

# Systematics

- **Systematics** is the study of the historical relationships of groups of biological organisms – the recognition and understanding of biodiversity.
- The term systematics was coined by **Linnaeus (1735)**.
- The terms systematics, taxonomy and classification are often held as **synonyms but technically they carry different meanings**.
- **G. Simpson (1961)** has distinguished the three terms.
- **Taxonomy** is the branch of study which deals with **identification, nomenclature and classification of organisms**.
- Term taxonomy was first given by French botanist **A.P. de Candolle (1778-1841)** for the theory of plant classification.
- Taxonomy is also called **systematic botany**.
- **Carolus Linnaeus** is called **father of taxonomy**.
- **H. Santapau** is called the **father of Indian taxonomy**.
- Taxonomy is of **three types** – **alpha ( $\alpha$ ) taxonomy**, **beta ( $\beta$ ) taxonomy** and **omega ( $\omega$ ) taxonomy**.
- When only morphological characters are used for identification and classification of plants then it is called **alpha taxonomy**.
- $\beta$ -taxonomy involves **genetical, anatomical, cytological, palynological, physiological and other characters**.
- $\beta$ -taxonomy is also called **biosystematics**.
- $\alpha$  and  $\beta$  taxonomy terms were given by **Turill**.
- Analysis and synthesis of all information and types of data to develop classification system based on phylogenetic relationships is called **omega taxonomy**.
- **Classification** is the placing of an organism or a group of organisms in category according to a particular system and in conformity with a nomenclature system.
- **Aristotle (father of zoology)** made the first recorded attempt to classify the animals in his book *Historia Animalium*.
- Aristotle made two main groups - **anaima** (animals with no RBC, invertebrates) and **enaima** (animals with RBC, vertebrates).
- **Theophrastus (372 - 287 BC)**, referred to as **father of botany**, classified plants on the basis of form and texture and described 480 plants in his book *Historia Planatarum*.
- **Identification** is to determine the exact place or position of an organism in the set plan of classification. Identification is **carried out with the help of taxonomic keys**.
- A **key** provides a convenient way for easy identification of an organism by applying **diagnostic or distinguishing characters**.
- Taxonomy **discovers and describes new species**, while systematics **uses evolutionary relationships** to understand biogeography, coevolution, adaptation and options for biological conservation.
- **Systematists or taxonomists** are thus the scientists whose expertise provides the data about the identification, description, distribution and relationship of life on Earth.
- **New systematics or biosystematics** is concept of systematics which brings about taxonomic affinity on the basis of evolutionary genetic and morphological traits.
- **Julian Huxley (1940)** proposed the term **new systematics**.

**Table :** Types of taxonomy

<b>Cytotaxonomy</b>	based on cytological study
<b>Karyotaxonomy</b>	based on nucleus and chromosomes
<b>Morphotaxonomy</b>	based on morphological characters
<b>Biochemical taxonomy</b>	based on biochemical studies
<b>Chemotaxonomy</b>	based on specific chemicals like secondary metabolites
<b>Numerical taxonomy</b> (also called adansonian taxonomy)	based on statistical methods
<b>Experimental taxonomy</b>	based on experimental determination of genetical inter-relationships and role of environment in their formation

## Nomenclature

- **Nomenclature** is giving distinct scientific names to various structures including living organisms, for their identification.
- Biological nomenclature is of **two types** - **vernacular** and **scientific**.
- Common names by which plants and animals are known in their regional places are called **vernacular names**.
- The vernacular name or common names are **based on some peculiarity of the organisms**, eg. Kandiali (a plant having spines).
- **Scientific name** are names given to organisms based on agreed principles and criteria for their acceptability all over the world.
- Scientific names are distinct and specific, they **have particular spellings which are not changed**.
- **Three types of nomenclature** are – **polynomial**, **trinomial** and **binomial nomenclature**.
- **Polynomial nomenclature** was the **first scientific attempt at nomenclature**, in which an organism is given a name consisting number of words that incorporate all its important characteristics. Eg. *Caryophyllum saxatilis folis gramneus umbellatis corymbis* which means caryophyllum growing on rocks, having grass like leaves and umbellate corymb flowers.
- **Trinomial nomenclature** is a taxonomic naming system that extends the standard system of binomial nomenclature by adding a third taxon. It is used in biology when the organisms within a species fall into separate groupings that need to be distinguished.
- Trinomial nomenclature is **different for animals and plants**.
- In animals **trinomen** or **trinominal name** refers to **the name of a subspecies**.
- **Trinomen** is a name **consisting of three names** – **generic name**, **specific name** and **subspecies name**. All three names are typeset in italics and **only the generic name is capitalised**. Eg. *Buteo jamaicensis borealis* is one of the subspecies of the red tailed hawk (*Buteo jamaicensis*).
- For plants trinomial nomenclature provides three part name (**ternary name**) for any taxon below the rank of species.
- **Binomial nomenclature** is a system of providing distinct proper scientific names to organisms with each name consisting of two words, **generic** and **specific**.
- Binomial nomenclature was **developed by Linnaeus** (a swedish biologist) who gave certain principles (called **Linnaean principles**) for this in his book *Philosophica Botanica* (1751). The standard references recognised for this are *Species Planatarum* (1733) and *Systema Naturae* (1758).
- According to binomial system, each organism is given a name made of **two Latin words**.
- For nomenclature the Latin language is used because **it is the dead language and no changes are supposed to occur in it**.
- Binomial system of nomenclature was introduced by **Gaspard Caspar Bauhin (1956)**. But he did not follow it scrupulously.
- Binomial names are of **universal application** for all the countries and languages.
- The **names indicate relationship of a species with others present in the same genus**.
- In binomial nomenclature following **rules are applicable**.
  - Name consist of two words – first word represents **the genus** and is called **generic name (generic epithet)**, whereas the second word represents the **species** called the **specific name (specific epithet)**.
  - The **generic epithet** always starts with **capital**

letters & specific epithet starts with **small letter**.

- Both these name must be **underlined separately (if handwritten) or italicised (if printed)**.
- **No comma, hyphen etc.** between specific and generic name is used.
- To the two word, name is appended the name of taxonomist who discovered the organism and provided with a scientific name, *e.g., Ficus bengalensis L, Homo sapiens L.*
- The different names given to same species by different workers are called **synonyms**, but the name given first is considered to be valid.
- The foundations of **International Code of Botanical Nomenclature (ICBN)** was found in **Philosophia Botanica**, a book written by **C. Linnaeus**. Current code of botanical nomenclature appeared in **1978**.
- Botanical nomenclature is **independent of zoological and bacteriological nomenclature which are governed by their own code**.

Some important abbreviation	
ICBN	– International code of botanical nomenclature
ICZN	– International code of zoological nomenclature
ICBacN	– International code of bacteriological nomenclature
ICVN	– International code of viral nomenclature
ICNCP	– International code of nomenclature for cultivation plants

## Types of specification

- The particular illustration designed by author of the species to represent the type of species is called **holotype**.
- A specimen which is a duplicate of the holotype, collected from the same place, same time and by the same person is called **isotype**.
- Any one of the two or more specimens cited by the author when no holotype was designated, or any one of the two or more specimens simultaneously designated as types is called **syntype**.
- A **paratype** is a specimen cited in the protologue that is neither the holotype nor an isotype, nor one of the syntypes if two or more specimens were simultaneously designated as **types**.

- A specimen or other element selected from the original material cited by the author when no holotype was originally selected or when it no longer exists is called **lectotype**.
- A lectotype is selected from **isotypes, paratypes or syntypes**.
- A specimen or illustration selected to serve as nomenclatural types as long as all of the material on which the name of the taxon was based is missing is called **neotype**.
- **Epitype** is a specimen or illustration selected to serve as an interpretative type when the holotype, lectotype or previously designated neotype, or all original material associated with a validly published name is demonstrably ambiguous and cannot be critically identified for purposes of the precise application of the name of a taxon.
- **Topotype** is often the name given to a specimen collected from the same locality from which the holotype was originally collected.
- When many names are given to the same species, then the name under which the **species was first described is valid**, provided the publication is **effective and valid**.

## Taxonomic hierarchy or Linnaean hierarchy

- **Taxonomic hierarchy** is the sequence of arrangements of taxonomic categories in a descending order during the classification of an organism.
- The word **taxa** represents taxonomic groups of any rank *i.e.* **any unit of classification**.
- In Linnaean hierarchy, the **number of taxa is five**, namely – class, order, genus, species and variety.
- The rank of species is basic and relative order of the rank of taxa are **species, genus, tribe, family, order, series, class, division (= phylum) and kingdom**.
- These categories/rank are ranked one over the other called '**hierarchy**'.
- **Kingdom** is the **highest** and **species** is the **lowest** category in this hierarchy.
- **Species** is the **basic unit of taxonomy**.
- **John Ray** introduced the term animal species.
- Species inhabiting the same geographical area (identical or overlapping) are **sympatric**.
- Species inhabiting different geographical areas are **allopatric**.

- Related species which are reproductively isolated but morphologically similar are called **sibling species**.
- A species restricted to a given area is called **endemic species**.
- Classical systematics is based on the 'typological concept' by **Plato** and **Aristotle**.
- The traditional concept of species was given by Linnaeus in *Systema Naturae*; this is based on morphology, and is **also known as 'morphological concept'**.
- **Genetic species concept** was given by **Lotsy** (1918), according to which, **a species is a group of genetically identical individuals**.
- Species that contain two or more subspecies are called **polytypic species**.
- Species that are not subdivided into subspecies are called **monotypic species**.
- Modern concept of species is **biological species concept** introduced by **Ernst Mayr** (1942).
- **Mayr defined species** as groups of interbreeding natural populations that are reproductively isolated from each other group.
- **Genus** is an assembly of related species which evolved from a common ancestor and have certain common characters called correlated characters, e.g., *Solanum tuberosum* and *Solanum melongena* are two species which belong to same genus of *Solanum*.
- A **family** subdivision of an order consists of a group of closely related genera, which in turn are composed of groups of closely related species.
- The taxon **commonly encountered in routine taxonomic work** is the **family**.
- Family with a single genus is called **monogeneric family**.
- An **order** is a **category within a class**. Carnivora is an order of flesh-eating animals within the class mammalia and there are several other orders of mammals like cattle, rodents, bats, seals, whales, etc.
- A **class** is a subdivision within a phylum made of one or more related orders, for e.g., within the phylum chordata there are five classes: mammals, birds, reptiles, amphibians and fishes.
- **Georges Leopold Cuvier** (1769-1832), the French naturalist, added the '**phylum**' in taxonomy.
- In taxonomy, the **correct sequence** is: **class - order - family - tribe - genus - species**.

- Microbiologists and botanists (**Eichler**) use the term '**division**' instead of '**phylum**'.
- All **kingdoms** have **more than one phylum**.
- The kingdom plantae contains several divisions (=phyla), including flowering plants, conifer trees, mosses, ferns and several other groups.
- Taxonomic hierarchy is useful in that it **provides information about relationships of an organism with others quick identification of a taxon**, all major traits and nonrepetition of correlated traits of various categories.
- According to ICBN different ranks or categories have following specific '**endings**' (*Refer table given below*).

Ranks	Plants	Algae	Fungi	Animal
Division/ Phylum	- phyta		- mycota	
Subdivision/ subphylum	- phytina		- mycotina	
Class	- opsida	- phyceae	- mycetes	
Subclass	- idae	- phycidae	- mycetidae	
Superorder		- anae		
Order		- ales		
Suborder		- ineae		
Infraorder		- aria		
Superfamily		- acea		- oidea
Family		- aceae		- idae
Subfamily		- ordeae		- inae
Tribe		- eae		- ini
Subtribe		- inae		- ina

**Table :** Taxonomic status of human & pea

Rank	Human	Pea
Domain	Eukarya	Eukarya
Kingdom	Animalia	Plantae
Phylum or Division	Chordata	Magnoliophyta
Subphylum or Subdivision	Vertebrata	Magnoliophytina
Class	Mammalia	Magnoliopsida
Subclass	Placentalia	Magnoliidae
Order	Primates	Fabales
Suborder	Haplorrhini	Fabineae
Family	Hominidae	Fabaceae
Subfamily	Homininae	Faboideae
Genus	<i>Homo</i>	<i>Pisum</i>
Species	<i>H. sapiens</i>	<i>P. sativum</i>

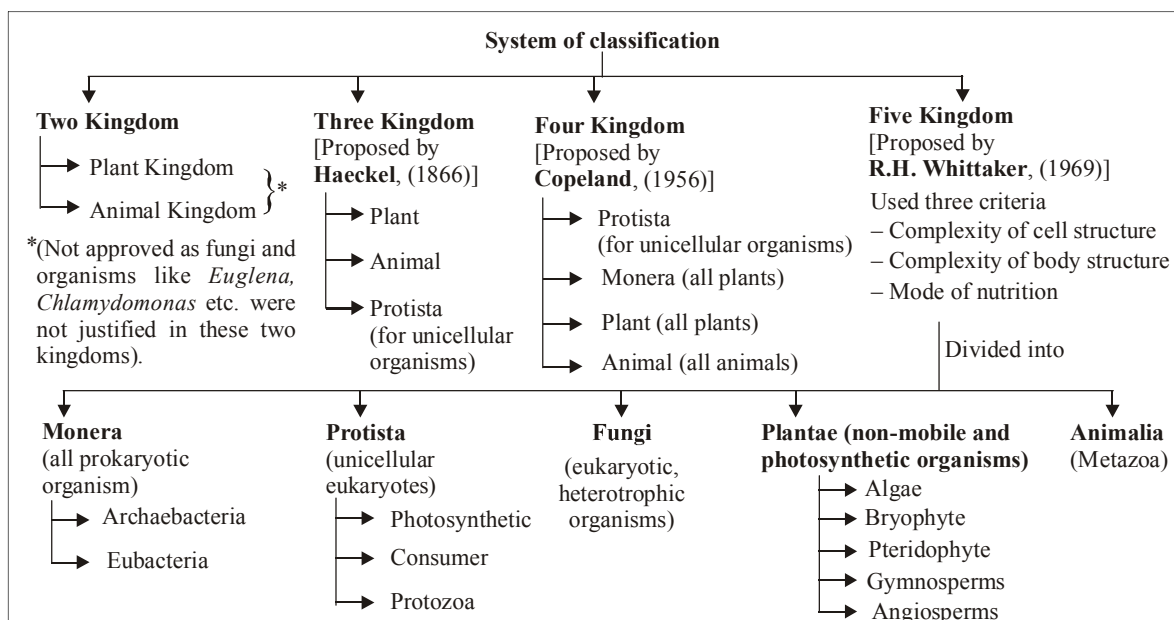
## System of biological classification

- There are **four different systems of classification**, mainly used by taxonomists. They are (i) **artificial**, (ii) **natural**, (iii) **phylogenetic**, and (iv) **phenetic**.
- A classification based on one or a few superficial similarities is called an **artificial system of classification**.
- Artificial system of classification was adopted by **Pliny the Elder** (first century AD) for animals on the basis of habitats, *e.g.*, land, air and water.
- The plants are classified on the basis of habit into (i) herbs, (ii) undershrubs, (iii) shrubs, (iv) trees in an artificial classification.
- The Linnaean system of classification of plants **on the basis of number and arrangement of stamens is artificial**. Linnaeus used number, union, length and certain other characters of stamens as the basis of classification of plants in his book '*Genera Plantarum*' (1737).
- In **natural systems of classification** organisms are arranged according to their natural affinities through the use of all important permanent characteristics, especially structural, cytological (chromosomal) reproductive and biochemical.
- **The first natural system of plant classification** was proposed by **Schimper (1879)** followed by **Eichler (1833)**.
- The **most important and last of natural systems for classification of seed plants** was developed by **Bentham (1800–1884)** and **Hooker (1817–1911)** in the treatise called *Genera Plantarum* (1862–1883).
- **The first natural system of animal classification** was developed by **Linnaeus** in his book "*Systema Naturae*". Improvements were subsequently made by Haeckel (1864) and Lankester (1874).
- The classification **based on evolutionary sequence and the genetic relationships among the organisms** is termed **phylogenetic system**.
- Darwin's book "**On the Origin of Species by Means of Natural Selection**" (1859) provided support to taxonomy.
- The phylogenetic classification of the plant kingdom was proposed by **Adolf Engler** (1844–1930) and his associate **Karl Prantl** (1849–1893) in their book *Die Natürlichen Pflanzen Familien*.

- In this system, flowering plants are placed in ascending series related to complexity of floral morphology.
- This classification was also adopted by the English botanist **John Hutchinson** (1884–1972) in two volumes of his book "**Families of Flowering Plants**".
- "Taxonomy without phylogeny is similar to bones without flesh" is the statement of **A.L. Takhtajan** (1967) who wrote the book "**A system of phylogeny of flowering plants**".
- According to zoologists, the natural system of classification **includes the phylogenetic and evolutionary trends**.
- A modern method of classification called **cladistics** is based on evolutionary history.
- The phylogenetic tree is also known as **genealogical tree** or **dendrogram**.
- **Phenetic taxonomy (classification)** is based on the overall similarity of organisms evaluated without regard to phylogeny.
- **Phenetic classification is based on observable characteristics of existing organisms**.
- Phenetic classification **did not have a strong impact on animal classification** and **scientific interest in this approach is on the decline**.

**Table : Historical accounts**

A.P. de Candolle (1813)	–	Term Taxonomy
E.H. Haeckel (1866)	–	Three Kingdom Classification
Copeland (1956)	–	Four Kingdom Classification
Whittaker (1969)	–	Five Kingdom Classification
John Ray (1627-1705)	–	Termed species
Carolus Linnaeus (1753)	–	Binomial System of Classification
Adolf Meyer (1926)	–	Used taxon term w.r.t. animal kingdom
H.J. Lam (1948)	–	Used term taxon in plant kingdom
Haeckel	–	Concept of phylogeny
Turill (1938)	–	Alpha taxonomy
Julian Huxley (1940)	–	Termed New systematics
Cuvier	–	Coined term phylum



- Organisms are classified according to two, three, four, five and six kingdom system (*Refer flowchart*).
- The **major criteria used for delimitation of kingdoms** are - **modes of nutrition, presence or absence of locomotion, complexity of organisation, and cell structure.**
- Viruses** do not fit neatly into any classification of living organisms because they have a very simple noncellular structure and cannot exist independently of other organisms.
- Herbarium** is a collection of plant parts that usually have been dried, pressed, preserved on sheets.
- Largest herbarium** of the world is at Kew.
- Botanical gardens** are the collections of living plants maintained for reference.
- The **largest botanical garden is the Main Botanical Garden, Moscow** covering an area of 900 acres.
- The Royal Botanical Garden, Kew England covers an area of 300 acres.
- Indian Botanical garden, Sibpur, Kolkata**, is the **largest botanical garden in India.**
- The collection of plants and animals are preserved and kept in museums for study and reference.
- Zoological parks** are zoos which help to study wild animals and their food habits.
- Camerarius** was the person who first recognised **sexuality in plants.**
- If the generic and specific names are same it is called **tautonym**. But tautonyms have been rejected by modern scientists.
- Angiosperms** are the most advanced type of plants.
- Angiosperms contain **seeds enclosed in fruits.**

**End of the Chapter**