THE LIVING WORLD

INTRODUCTION

- The study of living world is a special endeavor of humans.
- Humans are biological beings and are little different from other living organisms.

✍ Several animals have curiosity but humans are particularly more curious about natural world and their surroundings, this feature that makes humans singularly different from other living organisms.

- We keep pets, nurture plants, visit zoological and botanical gardens, climb mountain peaks or dive deep into the sea and undertake trekking in the forests to enjoy the serenity of wilderness along with its vast living and non-living resources. All these activities reflect the innate attraction of humans for natural world and their feeling of connectedness to living things.
- In fact, the scientific extension of human curiosity has given birth to the science of biology.

WHAT IS 'LIVING'?

- When we try to define 'living', we conventionally look for distinctive characteristics exhibited by living organisms.
- **Growth, reproduction,** ability to **sense** environment and mount a suitable response come to our mind immediately as unique features of living organisms.
- One can add a few more features like **metabolism,** ability to self-replicate, self-organise, interact and emergence to this list.

  Let us try to understand each of these.

1. GROWTH

- Increase in **mass** and increase in **number** of individuals are twin characteristics of growth.
- A multicellular organism grows by cell division.
- In plants, this growth by cell division occurs continuously throughout their life span (Indeterminate growth)
- In animals, this growth is seen only up to a certain age (Determinate growth). However, cell division occurs in certain tissues to replace lost cells.
- Unicellular organisms multiply by cell division. One can easily observe this in *in vitro* cultures by simply counting the number of cells under the microscope.

✍ In majority of higher animals and plants, growth and reproduction are **mutually exclusive events**.

- One must remember that **increase in body mass is considered as growth** but non-living objects also grow if we take increase in body mass as a criterion for growth. **e.g.** Mountains, boulders and sand mounds do grow. However, this kind of growth exhibited by non-living objects is by accumulation of material on the surface.

✍ In living organisms, growth is from inside. Growth, therefore, **cannot be taken as a defining property** of living organisms.

- Conditions under which it can be observed in all living organisms have to be explained and then we understand that it is a characteristic of living systems. A dead organism does not grow.

2. REPRODUCTION

- In multicellular organisms, reproduction refers to the production of progeny possessing features more or less similar to those of parents. Invariably and implicitly we refer to sexual reproduction.
- Organisms reproduce **by asexual** means also.
- Fungi multiply and spread easily due to the millions of **asexual spores** they produce.
- In lower organisms like yeast and hydra, we observe **budding**.
- In *Planaria* (flat worms), we observe true **regeneration,** i.e., a fragmented organism regenerates the lost part of its body and becomes, a new organism.
- The fungi, the filamentous algae, the protonema of mosses, all easily multiply by **fragmentation**.

⇘ When it comes to **unicellular** organisms like bacteria, unicellular algae or *Amoeba*, **reproduction is synonymous with growth,** i.e., increase in number of cells.

- We have already defined growth as equivalent to increase in cell number or mass.
- Hence, we notice that in single-celled organisms, we are not very clear about the usage of these two terms – growth and reproduction.

⇘ There are many organisms which do not reproduce (**mules, sterile worker bees, infertile human couples,** etc). Hence, reproduction also cannot be an all-inclusive defining characteristic of living organisms.

- Of course, no non-living object is capable of reproducing or replicating by itself.

3. METABOLISM

- All living organisms are made of chemicals.
- These chemicals, small and big, belonging to various classes, sizes, functions, etc. are constantly being made and changed into some other biomolecules. These conversions are chemical reactions or metabolic reactions.
- There are thousands of metabolic reactions occurring simultaneously inside all living organisms, be they unicellular or multicellular.
- All plants, animals, fungi and microbes exhibit metabolism.

⇘ **The sum total of all the chemical reactions occurring in our body is metabolism.**

- No non-living object exhibits metabolism.

⇘ Metabolic reactions can be demonstrated outside the body in cell-free systems**.** An isolated metabolic reaction(s) outside the body of an organism, performed in a test tube is neither living nor non-living.

⇘ Hence, while metabolism is a defining feature of all living organisms without exception, isolated metabolic reactions *in vitro* are not living things but **surely living reactions.**

⇘ Hence, cellular organisation of the body is **the defining feature of life forms.**

4. CONSCIOUSNESS

- Perhaps, the **most obvious and technically complicated feature** of all living organisms is this ability to sense their surroundings or environment and respond to these environmental stimuli which could be physical, chemical or biological. We sense our environment through our sense organs.
- Plants respond to external factors like light, water, temperature, other organisms, pollutants, etc. All organisms, from the prokaryotes to the most complex eukaryotes can sense and respond to environmental cues.

⇘ **Photoperiod** affects reproduction in seasonal breeders, both plants and animals.

- All organisms handle chemicals entering their bodies.

- All organisms therefore, are 'aware' of their surroundings.
- Human being is the only organism who is aware of himself, i.e., **has self-consciousness**. **Consciousness therefore, becomes the defining property of living organisms.**
- When it comes to human beings, it is all the more difficult to define the living state. We observe **patients lying in coma** in hospitals virtually supported by machines which replace heart and lungs. The patient is otherwise **brain-dead.** The patient has no self-consciousness.
- Properties of tissues are not present in the constituent cells but arise as a result of interactions among the constituent cells.
- Similarly, properties of cellular organelles are not present in the molecular constituents of the organelle but arise as a result of interactions among the molecular components comprising the organelle.
- These interactions result in emergent properties at a higher level of organization.
- This phenomenon is true in the hierarchy of organizational complexity at all levels.
- Therefore, we can say that living organisms are self-replicating, evolving and self-regulating interactive systems capable of responding to external stimuli.
- Biology is the story of life on earth. Biology is the story of evolution of living organisms on earth.
- All living organisms – present, past and future, are linked to one another by the sharing of the common genetic material, but to varying degrees.

Note: Consciousness, cellular organisation and metabolism are defining properties of living.

DIVERSITY IN THE LIVING WORLD

- The number of species that are known and described ranges between **1.7-1.8 million (1.25 Million animals and 0.5 million plants)**.
- This refers to **biodiversity or the number and types of organisms present on earth.**

TAXONOMY:

- **Taxonomy:** The term **Taxonomy** used by **A.P. de Candolle** in his book **'Theory of elementary de la botanqui'**.
- **Father of taxonomy:** Carolus Linnaeus
- **Characterization, identification, classification and nomenclature** are the processes that are basic to taxonomy.
- Based on characteristics, all living organisms can be classified into different taxa. This process of classification is **taxonomy**.
- External (Morphology) and internal structure (Anatomy), along with the structure of cell (Cytology), development process and ecological information of organisms are essential and form the basis of modern taxonomic studies.

SYSTEMATICS:

- The term **systematics** coined by **Carolus Linnaeus**. The latter is known as **'Father of Taxonomy'**.
- The word systematics is derived from the Latin word 'systema' which means systematic arrangement of organisms. Linnaeus used ***Systema Naturae*** as the title of his publication.
- It is the study of diversity and differentiation of organisms based on their phenotypic, genetic and phylogenetic relationships.
- Systematic includes **identification, nomenclature, classification and evolutionary relationships between organisms.**

	Difference between Classical Taxonomy and Modern Taxonomy	
	Classical Taxonomy	**Modern Taxonomy/ biosytematics**
1.	It deals with morphospecies (typological concept.)	It deals with biological species concept.
2.	Called **α–taxonomy** by Turril.	Called **ω–taxonomy** by Turril.
3.	Species is considred to be static.	Species is considered to be dynamic.
4.	Evolutionary relationship are not considered.	Based on evolutionary relationships (Cladistic).
5.	Supported by Aristotle, Theophrastus and Linnaeus.	Supported by Lamark, Huxley and other modern scientist.

New branches of systematics are as follows:

(a) Cytotaxonomy:

- It is based on cytological information like **chromosome number, chromosome structure and chromosome behaviour.**
- Karyotaxonomy is the most advanced branch of taxonomy.

(b) Numerical Taxonomy (Phenetics or Taximetrics) or Adansonian Taxonomy:

- It was developed by **Adanson**.
- It is based on all observable characteristic.
- Each character is given equal importance.
- Hundreds of character can be consider at the same time.
- Number and code are assigned to all character and data and then processed **using computer** or statistical method.

(c) Chemotaxonomy or Biochemical taxonomy:

- It is based on chemical constituent of plants.
- It involve **study of biomolecules** particularly secondary metabolites of the cell like betacyanin pigment in beet roots, raphides and cystolith crystals, sequencing of DNA and chemical nature of proteins.

NOMENCLATURE

- It is assigning of names to organisms. There is a need to standardize the naming of living organisms such that a particular organism is known by the same name all over the world. This process is called **nomenclature**.
- In ancient time organisms are given local names / vernacular names based on their characteristic or uses but local names vary from place to place, even within a country. **e.g.** Bottle guard is known by different name in different parts of country like - Louki, Dudhi, Ghiya etc.
- Nomenclature or naming is only possible when the organism is described correctly and we know to what organism the name is attached to. This is **identification.**
- Biologists follow universally accepted principles to provide scientific names to known organisms.
- Rules of standard naming is given by ICN (International code of nomenclature).

  ICZN (International Code of Zoological Nomenclature)

  ICBN (**International Code for Botanical Nomenclature-1961)**

  ICVN (**International Code of Viral Nomenclature**),

  ICNB (**International Code for Nomenclature of Bacteria**),

  ICNCP (International Code for Nomenclature of Cultivated Plants)

BINOMIAL NOMENCLATURE

- Initial idea of binomial nomenclature was given by **Gespard Bauhim.**
- Binomial nomenclature was given by C. Linnaeus.
- Each name has two components – the **Generic name (Genus)** and the **specific epithet (Species)**. This system of providing a name with two components is called **binomial nomenclature** (L. bi: two; *nomen*: name). e.g. Mango - *Mangifera indica*; Honey bee - *Apis indica*
- The binomial system became a common and established practice.
- This naming system using a two word format was found convenient.

GUIDELINES FOR NAMING OF ORGANISMS

Let us study some of the universally accepted norms for nomenclature.

i. A scientific name generally has **two words in Latin** or derived from Latin irrespective of their origin.

ii. **First word denotes the genus** whereas the **second one is for species**.

iii. Names are **printed in italics** or are separately **underlined** to indicate their Latin origin.

iv. Generic name starts with a **capital letter** and the specific name with a **small letter**, e.g. *Mangifera indica.*

v. The name of the author is written in abbreviated form after the species name and it is printed in Roman, e.g. *Mangifera indica* Linn. It indicates that this species was first described by Linnaeus.

vi. Each taxonomic group can have only one correct name.

vii. The name should be **short, precise and easy to pronounce**.

CLASSIFICATION:

- Nature has vast diversity of living organisms so it is nearly impossible to study all the living organisms, it is necessary to devise some means to make this possible. This process is **classification**.
- It is the process by which anything is grouped into convenient categories (according to a systematic plan or an order) based on some easily observable characters. **e.g.** We recognize groups / categories like plant, animals, dog, cat, mammals, wheat etc. on the basis of certain associated characters called as taxa.
- The purpose of biological classification is to organize the vast number of known plants and animals into categories that could be named, remembered and studied.
- The **earliest classifications were based on the 'uses' of various organisms** because in early days, human beings needed to find sources for their basic needs of food (e.g. oil yielding plants – Coconut, Mustard, Sesame), clothing (Cotton) and shelter (e.g. Medicinal plants – Turmeric, Rauwolfia).
- But now systematic is used for knowing more about different kinds of organisms and their diversities, and also the relationships among them.
- Classification is not a single step process but involves hierarchy of steps in which each step represents a rank or category.

TAXONOMIC CATEGORIES

- There are **7 main taxonomic categories (known as obligate or essential or broad categories)** which are essentially used in classification of organism.
- There are many **intermediate categories** like subkingdom, super phylum or super division, sub division, super class, sub-class, super order, sub order, super family, sub family, Tribe, sub species, variety etc. to facilitate more sound and scientific placement of various taxa.

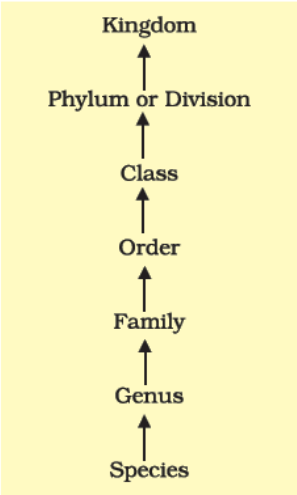


Fig.: Taxonomic categories (ascending hierarchy)

- Kingdom is the highest category.
- Species is smallest category / basic unit of classification.
- Descending or Ascending arrangement of taxonomic categories known as hierarchy of classification.
- Classification of any organism is written in descending order.
- No suffix for kingdom, genus and species.

TAXON V/S CATEGORY

- Taxon deals with real objects/living while category deals with ranking / abstract term.
- Taxon belong to any rank while category belongs to one particular rank.

  e.g. Bryophyta is a taxon while division is a category. Similarly pea is a taxon while species is a category.
- The number of common character goes on decreasing from species (more common character) to kingdom (less common character). **e.g.** order being a higher category is the assemblage of families which exhibit a few similar character. And the similar character are less in number as compared to different genera included in family.

Kingdom ⟶ Species
Common character increases

- Higher the category, greater is the difficulty of determining relationship to other taxa at the same level so problem the classification become more complex.

A. SPECIES

- Taxonomic studies consider **a group of individual organisms** with fundamental similarities as a **species**.
- Species is a **basic unit** for understanding taxonomy as well as evolution.
- one species can be distinguished from the other closely related species based on the distinct **morphological differences**.

e.g.
Mango – *Mangifera indica*
Potato – *Solanum tuberosum*
Brinjal – *Solanum melongena*
Makoi – *Solanum nigrum*
Lion – *Panthera leo*
Tiger – *Panthera tigris*
Human – *Homo sapiens*

indica, tuberosum, melongena, nigrum, leo, tigris, sapiens represent the specific epithets

Species concept:

- Species term and species concept was proposed by **John Ray.**
- Biological species concept was given by **Ernst Mayr**. According to Mayr "species is group of organism with similar morphology which can interbreed among themselves and produce fertile offspring". It is based on reproductive isolation.

B. GENUS

- Genus comprises **a group of related species** which has more characters in common in comparison to species of other genera.
- Each genus may have one or more than one specific epithets representing **different organisms, but having morphological similarities.**
- Genus may be monotypic (Single species in a genus e.g. *Gregoria fenestrata*) and Polytypic (many species in a genus).

Solanum (Genus)
- Tomato - *Solanum lycopersicum*
- Brinjal - *Solanum melongena*
- Potato - *Solanum tuberosum*

Panthera
- Lion – *Panthera leo*
- Tiger – *Panthera tigris*
- Leopard – *Panthera pardus*
- Jaguar – *Panthera onca*

Felis (Cat) and Canis (Dog)

C. FAMILY (Suffix – aceae)

- **Family** has **a group of related genera** with still less number of similarities as compared to genus and species.
- Families are characterised on the **basis of both vegetative and reproductive features** of plant species.

Solanaceae (Family)
- Solanum
- Petunia
- Datura

Falidae (cat family)
- Felis (Cats)
- *Panthera*

Canidae (Dog family)

D. ORDER (Suffix – ales)

- Order being a higher category, is the **assemblage of families.**

Polymoniales (Order)
- Convolvulaceae
- Solanaceae

Carnivora
- Felidae
- Canidae

Primata
- Cercopithecidae (Catarrhini) (Monkey)
- Hylobatidae (Gibbon)
- Pongidae (Gorilla and Chimpanzee)
- Hominidae (Human)

E. CLASS (Suffix – ae, – opsida, – phyceae)

- This category includes **related orders**.

Mammalia (Class)	Carnivora (order), Primata
Dicotyledoneae (Magnoliopsida)	Sapindales, Lamiales

F. PHYLUM / DIVISION (Suffix – phyta)

- Phylum (Animals) / Division (Plants) include related classes.

  Chordata (Phylum) → Pisces, Amphibia, Reptilia, Aves, Mammalia.

  Angiosperm (division) → Dicotyledoneae, Monocotyledoneae.

G. KINGDOM

- **Highest Taxonomical category**
- Plant Kingdom includes different divisions of plants and Kingdom Animalia includes all phylum of animals.

Organisms with their Taxonomic Categories

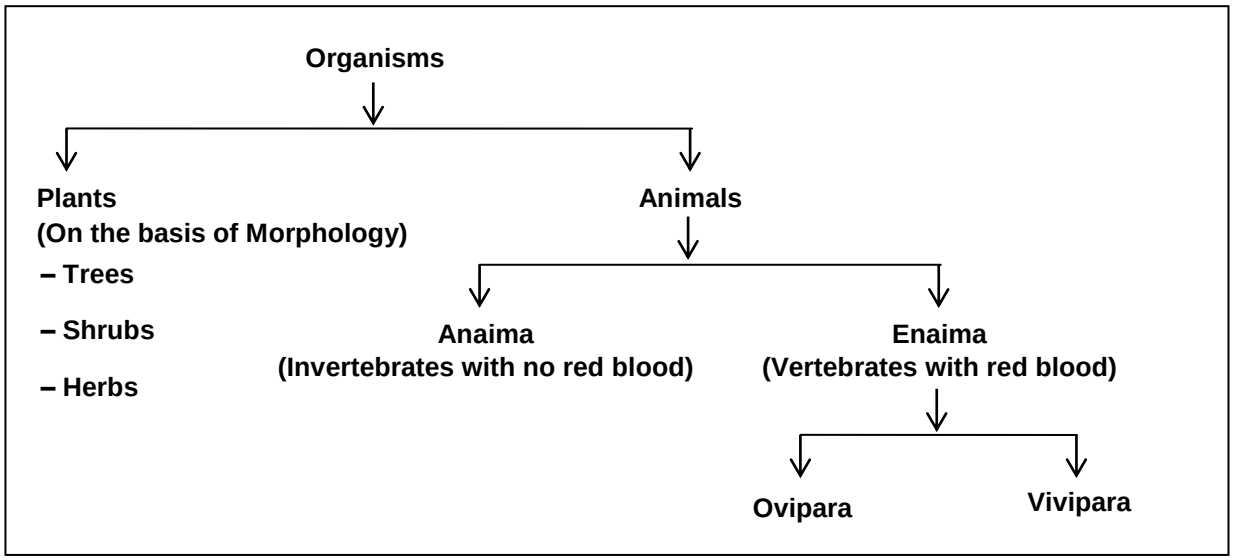
Common Name	Biological Name	Genus	Family	Order	Class	Phylum/ Division
Human	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda
Mango	*Mangifera indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	Angiospermae
Tulsi	*Ocimum sanctum*	*Ocimum*	Lamiaceae	Lamiales	Dicotyledonae	Angiospermae
Dog	*Canis familiaris*	*Canis*	Canidae	Carnivora	Mammalia	Chordata

BIOLOGICAL CLASSIFICATION:

- Three types of systems of classification have been recognized.
  (I) Artificial (II) Natural (III) Phylogenetic

(I) ARTIFICIAL SYSTEMS OF CLASSIFICATION:

- **Aristotle:** He was the earliest to attempt a more scientific basis for classification of plant and animal.



- **Carolus Linnaeus (1707-1778):** He proposed an artificial system of classification **(Also called sexual system of classification)** on the basis of few sexual characters like on the **androecium structure (number of stamens)**, in his book **Genera Plantarum**. He classified plants into **24 classes**. Out of them, **23 were of phanerogams** and **24th class was of cryptogams**.
- The earliest systems of classification used only gross superficial morphological characters such as habit, colour, number and shape of leaves, etc.
- They were based mainly on vegetative characters or on the androecium structure (system given by Linnaeus).

Demerits of artificial system:

(a) They separated the closely related species since they were based on a few characteristics.

(b) The artificial systems gave equal weightage to vegetative and sexual characteristics; this is not acceptable since we know that often the vegetative characters are more easily affected by environment.

(II) NATURAL SYSTEMS OF CLASSIFICATION:

- This system is based on natural affinities among organisms.
- In these systems organisms are classified on the basis of mainly external morphology and internal feature like ultrastructure, anatomy, embryology features, phytochemistry etc.
- Evolutionary evidences are not included.
- These were also proposed by Jussiaeu, de Candolle, Bentham and Hooker.

Bentham and Hooker's Classification:

- **George Bentham and JD Hooker (1862–83)** proposed a natural system of classification of angiosperms that was published in **'Genera Plantarum'** in 3 volumes. It is based on **A.P. de Candolle's system.**

They classified plant kingdom into two subkingdoms–**Cryptogamia and Phanerogamia. The phanerogamia classified in to three classes–Dicotyledons, Gymnosperms and Monocotyledons.**

Merits:

(i) It is practically important, **most of the herbaria of the world are based on this system.**

(ii) They placed Ranales (most primitive) in the beginning of classification that is phylogenetically true.

(iii) They placed monocots after dicots that is similar to phylogenetic systems.

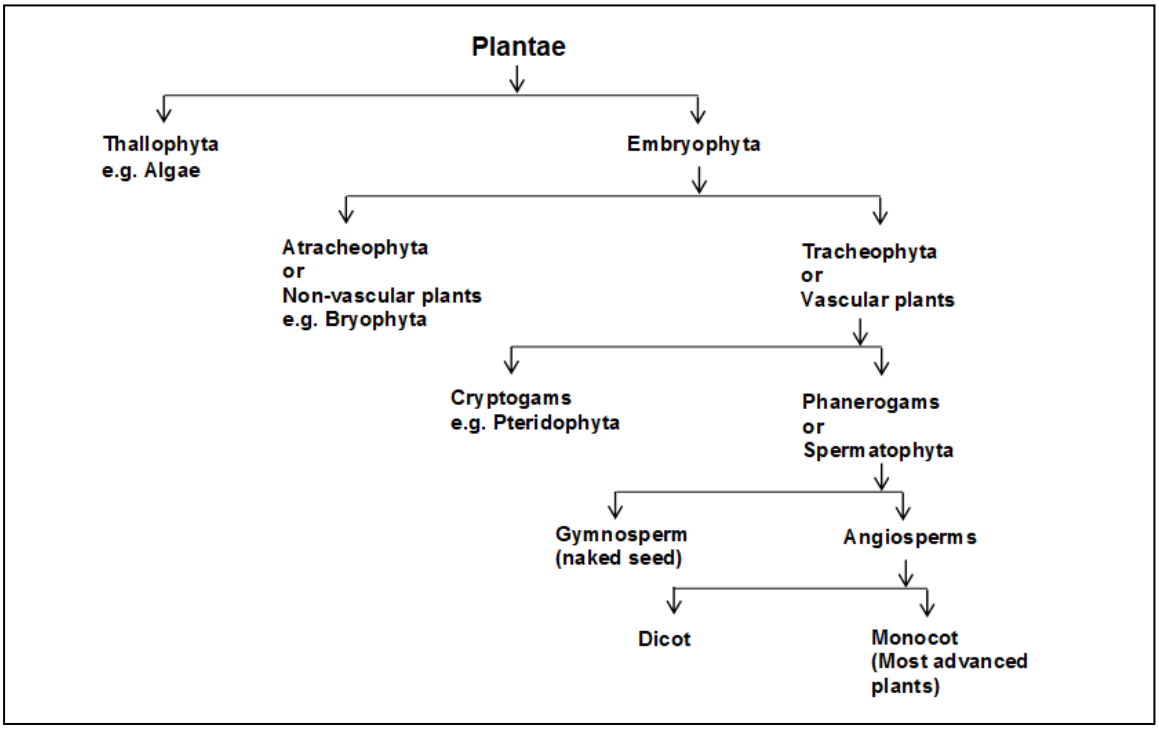
Demerits:

(i) They did not use phylogenetic trends in their classification.

(ii) Gymnosperms placed between dicots and monocots that is not acceptable.

(III) PHYLOGENETIC SYSTEMS OF CLASSIFICATION:

- Evolutionary history of the organism is called **Phylogeny (this term was coined by Lamarck)**. These systems are based on **Phylogenetic relationships** of organisms.
- Phylogenetic systems are also called **Cladistics** (Systematic classification based on evolutionary relationships of organisms in order of their assumed divergence from ancestral forms) and the graphic representation of evolutionary relationships is called family tree or **Cladogram**.
- **Engler and Prantl** proposed first phylogenetic classification (but it is very little phylogenetic) and published in their book **"Die Naturlichen Pflanzenfamilien"** in 23 volumes.
- **Engler and Prantl** divided plant kingdom into two sub kingdom **(1) Cryptogamia:** invisible sex organs e.g. Thallophyta, Bryophyta and Pteridophyta.; **(2) Phanerogamia:** visible sex organs e.g. Gymnosperm and Angiosperm.
- Later on well-developed phylogenetic systems of classification were created by **Hutchinson, Tippo, Takhtajan, Robert Whitaker, Robert thorne and Cronquist**.
- **Oswald Tippo** proposed biggest phylogenetic classification of plant kingdom and it is most accepted for books and study.
- Fossil records are most important evidences in systematics but if fossil record are not available then other branches of taxonomy like Karyotaxonomy, Cytotaxonomy, numerical, Chemotaxonomy etc. play important role to find out phylogeny
- Thallophyta includes those plants in which root, leaf and stem are not differentiated like fungi, Algae and Bryophyta.
- Pteridophyts are considered as vascular cryptogams.
- Thallophyta, Bryophyta and Pteridophyta are zoodiogamous plants (Motile male gamete) while Gymnosperm and Angiosperms are siphonogamous plants (Pollen tube formation).



BIOLOGICAL CLASSIFICATION:

On the basis of number of Kingdom.

1. TWO KINGDOM SYSTEM OF CLASSIFICATION:

- Proposed by **C. Linnaeus** and he classified all organisms into two kingdoms – **Kingdom plantae and kingdom Animalia**.

✍ Kingdom plantae involves autotrophic, fixed organisms while kingdom Animalia includes motile, heterotrophic organisms. Microorganisms involved in both the kingdoms.

Advantage of two Kingdom classification:

- Classification of organisms into plants and animals was easily done and was easy to understand.

Shortcomings of Two-Kingdom System:

(i) This system **did not distinguish between the eukaryotes and prokaryotes**. e.g. Bacteria and cyanobacteria are included under plants but the formers are prokaryotes.

(ii) **Unicellular and multicellular forms** have been placed in both the kingdoms though they have different organisation.

(iii) **A large number of organisms did not fall into either category.** e.g. Viruses are neither plants nor animals and placed at the border line of living and non-living.

(iv) **Photosynthetic (green algae) and non-photosynthetic (fungi) organisms were placed together.**

Thus two kingdom system of classification used for a long time was found inadequate.

2. THREE KINGDOM SYSTEM:

- **Ernst Haeckel** proposed it and three kingdoms are Plantae, Animalia and Protista.
- He separated all **one celled Eukaryotes** (Algae, Slime moulds, Protozoans, Fungi, bacteria) into separate kingdom **Protista**.

3. FOUR KINGDOM SYSTEM:

- It was proposed by **Copeland (1956)**.
- He established a new **kingdom Monera** for **all acellular prokaryotes** containing incipient nucleus like bacteria, blue green algae. The four kingdoms are monera, protista, plantae (metaphyta) and animalia (metazoa).
- **Copeland** used the term **Mycota for monerans**. **Dougherty** used the term **Monera**.

4. FIVE KINGDOM SYSTEM:

- It was proposed by **Whittaker (1969)**.
- It is a **phylogenetic system** that is based on following criteria.
  - **(i) Complexity of cell structure:** Prokaryotes and eukaryotes.
  - **(ii) Complexity of organisms:** i.e., thallus organisation (unicellular or multicellular organisms).
  - **(iii) Mode of nutrition:** Autotrophic (holophytic) or heterotrophic [saprophytic and holozoic]. It is major criteria of classification in this system.
  - **(iv) Reproduction**
  - **(v) Phylogenetic relationship**.

Table: Characteristics of the Five Kingdoms

Character	**Five Kingdoms**				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell Wall	Noncelluloic (Polysaccharide + amino acid)	Present in some	Present (without cellulose) with chitin	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 and photosynthetic and Heterotrophic (saprophytic / parasitic)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (saprophytic / parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic/ saprophytic etc.)

Merits:

(i) Fungi are separated from plants or protista and established as kingdom.

(ii) Prokaryotes and eukaryotes are separately recognised in this system.

Demerits:

(i) The position of Viruses is not clear.

(ii) Algae is placed into monera, protista and Plantae.

(iii) Protista is an artificial group.

Issues and considerations that influenced the classification system:

Issues:

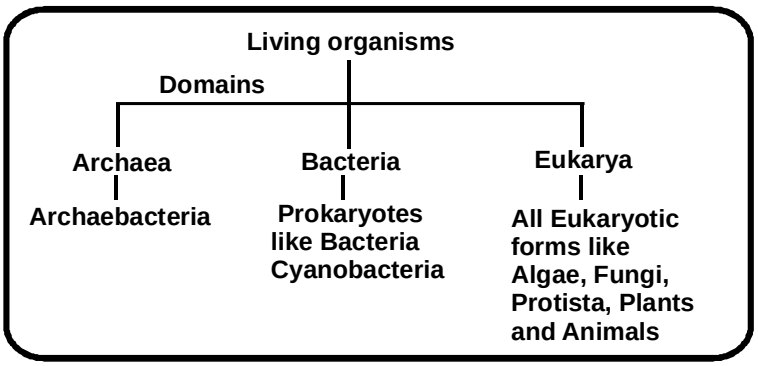
- Besides, gross morphology a need was also felt for including other characteristics like cell structure, nature of wall, mode of nutrition, habitat, methods of reproduction, evolutionary relationships, etc.
- Earlier classification systems plants included bacteria, blue green algae, fungi, mosses, ferns, gymnosperms and the angiosperms because all of these have cell wall.
- Prokaryotic bacteria and BGA were classified with eukaryotic groups.
- Unicellular organism like *Chlamydomonas* and *Spirogyra* were placed together under algae which is multicellular.
- Heterotrophic / Saprotrophic group like fungi were classified autotrophic green plants though they also showed a characteristic difference in their walls composition – the fungi had chitin in their walls while the green plants had a cellulosic cell wall.

Consideration:

- Fungi were placed in separate Kingdom because of difference in nutrition and cell wall.
- All prokaryotic organisms were grouped together under Kingdom Monera and the unicellular eukaryotic organisms were placed in Kingdom Protista.
- It has put together organisms which, in earlier classifications, were placed in different kingdoms. e.g. Kingdom Protista has brought together *Chlamydomonas, Chlorella* (earlier placed in Algae within Plants and both having cell walls) with *Paramoecium* and *Amoeba* (which were earlier placed in the animal kingdom which lack cell wall).
- This happened because the criteria for classification changed with time and this kind of changes will also take place in future too depending on the improvement in our understanding of characteristics and evolutionary relationships.
- Though plant and animal kingdoms have been a constant under all different systems, the understanding of what groups/organisms be included under these kingdoms have been changing; the number and nature of other kingdoms have also been understood differently by different scientists over the time.

THREE DOMAIN SYSTEM:

- **Carl woese** proposed three **domains system – Archaea, Bacteria and Eukarya.**
- It is based on genetic characters particularly genetic analysis of **16S rRNA.**
- **6 Kingdoms** are included in three domains (6th Kingdom is Archaebacteria)
- **Domain** is an intermediate category in classification and represented as super Kingdom.



TAXONOMICAL AIDS

- Taxonomic studies of various species of plants, animals and other organisms are useful in **agriculture, forestry, industry and in general in knowing our bioresources and their diversity.**
- These studies would require correct classification and identification of organisms.
- Identification of organisms requires intensive laboratory and field studies.
- **The collection of actual specimens of plant and animal species is essential and is the prime source of taxonomic studies.**
- These are also fundamental to studies and essential for training in **systematics.**
- It is used **for classification of an organism**, and the information gathered is also stored along with the specimens. In some cases the specimen is preserved for future studies.
- Biologists have established certain procedures and techniques to store and preserve the information as well as the specimens. Some of these are explained to help you understand the usage of these aids.

A. HERBARIUM:

- Herbarium is a **store house of collected plant specimens** that are **dried, pressed and preserved** on sheets. Further, these sheets are arranged according to a universally accepted system of classification.
- These specimens, along with their descriptions on herbarium sheets, become a store house or repository for future use.
- The herbarium sheets (standard size 16.5 × 11.5 inch.) also carry a label **providing information about date and place of collection, English, local and botanical names, family, collector's name**, etc.
- Herbaria also serve as **quick referral systems** in taxonomical studies.
- One has to carry certain simple tools for collection of specimens or their parts.
- The individual parts of a plants are quite useful in identification.
- In the field, one requires digger for digging roots, scissors for cutting twigs, knife for woody twigs and a pole with a hook for collecting parts of tall trees.
- The collected specimens are carried in a box called vasculum to avoid loss of moisture and distortions by drying and shriveling up.

Types of herbaria

i. **National herbaria** have plant specimens of many parts of the world.
ii. **Regional herbaria** have plant specimens of a region.
iii. **Local herbaria** have plant specimens of a local area.

B. BOTANICAL GARDENS:

- These specialised gardens have **collections of living plants (only)** for reference.
- Plant species in these gardens are grown for identification purposes and each plant is **labelled indicating its botanical/scientific name and its family.**
- The famous botanical gardens are at **Kew (England)**, **Indian Botanical Garden**, Howrah (India) and at **National Botanical Research Institute,** Lucknow (India).

C. MUSEUM:

- Biological museums are generally set up in **educational institutes such as schools and colleges**.
- Museums have **collections of preserved plant and animal specimens** for study and reference. Specimens are **preserved in the containers or jars in preservative solutions.**
- Plant and animal specimens may also be preserved as **dry specimens**.
- Insects are preserved in insect boxes after collecting, killing and pinning.
- Larger animals like birds and mammals are usually **stuffed and preserved.**
- Museums often have collections of skeletons of animals too.
- Among plants it store only those plants which cannot be stored in Herbarium like cones of Gymnosperms.

D. ZOOLOGICAL PARKS:

- These are the places where wild animals are **kept in protected environments** under human care and which enable us to **learn about their food habits and behavior**.
- All animals in a zoo are provided, as far as possible, the conditions similar to their natural habitats. Children love visiting these parks, commonly called Zoos.




E. KEY:

- Key is another taxonomical aid used for **identification of plants and animals based on the similarities and dissimilarities**.
- Keys are generally **analytical in nature**.
- The keys are based on the **contrasting characters** generally in a pair called **couplet**.
- It represents the choice made between two opposite options.
- This results in acceptance of only one and rejection of the other.
- Each statement in the key is called a **lead**.
- Separate taxonomic keys are required for each taxonomic category such as family, genus and species for identification purposes.

Resonate the Concept

Type of keys

- Being analytical in nature these are generally of two types:

(a) Yoked or indented key

- The **indented key** provides sequence of choices between two or more statements of characters of species. The user has to make correct choice for identification.

(b) Bracketed key (More popular).

- In the **bracketed key**, the pairs of contrasting statements are used for identification. The number on the right indicates the next choice of paired contrasting statements.

F. FLORA:

- Flora contains the actual account of **habitat and distribution and index to the plant species** found in a particular area.

G. MANUALS:

- It contains compiled information about area covered, keys and description of families, genus and species.
- They are useful in providing **instruction** for **identification** of names of species, **occurance and collection** of plants found in an area.

H. MONOGRAPHS:

- Monographs contain **information on any one taxon** like families, genus etc.

I. CATALOGUES:

- Used **for identification of organisms** and it is list of all species in an area with brief description.

G. PUBLICATIONS:

- It like periodicals and dictionaries are brought out to provide information about new additions and updated information.

ADDITIONAL INFORMATION

- **Biology:** (Bios: life; logos: to discourse). Science that deals the study of living things.
- **Lamarck and Treviranus** (1801) were the first to use the term Biology.
- The branch of biology which deals with the study of animals is called **zoology** (zoon: animal; logos: to discourse). **Aristotle** is regarded as **Father of Zoology. Book - Historia animalia.**
- The study of plants is called **Botany** (botane: plant). **Theophrastus (370-287 B.C.)** prepared a list of 500 plants and is called **"Father of Botany". Book - Historia plantarum.**
- In **Chandyogya Upanishad** animals were classified into 3 categories i.e. **Jivaja (Viviparous), Andaja (Oviparous) Udbhija (Vegetal origin).**
- **Charaka** was the first physician to present the concepts of digestion, metabolism and immunity. According to him, a body functions because it contains three doshas, namely, bile (pitta), phlegm (cough) and wind (vata) and illness is caused when the balance among the three doshas in a human body is disturbed. These are the basis of the indigenous system of medicine in India which is known as **Ayurveda**.
- **Aristotle (384 – 322 BC):** Greek; classified animal species and arranged them in hierarchies.
- **C. Linneaus: Books – Species plantarum (1753, 5900 plant species) and Systema naturae (1758, 4326 animal species).** He also gave term systematics and class.
- **Apoplasmic substances** are non-living components formed by cell e.g. Cell wall, fibers in connective tissue, matrix of bone etc.
- We can't create protoplasm because of lack of organisation of biomolecules.
- Silent valley rain forest of Kerala saved from submergence under proposed dam on river **Kuntizha.**
- **Microfossils** is used for impression and remains of microorganism as well as microscopic remains of large organisms.
- **Theophrastus:** On the basis of **habit**, He classified 480 plants into **four group's - herbs, under shrubs, shrub and trees**.
- **Tautonyms:** Scientific name in which genus and species name are same are called Tautonyms. Tautonyms are valid for animal nomenclature only.

  e.g. Rat (*Rattus rattus*), Cobra (*Naja naja*)

FATHER IN THE FIELD OF BIOLOGY

Father of Biology	**–**	Aristotle
Father of Botany	**–**	Theophrastus
Father of Zoology	**–**	Aristotle
Father of Taxonomy	**–**	Carl Linnaeus
Father of Genetics	**–**	G.J. Mendel
Father of Medicine	**–**	Hippocrates
Father of Surgery	**–**	Susruta

SOME INTERESTING FACTS OF BIOLOGY

ANIMAL WORLD

National bird	–	*Pavo cristatus* (Peacock)
Living fossil arthropod	–	*Limulus*
Living fossil fish	–	*Latimeria chalumnae*
Living fossil reptile	–	*Sphenodon*
Smallest Mammal	–	Shrew
Smallest bird	–	Humming bird of cuba (5.5 cm)
Smallest bone	–	Stapes
Smallest virus	–	Foot mouth virus of cattle (20 micron)
Largest mammal	–	Blue whale
Largest Invertebrate	–	Giant squid
Largest cell	–	Egg of Ostrich
Tallest mammal	–	Giraffe
Longest cell	–	Nerve cell (Neuron)
Largest gland	–	Liver
Largest vein	–	Inferior vena cava
Largest virus	–	Pox virus
Fastest mammal	–	Cheetah (*Actiononyx jubatus*)
Fastest bird	–	Spine tailed shift of Japan

PLANT WORLD

National flower of India	–	Lotus (*Nelumbo nucifera*)
National fruit of India	–	Mango (*Mangifera indica*)
Joker of plant kingdom	–	Mycoplasma (PPLO)
Largest flower	–	*Rafflesia arnoldi* (1 mt in dia, wt 7 kg)
Largest Botanic Garden of India	–	Indian Botanic Garden, Sibhpur (Howrah) Kolkata
Largest herbarium of India	–	Central National Herbarium (CNH), Howrah, WB

IMPORTANT BOOKS

Historia Animalium	–	Aristotle
Historia Plantarum	–	Theophrastus
Origin of species	–	Charles Darwin
Philosophic Zoologique	–	Lamarck
Philosophia Botanica	–	C. Linnaeus
Species Plantarum	–	C. Linnaeus
Systema Naturae	–	C. Linnaeus
Micrographia	–	Robert Hooke
Historia naturalis	–	Pliny and Elder
Historia generalis plantarum	–	John ray (gave term species, family and genus)