CHAPTER 01

DIVERSITY IN LIVING ORGANISMS

"Man perfected by society is the best of all animals he is the most terrible of all when he lives without law, and without justice".

"ARISTOTLE (384-322 BC)"

INTRODUCTION

The living world around us exhibits a vast range of life forms which make this planet a wonderful and amazing place to reside. The variety of living organism flourishing on earth is infinite. Similarly variety of relationships are known to occur at micro level, i.e. cellular level too. Such molecular interactions occur inside, around and among the cells, which reveal astonishing facts about life. The Second approach is philosophical one, which mainly focuses on purpose of life to living organisms. Biological classification is the scientific procedure to classify the organisms into different groups on the basis of their similarities and dissimilarities also placing the groups ina a hierarchy of categories.

Life is a characteristic quality that differentiate an inanimate (non-living) object from the animate (living) forms. It is a unique, complex organisation of molecules that expresses itself through chemical reactions which lead to growth, development, responsiveness, adaptation and reproduction. The objects exhibiting growth, development, responsiveness and other characteristics of life are designated as **living beings.**

Diversity in the Living World

Science :

The word science cover from the Latin word *'Scientia'* which means knowledge.

So the definition of science is : Knowledge attained through practice or study.

'OR'

Knowledge or a system of knowledge covering general truth by actual observation, found correct on verification.

Biology :

It is a fusion or composition of 2 Greek words bios and logos.

Bios = Life

Logos = Study

Thus, biology is the science of life or living matter in all its forms and phenomenon especially with reference to origin, growth, reproduction, structure & behaviour.

'OR'

It is the science of life forms and living process.

The first major biological observation was made by ancient Greek naturalist named as **'Aristotle'** (384 - 322 B.C.).

Aristotle was awarded by the title as 'Father of Biology'. French biologist, Jean - Baptiste Pierre Antoine de Monet de Lamarck (1744 – 1829) & Gottfried Peinhold Trevirances coined the term biology.

Biology is then further divided into two parts :-

(1) Botany (2) Zoology

Botany :

The science or study of plants is called Botany.

The term 'Botany' come from the Ancient Greek word botane which means pasture or fadder. Although, technically botany is called Phytology (Phyto means plants) & logy (study).

Theophrastus (320 – 287 B.C.) is known as Father of Botany.

Zoology :

The science or study of animals is called Zoology. The term 'Zoology' came from the ancient Greek word zoion which means animal and logy means study. The father of zoology is Aristotle.

Microbiology :

It is the branch of biology which deals with different aspects of micro-organism. Leuwenhoek is called Father of Microbiology.

TAXONOMY

All living organisms are arranged into various groups based on their features according to the principle of identification, nomenclature and classification. This branch of study is called as Taxonomy.

Taxis = arrangement, nomos = law → Taxonomy is the study of principles and procedures of classification.

This word was proposed by **A.P. de. Candolle** in his book **"Theories elementaire de la botanique"** (Theory of elementary botany)

Taxonomy includes study of following 4 points

(1) Identification - Identification of living organisms

(2) Nomenclature - Nomenclature of living organisms

(3) Classification - Classification of living organisms in groups

(4) Affinities - Study of inter relationship between living organisms

Systematics :- (Branch related with taxonomy) that deals with nomenclature & classification.

(1) The term "Systematics" was proposed by Linnaeus

(2) Systematics, is the study of diversity of organisms and all their comparative and evolutionary relationship. It includes description of external morphological characters of plants or living organisms.

Eg. Morphological characters of Root, Stem, Leaves, Flowers

New systematics or Neo systematics or Biosystematics :-

(1) Neo - systematics ; A new branch whose name was given by **Julian Huxley** (1940).

(2) It includes description of all the characters (internal) including morphological characters (external) of plants or living organism.

(3) It is used to know the inter relationship among living organisms.

CHECKPOINT: New systematics is mainly based on evolutionary as well as genetic relationship(experimental taxonomy) as compared to morphological characters.

Some Informations :

- Maximum diversity is found in tropical rain forests.
- Second maximum diversity is found in coral reefs
- Practical significance of taxonomy is → Identification of unknown organism.

NOMENCLATURE

This is a system of giving names to particular species.

Polynomial System :

According to this system name of any plant consists of many words.

In the century before Linnaeus, plants and animals were given long, descriptive names (known as polynomials) to differentiate them.

For eg. Caryophyllum–Caryophyllum saxatilis folis gramineus umbellatis corymbis

These were not in universal record because polynomials were too long and difficult to record.

Binomial system :

(1) Binomial system was first proposed by **Gaspard Bauhin** in his book - "Pinax Theatre Botanica"

(2) **Carolus Linnaeus** :- Linnaeus used this nomenclature system for the first time on large scale and proposed scientific name of all the plants and animals.

- Linnaeus was the founder of binomial system.
- Linnaeus proposed scientific name of plants in his book **"Species plantarum"**. It was published on 1 st May 1753. So this was the initiation of binomial system for plants.So any name proposed (for plants) before this date is not accepted today.
- Linnaeus proposed scientific name of animals in his book "Systema naturae" (10^{th} edition).
- This 10^{th} edition of **Systema naturae** was published on 1 August 1758. So initiation of binomial system for animals is believed to be started on 1 Aug, 1758.

  According this system, the name of plant or animal is composed of two latin words. The first word is generic name indicates the name of the genus with capital letter and second word indicates the name of species or **specific epithet**. Generic name always begins with capital letter and specific name with small letter and printed in italics. Sometimes a species is described under different author by different names. There names are known as synonyms.

Trinomial Nomenclature :

Trinomial nomenclature is used to name subspecies. It was proposed by **Huxley and Stricklandt.** It refers to three part description that is each name has 3 parts.

The first part will be genus name

The second part will be species name

The third part will be subspecies name **(Variety).**

For example :

In animals

The species of crow is named as Carvus splendora – Indian crow

In plants

Brassica oleracea var. botrytis – Cauliflower

Principle of Priority :-

The nomenclature is done by principle of priority. If two names are proposed for any plant after the 1753, the valid name is the earlier name proposed just after 1 May, 1753.

ICBN

"International Code of Botanical Nomenclature"

ICBN - Book of rules of nomenclature

- ICBN was first accepted in **1961**.
- Collection of rules regarding scientific - nomenclature of plants is known as ICBN.
- ICBN was firstly proposed by –
  Sprague, **Hitchcock**, **Green (1930)**
- 12th International congress, Leningrade, revised ICBN in 1975.
- After revision it was republished in 1978. So that ICBN was published two times
  (1) 1961 (2) 1978

Main Rules of ICBN :-

(1) According to binomial system name of any species consists of two names -

(i) Generic name - Name of genus

(ii) Specific epithet - Trivial name

e.g. **Solanum tuberosum** (Potato) **Mangifera indica** (Mango)

↓ ↓ ↓ ↓

Generic name Specific epithet Generic name Specific epithet

(2) In plant nomenclature (ICBN) tautonyms are not valid i.e. generic name and specific name should not be same in plants.

eg. Mangifera mangifera

But tautonyms are valid in animal nomenclature (ICZN-International Code of Zoological Nomenclature)

eg. Naja naja (Indian cobra) , Rattus rattus (Rat)

(3) Length of generic name or specific name should not be less than **3** letters and not more than **12** letters.

eg. Mangifera indica

Exception :- Riccia pathankotensis - More than 12 letters

According to ICBN this name is not valid but this name was proposed before 1961, so it is valid.

(4) First letter of generic name should be in capital letter and first letter of specific name should be in small letter.

eg. Mangifera indica

But if specific name is based on the name of some person, its first letter should be in capital letter.

eg. Isoetes Pantii

(5) When written with free hand or typed, then generic name and specific name should be separately underlined. But during printing name should be italized.

(6) Standard size of herbarium sheet is 11.5 × 16.5 inches.

(7) Name of scientist should be neither underlined nor written in italics, but written in roman letters (simple alphabets)

(8) If any scientist has proposed wrong name then his name should be written in bracket and the scientist who corrected the name should be written after the bracket.

eg. *Tsuga canadensis* (Lin.) Salisbury

Note : Linnaeus named this plant as *Pinus canadensis*

(9) Scientific names should be derived from Latin or Greek languages because they are dead languages.

(10) Type specimen (Herbarium Sheet) of newly discovered plant should be placed in herbarium (Dry garden).

(11) Name of scientist (who proposed nomenclature) should be written in short after the specific name

eg. *Mangifera indica Lin.*

Type Specimen (Herbarium sheet) are of Different Type

Holotype

Isotype

Neotype

Syntype

Lectotyp

Paratype

CHECKPOINT: Nomenclature is invalid in absence of Herbarium sheet.

ICNB = International Code of Nomenclature for Bacteria

ICVN = International Code of Viral Nomenclature

ICNCP = International Code of Nomenclature for Cultivated Plants

ICZN

"International Code of Zoological Nomenclature"

- Founded in 1895, accepted in 1964.
- Rules the formal scientific naming of organisms treated as animals.
- Animals are named according to bionomial and trinomial nomenclature.

Trinomial System :-

(1) Proposed by **Huxley** and **Stricklandt**

(2) According to this system name of any plant or species is composed of three names -

(i) Generic name

(ii) Specific name

(iii) Subspecific name (Name of variety)

When members of any species have large variations then trinomial system is used. On the basis of dissimilarities this species is classified into sub species -

eg. **Brassica oleracea** var. **botrytis** (Cauliflower)

Brassica oleracea var. **capitata** (Cabbage)

Brassica oleracea var. **caulorapa** (Knol-Khol)

CLASSIFICATION

Biological classification :–

The art of identifying distinctions among organisms and placing them into groups that reflect their most significant features and relationship is called biological classification.

The purpose of biological classification is to organise the vast number of known organisms into categories that could be named, remembered and studied.

According to **"A.P. de Candolle"**, Classification is of two types

(1) Empirical Classification

(2) Rational Classification

1. Empirical Classification :-

(i) In this type, the actual nature or character of plants is not considered.

(ii) Plants are classified on the basis of their **alphabetical order**. i.e. on the basis of the name of plant.

(iii) On the basis of name, plant kingdom can be classified in 26 groups.

(There are 26 alphabets in English - According to this classification, all plants having same initial alphabet, are placed in one group. For example :- If the name of plants, starts from 'A', then it is placed in "A - group". Similarly if it starts with 'B', then it is placed in 'B - group")

(iv) This is not a true classification. It has only one application :- "Listing of flora".

(v) If any scientist, writes the flora of a particular area then he uses empirical classification.

Flora $\rightarrow$ Plants growing in a particular area.

- Two books in which flora of India is written

(i) Flora British Indica $\rightarrow$ By **J.D. Hooker** **(ii) Flora Indica** $\rightarrow$ By **William Rouxburgh**

2. Rational Classification :-

In this classification, plants are classified on the basis of their actual character or nature i.e. by viewing the characters.

Type of Rational Classification

(i) Artificial Classification :- In this type of classification plants are classified on the basis of one or two morphological characters. i.e. over all morphology is not considered.

for e.g. - Classification proposed by Linnaeus is Artificial

Linnaeus classified plant kingdom on the basis of only two characters

(1) **Stamens** (2) **Carpel**

On the basis of stamens and style, Linnaeus classified plant kingdom in to 24 classes

(1) Monandria — Those flowers in which only 1 stamen is present.

(2) Diandria — 2 stamens in flower

(3) Triandria — 3 stamens in flower

↓

(23) Polyandria — Many stamens

(24) Nonandria/Cryptogamia — No stamens

Note : Linnaeus divided flowering plants into 23 classes starting with class monandria with a single stamen (eg. *Canna*) and plants with twenty or more stamens attached with calyx were assigned to class **Icosandria**. He also included all non-flowering plants such as algae, fungi, lichens, mosses and ferns in a separate class called cryptogamia or nonandria.

(ii) Practical Classification :- In this type of classification, plants are classified on the basis of their economic importance. In this type of classification morphology of plants is not considered.

e.g. Oil yielding plants $\rightarrow$ Coconut, Walnut, Soyabean

Fibre yielding plants $\rightarrow$ Jute, Cotton

Medicinal plants $\rightarrow$ *Rauwolfia, Cinchona, Eucalyptus*

Note : In this classification, any one plant can be a member of more than one group.

eg. Turmeric : Multi uses of plant, it gives both medicines and spices.

(iii) Natural classification :- In this type, plants are classified on the basis of their **complete morphological** characters of stem, root, leaves, flowers etc. Maximum characters are taken as base in this classification.

Importance –

Natural classification is believed to be the **best classification**, because it represents the natural similarities and dissimilarities of plants i.e. it represents the interrelationship among plants.

In this classification, the plants belonging to the same group shows many similarities, while in artificial classification, the plants belonging to the same group shows only, 1 or 2 similar characters. They have many dissimilarities.

Natural Classification is of Two Types

(a) Natural formal

(b) Natural phylogenetic

(a) Natural formal → In this classification, the phylogeny of the plant is not considered i.e. only the morphology of the plant is considered.

(b) Natural phylogenetic → In this classification, both morphology and phylogeny are considered. In phylogenetic classification, the plants are arranged on the basis of their evolution.

Lamarck :- Proposed the term "Phylogeny"

Ernest Haeckel :- Gave the concept of phylogeny

Charles Darwin :- Gave broad explanation of phylogeny in his book "ORIGIN OF SPECIES"(1859)

(Geneology → Sequence of evolution)

Geneology of plant kingdom :-

Thallophyta → Bryophyta → Pteridophyta → Gymnosperm → Angiosperm (most advanced plants)

Note : Phylogenetic classification also known as cladistic classification

(iv) Adansonian system or phenetic classification or Numerical classification :-

Proposed by "Sokel and Sneath". In this plants are classified on the basis of numbers of similarities and dissimilarities.

Note :

In this, importance to any one character is not given , all characters have same importance. While in natural classification floral (reproductive) characters have more importance than vegetative (root, stem and leaves) characters.

TAXONOMIC CATEGORIES

There are **7 main** taxonomic categories.They are **obligate categories** i.e. they are strictly used at the time of any plant classification.

There are some extra categories, like sub division, sub order, sub family, tribe, sub tribe, etc. They are not regularly used. They are used only when they are needed.

Classification of Radish :-

Categories		Taxoms
Kingdom	–	Plantae
Division	–	Spermatophyta
Class	–	Dicotyledonae
Order	–	Parietales
Family	–	Brassicaceae
Genus	–	*Raphanus*
Species	–	*R.sativus*

Biggest group →
- Kingdom
- Division
- Class
- Order - Cohort
- Family
- Genus
- Species

- **Taxon** :- Plant groups or animal groups included in categories are called Taxon.

- **Adolf Mayer** - First proposed the term "Taxon" - for animals.
- **H.J. Lan** :- First proposed the term "Taxon" - for plants.
- The classification of any plant or animal is written in descending order.
- **Hierarchy** - Descending arrangement of taxonomic categories is known as hierarchy.
- **Species** :- Smallest taxonomic category → It is basic unit of classification

Suffix for taxa (Taxon)

Division	—	phyta
Sub div	—	phytina
Class	—	opsida, phyceae,ae
Order	—	ales
Sub- order	—	ineae
Family	—	aceae
Sub Family	—	oideae
Tribe	—	eae
Sub tribe	—	inae

Note : There is no suffix for Genus, Species and Kingdom

SPECIES CONCEPT

John Ray :- Proposed the **term** and **concept of species**

To explain the species different concepts were proposed, which are as follows

(A) Biological concept of species :-

(1) **Mayr** proposed the **biological concept of species**.

(2) Mayr defined the "species" in the form of biological concept.

(3) The main character in determination of any species is interbreeding. But this character is not used in taxonomy. In taxonomy, the determination of species is based on other characters.

eg. - Mainly morphological characters

(4) In higher plants, the determination of species is mainly based on the morphology of flower (floral morphology). Because floral (reproductive) characters are more conservative as compared to vegetative (Root, Stem, Leaf) characters i.e. they do not show major changes.

(5) According to Mayr "All the members that can interbreed among themselves and can produce fertile offsprings are the members of same species"

But this definition of Mayr was incomplete because this definition is applicable to sexually reproducing living beings because there are many organisms that have only asexual mode of reproduction.

eg. Bacteria, Mycoplasma, BGA

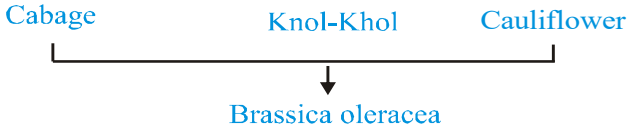
(6) When the species is determined on the basis of interbreeding then it is called as biological species.

eg. All the humans in this world can interbreed among themselves.

So all the humans are the members of one biological species.

(7) When the determination of species is based on other characters then it is called as **taxonomic species**.

eg.



These 3 have same morphological characters. Therefore they belong to same taxonomic species i.e. **one taxonomic species**. But these three can not interbreed among themselves. Therefore on the basis of interbeeding these are **three biological species**.

(B) Static concept of species :-

(1) The static concept of species was proposed by Linnaeus. According to Linnaeus "species is un-changeable" i.e. there is no change in the character of species. The species of present day are same as they were in past and they will remain same in future.

(2) Linnaeus believed in the **"Theory of Special creation"**

Father Suarez - gave the principle of special creation. According to this theory "All the living organisms are created by God (Every life is created by God) and God gave the basic size and shape of all living organisms, as they are still present in their actual former form. But Lamarck rejected this hypothesis.

(C) Typological concept :-

(1) It was proposed by "Aristotle" and "Plato".

(2) According to this concept "There is a definite type or pattern of characters in the each species of every living organisms and all the members of species show maximum resemblance with this pattern. (Typological concept is based on single individual of species)

The species in which a fixed pattern of characters is present are called as **monotypic** species.

eg. Bacteria, BGA

(3) In many species, more than one type or pattern of characters are present. These are called **"Polytypic species"** or **"Macrospecies"**.

eg. *Brassica oleracea* → Cauliflower, Cabbage, Knol - khol

(D) Dynamic concept of species :-

(1) It was proposed by **"Lamarck"**.

(2) According to this concept "Species is always changeable". Changes always occur in the characters of species from one generation to next generation. And these changes are known as "evolution".

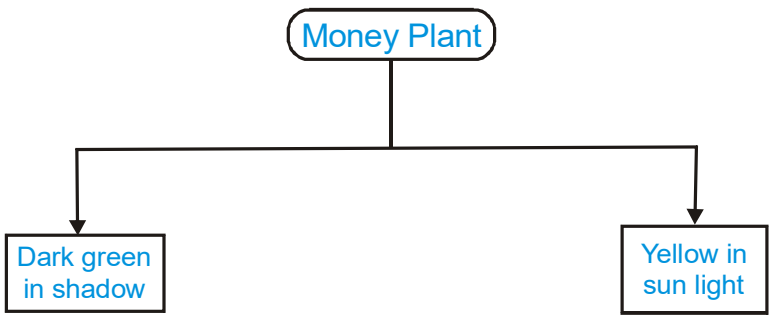
POLYTYPIC SPECIES ARE OF THREE TYPES

- **Biotype** – eg. Cauliflower, Cabbage, Knol–Khol are three biotypes of one species
- **Ecotypes** – **eg.** Crow (**Corvus splendense**) found in different regions are ecotype of one species

  Corvus splendense splendense – Indian crow

  Corvus splendense insolense – Myanmar crow

  Corvus splendense protegatus – Srilankan crow
- **Ecads or Ecophenes** – *eg. Every living being*



CHECKPOINT :- This hypothesis is believed to be most acceptable.

TAXONOMIC CATEGORIES

Classification is not a one step process but it includes heirarchy of steps. In this path each step represent a rank or category since the category is part of overall taxonomic arrangement, it is called the taxonomic category. Each category represnens a rank and is called taxon.

SPECIES: Taxonomic studies consider a group of individual organism with fundamental similarities as a species. One should be able to distinguish one species from the other closely related species based on the distinct morphological differences.

GENUS : Genus comprises a group of related species which has moe characters in common in comparison to species of other genera.

For example: Potato and Brinjal are two different spesies but both belong to the genus Solanum.

FAMILY : Family has a group related with still less number of similarities as compared to genus and species. Families are charcterised on the basis of both vegetative and reproductive features of plant species but reproductive or sexual or floral characters are used mainly.

For example: Three different genera Solanum, Petunia and Datura are included in family solanaceae.

ORDER : Order being a higher category is the advantage of families which exhibit a few similar character.

For example: Plant families like Convolvulaceae, Solanaceae are included in the order Polynomiales mainly based on the vegetative and floral or reproductive or sexual characters.

CLASS: Class includes organism related orders having less similarities than orders.

DIVISION: Division includes all organisms belonging to different classes having a few common characters.

HISTORY OF TAXONOMY

(1) Aristotle (382 B.C.) :- Father of biology & father of zoology

(2) Theophrastus :-

(A) Time - 370 - 285 B.C.

(B) He is known as father of ancient plant taxonomy and father of botany.

(C) Both Theophrastus & Aristotle are Greek political philosophers.

(D) Theophrastus wrote many books on plants. Few of them are as follows

(a) Historia plantarum **(b) Causes of plants** **(c) Enquiry into plants**

(E) Theophrastus gave names and descriptions of 480 plants in his book Historia plantarum.

(F) Theophrastus proposes the first classification of plant kingdom. He classified plant kingdom into **four** groups on the basis of **growth habit** -

(a) Trees (b) Shrubs (c) Under shrubs (d) Herbs

(G) It is artificial classification.

(H) He proposed the term Annual, Biennial and Perennials.

(3) A.P. De Candolle :-

(A) He wrote the book "Theories Elementaire de la botanique"

(B) He was the first to propose the significance of vascular tissue in taxonomy.

On this basis of vascular tissue he classified plants into two groups

(a) Cellular plants (Non vascular plants) - this group includes Thallophyta and Bryophyta

(b) Vascular plants - This group includes Pteridophyta, Gymnosperm and Angiosperms.

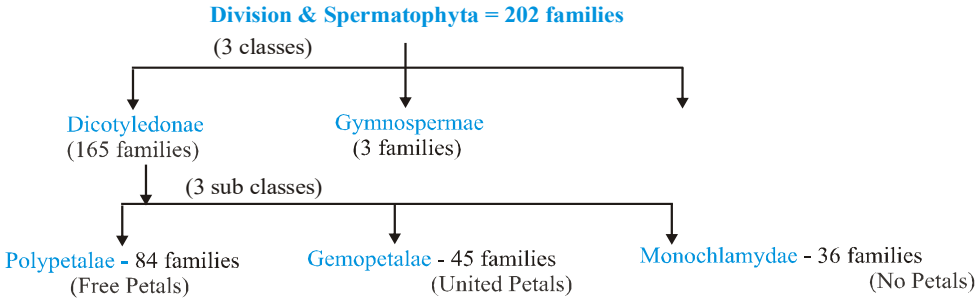
(4) George Bentham (1800 - 1884) and Joseph Dalton Hooker (1817 - 1911) :-

(A) Both Bentham and Hooker were related to Royal botanical garden.

(B) Scientists working in botanical garden are known as *curator*.

(C) They wrote the book "Genera plantarum" (1862 - 1883).

In this book, Bentham and Hooker gave the **biggest** and **natural classification** of spermatophyta i.e. plants with seeds.



- In Genera plantarum, there is description of 202 families. In this, basically the description of seeded plants is present.

Merits of Bentham and Hooker classification :-

- The classification of Bentham and Hooker was **natural formal**.
- The classification of Bentham and Hooker was mainly based on the **floral characters**. This was very appreciable because floral characters are more stable than vegetative (root, stem, leaves) characters.
- It is the simplest classification. Therefore the arrangement of all plants in the botanical gardens and herbarium of the world is based on it. Although it is **not the best** classification but yet the arrangement of plants in botanical gardens and herbariums is based on it, because it is the simpler one. The main reason for its simplicity is that this classification is based on **actual observations**.

Demerits of Bentham and Hooker classification :-

- In this classification the phylogeny of plants is not considered, because in it, gymnosperms are placed in between dicots and monocots. The sequence of evolution is as follows :-

Phylogeny = Gymnosperm $\rightarrow$ Dicots $\rightarrow$ Monocots

(5) Carolus Linnaeus :- [1707 - 1778]

(A) His real name was -**Carl Von Linne**

(B) On the basis of work in latin language, he changed his name to Carolus Linnaeus. He was the Swedish scientist

(C) He is known as father of taxonomy, father of plant taxonomy and father of animal taxonomy.

(D) Linnaeus gave the **two kingdom** system classification. He grouped plants and animals into kingdom **Plantae** and kingdom **Animalia** respectively.

(E) **Linnaeus** wrote many books. Some important **books** are :-

(1) Hortus uplandicus - First book **(2) Flora lapponica**

(3) Philosophia botanica **(4) Critica botanica**

(5) Systema naturae (1737) **(6) Genera plantarum**

(7) Species plantarum - last book (1753)

(F) In **"Philosophia botanica"** Linnaeus gave the principles of nomenclature.

(G) In **"Systema naturae"** Linnaeus gave the scientific names of animals. In this book he gives the detailed description of animal kingdom.

- He also gave the outline classification of plant kingdom in this book.

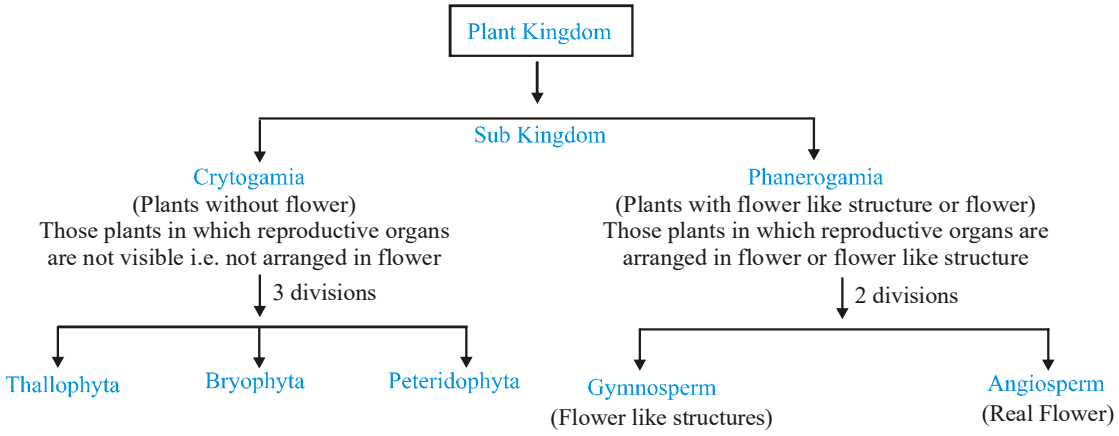
(H) In "**Genera plantarum**" Linnaeus gave the detailed description of plant kingdom.

- He classified the plant kingdom into 24 classes on the basis of stamens and style.
- This was an artificial classification.
- The main basis of Linnaeus classification was the "Sex organs". Therefore this classification is also known as "Sexual classification".

(I) In **"Species plantarum"** he gave the scientific names of plants. [He gave the description of 6000 plant species]

(6) A.W. Eichler :-

- Syllabus de vorlesungen uber phanerogamen kunde - Book written by Eichler.
- In this book, Eichler gave the **first phylogenetic classification** of plant kingdom.
- The classification of Eichler is very **little phylogenetic.**



In this way Eichler classified plant kingdom into **five divisions** and arranged them in the order of evolution (Phylogeny).

Thallophyta → Bryophyta → Pteridophyta → Gymnosperm → Angiosperm

(7) Engler (1844 - 1930) & Prantl (1849 - 1893) :-

Book - "Die Naturlichen Pflanzen Familien"

He gave the phylogenetic classification of plant kingdom. This classification was more phylogenetic as compared to Eichler's classification.

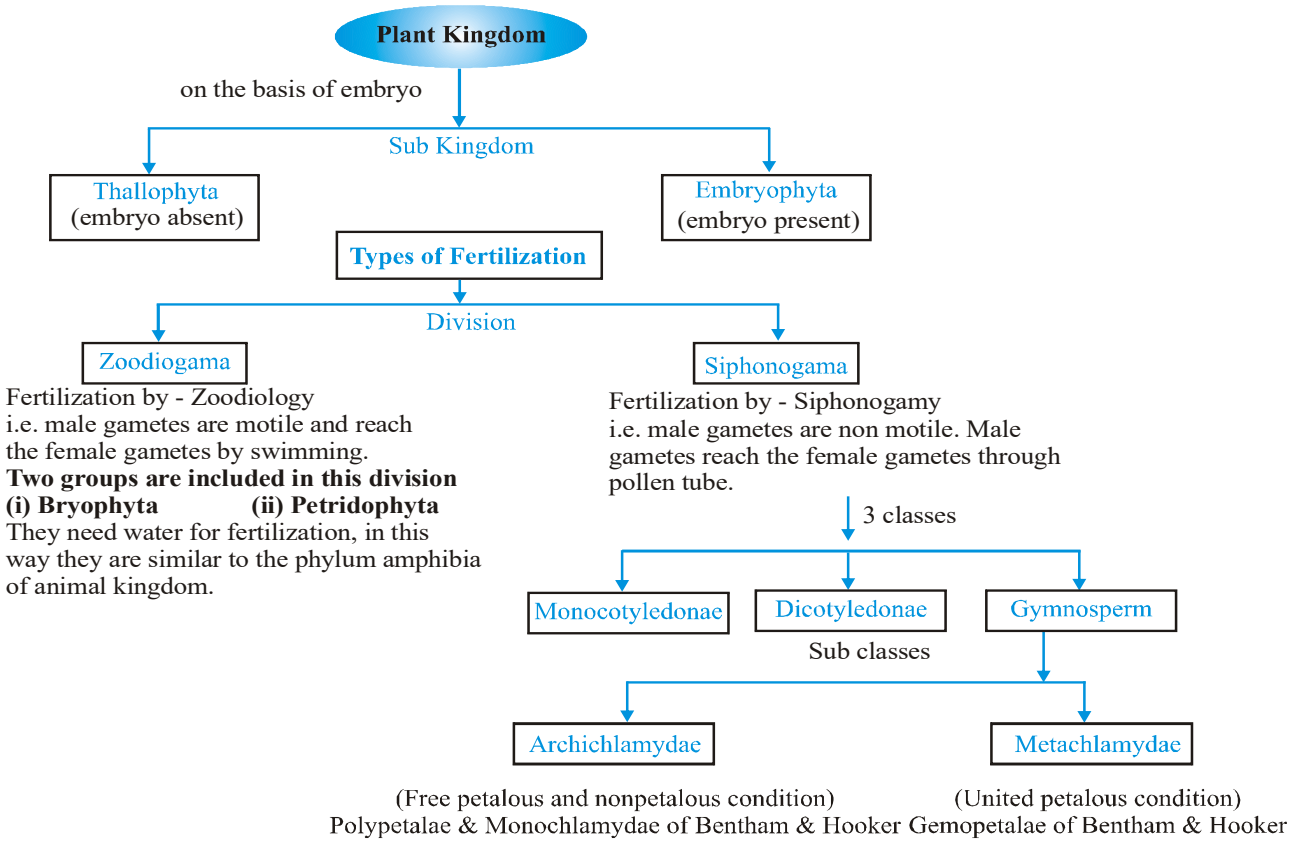
TAXONOMICAL AIDS

Biologists have established certain procedures and techniques to store & preserve the information as well as the sepcimens.

1. **Herbarium:** It is a store house of collected plant specimens that are dried, pressed and preserved on sheet. Its standard size is 11.5*16.5 inches. Further, these sheets are arranged according to universally accepted system of classification. These specimens, along with their descriptions on herbarium sheets, becomes a store house or repository for future use. The herbarium sheets 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 a quick refrerral systems in taxonomical studies.
2. **Botanical Gardens:** These specialised gardens have collections of living plants 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 Reasearch Institute, Lucknow (India).

3. **Museum:** Biological museums are generally set up in educational institutes such as schools and colleges. Museum 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 animals 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.
4. **Zoological Parks:** These are the places where wild animals are kept in protected environment under human care and which enable us to learn about their food habits and behaviour. All animals in a zoo are provided, as far as possible, the conditions similar to their natural habitats.
5. **Key :** Key is used for identification of plants and animals based on the similarities and dissimilarities. The key are based on contrasting characters generally in a pair called couplet. It represents the choice made between the two opposite options. Each statement of couplet is called Lead. Key are generally analytical in nature.



(8) Oswald Tippo :-

(A) Proposed the **biggest phylogenetic classification** of plant kingdom.

(B) This classification is the complete classification of plant kingdom.

(C) This is the **most acceptable** classification for books and study.

Plant Kingdom

Sub-Kingdom

Thallophyta - 10 Divisions — **Embryophyta**

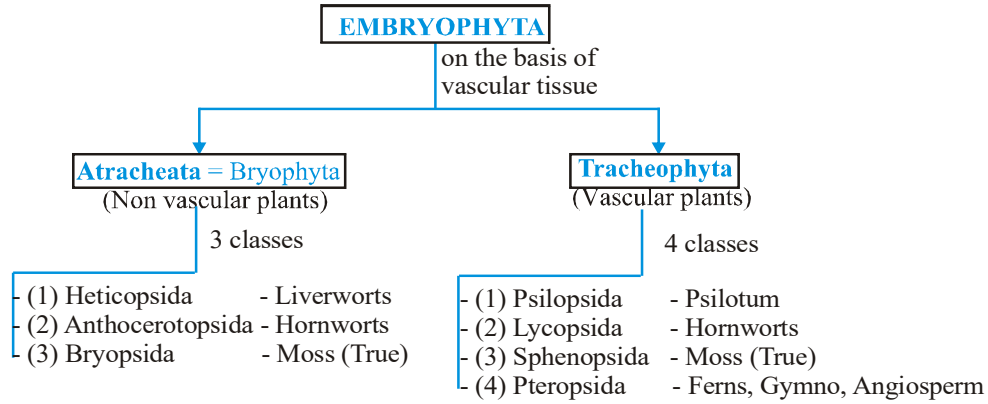
(1) Cyanophyta – B.G. Algae

(2) Euglenophyta – Euglenoids

(3)	Chlorophyta	–	Green algae
(4)	Chrysophyta	–	Yellow - Green - algae
(5)	Pyrrophyta	–	Dinoflagellates & Diatoms
(6)	Phaeophyta	–	Brown algae
(7)	Rhodophyta	–	Red algae
(8)	Schizomycophyta	–	Bacteria
(9)	Myxomycophyta	–	Slime molds (false fungi)
(10)	Eumycophyta	–	True fungi

These ten divisions include three types of organisms

(1) Algae	(2) Bacteria	(3) Fungi
(7 - division)	(1 - division)	(2 - division)



Note : Tippo did not use the word pteridophyta

(9) Haeckel :-

(A) Haeckel gave the **three kingdom (Protista, Plantae, Animalia) system** of classification.

(B) Haeckel established the kingdom Protista.

(C) The term 'Protista' was given by C. Cuvier.

(D) Haeckel grouped those living organisms in Protista which did not have tissues.

Kingdom Protista $\rightarrow$ Prokaryotes, Protozoa, Porifera, Algae & fungi

- First tissue was originated in animal kingdom in $\rightarrow$ Coelentrata
- First tissues was originated in plant kingdom in $\rightarrow$ Bryophyta

(10) Karl Menz :

(A) He showed the importance of **serology** in taxonomy.

(B) Similarities and dissimilarities in structure of proteins help to know the phylogenetic relationship of living beings. Living organisms which are phylogenetically close relatives have more similarities in their proteins. Organisms which are distantly related have different proteins.

Note : Phylogenetic relationship of plants and animals can be established by animal serum.Serology indicates that chimpanzee is closest relative of man.

(11) R. H. Whittaker (1969) :-

(A) He gave the **Five kingdom** system of classification.

(B) This classification was believed to be modern

The five kingdom classification of Whittaker was based on 3 main characters

(a) Complexity of Cell :-

Cell is prokaryote or Eukaryote , on this basis , kingdom Monera is formed. And all the prokaryotes are grouped in to it.

(b) Complexity of organism :-

Organism is unicellular or multicellular , on this basis kingdom Protista was formed, and all the unicellular eukaryotes are grouped into it.

(c) Nutrition :-

Organism is autotrophic or heterotrophic , on this basis kingdom Mycota, Plantae and Animalia were formed. Except fungi (heterotrophic) all the plants are autotrophs. Therefore fungi is separated from plants and placed in kingdom mycota. And remaining all the autotrophic plants are placed in kingdom - Plantae. Since all the animals are heterotrophs, therefore they are placed in fifth kingdom i.e. kingdom Animalia.

(12) Copeland :-

He gave the Four kingdom system of classification.

(i) Mycota :- Dougherty & Allen gave the name "Monera" to Mycota of Copeland. All the prokaryotes are grouped in Monera

(ii) Protista :- Copeland grouped those eukaryotes in protista, which are visually different than normal plants and animals.

eg. Brown algae, Red algae, Fungi, Protozoa

(iii) Plantae or Metaphyta :- Remaining all eukaryotic plants are grouped.

(iv) Animalia or Metazoa :- Remaining all eukaryotic animals are grouped.

TYPE OF TAXONOMY

(A) Alpha taxonomy or classical taxonomy : It is based on **external** morphology characters of plants.

(B) Beta taxonomy : Besides **external** morphology, it also includes **internal** characters like embryological, cytological, anatomical characters etc.

(C) Omega taxonomy : Omega taxonomy has widest scope. It is based on **all the informations** or data available about plants.

(D) Cytotaxonomy : The use of cytological characters of plants in classification or in solving taxonomic problems is called cytotaxonomy. Cytological characters constitute an important aid to plant taxonomy, especially in determining affinities at the generic and infrageneric levels.

(E) Chemotaxonomy : The uses of chemical characters of plants in classification or in solving taxonomic problems is called chemotaxonomy or chemical taxonomy. It is based on the chemical constitution of plants. The fragrance and taste vary from species to species.

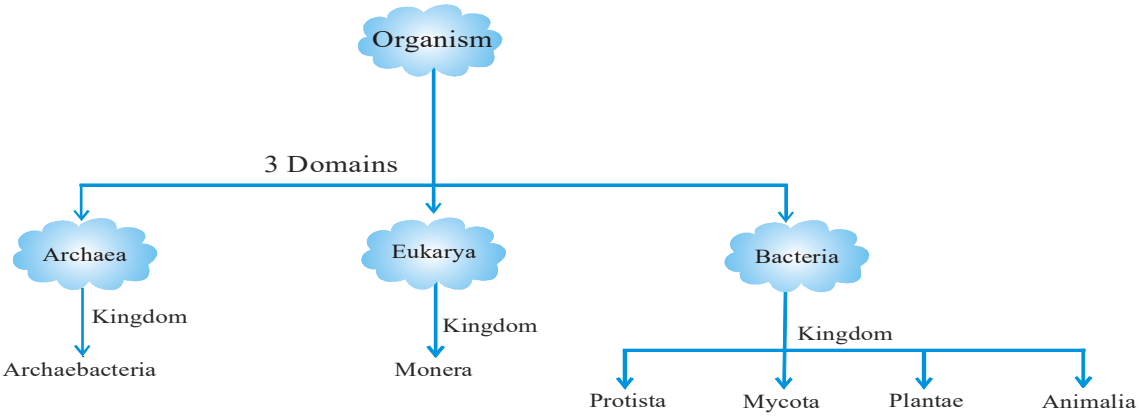
The basic chemical compounds used in chemotaxonomy are alkaloids, carotenoids, tannins, polysaccharide, nucleic acids, fatty acids, amino acids, aromatic compounds etc.

(F) Karyotaxonomy : Based on characters of nucleus and chromosomes. Pattern of chromosomal bands (dark bands and light bands) is most specific characters.

FIVE KINGDOM

1. **Monera :-** All the prokaryotes (Eubacteria, Rickettsia Actinomycetes, BGA, Archaebacteria, Mycoplasma)
2. **Protista :-** All the Unicellular eukaryotes (Dinoflagellates, Diatoms, Euglenoids, Slime moulds and Protozoans)
3. **Mycota :-** True fungi
4. **Plantae :-** All the multicellular plants – Algae, Bryophyta, Pteridophyta, Gymnosperm,Angiosperm
5. **Animalia :-** All the multicellular animals

Note : **Carl Woese** suggested separate kingdom for "Archaebacteria". He proposed six kingdom classification.



Note : **Domain is a super kingdom category and extra taxonomic catagory**

KINGDOM-MONERA (PROKARYOTES)

- **Christensen & Dougherty** - gave the term **'prokaryota'** and **'eukaryota'**
- **C.B. Van Neil** - Divided the living organisms into **prokaryotes** and **eukaryotes.**

Main Characteristic of Prokaryotes :-

(1) Cell wall :-

Cell wall of prokaryotes is made up of peptidoglycan (or murein) which is a type of mucopeptide.

The structure of peptidoglycan has two parts

(A) Polysaccharides :- They are made up of glucose, mannose, galactose and amino sugars units.

Amino sugars $\rightarrow$ N-acetyl glucosamine, N-acetyl muramic acid

(B) Amino acids :- Following amino acids are present in the cell wall of prokaryotes :-

(i) L - alanine (ii) L - Lysine (iii) D - alanine (iv) D - glutamic acid

- **Diaminopimelic acid** – This non proteineous amino acid is found in all eubacteria (Gram + & Gram –) and blue green algae.
- **Muramic acid** – This acid is found in eubacteria and BGA
- **Teichoic acid** – This acid is found only in Gram (+) eubacteria.

Note : The structure of cell wall in prokaryotes is complicated and this is the primitive character. Generally the cell wall of prokaryotes is not made up of cellulose but exceptionally there are some prokaryotes in which cell wall is made up of cellulose, which are as follows-

eg. *Acetobacter acetogenum, Acetobacter xylenum, Zymosarcina*

Prokaryotes which lack cell wall

eg. *Mycoplasma*

(2) Cell membrane :-

(A) Like eukaryotes the cell membrane of prokaryotes is made up of lipoprotein [lipid + protein]

(B) The space between cell wall and cell membrane is known as periplasmic space. This space, is **analogus** to lysosome because in this space the digestion of complex substance is done.

(3) Cytoplasm :-

(A) The cytoplasm of prokaryotes lacks membrane bound cell organelles.

(B) In Prokaryotic cell, the nucleus is indistinct. The nucleus of prokaryotes is also known as **incipient nucleus, genophore, nucleoid** or **fibrillar nucleus**. Nuclear membrane is absent around nucleus. It also lacks nucleolus.

Prokaryotes also lack the true chromosome. Instead of it, a false chromosome is present, which is made up of ds circular naked DNA + Non histone protein. Non histone proteins are polyamines. This false chromosome coils and forms the chromosomal region, which is known as nucleoid.

(C) In prokaryotes ribosomes are of 70s type.

(4) Movement :-

Prokaryotes are both motile & Non motile

(A) Motile prokaryotes -

In prokaryotes two types of locomotion are present

- Gliding :- Locomotion by slipping → They secrete mucilage and then glide on this mucilage. There is no particular structure like flagella for locomotion.
  eg. Myxobacteria, Cyanobacteria (BGA)
- Swimming :- Flagella are present in many prokaryotes for swimming.
  eg. Eubacteria

(B) Non motile prokaryotes -

eg. Mycoplasma

Examples of Prokaryotes

(1) Eubacteria (True bacteria) **(2) Actinomycetes**
(3) Blue Green Algae **(4) Archaebacteria**
(5) Rickettsia

EUBACTERIA HISTORY

1. They were first observed in rainy water and later in teeth scum by **Leeuwenhoek** (1675) and called them "Animalcule".
   This discovery was published in his book "The Secrets of Nature Discovered by Leeuwenhoek".
2. **F.J. Cohn** and Ehrenberg first of all coined the name "Bacteria".
3. **Bergey** placed bacteria in "Prosophyta group" and wrote a book "Manual of Determinative Microbiology". This book is known as "Bible of bacterial classification".
4. **Lister** developed "**culture technique**". He also developed the "**sterilization technique**" to sterilize the surgical instruments. He is regarded as father of antiseptic surgery
   He discovered the antiseptic nature of carbolic acid. Lister first of all cultured bacteria artificially.
5. **Louis Pasteur** proposed "**germ theory**" and called the bacteria "germ". He discovered the "Pasteurisation technique".
   (Pasteurisation technique - it is a process which means heating of drinks. It is carried out at 60°C temperature for 30 minutes duration.)
6. **Robert Koch**
   - Koch first obtained pure culture of bacteria .
     He discovered the Anthrax, T.B. and Cholera causing bacteria.
   - Koch gave some rules to prove that the bacteria are the cause of disease. These rules are known as "Koch postulates".
   - He awarded "Nobel Prize" for his work.
   - Koch postulates do not applicable on obligate parasite **(eg. Mycobacterium leprae)**