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Sundarakkottai, Mannargudi-614 016. Thiruvarur (Dt.),

Tamil Nadu, India.

MBE – I FUNDAMENTALS OF BOTANY AND ZOOLOGY

(16SMBEMB1)

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III B.Sc., MICROBIOLOGY

Semester : V

MAJOR BASED ELECTIVE I- MBE –I FUNDAMENTALS OF BOTANY AND ZOOLOGY -16SMBEMB1

Inst. Hours/Week : 5 **Credit : 5**

Objectives:

1. To gain the basic knowledge about plants and animals.
2. To study the bio- control measures of plants.

UNIT I

Introduction, Plant nomenclature- Binomial system, International code of Botanical Nomenclature (ICBN). Classification - Artificial and Natural system. Plant taxonomy.

UNIT II

Salient features, distribution and economic importance of angiosperms, gymnosperms, pteridophytes, bryophytes and Lichens.

UNIT III

Physiology and reproduction of plants - photosynthesis, sexual and asexual reproduction.

UNIT IV

Introduction to animal kingdom - Evolution theory. – Brief introduction of invertebrates and vertebrates.

UNIT V

Cell reproduction – Mitosis and Meiosis - Origin of germ cells - process of spermatogenesis and oogenesis. Types of eggs.

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INTRODUCTION TO PLANTS

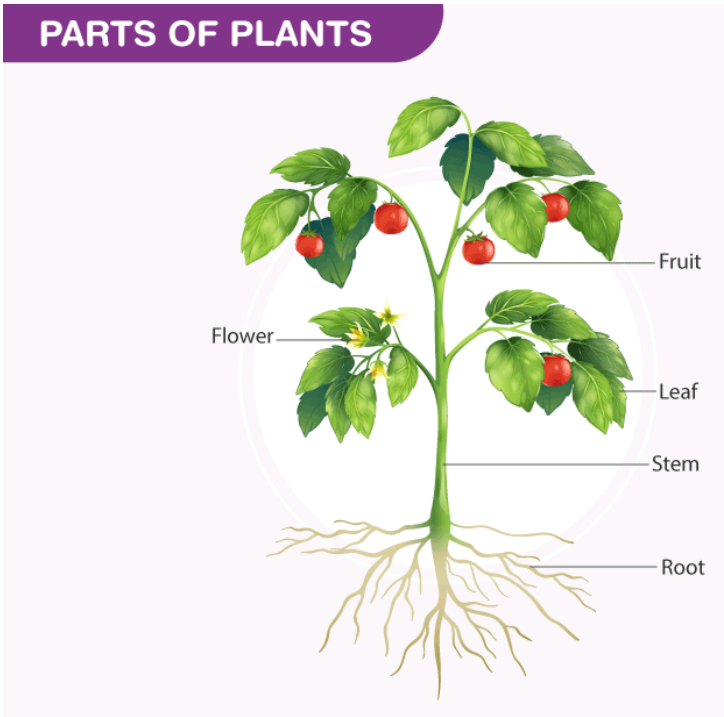
Plants are one of the most essential living organisms on earth. They are immensely beneficial to both animals and human beings. They produce oxygen which is crucial for the survival of living organisms. Trees provide shelter to animals and are also known for their medicinal benefits. Overall, different parts of plants exhibit different roles. They act as a source of food and oxygen and maintain the ecological balance.

A plant has many parts. Different parts perform different functionalities. The part of the plant that appears above the ground level is called the shoot system while the part of the plant which lies underneath the soil is called the root system.

Parts Of Plants

The main parts of a plant include:

- Roots
- Stem
- Leaves
- Flowers
- Fruits



Parts Of Plants Diagram

Roots

Roots are the important and underground part of a plant, which are collectively called the **root system**. They are the major part that anchors the plant firmly in the soil. They absorb water and minerals from the soil, synthesise plant growth regulators, and store reserve food material. The apical part of the root is covered by the root cap that protects the root apex.

The direct elongation of radicle leads to the formation of primary roots that grow inside the soil in dicots. It bears lateral roots that are known as secondary and tertiary roots.

In monocots, the primary root is replaced by a large number of roots because it is short-lived. In some plants such as Banyan tree, the roots arise from the parts of the plant and not from the radical. Such roots are known as adventitious roots.

Few plants that grow in swampy areas ave roots growing vertically upwards to get oxygen for respiration. Such roots are known as pneumatophores.

Stem

The stem is the part of the plant which is found above the ground. The bark of trees are brown in colour and younger stems are green in colour. It forms the basis of the shoot system and bears leaves, fruits and flowers. The region where the leaves arise is known as the node and the region between the nodes is known as the internode.

Stems arise from the plumule, vertically upwards to the ground. Initially, stems are usually weak and cannot stand straight. It eventually grows to become the toughest part of the plant called the trunk. The trunk is covered by a thick outer covering known as the bark. Overall stem provides a definite framework and structure to a plant, which later develops into a tree.

The stem provides support to the plant. They also protect the plant and help in **vegetative propagation**. A few underground stems such as potato and ginger are modified to store food.

The important functions of a stem include:

- A stem carries out a number of functions essential for various processes such as photosynthesis.
- Provides a definite framework and structure to a plant which later develops into a tree.
- **Support:** Primary function of the stem is to hold up buds, flowers, leaves, and fruits to the plant. Along with the roots, a stem anchors the plants and helps them to stand upright and perpendicular to the ground.
- **Transportation:** It is the part which transports water and minerals from the root and prepared food from leaves to other parts of the plant.
- **Storage:** Stems are one of the storerooms of plants where the prepared food is stored in the form of starch. The stems of a few plants in the desert areas, such as Opuntia, get

modified into thick, fleshy structures that store food and prevent excessive water loss due to transpiration.

- **Reproduction:** Few stems help in reproduction through vegetative propagation and also help to bear flowers and to produce fruits.
- **Guards**: Protects Xylem and phloem allowing them to perform their functions. The stem tendrils are spirally coiled and help the plant to climb support. The axillary buds also get modified into thorns that protect the plant from grazing animals.
- The stems of a few plants in the desert areas, such as Opuntia, get modified into thick, fleshy structures that store food and prevent excessive water loss due to transpiration.

Leaves

Leaves are the most important part of a plant. They contain chlorophyll that helps the plants to prepare their food using sunlight, carbon dioxide and water. A leaf consists of three main parts- petiole, leaf base and lamina.

1. The petiole keeps the leaf blade exposed to wind and cools the leaf.
2. The leaf base is a protruding part of a leaf**.**
3. The lamina of the leaf contains veins and veinlets that provide rigidity to the leaf blade and help in the transport of mineral nutrients.

Primarily, leaves have three main functions:

- **Photosynthesis:** Green leaves prepare food for plants by using water and carbon dioxide in the presence of sunlight. This process is called photosynthesis.

- **Transpiration:** Other than photosynthesis, leaves play a crucial role in the removal of excess of water from plants through tiny pores called stomata. This is the process of transpiration.
- **Reproduction:** Leaves of some plants helps in reproduction also. For e.g. leaves of Bryophyllum give rise to a new Bryophyllum plant.

Leaf and its parts

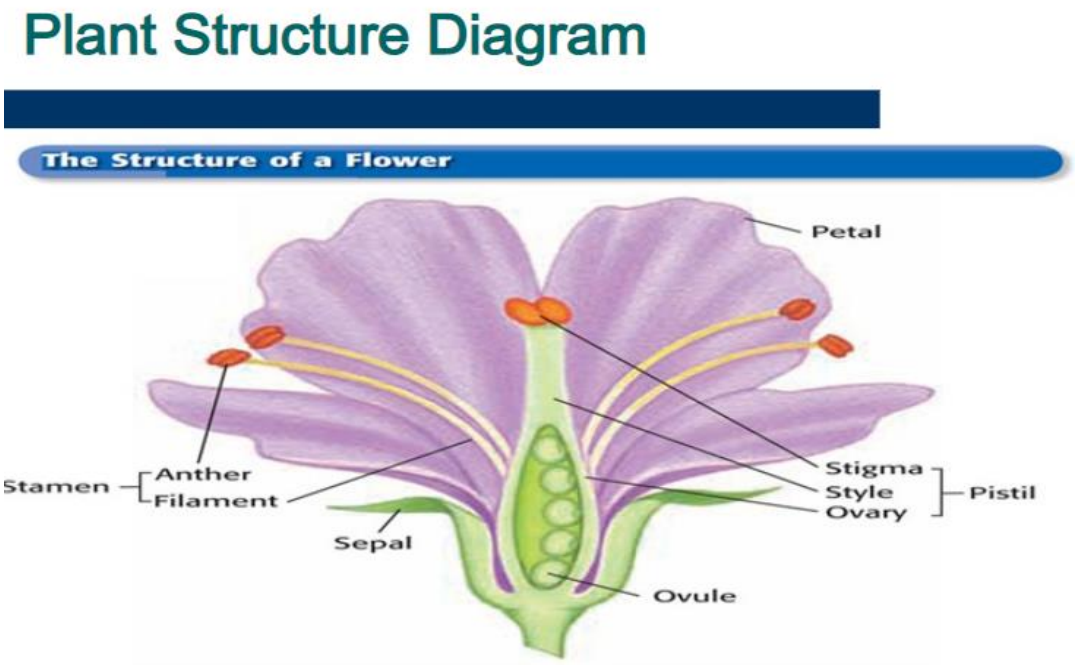
Other Parts of Plants

The other parts of a plant include flowers and fruits.

Flowers

Flowers are the most beautiful and colourful part of a plant. They are the reproductive part of a plant. A flower has four major parts, namely,

- **Petals:** It is the colourful part of a flower which attracts insects and birds.
- **Sepals:** Sepals are green leafy parts present under petals and protect the flower buds from damage.
- **Stamens:** This is the male part of the flower consisting of anther and filament.
- **Pistil:** This is the female part of the flower consisting of stigma, style, and ovary.



Fruits

Fruits are the main features of a flowering plant. It is a matured ovary that develops after fertilisation. Some fruits are developed without fertilization and are known as **Parthenocarpy** or parthenocarpic fruits.

Thus, we see how different parts of a plant help in the growth and development of a plant. All the plant parts are beneficial and work in coordination with each other.

Principles of Plant Taxonomy

Objectives of Plant Taxonomy:

The first object of plant taxonomy is to identify all the kinds of plants on earth with their names, distinctions, distribution, habit, characteristics and affinities. It also tries to correlate the studies with scientific data contributed by various researches in the field of botanical science. It gives an accumulated information and scientific knowledge of the world's plant resources.

The second objective is to arrange the kinds of plants into a scheme of classification or an orderly arrangement. There are some species that are closely related to each other than others. Such species are placed in a higher group; similarly the closely related higher groups to still higher groups and so on.

The third objective is to study the factors of evolution to find out the origin of species and their interrelationships. Hence a taxonomist not only studies the species existing today but also reveals the changes that they have undergone through the past.

The fourth objective of plant taxonomy is the correct naming of plants according to the international code of nomenclature. The naming of the plant is guided and regulated by international rules of botanical nomenclature.

In this system, to every plant a binomial name is given e.g., Cicer arietinum L.; the first name refers to its genus, the second to its species, L. for Linnaeus – the name of the person or author who first observed and reported the plant.

The fifth is the documentation which includes the preservation of living or fossil flora in a herbarium.

Manson H.L. (1950) in his paper **"Taxonomy, Systematic botany and Biosystematics"** thought that the science of taxonomy may be a synthesis of four inter-related fields viz.,

Systematic botany:

It is the fact finding field of taxonomy which includes genetically and cytological studies as well as other techniques applicable to the problem.

The taxonomic system:

It is based on the facts found by systematic botany and includes:

(a) Taxonomic concepts of plant groups or taxa.

(b) Concepts of the evolutionary sequence of characters.

(c) Classification and arrangement of taxa.

(d) Description of taxa and phytography.

Nomenclature:

It is a method of naming plants based on international rules which permit only a single valid name for each kind of plant.

Documentation:

It includes the preservation of living or fossil type specimens and illustrations in a museum or herbarium.

By all these fields of plant taxonomy light has already been thrown on plant or plant population, their units, interrelationship, distribution and evolutionary tendencies.

Principles of Plant Taxonomy:

Taxonomy is a functional science. The direction and character of its functions are governed by principles. The principles developed with the increase in knowledge of plants themselves.

It developed in the nineteenth century. This was mainly concerned with the observation of similarities, and differences in the gross morphological characters of plants known at that time. This began with the works of Tournefort, de Jussieu and Linnaeus. In this principle the plants were described and classified on the basis of morphological characters.

Experimental taxonomy:

This principle was introduced in the 20th century. Primary importance was given to morphological distinctness and affinity, but it was influenced appreciably by the findings of cytologist, geneticist, anatomist, physiologist and embryologist.

Phylogeny:

Modern taxonomists of the 20th century use phylogeny as the main principle of plant taxonomy. Phylogeny is the evolutionary history of a taxon. By this principle attempt is made to account for the origin and development of species. To determine the origin of a species a taxonomist has to depend on the science of palaeobotany which includes all taxa of extinct plant groups.

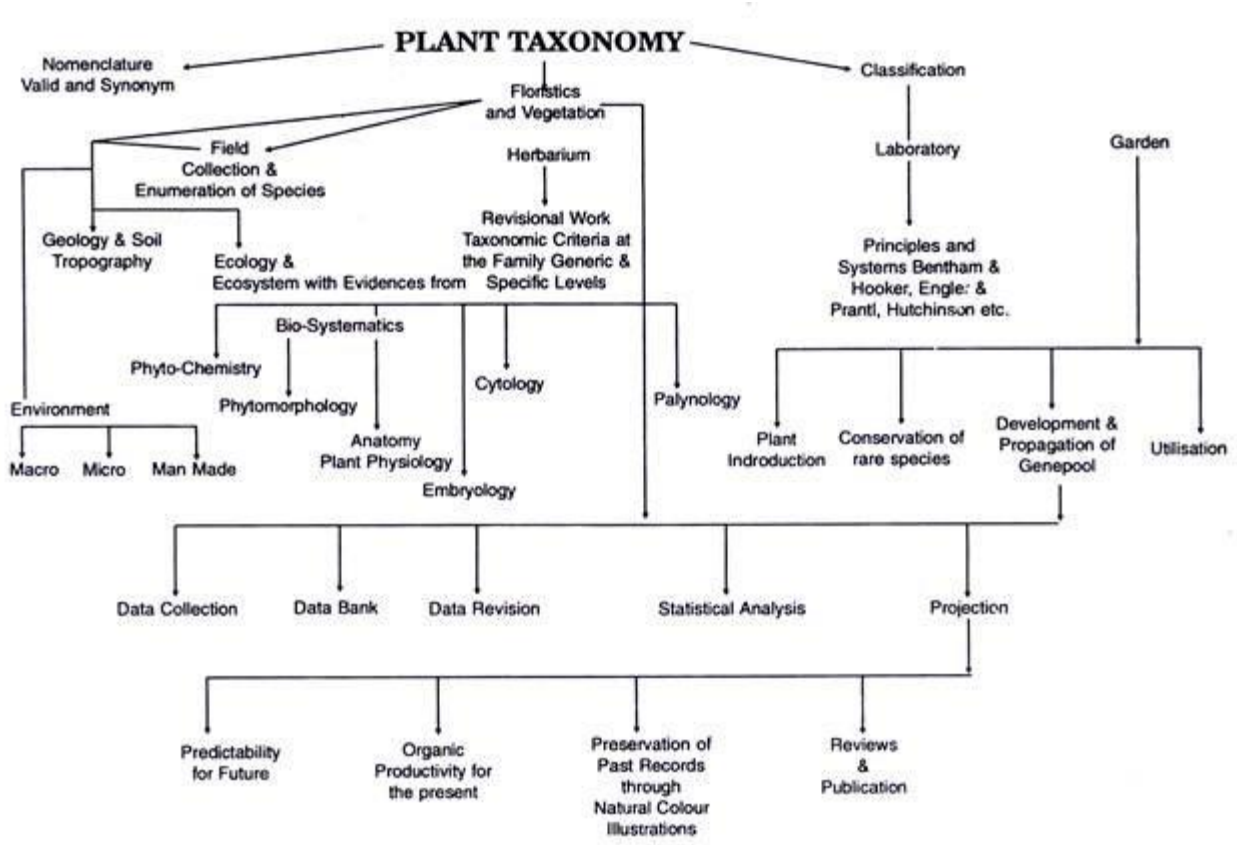


Fig. 1. A Chart showing the scope of plant taxonomical studies and applications.

Classification of Plant Taxonomy:

Classification is the ordering of organisms into groups (or sets) on the basis of their relationships i.e. phylogenetic relationship.

Types of Botanical Classification:

i. Empirical classification:

In this classification botanists have arranged the plants in alphabetical (ABC ……) order. The system may be compared with the alphabetical arrangement of words in dictionary. There was no character into consideration.

ii. Reasonable classification:

In this classification the plants were placed together on the basis of some natural characters which may link them.

This type of classification may further be divided into following three types:

(a) Practical classification:

This classification is mainly based on the properties of plants particularly to their value or use to human race.

(b) Artificial classification:

This is more or less arbitrary as the plants are classified on the basis of one or at the most few characters, which, however, do not throw any light on the affinities or relationship of the plants with one another.

According to recent understanding, Artificial classification (key classification) is a classification structured for convenience, using easily observed phenotypic characters and not necessarily indicating phylogenetic relationships.

Natural classification (phylogenetic classification) is a hierarchical classification based on hypothetical phylogenetic relationships such that the members of each category in the classification share a single common ancestor.

(c) Natural system of classification:

This system is based not only on the characters of reproductive organs and structural relationship but all the other important characters are also taken into consideration and the plants are classified according to their related character. It helps us not only to ascertain the name of a plant but also its relationship and affinities with other plants. All the modern systems of classification are natural.

(d) Phylogenetic system of classification:

This type of system classifies plants according to their evolutionary and genetic relationships. It enables us to find out the ancestors or derivatives of any taxon. Our present day knowledge

is insufficient to construct a perfect phylogenetic classification and all present phylogenetic systems are formed by the combination of natural and phylogenetic evidences.

Identification of Plant Taxonomy:

This is the allocation or assignment of additional unidentified objects to the correct class once a classification has been established.

Phylogeny:

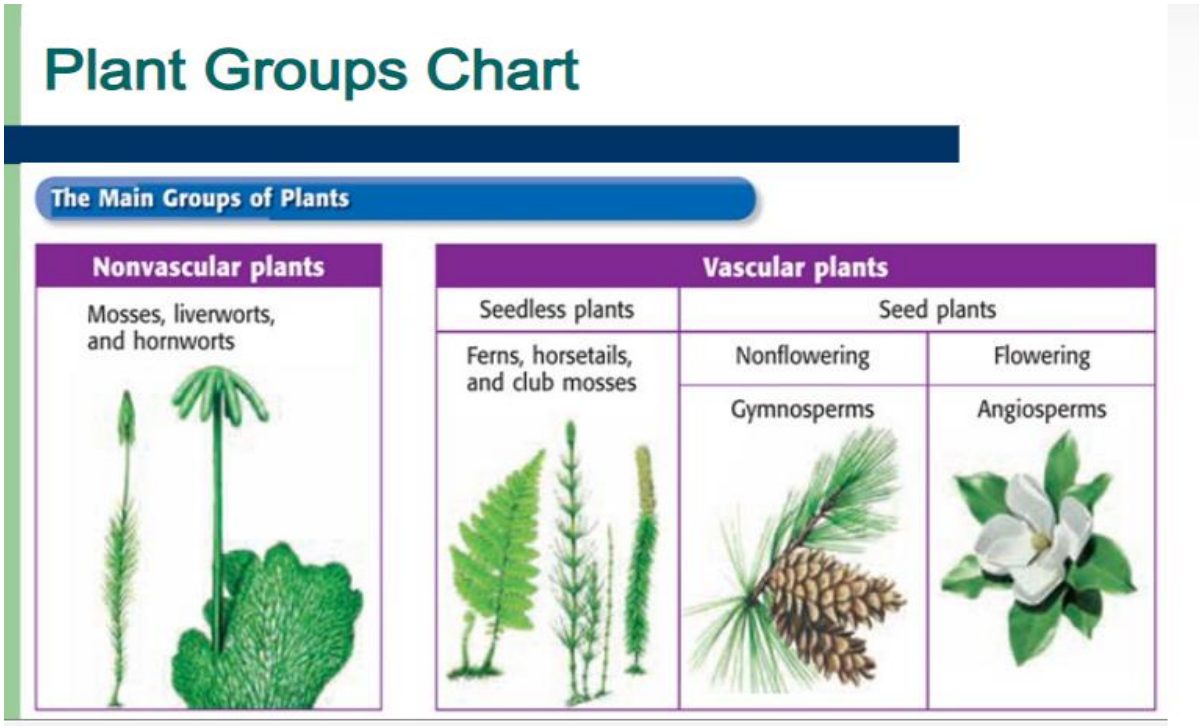
Phylogeny is the origin and evolution of taxa.

Phylogenetic:

It stresses the ancestral relationship of taxa to one another.

Phyletic:

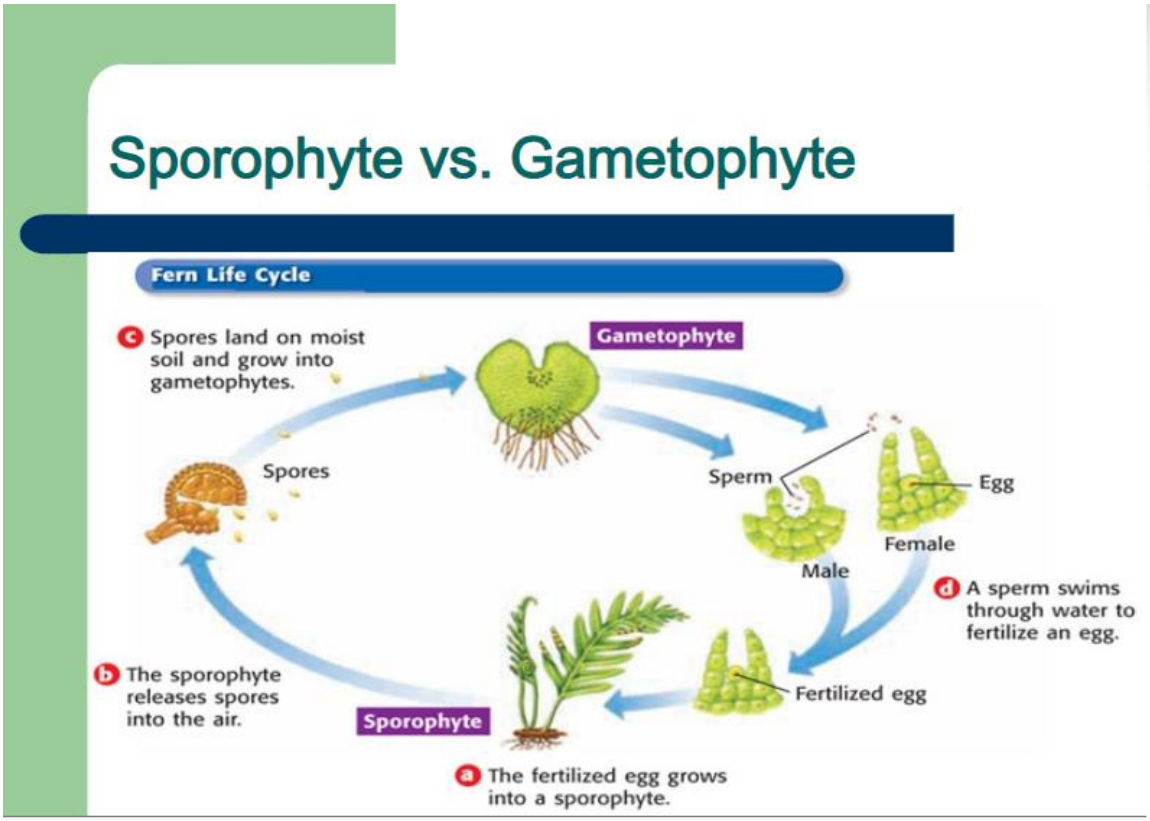
It emphasises belonging to particular line of descent (phyletic line).



Plant Characteristics

- Plants have 2 stages in their life cycle:
  - Sporophyte stage: plants make spores
    - In suitable environments, the spores of these plants grow into new plants.
  - Gametophyte stage: plant produces sex cells
    - These cells cannot grow into new plants.
    - Instead the cells grow into spores and the cycle repeats.

Sporophyte vs. Gametophyte

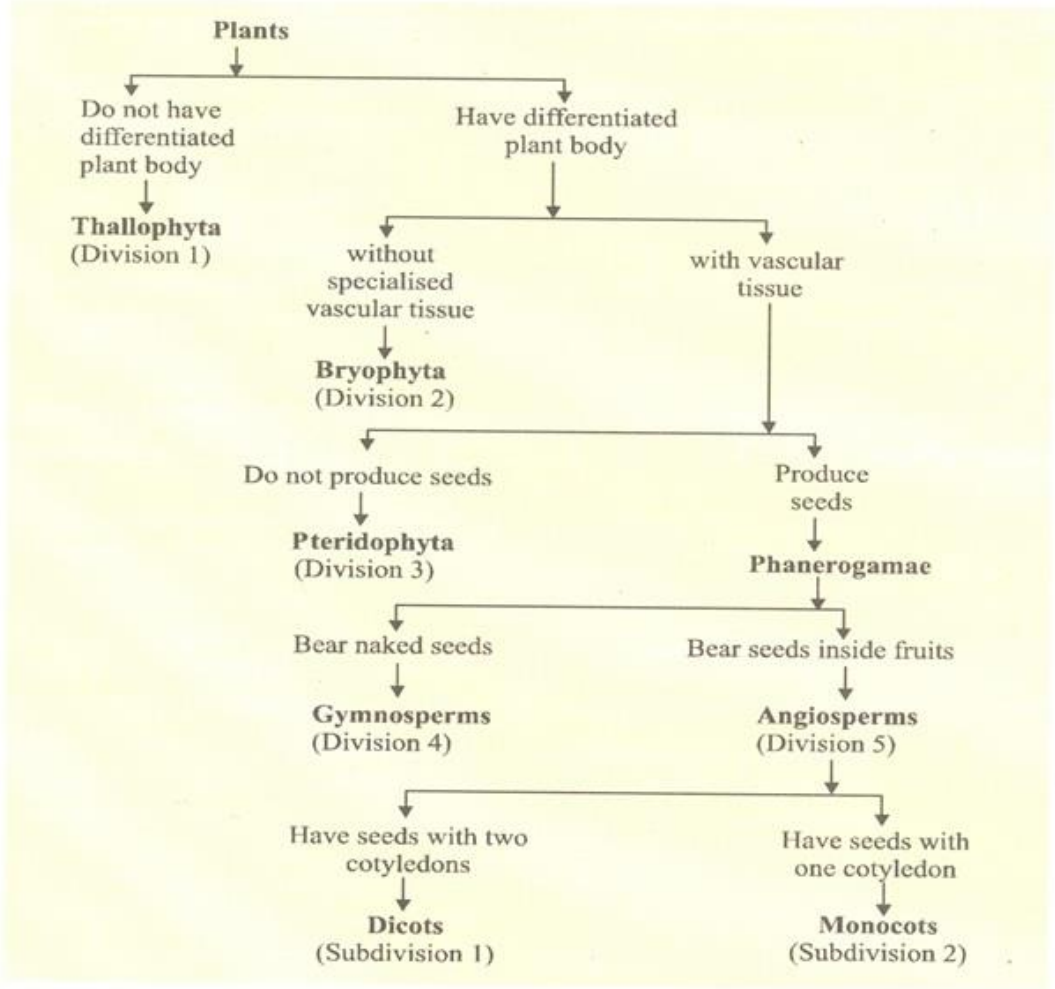


Classification of Plant Kingdom

Taxonomy is the Science of classification which makes the study of wide variety of organisms easy and helps us to understand the interrelationships among different groups of organisms. In Plant Kingdom the first level of classification depends whether plant body is differentiated, have special tissues for transportation, ability to bear seeds and whether the seeds are enclosed within fruits or not.

CLASSIFICATION OF PLANT KINGDOM

Plant Kingdom is divided in to:



(I) Thallophyta: Various types of microorganisms like algae, fungi and bacteria have been kept under it. Algae are classified in to three categories: Red, Brown and Green algae.

Chief characteristics of algae are:

- Cell wall of algae is made up of cellulose.

- Sex organs of algae are unicellular.

- Algae store their food in the form of starch.

Reproduction: Vegetative, Asexual and Sexual reproduction.
Economic Utilities: It is useful in the form of food stuffs, agriculture, in trade and business, in biological research, as the fodder of domestic animals, in the form of medicines and in the formation of land. But there are many algae which act like pollutants and contaminate the drinking water. Also, watery equipments are rottened by the algae. Celphaleuros algae produce a disease called red rust in the tea plants.
(I) Bryophytta: Plants are found at land and water but are amphibians like Liver warts, Horn warts, Moss etc. These plants are also autotrophic as chloroplasts are present.
Economic Utilities: These plants have good absorption capacity of water and thus can be used as flood preventive measure. Also used in stopping soil erosion. Moss plant is used as a fuel called peat energy and as antiseptics.
(II) Tracheophyta: These plants have well developed vascular tissues and divided in to xylem and phloem. Further it is divided in to three subgroups: Pteridophyta, Gymnosperms and Angiosperm.
(a) Pteridophyta: In these plants there are lack of seeds and flowers.
Examples: Club Mosses, horsetails, ferns etc.

Characteristics:

- These plants are sporophyte. As spores of these plants are produced in sporangia.

- The leaves in which sporangia produces is called sporophyll.

- On Gametophyte there exist male and female sex organ.

- Alternation of genes is also appeared.

- Zygospores are formed through zygote.

Utilities: This plant is used as fodders for the domestic animals, while the seed is used as medicines.

(b) Gymnosperm: The plants whose seeds are completely uncoated and there is complete lack of ovary.
Examples: Cycas, Pinus (Pines), Cedrus (Deodar) etc.

Characteristics:

- These plants are perennial and xerophytic.

- Have clear cut annual rings.

- Undergo wind- pollination and have polyembryony- characteristics.

- One or more cotyledons in an embryo exists with radicle and plumule.

Economic Utilities: Used in the form of food, timber & medicine. For decorative and domestic use. In making volatile oils & also used in the form of tanning and resin.

(c) Angiosperm: This is the most- important subgroup of plants, whose seeds are coated and developed in an organ or ovary. Our major food, fibre, spice and beverage crops are flowering plants (angiosperms). Also used as medicinal plants and the respondent flavour species, latex products like rubber etc. These plants are also utilised in making perfumes, soaps and cosmetics from their oils.
Characteristics:

- The reproductive organ of this plant is flower and double fertilization takes place.

- Are saprophytic, symbiotic and parasitic. Some are autotrophic also.

- Normally appear on land but few are aquatic.

- The vascular tissues are extremely well developed.

Further Angiosperm is classified into two categories:
(a) Monocotyledonae (monocot): Leaves of these plants are much longer rather than broad. Stems of monocot lack cambium and hence they increase little in girth except palm tree. Examples: Maize, wheat, rice, onion, sugarcane, barley, banana, coconut etc.
Characteristics:

- In the seed of these plants one cotyledon is found.

- Their leaves have parallel venation.

- The roots of these plants are not developed.

- The flowers are trimerous i.e have three or multiple of three petals.

- In the vascular part, cambium doesn't exist.

(b) Dicotyledonae (Dicot): These plants have two seed leaves. Have veins forming a network in their leaves. Almost have all the hardwood tree species, pulses, fruits, vegetables etc. Examples: Pea, potato, sunflower, rose, banyan, apple, neem etc.
Characteristics:

- In the seed of these plants two cotyledons are found.

- In the vascular part cambium exists.

- The flower of the plant has multiples of four or five petals.

- These dicots plants have secondary growth.

Kingdom Plantae

Cryptogamae

Thallophyta
(Commonly called Algae)
- Plant not differentiated into roots, stem and leaves
- Aquatic

Spirogyra

Bryophyta
- Differentiated body (stem, leaf-like, root-like structures)
- Special tissue for conduction of water absent
- Terrestrial

Riccia

Pteridophyta
- Differentiated body (Roots, stem, leaves)
- Vascular plants – have special tissue to conduct water
- Spores – naked embryos
- Inconspicuous reprodu - ctive organ

Marsilea

Phanerogamae
- Seed-bearing plants
- Differentiated body (Roots, stem, leaves)
- Well-developed vascular system
- Differentiated reprodu - ctive system

Gymnosperms
- Naked seeds (no fruit formation)
- Perennial, evergreen, woody
- Reproductive organ - Cones/Strobilus

Pinus

Angiosperms
- Flowering plants, seeds inside fruit
- Annual/Biennial/ Perennial
- Double fertilization occurs

Mustard

Monocotyledonous Plants
- Single cotyledon
- Vascular bundles arrangement – complex

Dicotyledonous Plants
- Two cotyledons
- Vascular bundles arranged in a ring

ICBN

History of ICBN:

Before the middle of the 18th century, plant names were usually polynomials i.e. made up of several words in a series. It was superseded by the binomial system, which was first applied for the plant kingdom by Linnaeus in his Species Planetarium. It was Linnaeus who proposed the elementary rules of naming plants first in 1737 in his Critica botanica and then in 1751 in Philosophia Botanica.

Elementary rules were framed to serve as a guide to botanists. Later in 1813, A.P. de Candolle in his Theories elementary de la botanique gave a detailed set of rules regarding plant nomenclature.

However discovery of new plants from later explorations caused concern over procedures for naming these species. Thus, with the passage of time, the need for an international system and rule for naming plants became increasing apparent.

It was then that Alphonse de Candolle, son of A.P. de Candolle convened an assembly of botanists of several countries to present a new set of rules. Candolle convened the First International Botanical Congress held at Paris in 1867.

Subsequent meetings of the International Botanical Congress were held in 1892 (Rochester Code), 1905 (Vienna Code), 1907 (American Code) and 1910, but a general agreement regarding the internationally acceptable rules of plant nomenclature was reached in 1930 at the IBC meeting at Cambridge where for the first time in botanical history, a code of nomenclature came into being that was international in function as well as in name.

This code is called the International Code of Botanical Nomenclature (ICBN). The modifications or amendments as suggested by the International Botanical Congress at the subsequent meetings have been incorporated in the ICBN on a regular basis.

(i) Paris Code (1867):

The First International Botanical Congress was held at Paris in August, 1867, and was aimed at the standardization and legislation of proper nomenclature practices. About 150 American and European botanists were invited to attend the congress.

It was resolved that the Laws, as adopted by the Assembly, shall be recommended as the best Guide for Nomenclature in the Vegetable Kingdom. These Laws were called the Paris Code, as they were adopted at the French capital, or de Candolle rules, as they were prepared by Alphonse de Candolle. According to the Paris Code, the starting-point for all nomenclature was fixed with Linnaeus.

However no date or any work was specified. The rule of priority was considered as basic with no provisions for exceptions. It was very important that the publication be valid and attention was given to author citation and terms applied to categories of plants. Although the Paris Code guided taxonomic activity in most countries to a considerable degree, but their application showed many inherent defects.

As time went on, American and British botanists deviated from the rules and they started practicing the unwritten law named Kew Rule according to which if a species was transferred to another genus, the specific epithet need not be transferred to the new genus but the author was free to use a new epithet in the new combination.

(ii) Rochester Code (1892):

In 1892 a batch of botanists headed by N.L. Britton met at Rochester, New York, in the United States and developed a set of rules to govern nomenclature.

These rules, which are based, on modifications of the Paris Code, are commonly known as the Rochester Code and include some new recommendations which are as follows:

(a) Establishment of the type concept to ascertain the correct application of names;

(b) Strict adherence to the principles of priority;

(c) Acceptance of alternate binomials resulting from employment of the principles of priority, even if the specific epithet repeats the generic name, and

(d) Interpretation of priority to apply to the precedence of a name in a publication in addition to the date of publication.

(iii) Vienna Code (1905):

The third International Botanical Congress was held at Vienna in June, 1905.

The new changes included the:

(a) Establishment of Linnaeus Species Plantarum (1753) as the starting-point for naming vascular plants.

(b) Nomina generica conservanda by which generic names having a wide use would be conserved over earlier but less well-known names.

(c) Banning of tautonyms, and

(d) Requirement that names of new taxa be accompanied by a Latin diagnosis.

(iv) American Code (1907):

Being dissatisfied with the results of the Vienna Congress, most proponents of the Rochester Code refused to accept the new rules and in 1907, they put forth a slight modification of the Rochester Code under the heading of the American Code. The first provision was that they would not subscribe to the principle of Nomina generica conservanda or of the requirement of Latin diagnosis, but they accepted the type concept.

Another provision of the revised code was that **'a binomial may not be used again for a plant in any way if it has been employed previously for another plant, even though the previous use may have been illegitimate'**.

Thus the Rochester Code and American Code created two opposing schools of thought in the United States. One was under the leadership of Britton and his students, who followed the provisions of the American Code and the other was under the direction of Asa Gray's pupils who followed the international rules.

(v) Brussels Code (1912):

The Fourth International Botanical Congress was held at Brussels, 1910. The most significant decision made at this Congress was the establishment of different starting points for priority of names of non vascular plants, the recognition of value of type concept and classification of phraseology of the Vienna rules.

(vi) Cambridge Code (1935):

The basic differences between the Vienna Code and American Code was finally reconciled at the Fifth International Botanical Congress held in 1930 at Cambridge, England and it brought about harmony among the major botanical factions. The new rules legislated at Cambridge constituted the code of nomenclature that was truly international in name and function.

The approved provisions were the following:

(a) The type concept should be pursued;

(b) There should be a list of Nomina generica conservanda;

(c) Tautonyms are not admissible, and

(d) Latin diagnosis is required after January 1, 1932.

(vii) Amsterdam Code (1947):

At the Sixth International Botanical Congress, Amsterdam (1935), a few major changes in the rules was made. It was resolved that "**from January 1, 1935, names of new groups of recent plants, except the Bacteria, are considered, as validly published only when they are accompanied by a Latin diagnosis"**. An attempt to select a list of nomina specified conservanda was thwarted by an overwhelming vote.

(viii) Stockholm Code (1952):

The Seventh International Botanical Congress met at Stockholm in 1950. It introduced certain number of definitions on types. The word taxon was introduced for the first time to designate any taxonomic group or entity.

(ix) Paris Code (1956):

The Eighth International Botanical Congress was held in Paris in July, 1954 in which great emphasis was laid on types, but the rule of Latin came under fire. It decided that the code should be published in English, French and German languages.

The separation of the Preamble and Principles from the Rules and Recommendations was the major feature of this code. Appendix II (nomina generica conservanda et rejicienda) was amended and supplemented.

(x) Montreal Code (1961):

The Ninth International Botanical Congress held at Montreal in August, 1959 appointed a special committee to study the question of conservation of family names (nomina familiarum conservanda for Angiospermae as Appendix II was introduced). In this code, it was specified that the naming of fossil plants should follow the same lines as that of recent ones.

(xi) Edinburgh Code (1966):

The report of the special committee appointed during the ninth Congress was submitted at the Tenth International Botanical Congress held at Edinburgh in August, 1964.

Some of the important points in the report are as follows:

(a) A.L. de Jussieu's Genera Plantarum (1789) is the starting-point for family names. Many of the names included in the list are not a matter of dispute, but their inclusion in the list forms a ready reference providing correct names of families together with a type genus for each family.

(b) In the list of nomina familiarum conservanda, a few names are found with a spelling somewhat different from the long-established names, e.g. Cannabaceae for Cannabinaceae, Capparaceae for Capparidaceae, Haloragaceae for Haloragidaceae, Melastomataceae for Melastomaceae, etc.

(c) The rule of Latin for new diagnoses was finally settled and no amendments were proposed at this congress.

At this congress, a committee was set up to prepare a glossary of the main technical terms occurring in the code which resulted in An annotated glossary of botanical nomenclature.

(xii) Seattle Code (1972):

The Eleventh International Botanical Congress was held at Seattle in August, 1969 which proposed the Seattle Code which was edited by F.A. Stafleu and published in 1972. Most of the proposals submitted to the Eleventh Congress were concerned with refinements and increased precision.

The chief issues in Seattle Code include the tautonymous designations of taxa between genus and species and below species, the perennial question of superfluous names and a reorganization of the rules for hybrids. The word autonym (automatically established names) was introduced in this code.

(xiii) Leningrad Code (1978):

The Twelfth International Botanical Congress was held in July, 1975 at Leningrad, Russia and its recommendations came out in 1978.

This Code indicates only small differences from the Seattle Code and includes the following changes:

(a) The concept of organ genera is eliminated for fossil plants.

(b) The Code does not apply to names of organisms treated as bacteria and does apply to all other organisms treated as plants.

(c) The principle of automatic typification is extended to those names of taxa above the family rank that are ultimately based on generic names and the application of the priority principle is recommended while selecting among names thus typified.

(d) A name or combination published before 1953 without indicating the rank is considered validly published but imperative in questions of priority except for homonymy and certain names to be accepted at the varietal rank.

(e) Art. 69 of the previous Code is modified on the basis of type method and Art. 70-71 dealing with discordant elements and monstrosities were deleted, but the Art numbers are retained to facilitate the use of the Code.

(f) The section on orthography is thoroughly rewritten.

(g) Individual paragraphs on all Articles and Recommendations are numbered in a decimal-like system, some being rearranged.

(xiv) Sydney Code (1983):
The Thirteenth International Botanical Congress was held in August, 1981 at Sydney, Australia.

(xv) Berlin Code (1988):
This includes the proposals made at the Fourteenth International Botanical Congress at Berlin, Germany in 1986. Nomina specifica conservanda was for the first time introduced at this Congress.

Two species names, Lycopersicon esculentum P. Miller and Triticum aestivum Linn., have been conserved against the rule of priority, as these names are widely used and any change may create confusion. Articles 66 and 67 were removed.

(xvi) Tokyo Code (1994):
The Fifteenth International Botanical Congress met at Yokohama, Tokyo in 1993. It has been translated into Chinese, French, German, Italian, Japanese, Russian and Slovak. In this code, extensive renumbering had taken place and therefore its preface included a tabulation comparing the placement of its provisions with those of the Berlin code.

(xvii) St. Louis Code (1999):
This includes the proceedings of the Sixteenth International Botanical Congress, which was held at St. Louis, Missouri in July-August, 1999 and supersedes the Tokyo Code. Like the Tokyo Code, it is anticipated that the St Louis Code, too, will become available in several languages in due course. The detailed provision of the Code is divided into Rules, set out in Articles, and Recommendations.

The object of the "**Rules**" is to put the nomenclature of the past into order and to provide for that of the future. Names contrary to a rule cannot be maintained. The Recommendations deal with subsidiary points, their object being to bring about great uniformity and clearness, especially in future nomenclature.
Names contrary to a recommendation cannot, on that account, be rejected, but they are not examples to be followed. The Rules and Recommendations apply to all organisms whether fossil or non-fossil, including fungi but excluding bacteria. A separate code called International Code of Nomenclature of Bacteria (ICNB) governs the nomenclature of bacteria.

The Seventeenth International Botanical Congress is scheduled to meet at Vienna in 2005.

Broad outline of the Saint Louis Code (Greuter et al. 1999)

Preamble : (Pre.1-Pre.11)

Division I : Principles (I-VI)

Division II : Rules and Recommendations (Art. 1-62)

- Chapter I : Taxa and their ranks (Art. 1,2,3,4,5)
- Chapter II : Status, typification, and priority of names (Art. 6-15)
  - Section 1 : Status definitions (Art. 6)
  - Section 2 : Typification (Art. 7,8,9,10)
  - Section 3 : Priority (Art. 11 and 12)
  - Section 4 : Limitation of the principle of priority (Art. 13, 14, 15)
- Chapter III : Nomenclature of taxa according to their rank (Art. 16-28)
  - Section 1 : Names of taxa above the rank of family (Art. 16 and 17)
  - Section 2 : Names of families and subfamilies, tribes and subtribes (Art. 18 and 19)
  - Section 3 : Names of genera and subdividions of genera (Art. 20, 21, 22)
  - Section 4 : Names of species (Art. 23)
  - Section 5 : Names of taxa below the rank of species (infraspecific taxa) (Art. 24, 25, 26, 27)
  - Section 6 : Names of plants in cultivation (Art. 28)
- Chapter IV : Effective and Valid publication (Art. 29-50)
  - Section 1 : Conditions and dates of effective publication (Art. 29, 30, 31)
  - Section 2 : Conditions and dates of valid publication of names (Art. 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45)
  - Section 3 : Author citations (Art. 46, 47, 48, 49, 50)
  - Section 4 : General recommendations on citation (Rec. 50A – F)
- Chapter V : Rejection of names (Art. 51, 52, 53, 54, 55, 56, 57, 58)
- Chapter VI : Names of fungi with a pleomorphic life cycle (Art. 59)
- Chapter VII : Orthography and gender of names (Art. 60 – 62)
  - Section 1 : Orthography (Art. 60 and 61)
  - Section 2 : Gender (Art. 62)

Division III : Provisions for the governance of the Code

Broad outline of the Saint Louis Code (Greuter et al. 1999)	
Appendix I	Names of hybrids (Art. H. 1, H. 2, H. 3, H. 4, H. 5, H. 6, H. 7, H. 8, H. 9, H. 10, H. 11, H. 12)
Appendix IIA	NOMINA FAMILIARUM ALGARUM, FUNGORUM, PTERIDOPHYTORUM ET FOSSILIUM CONSERVANDA ET REJICIENDA
	A. Algae
	B. Fungi
	D. Pteridophyta
	F. Fossil plants (excl. diatoms)
Appendix IIB	NOMINA FAMILIARUM BRYOPHYTORUM ET SPERMATOPHYTORUM CONSERVANDA
	C. Bryophyta
	E. Spermatophyta
Appendix IIIA	NOMINA GENERICA CONSERVANDA ET REJICIENDA
	A. Algae
	A1. Bacillariophyceae (incl. fossil diatoms)
	A2. Bodonophyceae
	A3. Chlorophyceae
	A4. Chrysophyceae
	A5. Cyanophyceae
	A6. Dinophyceae
	A7. Euglenophyceae
	A8. Phaeophyceae
	A9. Rhodophyceae
	A10. Trichomonadophyceae
	A11. Xanthophyceae
	B. Fungi
	C. Bryophyta
	C1. Hepaticae
	C2. Musci
	D. Pteridophyta
	E. Spermatophyta
	E1. Gymnospermae
	E2. Monocotyledones
	E3. Dicotyledones
	F. Fossil plants (excl. diatoms)
Appendix IIIB	NOMINA SPECIFICA CONSERVANDA ET REJICIENDA
	A. Algae
	B. Fungi
	C. Bryophyta
	D. Pteridophyta
	E. Spermatophyta
	F. Fossil plants (excl. diatoms)

Broad outline of the Saint Louis Code (Greuter et al. 1999)	
Appendix IV	NOMINA UTIQUE REJICIENDA A. Algae B. Fungi C. Bryophyta D. Pteridophyta E. Spermatophyta
Appendix V	OPERA UTIQUE OPPRESSA

Principles of ICBN	
Principle I :	Botanical nomenclature is independent of zoological and bacteriological nomenclature. The Code applies equally to names of taxonomic groups treated as plants whether or not these groups were originally so treated.
Principle II :	The application of names of taxonomic groups is determined by means of nomenclatural types.
Principle III :	The nomenclature of a taxonomic group is based upon priority of publication.
Principle IV :	Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the Rules, except in specified cases.
Principle V :	Scientific names of taxonomic groups are treated as Latin regardless of their derivation.
Principle VI :	The Rules of nomenclature are retroactive unless expressly limited.

Rules of ICBN:

(a) Rule of Priority:

It has been found that the number of published names for the various plants exceeds the actual number of taxa. This is because several names have frequently been attributed to the same taxon. Hence, it is very essential to have a way to decide which of the several names should be selected for a particular taxon.

This is where the Principle of Priority comes into play, which insists that each family or taxon of lower rank with particular circumscription, position and rank can bear only one correct name and each taxon is to be known by the earliest name validly published for the taxon, special exceptions being made for nine families for which alternative names are permitted.

Exceptions are also permitted at the family and genus levels, where names are conserved. The correct name for a taxon below the rank of genus, should be a combination of the earliest available legitimate epithet in the same rank with the correct name of the genus or species to which it is assigned, except in certain specified cases.

Although the code recommends that while selecting from among the typified names above the rank of family, the rules of priority should be followed by the taxonomist, it is not mandatory and will not affect the legitimacy of names selected otherwise.

An example of the nomenclatural history of a genus is given below:

Poli/gala L. (1753), Poligala Neck. (1768), Polygaloides Agosti (1770). According to the principle of priority the earliest name, Polygala L., is the correct name for the genus.

(b) Ranks of Taxa:

A taxon is referred to as a taxonomic group of any rank. The early part of the code deals with the ranks of taxa. Every individual plant is treated as belonging to a number of successively higher ranks with the species as the basic unit.

The principal ranks of taxa in ascending sequence are:

Species, genus, family, order, class, division and kingdom. If a greater number of ranks of taxa is required, the terms for these are made either by adding the prefix sub (sub-) to the terms denoting the ranks or by the introduction of supplementary terms.

(c) Typification:

The code has greatly emphasized on typification of taxa in order to bring about stabilization of names. The naming of taxonomic groups is determined by means of nomenclatural types where a nomenclatural type is that element, to which the name of a taxon is permanently attached, either as a correct name or as a synonym. It is not necessarily the most typical or representative element of the taxon.

Following are some of the important nomenclatural types:

(i) Holotype:

It is the one specimen or other element used by the author or designated by him as the nomenclatural type. The holotype is chosen by the original author from a single gathering made by a collector at one time, and expressed definitely at the time of original publication.

(ii) Iso-type:

An iso-type is any duplicate (part of a single gathering made by a collector at a time) of the holotype. For example, if a new species is based on a single gathering that consist of four specimens of the same plant with the same field number placed on four separate herbarium sheets, the original author will designate one of them as a holotype and the remaining three as isotypes.

(iii) Para-type:

A para-type is a specimen cited with the original description other than the holotype or iso-type. For example, if a new taxon is collected in one season without flowers and fruits and the same taxon is collected in a different season with flowers and fruits, then the two collections will be given different field numbers.

Out of these two collections, the author will select one collection as the holotype and the iso-type, while the next gathering cited in the protologues will form the para-type.

(iv) Syntype:
A syntype is one of the two or more specimens cited by an author of a species when no holotype was designated, or it is any one of the two or more specimens originally designated as types (Art. 7.7).

(v) Lectotype:
It is a specimen or other element selected from the original material to serve as a nomenclatural type when no holotype was designated at the time of publication or as long as it is missing (Art. 7.5). If the holotype is lost or destroyed, the lectotype is selected from the isotypes, or, when, two or more specimens have been designated as types by the author of a species, the lectotype must be chosen from among these types.

(vi) Neo-type:
It is a specimen or other element selected to serve as nomenclatural type as long as all of the material on which the name of the taxon was based is missing (Art. 7.8).

(vii) Topotype:
It refers to the specimen collected from the same locality from where the holotype was collected.

(d) Effective and valid publication:
The new name of a taxon is considered valid or effective for publication, only when it is distributed in a printed form to the general public, or at least to ten well established botanical institutions with libraries accessible to botanists generally.

The new name is not considered valid if communicated at a public meeting or by placing of names in collections or gardens open to public or by the issue of microfilm made from manuscripts, typescripts or other unpublished material.

Further, the name of a taxon when published has to fulfil certain conditions for validity. Those that have been published on or after 1.1.1935 must be accompanied by a Latin description or diagnosis or by a reference to a previously and effectively published Latin description or diagnosis of the taxon.

The name of a new taxon of the rank of family or below that has been published on or after 1.1.1958, is valid only when its nomenclatural type is mentioned along with the name of the place where the type specimen is permanently conserved.

Those, that have been published on or after 1.1.1953, are valid only if there is a clear indication of the rank of the taxon and whether it is a new genus, new species or a new combination etc..

(e) Author Citation:

The name of a taxon (unitary, binary or ternary) is incomplete unless the name of the author or authors who first validly published the name, is cited along with it. This helps in verifying the dates of publication and in imparting precision in biological nomenclature.

There are several rules for author citation:

(i) Usually the names are cited in abbreviated forms but never underlined or typed in Italics, e.g.

(1) Vitex Linn.,

(2) V. trifolia Linn.,

(3) V. trifolia, var. simplicifolia Cham.

(ii) These citations can indicate bibliographic references, which are especially helpful in the recognition of homonyms. For e.g. Utricularia caerulea Linn., and Utricularia caerulea Clarice are two names referring to two different taxa, but it would have been impossible for us to recognize this, if the citation of author's names appended to the respective plant names were not given.

(iii) If the name of the plant is jointly published by two authors, their names should be linked by means of et al or an ampersand (&)

(iv) When more than three authors are involved, citation is normally restricted to the first author and is followed by et al.

(v) If an author validly publishes a name but ascribes it to another person, for example to the author who suggested the name but failed to publish it validly, or to an author who published the name before the starting point of the group, then the name of the latter should be connected to the name of the person who validly publishes the name by an ex as for e.g. Acalypha racemosa Wall, ex Baill.

(vi) If a genus or taxon of lower rank is altered in rank or position, but retains its name or epithet, the name of the author who first published the name or epithet (basionym) must be cited in parenthesis followed by the name of the author who effected the change. This is called

double citation, e.g Leucaena latisiliqua (Linn.) Gillis (1974).Basionym: Mimosa latisiliqua Linn.

(vii) If a taxon is of garden origin, then while citing the name it should be ascribed to hort. (hortulanorum) and connected to the name of the author who published it by an ex, e.g. Geaneria dwklarii hort. ex Hook.

(f) Choice of Names:

Following are some of the important criteria for choice of name of a taxon:

(i) When the taxon rank is changed, for e.g., a species becomes a genus, the earliest legitimate name in its new rank is its correct name.

(ii) When two or more taxa of the same rank are united into one, e.g. two or more genera are united, the oldest legitimate name of these taxa should be retained as the name of the united taxon.

(iii)When a genus or a species is divided into two or more genera or species, the original name of the genus or species must be retained.

(iv) When a species is transferred to another genus without the change of rank, the original name must be retained.

(g) Rejection of Names:

A legitimate name or epithet must not be rejected merely because it is inappropriate or disagreeable, or because another is preferable or better known, or because it has lost its original meaning.

However, a name must be rejected if it was nomenclatural superfluous when published. Similarly, a name or epithet rejected is replaced by the oldest legitimate name or in a combination by the oldest available epithet in the rank concerned.

The following types of name can be considered to be illegitimate and unusable:

i. Synonyms:

They are the different names used for the same taxonomic group or taxon.

ii. Tautonyms:

These are names where the specific epithet exactly repeats the generic name with or without transcribed symbol.

iii. Typonyms:

A name is rejected if there is an older valid name based on the same type.

iv. Metanyms:

A name is rejected when there is an older valid name based on another member of the same group.

v. Homonyms:

A name is rejected when preoccupied i.e. identical names cannot be applied to two different taxa.

vi. Hyponyms:

A name is rejected when the natural group to which it applies is undetermined.

PLANT TAXONOMY

The term **"taxonomy"** originates from two words, ***"taxis"*** meaning arrangement and ***"nomos"*** meaning laws. **Plant taxonomy** deals with the classification of plants according to certain set rules. The term taxonomy was coined by the Swiss botanist **A. P. de Candolle** in his book **"Theories elementaire de la botanique".**

Plant taxonomy can be defined as the branch of botany which deals with characterisation, identification, classification and nomenclature of plants based on their similarities and differences.

The goals of plant taxonomy are:

1. **Characterisation:** to describe all the characteristics of the newly identified species
2. **Identification:** identify the unknown species based on its characteristics and by comparing with already existing species
3. **Classification:** placing and arranging the known species into different groups or taxa according to similarities and dissimilarities
4. **Nomenclature:** giving the scientific name according to the convention

Taxonomy and Systematics

The word systematics comes from the word '*systema*', meaning the systematic arrangement of the organisms. It takes into consideration the evolutionary relationship of the organisms. Plant systematics deals with interrelation between plants and their evolutionary descent. Systematics studies biological diversity and organises the information into a classification.

Organisms are classified on the basis of similarities, closeness or relationship between them. It shows the phylogenetic relationship between different organisms and shows their line of descent. The similarities among individuals show that they might have developed from the common ancestor. It shows the evolutionary pathway of modern living organisms. Closely related organisms are included in a group, which share a common gene pool.

Organisms are categorised into different taxonomic categories according to the similarities and specific features. The different taxonomic categories in their hierarchical order are:

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

The number of common characteristics decreases as we move from species to the kingdom, where species having fundamental similarities and organisms in the same kingdom having least common features.

List of Systems of Plant Taxonomy

The earliest system of classification considered only a few vegetative characters. Modern taxonomic studies have been more elaborate and taken into consideration various morphological, cellular and molecular characteristics, e.g. cellular and reproductive features, mode of nutrition, habitat, evolutionary relationships, etc. along with morphological features.

There are three main types of systems for plant classification. Here is the list of systems of plant taxonomy:

1. Artificial systems
2. Natural systems
3. Phylogenetic systems

1. Artificial systems: Artificial systems were the earliest systems, which attempted to classify organisms based on a few superficial characters.

These were important in the history of biological classification as this was a novel attempt to organise living organisms. The demerit was that it didn't consider morphological details and the evolutionary relationship. They gave equal importance to vegetative and sexual characters but it is not true. Vegetative characters are greatly influenced by the environment. As a result, the closely related species were kept apart.

Aristotle classified plants more than 2000 years ago on the basis of simple morphological characters into **herb, shrub and trees**.

Theophrastus in his book **"Historia Plantarum or Enquiry into plants"** attempted to arrange plants in various groups based on how plants reproduce and its uses. He is called **"Father of Botany".**

Carl Linnaeus is known as the **"Father of Modern Taxonomy".** In his book **"Systema Naturae" (1735),** he gave the **hierarchical system of classification** of the natural world into the plant kingdom, the animal kingdom and mineral kingdom.

He understood the importance of floral characters and classified plants based on the number of stamens present in them. It is also known as the **sexual system** of classification.

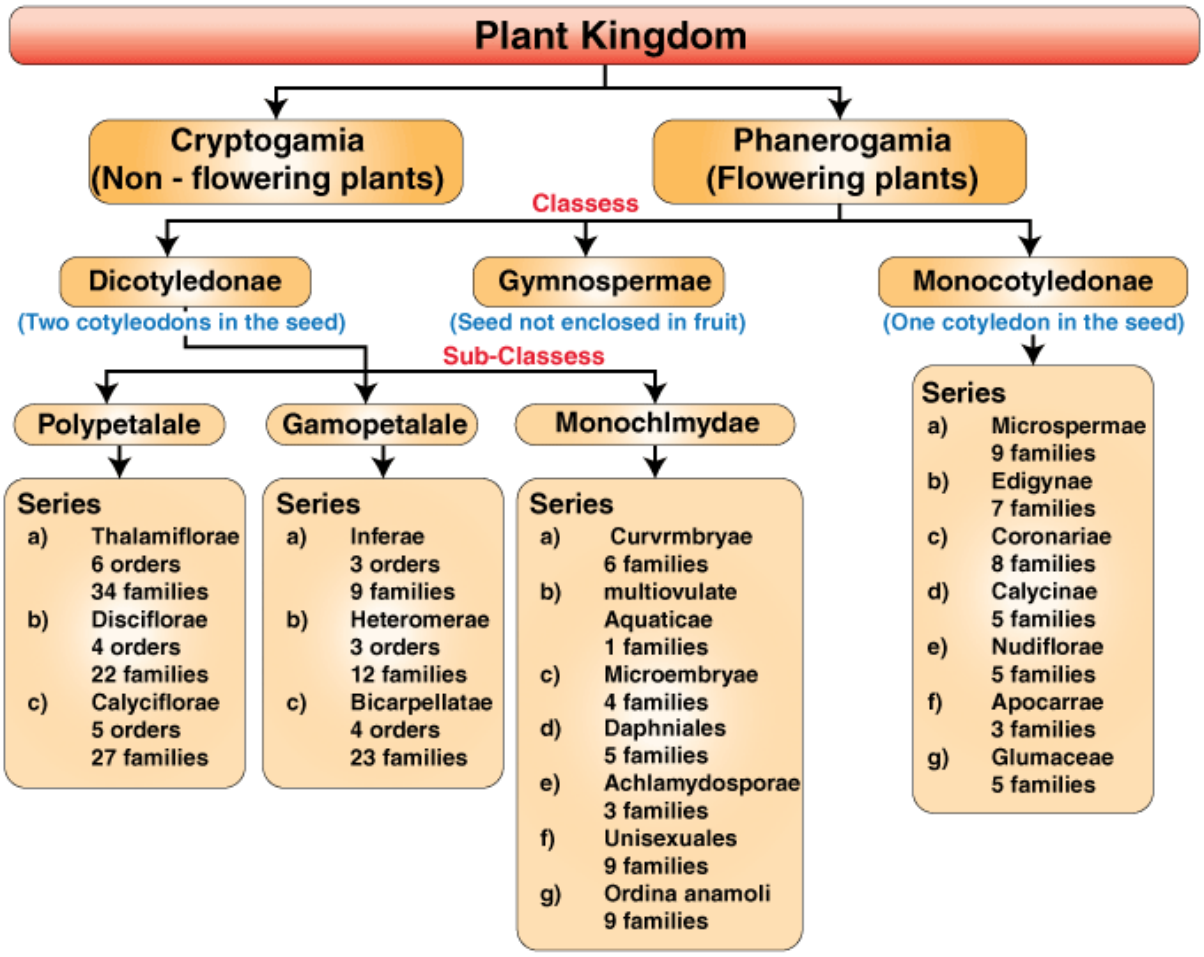
Linnaeus kept on adding new work to his publications. In **"Species Plantarum" (1753),** he gave a brief description of all the species known to him. He described around 7,300 plant

species in it. He divided the plant kingdom into 24 classes based on the structure, union, length and the number of stamens. E.g. Monoandria (1 stamen), Diandria (2 stamens), Polyandria (more than 12 stamens), Monoadelphia (stamens united in a single bundle), Monoecia, Dioecia, Polygamia (polygamous plants), Cryptogamia (flowerless plants), etc.

He gave the **Binomial nomenclature system.** In **"Philosophia Botanica",** he had given rules for naming every species. It is called binomial because each name has two components, genus name and species name, e.g. *Solanum melongena* (brinjal), *Solanum tuberosum* (potato) having the same genus but different species name.

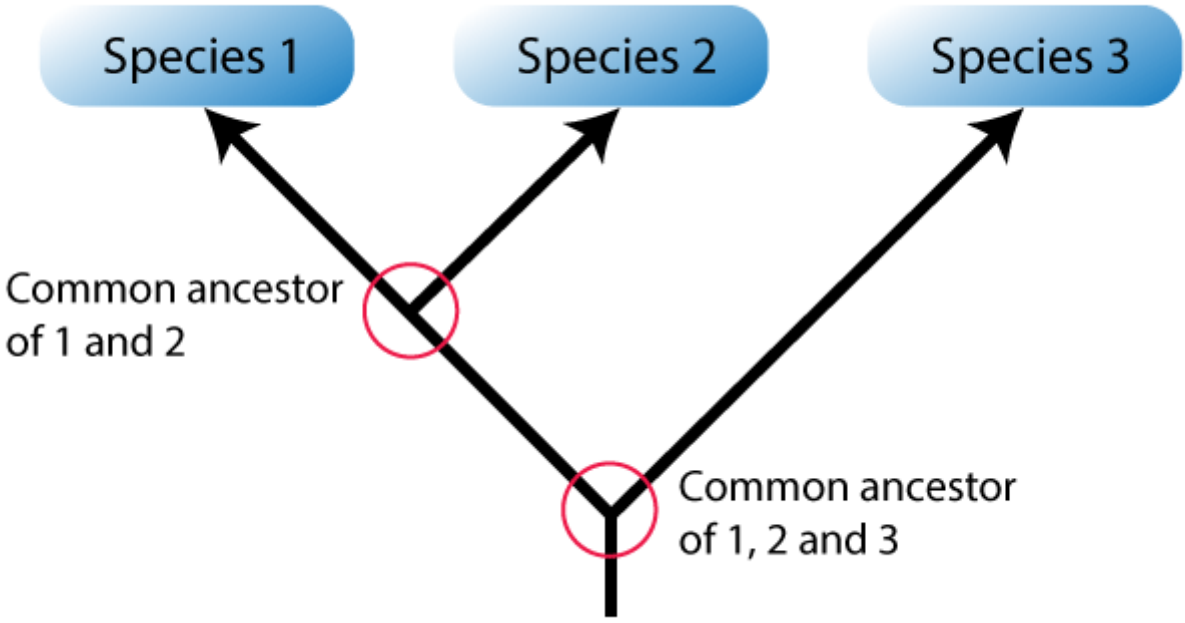
2. Natural systems: In this system of classification, more characters were considered while classifying. It was based on the natural similarities of vegetative and floral characters among the organisms. It took into consideration various external and internal features like the anatomy of a cell, types of embryo and phytochemistry.

Bentham and Hooker proposed the most important natural system of classification of flowering plants. They classified plants into **Cryptogams** (non-flowering plants) and **Phanerogams** (flowering plants).



It helped to determine relationships between the various groups of plants but failed to identify phylogenetic relationships among different groups of plants. It wrongly placed gymnosperms between monocotyledons and dicotyledons.

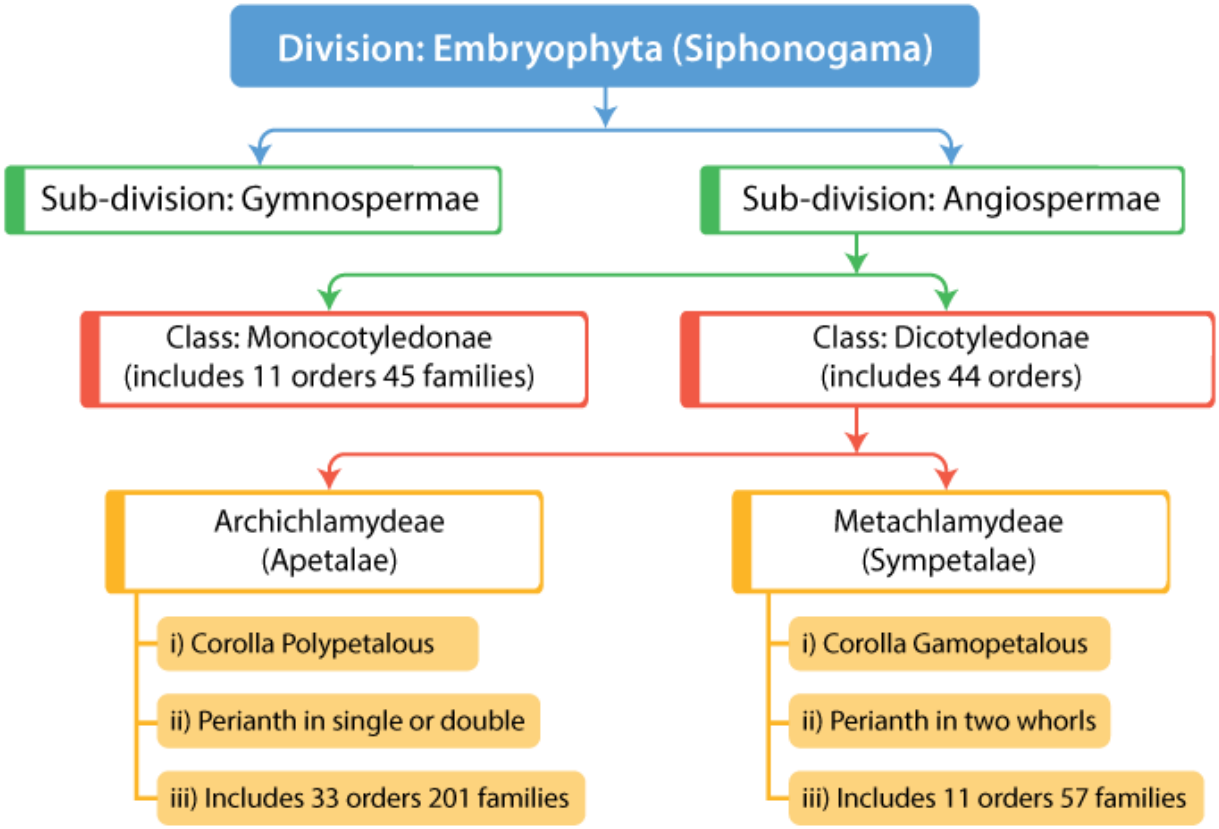
3. Phylogenetic systems: This system is based on evolutionary sequence and genetic relationship. This system was developed after the publication of Darwin's theory of evolution. Apart from the morphological characteristics found from fossil records, genetic constituents were also considered. It has been widely accepted by biologists all over the world. According to this system, all the organisms belonging to the same taxa originated from the common ancestor.



Various scientists namely Engler and Prantl, Hutchinson, Takhtajan, Cronquist, Rolf Dahlgren and Robert F Thorne contributed to the phylogenetic system of classification.

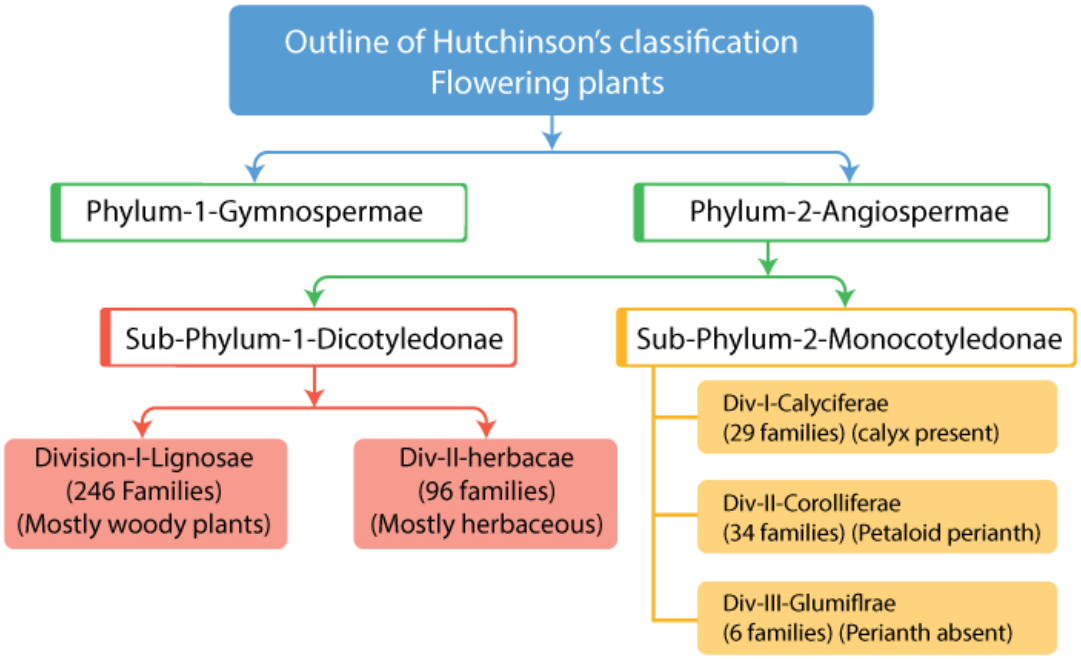
The two main phylogenetic systems of classification are:

- **Engler and Prantl system of classification:** In this type of system floral characters like single whorl or no perianth, unisexual flowers pollinated by wind were considered primitive characters as compared to two whorls in the perianth and bisexual flowers pollinated by insects. They arranged plants based on the increasing complexity of the flower morphology.



- The plant kingdom was divided into 13 divisions:
  - 11 are **Thallophytes**
  - 12th **Embryophyta Asiphonogama**, i.e. plants having embryos but pollen tubes are absent (bryophytes and pteridophytes)
  - 13th **Embryophyta Siphonogama**, i.e. plants with embryo and pollen tubes (seed plants)

- **Hutchinson's classification:** Hutchinson classified angiosperms into monocotyledons and dicotyledons.
  - Dicotyledons were further divided into two divisions, namely, Lignosae (woody plants) and Herbaoae (herbaceous plants)
  - Monocots were divided into 3 divisions on the basis of flower morphology, namely, Calyciflerae (calyx present), Corolliferae (petaloid perianth) and Glumiflorae (perianth absent)



Modern Taxonomic advancements:

With the advent of molecular biology, many techniques to identify genetic materials have been developed. This has equipped us to compare individuals at different taxonomic levels and resolve the difficulties of classifying them even if there is no fossil evidence.

1. **Numerical taxonomy:** It is done by using computers and all the observable characters are taken into consideration. Each character is assigned with a code and a number. Hundreds of characters can be considered together and given equal importance.
2. **Cytotaxonomy:** it utilises cytological information like chromosome number, shape size, etc. to understand the taxonomy.
3. **Chemotaxonomy:** Use of chemical constituents of plants for taxonomic studies is known as chemotaxonomy. Proteins, amino acids, nucleic acids and peptides, starch grains, wax, fat, oil, phenols are studied in chemotaxonomy.

Importance of Plant Taxonomy

- It gives a detailed overview of various morphological and anatomical structures of a plant species
- It organises all the information of plants into an orderly fashion
- It indicates the phylogenetic relationship between species and its ancestry
- Plant taxonomy enables to identify any unknown species and its place in the classification by comparing with known species
- Analysis of genetic constituents can be done on the basis of systematics
- It is used to scientifically name any species, which helps in the uniformity of the name around the world and avoids confusion
- It helps to understand the biodiversity present at a place

- It helps in recording all the living species known until now
- Taxonomy is widely used in agriculture, medicine and forestry