botanical gardens all over the world.

OR

Types of classification

Taxonomic entities are classified in three ways. They are artificial classification, natural classification and phylogenetic classification.

2. Artificial system of classification

Carolus Linnaeus (1707 -1778) was a great Swedish Botanist and said to be the "Father of Taxonomy." He outlined an artificial system of classification in "Species

Plantarum" in 1753, wherein he listed and described 7,300 species and arranged in 24 classes mostly on the basis of number, union (adhesion and cohesion), length, and distribution of stamens. The classes were further subdivided on the basis of carpel characteristics into orders. Hence the system of classification is also known as sexual system of classification.

This system of classification though artificial, was continued for more than 100 years after the death of Linnaeus, due to its simplicity and easy way of identification of plants.

However the system could not hold well due to the following reasons.

Totally unrelated plants were kept in a single group, whereas closely related plants were placed in widely separated groups. Example:

Zingiberaceae of monocotyledons and Anacardiaceae of dicotyledonous were placed under the class Monandria since these possess single stamens.

Prunus was classified along with Cactus because of the same number of stamens.

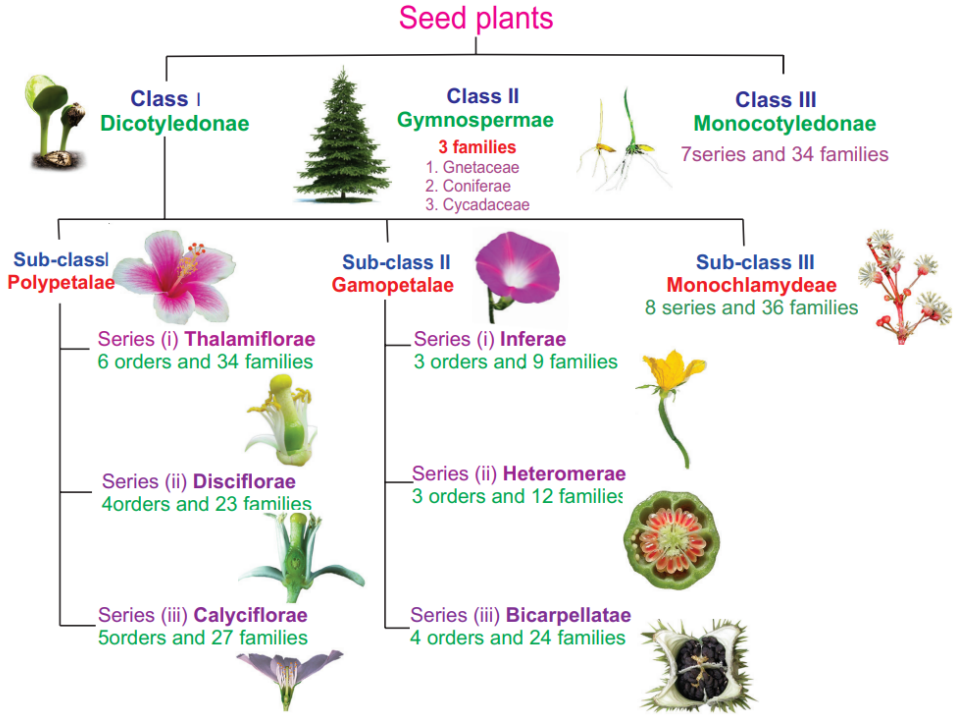
No attempts were made to classify plants based on either natural or phylogenetic relationships which exist among plant groups.

Natural system

Botanists who came after Linnaeus realised that no single character is more important than the other characters. Accordingly an approach to a natural system of classification sprouted in France. The first scheme of classification based on overall similarities was presented by Antoine Laurent de Jessieu in 1789.

3. Bentham and Hooker system of classification

A widely followed natural system of classification considered the best was proposed by two English botanist George Bentham (1800 – 1884) and Joseph Dalton Hooker (1817–1911). The classification was published in a three volume work as "Genera Plantarum" (1862–1883) describing 202 families and 7569 genera and 97,205 species. In this system the seeded plants were classified into 3 major classes such as Dicotyledonae, Gymnospermae and Monocotyledonae.



Class I Dicotyledonae: Plants contain two cotyledons in their seed, leaves with reticulate venation, tap root system and tetramerous or pentamerous flowers come under this class. It includes three sub-classes – Polypetalae, Gamopetalae and Monochlamydeae.

Sub-class 1. Polypetalae: Plants with free petals and dichlamydeous flowers come under polypetalae. It is further divided into three series – Thalamiflorae, Disciflorae and Calyciflorae.

Series (i) Thalamiflorae: Plants having flowers with dome or conical shaped thalamus and superior ovary are included in this series. It includes 6 orders and 34 families.

Series (ii) Disciflorae: Flowers having prominent disc shaped thalamus with superior ovary come under this series. It includes 4 orders and 23 families.

Series (iii) Calyciflorae: It includes plants having flowers with cup shaped thalamus and with inferior or sometimes with half inferior ovary. Calyciflorae includes 5 orders and 27 families.

Sub-class 2. Gamopetalae: Plants with united petals, which are either partially or completely fused to one another and dichlamydeous are placed under Gamopetalae. It is further divided into three series – Inferae, Heteromerae and Bicarpellatae.

Series (i) Inferae: The flowers are epigynous and with inferior ovary. Inferae includes 3 orders and 9 families.

Series (ii) Heteromerae: The flowers are hypogynous, superior ovary and with more than two carpels. Heteromerae includes 3 orders and 12 families.

Series (iii) Bicarpellatae: The flowers are hypogynous, superior ovary and with two carpels. Bicarpellatae includes 4 orders and 24 families.

Sub-class 3. Monochlamydeae: Plants with incomplete flowers either apetalous or with undifferentiated calyx and corolla are placed under Monochlamydeae. The sepals and petals are not distinguished and they are called perianth. Sometimes both the whorls are absent. Monochlamydeae includes 8 series and 36 families.

Class II Gymnospermae: Plants that contain naked seeds come under this class. Gymnospermae includes three families – Gnetaceae, Coniferae and Cycadaceae.

Class III Monocotyledonae: Plants contain only one cotyledon in their seed, leaves with parallel venation, fibrous root system and trimerous flowers come under this class. The Monocotyledonae has 7 series and 34 families.

The Bentham and Hooker system of classification is still supposed to be the best system of classification. It has been widely practiced in colonial countries and herbaria of those countries were organised based on this system and is still used as a key for the identification of plants in some herbaria of the world due to the following reasons:

- Description of plants is quite accurate and reliable, because it is mainly based on personal studies from actual specimens and not mere comparisons of known facts.
- As it is easy to follow, it is used as a key for the identification of plants in several herbaria of the world.
- Though it is a natural system, this system was not intended to be phylogenetic.

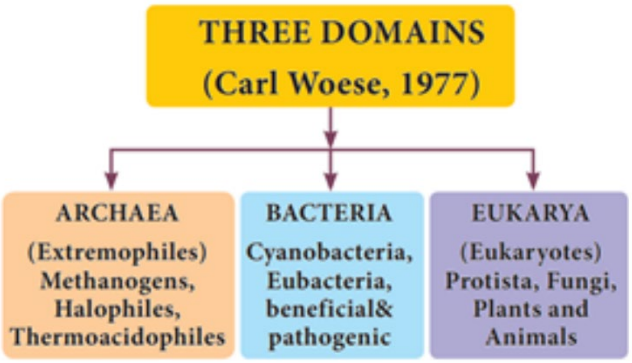
3. Phylogenetic system of classification

The publication of the Origin of Species (1859) by Charles Darwin has given stimulus for the emergence of phylogenetic system of classification.

4. Three Domains of life

Three domain classification was proposed by Carl Woese (1977) and his co-workers. They classified organisms based on the difference in 16S rRNA genes. The three domain system adds the taxon 'domain' higher than the kingdom. This

system emphasizes the separation of Prokaryotes into two domains, Bacteria and Archaea, and all the eukaryotes are placed into the domain Eukarya. Archaea appears to have more in common with the Eukarya than the Bacteria. Archaea differ from bacteria in cell wall composition and differs from bacteria and eukaryotes in membrane composition and rRNA types.



1. Domain Archaea

This domain includes single celled organisms, the prokaryotes which have the ability to grow in extreme conditions like volcano vents, hot springs and polar ice caps, hence are also called extremophiles. They are capable of synthesizing their food without sunlight and oxygen by utilizing hydrogen sulphide and other chemicals from the volcanic vents. Some of the them produced methane (methanogens), few live in salty environments (Halophiles) and are thermoacidophiles which thrive in acidic environments and at high temperatures.

2. Domain Bacteria

Bacteria are prokaryotic, their cells have no definite nucleus and DNA exists as a circular chromosomes and do not have histones associated with it. They do not possess membrane bound organelles except for ribosome (70S type). Their cell wall contains peptidoglycans. Many are decomposers, some are photo-synthesizers and few cause diseases. There are beneficial probiotic bacteria and harmful pathogenic bacteria which are diversely populated. Cyanobacteria are photosynthetic blue green algae which produce oxygen. These had played a key role in the changes of atmospheric oxygen levels from anaerobic to aerobic during the early geologic periods.

3. Domain Eukarya (Eukaryotes)

Eukaryotes are animals which have true nucleus and membrane bound organelles. DNA in the nucleus is arranged as a linear chromosome with histone proteins,

ribsosomes of 80S type in the cytosol and 70S type in the chloroplast and mitochondria. Organisms in this domain are classified under kingdoms, namely, Protista, Fungi, Plantae and Animalia.

In 1987, Cavalier-Smith revised the six kingdom system to Seven Kingdom system. The concept of super kingdom was introduced and revised to seven kingdom classification. The classification is divided into two Super Kingdoms (Prokaryota and Eukaryota) and seven kingdoms, two Prokaryotic Kingdoms (Eubacteria and Archaebacteria) and five Eukaryotic Kingdoms (Protozoa, Chromista, Fungi, Plantae and Animalia).

5. The Five Kingdom Classification

The five kingdom classification was proposed by R.H. Whittaker in 1969. Five kingdoms were formed on the basis of characteristics such as cell structure, mode of nutrition, source of nutrition and body organization.

1. Kingdom Monera – Bacteria

All prokaryotes belong to the Kingdom Monera, which do not posses true nucleus. Cells of prokaryotes do not have a nuclear membrane and any membrane bound organelles. Most of the bacteria are heterotrophic, but some are autotrophs. Bacteria and Blue green algae are examples for monera.

2. Kingdom Protista:

The Kingdom Protista includes unicellular and a few simple multicellular eukaryotes. There are two main groups of protists. The plant like protists are photosynthetic and are commonly called algae. Algae include unicellular and multicellular types. Animals like protists are often called protozoans. They include amoeba and paramecium.

3. Kingdom Fungi:

Fungi are eukaryotic, and mostly are multicellular. They secrete enzymes to digest the food and absorb the food after digested by the enzymes. Fungi saprophytes as decomposers (decay –causing organisms) or as parasites. Kingdom Fungi includes molds, mildews, mushrooms and yeast.

4. Kingdom Plantae:

Planatae (plants) are multicellular eukaryotes that carry out photosynthesis. Reserve food materials are starch and lipids in the form of oil or fat. Plant cells have cell wall

and specialized functions, such as photosynthesis, transport of materials and support. Kingdom Plantae includes ferns, cone bearing plants and flowering plants.

5. Kingdom Animalia:

Animalia (animals) are multicellular, eukaryotic and heterotrophic animals. Cells have no cell wall. Most members of the animal kingdom can move from place to place. Eg. Invertebrates like sponges, hydra, flatworms round worms, insects, snails, starfishes. Vertebrates like Fish, amphibians, reptiles, birds, and mammals including human beings belong to the kingdom Animalia.

Characteristics	**Monera**	**Protista**	**Fungi**	**Plantae**	**Animalia**
1. Cell Type	Unicellular, Prokaryotic.	Unicellular, Eu-karyotic.	Multicellular, Non – green and Eukaryotic.	Multicellular, Eukaryotic.	Multicellular, Eukaryotic.
2. Nucleus	Absent.	Present.	Present.	Present.	Present.
3. Body Organisation	Cellular level of organization	Cellular level of organization is	Multi cellular with loose tissue.	Tissue level and organ level.	Tissue, organ and organ system.
4. Mode of Nutrition	Auto (or) Heterotrophic.	Auto (or) Heterotrophic.	Saprophytic, parasitic sometime symbioti	Autotrophic.	Heterotrophic.
5. Example	Bacteria and Blue green algae.	Spirogyra and Chlamydomo-nas.	Rhizopus and Agaricus.	Herb, Shrub and Trees.	Fish, frog, crocodile, Birds and human being

Merits of five Kingdom Classification

1. This system of classification is more scientific and natural.
2. This system of classification clearly indicates the cellular organization, mode of nutrition, and characters for early evolution of life.
3. It is the most accepted system of modern classification as the different groups of organisms are placed phylogenetically.
4. It indicates gradual evolution of complex organisms from simpler one.

Demerits of five Kingdom Classifications

1. In this system of classification of viruses have not been given a proper place.
2. Multicellular organisms have originated several times from protists.
3. This type of classification has drawn back with reference to the lower forms of life.
4. Some organisms included under protista are not eukaryotic.

6. Invertebrata and Chordata

Invertebrata

1. Phylum Porifera (Pore bearers)

These are multicellular, non-motile aquatic organisms, commonly called as sponges. They exhibit cellular grade of organization. Body is perforated with many pores called ostia. Water enters into the body through ostia and leads to a canal system. It circulates water throughout the body and carries food, oxygen. The body wall contains spicules, which form the skeletal framework. Reproduction is by both asexual and sexual methods. E.g- Euplectella, Sycon.

2. Phylum Coelenterata (Cnidaria)

Coelenterates are aquatic organisms, mostly marine and few fresh water forms. They are multicellular, radially symmetrical animals, with tissue grade of organization. Body wall is diploblastic with two layers. An outer ectoderm and inner endoderm are separated by non-cellular jelly like substance called mesoglea. It has a central gastrovascular cavity called coelenteron with mouth surrounded by short tentacles. The tentacles bear stinging cells called cnidoblast or nematocyst.

Many coelenterates exhibit polymorphism, which is the variation in the structure and function of the individuals of the same species. They reproduce both asexually and sexually. E.g. Hydra, Jellyfish.

3. Phylum Platyhelminthes (Flat worms)

They are bilaterally symmetrical, triploblastic, acoelomate (without body cavity) animals. Most of them are parasitic in nature. Suckers and hooks help the animal to attach itself to the body of the host. Excretion occurs by specialized cells called flame cells. These worms are hermaphrodites having both male and female reproductive organs in a single individual. e.g- Liverfluke, Tapeworm.

4. Phylum Aschelminthes (Round worms)

Aschelminthes are bilaterally symmetrical, triploblastic animals. The body cavity is a pseudocoelom. They exist as free-living soil forms or as parasites. The body is round and pointed at both the ends. It is unsegmented and covered by thin cuticle. Sexes are separate. The most common diseases caused by nematodes in human beings are elephantiasis and ascariasis. E.g-Ascaris, Wuchereria.

5. Phylum Annelida (Segmented worms)

These are bilaterally symmetrical, triploblastic, first true coelomate animals with organ-system grade of organization. Body is externally divided into segments called metameres joined by ring like structures called annuli. It is covered by moist thin cuticle. Setae and parapodia are locomotor organs. Sexes may be separate or united (hermaphrodites). e.g- Nereis, Earthworm, Leech.

6. Phylum Arthropoda (Animals with jointed legs)

Arthropoda is the largest phylum of the animal kingdom. They are bilaterally symmetrical, triploblastic and coelomate animals. The body is divisible into head, thorax and abdomen. Each thorasic segment bears paired jointed legs. Exoskeleton is made of chitin and is shed periodically as the animal grows. The casting off and regrowing of exoskeleton is called moulting.

Body cavity is filled with haemolymph (blood). The blood does not flow in blood vessels and circulates throughout the body (open circulatory system). Respiration is through body surface, gills or tracheae (air tubes). Excretion occurs by malphigian tubules or green glands. Sexes are separate. E.g., Prawn, Crab, Cockroach, Millipede, Centipedes, Spider, Scorpion.

7. Phylum Mollusca (Soft Bodied Animals)

They are diversified group of animals living in marine, fresh water and terrestrial habitats. Body is bilaterally symmetrical, soft and without segmentation. It is divided into head, muscular foot and visceral mass. The foot helps in locomotion. The entire body is covered with fold of thin skin called mantle, which secretes outer hard

calcareous shell. Respiration is through gills (ctenidia) or lungs or both. Sexes are separate with larval stages during development. e.g-Garden snail, Octopus.

8. Phylum Echinodermata (Spiny Skinned Animals)

They are exclusively free-living marine animals. These are triploblastic and true coelomates with organ-system grade of organization. Adult animals are radially symmetrical but larvae remain bilaterally symmetrical. A unique feature is the presence of fluid filled water vascular system. Locomotion occurs by tube feet. Body wall is covered with spiny hard calcareous ossicles.e.g- Star fish, Sea urchin.

9. Phylum Hemichordata

Hemichordates are marine organisms with soft, vermiform and unsegmented body. They are bilaterally symmetrical, coelomate animals with non-chordate and chordate features. They have gill slits but do not have notochord. They are ciliary feeders and mostly remain as tubiculous forms. E.g- Balanoglossus (Acorn worms).

Chordata

Chordates are characterized by the presence of notochord, dorsal nerve cord and paired gill pouches. Notochord is a long rod like support along the back of the animal separating the gut and nervous tissue. All chordates are triploblastic and coelomate animals. Phylum Chordata is divided into two groups: Prochordata and Vertebrata.

1. Prochordata

The prochordates are considered as the forerunners of vertebrates. Based on the nature of the notochord, prochordata is classified into subphylum Urochordata and subphylum Cephalochordata.

Subphylum Urochordata

Notochord is present only in the tail region of free-living larva. Adults are sessile forms and mostly degenerate. The body is covered with a tunic or test. e.g. Ascidian

Subphylum Cephalochordata

Cephalochordates are small fish like marine chordates with unpaired dorsal fins. The notochord extends throughout the entire length of the body. E.g. Amphioxus

2. Vertebrata

This group is characterized by the presence of vertebral column or backbone. Notochord in an embryonic stage gets replaced by the vertebral column, which forms the chief skeletal axis of the body. Vertebrata are grouped into six classes.

Class: Cyclostomata

Cyclostomes are jawless vertebrates (mouth not bounded by jaws). Body is elongated and eel like. They have circular mouth. Skin is slimy and scaleless. They are ectoparasites of fishes. E.g. Hagfish.

Class: Pisces

Fishes are poikilothermic (cold-blooded), aquatic vertebrates with jaws. The streamlined body is divisible into head, trunk and tail. Locomotion is by paired and median fins. Their body is covered with scales. Respiration is through gills. The heart is two chambered with an auricle and a ventricle. There are two main types of fishes.

i. Cartilaginous fishes, with skeleton made of cartilages e.g. Sharks, Skates.

ii. Bony fishes with skeleton made of bones e.g. Carps, Mullets.

Class: Amphibia (amphi- both; bios- life)

These are the first four legged (tetrapods) vertebrates with dual adaptation to live in both land and water. The body is divisible into head and trunk. Their skin is moist and have mucus glands. Respiration is through gills, lungs, skin or buccopharynx. The heart is three chambered with two auricles and one ventricle. Eggs are laid in water. The tadpole larva, transforms into an adult. e.g-Frog, Toad.

Class: Reptilia (repere- to crawl or creep)

These vertebrates are fully adapted to live on land. Their body is covered with horny epidermal scales. Respiration is through lungs. The heart is three chambered with an exemption of crocodiles, which have four-chambered heart. Most of the reptiles lay their eggs with tough outer shell e.g Calotes, Lizard, Snake, Tortoise, Turtle.

Class: Aves (avis – bird)

Birds are homeothermic (warm-blooded) animals with several adaptations to fly. The spindle or boat shaped body is divisible into head, neck, trunk and tail. The body is covered with feathers. Forelimbs are modified into wings for flight. Hindlimbs are adapted for walking, perching or swimming.The respiration is through lungs, which have air sacs. Bones are filled with air (pneumatic bones), which reduces the body weight. They lay large yolk laden eggs. They are covered by hard calcareous shell. e.g. Parrot, Crow, Eagle, Pigeon, Ostrich .

Class: Mammalia (mamma-breast)

Mammals are warm-blooded animals. The skin is covered with hairs. It also bears sweat and sebaceous (oil) glands. The body is divisible into head, neck, trunk and

tail. Females have mammary glands, which secrete milk for feeding the young ones. The external ears or pinnae is present. Heart is four chambered and they breathe through lungs. Except egg laying mammals (Platypus, and Spiny anteater), all other mammals give birth to their young ones (viviparous). Placenta is the unique characteristic feature of mammals.e.g Rat, Rabbit, Man.

7. Comparison of Gymnosperm with Angiosperms

Gymnosperms resemble with angiosperms in the following features

- Presence of well organised plant body which is differentiated into roots, stem and leaves.
- Presence of cambium in gymnosperms as in dicotyledons.
- Flowers in Gnetum resemble the male flower of the angiosperm. The zygote represent the first cell of sporophyte.
- Presence of integument around the ovule.
- Both plant groups produce seeds.
- Pollen tube helps in the transfer of male nucleus in both.
- Presence of eustele.

The difference between Gymnosperms and Angiosperms.

S.No	Gymnosperms	Angiosperms
1.	Vessels are absent [except Gnetales]	Vessels are present
2.	Phloem lacks companion cells	Companion cells are present
3.	Ovules are naked	Ovules are enclosed within the ovary
4.	Wind pollination only	Insects, wind, water, animals etc., act as pollinating agents
5.	Double fertilization is absent	Double fertilization is present

6.	Endosperm is haploid	Endosperm is triploid
7.	Fruit formation is absent	Fruit formation is present
8.	Flowers absent	Flowers present

8. Difference between Bryophytes and Pteridophytes

Bryophytes	Pteridophytes
Plant body cannot be differentiated into root, stem and leaf.	Plant body can be differentiated into root, stem and leaf.
Bryophytes are amphibians.	Pteridophytes are true land plants.
Vascular tissues are absent.	Vascular tissues are present.
The dominant phase of the plant body is gametophyte.	The dominant phase of the plant body is sporophyte.
Sporophytic generation depends on the gametophytic generation. E.g. Riccia	Gametophytic generation does not depend on sporophytic generation. Eg. Selaginella