Chapter 5

Unit II: Plant Morphology and Taxonomy of Angiosperm

Taxonomy and Systematic Botany

Learning Objectives

The learner will be able to,

- *Differentiate systematic botany from taxonomy.*
- *Explain the ICN principles and to discuss the codes of nomenclature.*
- *Compare the national and international herbaria.*
- *Appreciate the role of morphology, anatomy, cytology, DNA sequencing in relation to Taxonomy,*
- *Describe diagnostic features of families Fabaceae, Solanaceae and Liliaceae.*

Chapter Outline

5.1 Taxonomy and Systematics
5.2 Taxonomic Hierarchy
5.3 Concept of species – Morphological, Biological and Phylogenetic
5.4 International Code of Botanical Nomenclature
5.5 Taxonomic Aids
5.6 Botanical Gardens
5.7 Herbarium – Preparation and uses
5.8 Classification of Plants
5.9 Need for classification
5.10 Types of classification
5.11 Modern trends in taxonomy
5.12 Cladistics
5.13 Selected Families of Angiosperms

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Plants are the prime companions of human beings in this universe. Plants are the source of food, energy, shelter, clothing, drugs, beverages, oxygen and the aesthetic environment. Taxonomic activity of human is not restricted to living organisms alone. Human beings learn to identify, describe, name and classify food, clothes, books, games, vehicles and other objects that they come across in their life. Every human being thus is a taxonomist from the cradle to the grave.

Taxonomy has witnessed various phases in its early history to the present day modernization. The need for knowledge on plants had been realized since human existence, a man started utilizing plants for food, shelter and as curative agent for ailments.

Theophrastus (372 – 287 BC), the Greek Philosopher known as "**Father of Botany**". He named and described some 500 plants in his *"De Historia Plantarum"*. Later Dioscorides (62 – 127 AD), Greek physician, described and illustrated in his famous **"Materia medica"** and described about 600 medicinal plants. From 16^{th} century onwards Europe has witnessed a major developments in the field of Taxonomy. Some of the key contributors include Andrea Caesalpino, John Ray, Tournefort, Jean Bauhin and Gaspard Bauhin. Linnaeus ***'Species Plantarum'*** (1753) laid strong foundation for the binomial nomenclature.

Taxonomy is no more classical morphology based discipline but become a dynamic and transdisciplinary subject, making use of many branches of botany such as Cell Biology, Physiology, Biochemistry, Ecology, Pharmacology and also Modern Biotechnology, Molecular Biology and Bioinformatics. It helps to understand biodiversity, wildlife, forest management of natural resources for sustainable use of plants and eco restoration.

5.1 Taxonomy and Systematics

The word taxonomy is derived from Greek words ***"taxis"*** (arrangement) and ***"nomos"*** (rules or laws). Taxonomy is defined as as "the science dealing with the study of classification including the bases, principles, rules and procedures".

Simpson (1961) defined Systematics as, "Scientific study of the kinds and diversity of organisms and all relationships among them". Though there are two terms are used in an interchangeable way, they differ from each other.

5.2 Taxonomic Hierarchy

Taxonomic hierarchy was introduced by Carolus Linnaeus. It is the arrangement of various taxonomic levels in descending order starting from kingdom up to species.

Differences between Taxonomy and Systematics

Taxonomy	Systematics
• Discipline of classifying organisms into taxa. • Governs the practices of naming, describing, identifying and specimen preservation. • Classification + Nomenclature = Taxonomy	• Broad field of biology that studies the diversification of species. • Governs the evolutionary history and phylogenetic relationship in addition to taxonomy. • Taxonomy + Phylogeny = Systematics

Species is the lowest of classification and shows the high level of similarities among the organisms. For example, *Helianthus annuus* and *Helianthus tuberosus*. These two species differ in their morphology. Both of them are herbs but *Helianthus tuberosus* is a perennial herb.

Genus consists of multiple species which have similar characters but differ from the species of another genus. Example: *Helianthus*, *Tridax*.

Family comprises a number of genera which share some similarities among them. Example: Asteraceae.

Order includes group of families which show less similarities among them.

Class consists of group of orders which share few similarities.

Division is the next level of classification that consists of number of classes.

Example: Magnoliophyta.

Kingdom is the highest level or rank of the classification. Example: Plantae

Rank	Ending	Example
Kingdom	-	Plantae
Phylum = Division	-phyta	Magnoliophyta
Subphylum = Sub division	-phytina	Magnoliophytina
Class	-opsida	Asteropsida
Sub class	-idea	Asteridea
Order	-ales	Asterales
Suborder	-ineae	Asterineae
Family	-aceae	Asteraceae
Sub family	-oideae	Asteroideae
Tribe	-eae	Heliantheae
Genus	-	Helianthus
Sub genus	-	*Helianthus* subg. *Helianthus*
Series	-	*Helianthus* ser. *Helianthus*
Species	-	*Helianthus annuus*

5.3 Concept of species-Morphological, Biological and Phylogenetic

Species is the fundamental unit of taxonomic classification. Species is a group of individual organisms which have the following characters.

1. A population of organisms which closely resemble each other more than the other population.
2. They descend from a common ancestor.
3. In sexually reproducing organisms, they interbreed freely in nature, producing fertile offspring.

Species concepts can be classified into two general groups. Concept emphasizing process of evolution that maintains the species as a unit and that can result in evolutionary divergence and speciation. Another concept emphasises the product of evolution in defining a species.

Types of Species

There are different types of species and they are as follows:

1. Process of evolution - Biological Species
2. Product of evolution - Morphological Species and Phylogenetic Species

Morphological Species (Taxonomic species)

When the individuals are similar to one another in one or more features and different from other such groups, they are called **morphological species.**

Biological Species (Isolation Species)

According to **Ernest Mayr** 1963,“ these are groups of populations that interbreed and are reproductively isolated from other such groups in nature”.

Phylogenetic Species

This concept was developed by **Meglitsch** (1954), **Simpson** (1961) and **Wiley** (1978). Wiley defined phylogenetic species as “an evolutionary species is a single lineage of ancestor descendent populations which maintains its identity from other such lineages which has its own evolutionary tendencies and historical fate”.

5.4 International Code of Botanical Nomenclature (ICBN)

Assigning name for a plant is known as **Nomenclature.** This is based on the rules and recommendations of the International Code of Botanical Nomenclature. ICBN deals with the names of existing (living) and extinct (fossil) organisms. The elementary rule of naming of plants was first proposed by **Linnaeus** in 1751 in his *Philosophia Botanica*. In 1813 a detailed set of rules regarding plant nomenclature was given by **A.P. de Candolle** in his famous work “*Theorie elementaire de la botanique*”. Then the present ICBN was evolved by following the same rules of **Linnaeus, A.P. de Candolle** and his son **Alphonse de Candolle.**

ICBN due to specific reasons and in order to separate plant kingdom from other organisms, is redesignated as ICN. The International Botanical Congress held in Melbourne in July 2011 brought this change. The ICN stands for International Code of Nomenclature for Algae, Fungi and Plants.

ICN Principles

International Code of Nomenclature is based on the following six principles.

1. Botanical nomenclature is independent of zoological and bacteriological nomenclature.
2. Application of names of taxonomic group is determined by means of nomenclatural types.
3. Nomenclature of a taxonomic group is based on priority of publication.
4. Each taxonomic group with a particular circumscription, position and rank can bear only one correct name.
5. Scientific names of taxonomic groups are treated as Latin regardless of their derivation.
6. The rules of nomenclature are retroactive unless expressly limited.

Codes of Nomenclature

ICN has formulated a set of rules and recommendations dealing with the botanical name of plants. International Botanical Congress is held at different places every six years. Proposals for nomenclatural changes and changes in rules are discussed and implemented. Changes are published in their website.

18th International Botanical Congress held in 2011at Melbourne, Australia made the following major changes.

1. The code now permits electronic publication of names of new taxa.
2. Latin diagnosis or description is not mandatory and permits the use of English or Latin for the publication of a new name (Art-39).
3. "One fungus, one name" and "one fossil one name" are important changes, the concept of anamorph and teleomorph (for fungi) and morphotaxa (for fossils) have been eliminated. (Previously, sexual and asexual stages of the fungus/ fossils were provided with different names).

Anamorph – Asexual reproductive stage of fungus.
Teleomorph – Sexual reproductive stage of fungus.

4. As an experiment with "registration of names" new fungal descriptions require the use of an identifier from a "recognized repository". There are two recognized repositories **Index fungorum** and **Myco Bank**.

19th International Botanical Congress was held in Shenzhen in China in 2017. Changes accepted by International Botanical Congress are yet to be published.

Vernacular names (Common names)

Vernacular names are known as **common names.** They are very often descriptive and poetic references to plants. Common name refer to more than one plant or many plants may have same common name. These names are regional or local and are not universal. Example: *Albizia amara* . L belongs to *Mimosaceae* is called as *Usilai* in South Tamilnadu and *Thurinji* in North Tamilnadu.

Activity
Write common name and scientific name of 10 different plants around your home.

Scientific Names / Botanical Names

Each and every taxon as per the ICN (species, genus, family etc) can have only one correct scientific name. Scientific name of a species is always a binomial. These names are universally applied. Example: *Oryza sativa L.* is the scientific name of paddy.

Polynomial

Polynomial is a descriptive phrase of a plant. Example: *Ranunculus calycibus retroflexis pedunculis falcatis caule erecto folius compositis.* It means butter cup with reflexed sepals, curved flower stalks, erect stem and compound leaves. Polynomial system of naming a plant is replaced by a binomial system by Linnaeus.

Binomial

Binomial nomenclature was first introduced by **Gaspard Bauhin** and it was implemented by **Carolus Linnaeus**. Scientific name of a species consists of two words and according to binomial nomenclature, the first one is called **genus name** and second one is **specific epithet.** Example: *Mangifera indica*. *Mangifera* is a genus name and *indica* is specific epithet. This system is in vogue even now.

Author citation

This refers to valid name of the taxa accompanied by the author's name who published the name validly. Example: *Solanum nigrum* L. There are two types of author citation.

Single author: When a single author proposed a valid name, the name of the author alone is accompanied by his abbreviated name. Example: *Pithecellobium cinereum* Benth.

Multiple authors: When two or more authors are associated with a valid publication of name, their names should be noted with the help of Latin word *et* or &.

Example: *Delphinium viscosum* Hook. f. *et* Thomson.

Standard form of author's abbreviations has to be followed.

Author	Standard form of Abbreviation
Linnaeus	L.
G.Bentham	Benth.
William Hooker	Hook.
Robert Brown	R.Br.
J.P.Lamarck	Lamk.
A.P.de Candolle	DC.
Wallich	Wall.
Alphonse de Candolle	A. DC.

5.5 Taxonomic Aids

Taxonomic aids are the tools for the taxonomic study. Some techniques, procedures and stored information that are useful in identification and classification of organisms are called **taxonomical aids.** They are required in almost all branches of biological studies for their proper identification and for finding their relationship with others. Some of the taxonomical aids are keys, flora, revisions, monograph, catalogues, herbarium, botanical gardens etc.

Keys

Taxonomic keys are the tools for the identification of unfamiliar plants. These keys are based on characters which are stable and reliable. The most common type of key is a dichotomous key. It consists of a sequence of two contrasting statements. A pair of contrasting statements is known as **couplet.** Each statement is known as **lead.** The plant is correctly identified with keys by narrowing down the characters found in plant.

Example:

1. a) Flowers cream-coloured; fruiting calyx enclosing the berry ......*Physalis*

   b) Flowers white or violet; fruiting calyx not enclosing the berry *2*

2. a) Corolla rotate; fruit a berry .....*Solanum*

   b) Corolla funnel-form or salver-form; fruit a capsule: *3*

3. a) Radical leaves present; flowers in racemes; fruits without prickles ...*Nicotiana*

   b) Radical leaves absent; flowers solitary; fruits with prickles .....*Datura*

Another type of key for identification is the **Polyclave** or **Multi-entry key**. It consists of a list of numerous character states. The user selects all states that match the specimen. Polyclave keys are implemented by a computer algorithm.

5.6 Botanical Gardens

In true sense all gardens are not botanical gardens. Botanical gardens are centres for collection of plants in their various stages of living. Gardens existed for growing ornamental plants for aesthetic value, religious and status reasons. The famous "hanging gardens" of Babylon in Mesopotamia is an example. For the purpose of science and education the first garden was maintained by **Theophrastus** in his public lecture hall at Athens.

First modern botanical garden was established by **Luca Ghini** (1490-1556) a professor of Botany at Pisa, Italy in 1544.

Botanical garden contains special plant collections such as cacti, succulent, green house, shade house, tropical, alpine and exotic plants. Worldwide there are about 1800 botanical gardens and arboreta.

Role of Botanical Garden: Botanical Gardens play the following important roles.

1. Gardens with aesthetic value which attract

National Botanical Gardens

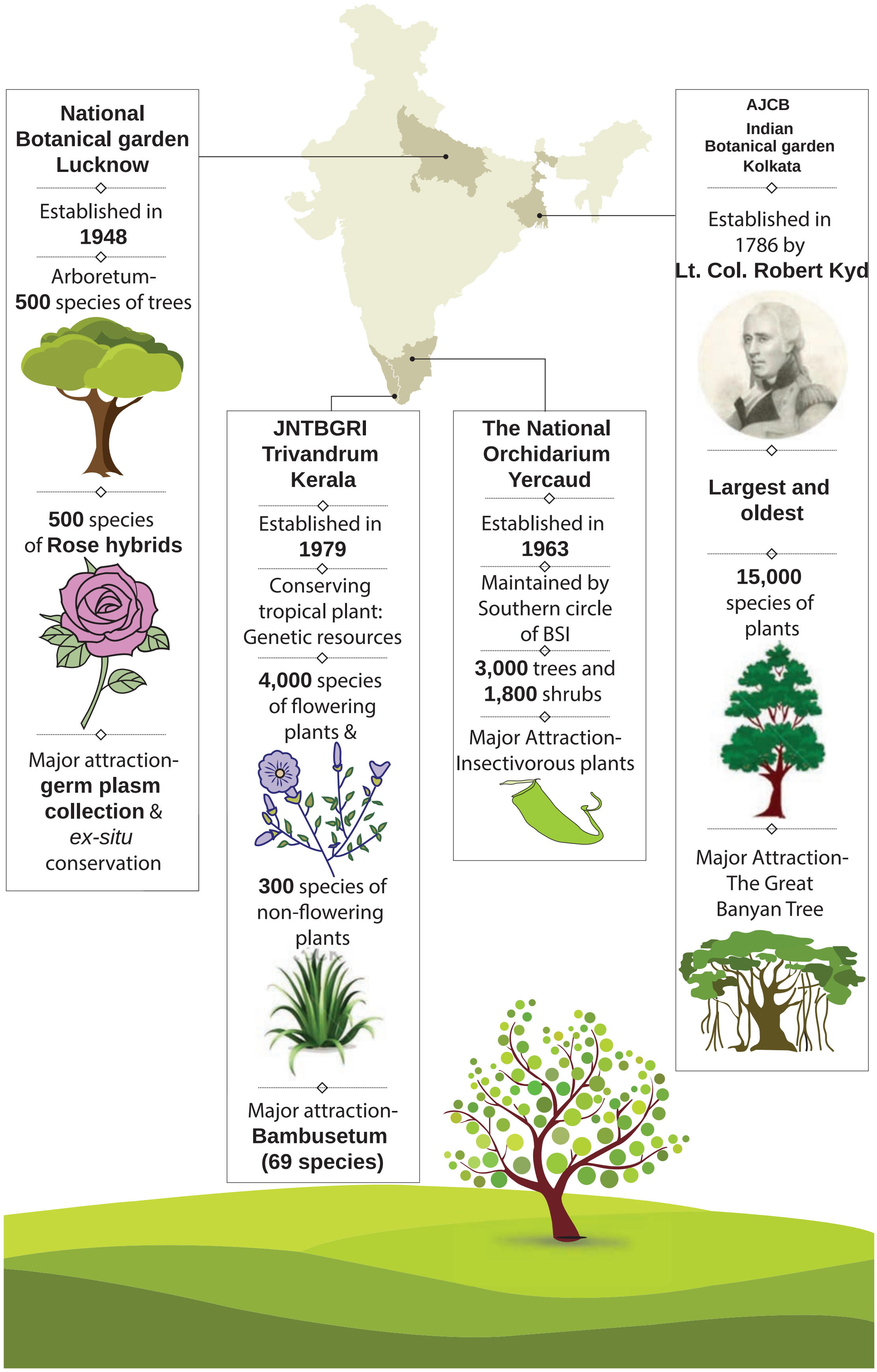


Figure 5.1: National Botanical Garden

a large number of visitors. For example, the Great Banyan Tree *(Ficus benghalensis)* in the Indian Botanical Garden at Kolkata.

2. Gardens have a wide range of species and supply taxonomic material for botanical research.
3. Garden is used for self-instruction or demonstration purposes.
4. It can integrate information of diverse fields like Anatomy, Embryology, Phyto-chemistry, Cytology, Physiology and Ecology.
5. Act as a conservation centre for diversity, rare and endangered species.
6. It offers annual list of available species and a free exchange of seeds.
7. Botanical garden gives information about method of propagation, sale of plant material to the general public.

Royal Botanic garden, Kew- England

Figure 5.2: Royal Botanic garden, Kew - England

Royal Botanic garden Kew- England is a non- departmental public body in the United Kingdom. It is the largest botanical garden in the world, established in 1760, but officially opened in the year 1841.

Plant collections include Aquatic garden, Arboretum with 14,000 trees, Bonsai collection, Cacti collection and Carnivorous plant collection.

5.7 Herbarium – Preparation and uses

Herbaria are store houses of preserved plant collections. Plants are preserved in the form of pressed and dried specimens mounted on a sheet of paper. Herbaria act as a centre for research and function as sources of material for systematic work.

Preparation of herbarium Specimen

Herbarium Specimen is defined as a pressed and dried plant sample that is permanently glued or strapped to a sheet of paper along with a documentation label.

Preparation of herbarium specimen includes the following steps.

1. **Plant collection:** Field collection, Liquid preserved collection, Living collection, Collection for molecular studies.
2. **Documentation of field site data**
3. **Preparation of plant specimen**
4. **Mounting herbarium specimen**
5. **Herbarium labels.**
6. **Protection of herbarium sheets against mold and insects**

Uses of Herbarium

1. Herbarium provides resource material for systematic research and studies.
2. It is a place for orderly arrangement of voucher specimens.
3. Voucher specimen serves as a reference for comparing doubtful newly collected fresh specimens.
4. Voucher specimens play a role in studies like floristic diversity, environmental assessment, ecological mechanisms and survey of unexplored areas.
5. Herbarium provides opportunity for documenting biodiversity and studies related to the field of ecology and conservation biology.

Kew Herbarium

Kew Garden is situated in South West London that houses the "largest and most diverse botanical and mycological collections in the world" founded in the year 1840. Living collection includes more than 30,000 different kinds of plants. While herbarium which is one of the largest in the world has over seven million preserved plant specimens. The library contains more than 7,50,000 volumes and the

Preparation of herbarium Specimen

Plant Collection
Plant specimen with flower or fruit is collected

↓

Documentation of field site data
Certain data are to be recorded at the time of plant collection. It includes date, time, country, state, city, specific locality information, latitude, longitude, elevation and land mark information. These data will be typed onto a herbarium label.

↓

Preparation of plant specimen
Plant specimen collected from the field is pressed immediately with the help of portable field plant press. plant specimen is transferred to a standard plant press (12” x 18”) which between two outer 12” x 18” frames and secured by two straps.

↓

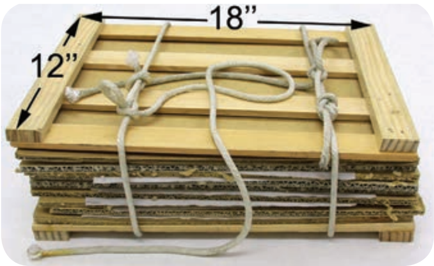
Mounting herbarium specimen
The standard size of herbarium sheet is used for mounting the specimen (29cm x 41cm). specimens are affixed to herbarium sheet with standard white glue or solution of Methyl cellulose.

↓

Herbarium label
Herbarium label size is generally 4-5” wide and 2-3” tall. A typical label contains all information like habit, habitat, vegetation type, land mark information, latitude, longitude, image document, collection number, date of collection and name of the collector.

↓

Protection of herbarium sheets against mold and insects
Apply cation of 2% Mercuric chloride, Naphthalene, DDT, carbon disulphide. Fumigation using formaldehyde. Presently deep freezing(**-20ºC**) method is followed throughout the world.



DO YOU KNOW?

World’s smallest water – lily *Nymphaea thermarum* was saved from extinction when it was grown from seed at Kew in 2009.

International Herbarium

S.No	Herbarium	Year Established	Acronym	Number of specimens
1.	*Museum National d'Histoire Naturelle*, Paris, France	1635	P ,PC	10,000,000
2.	New York Botanical Garden, Bronx, New York, U.S.A	1891	NY	72,00,000
3.	Komarov Botanical Institute, St.Petersburg (Leningrad), Russia	1823	LE	71,60,000
4.	Royal Botanic Gardens, Kew, England, U.K	1841	K	70,00,000

National Herbarium

S.No	Herbarium	Year Established	Acronym	Number of specimens
1.	Madras Herbarium BSI campus, Coimbatore	1955	MH	4,08,776
2.	Central National Herbarium West Bengal	1795	CAL	2,00,000
3.	Jawaharlal Nehru Tropical Botanical Garden and Research Institute Thiruvananthapuram, Kerala	1979	TBGRI	30,500
4.	Presidency College Herbarium, Chennai.	1844	PCM	15,000

illustrations and also a collection of more than 1,75,000 prints, books, photographs, letters, manuscripts, periodicals, maps and botanical illustrations.

5.8 Classification of Plants

Imagine walking into a library and looking for a Harry Potter story book. As you walk into the library you notice that it is under renovation and all the books are scattered. Will it not be hard to find the exact book you are looking for? It might take hours. So you decide to come the next day when all the books are arranged according to the genres. One rack for adventure, another for Detective, Fantasy, Horror, Encyclopaedia and so on. You automatically know Harry Potter is in the fantasy section and it takes less than ten minutes for you to find it. That is because the books have been classified and arranged according to a system.

Similarly there is a vast assemblage of group of plants in the world. Is it possible to study and understand all of these? No. Since it is difficult to study all these plants together, it is necessary to device some means to make this possible.

Classification is essential to biology because there is a vast diversity of organisms to sort out and compare. Unless they are organized into manageable categories it will be difficult for identification. Biological classifications are the inventions of biologists based upon the best evidence available. The scientific basis for cataloguing and retrieving information about the tremendous diversity of flora is known as **classification**.

Classification paves way for the arrangement of organisms into groups on the basis of their similarities, dissimilarities and relationships. The purpose of classification is to provide a systematic arrangement

Botanical Survey of India

On 13 February 1890, a survey was formally constituted and designated as the Botanical Survey of India. After independence, the need was felt for a more comprehensive documentation of the country's plant resources to boost the economy. Padmashree **Dr.E.K.Janaki Ammal** was appointed as officer on special Duty on 14th Oct 1952. Then reorganization plan was finally approved by the Govt. of India on 29 March 1954, with Calcutta as the headquarters of BSI. Jammu Tavi Botanical Garden has been named after Dr. E. K. Janaki Ammal.

Figure 5.3: Dr. E.K. Janaki Ammal

expressing the relationship between the organisms.

Taxonomists have assigned a method of classifying organisms which are called **ranks.** These taxonomical ranks are hierarchical. The scheme of classification has to be flexible, allowing newly discovered living organisms to be added where they fit best.

5.9 Need for Classification

- Understanding the classification of organisms can give an insight into other fields and has significant practical value.
- Classification helps us to know about different taxa, their phylogenetic relationship and exact position.
- It helps to train the students of plant sciences with regard to the diversity of organisms and their relationship with other biological branches.

5.10 Types of classification

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

5.10.1 Artificial system of classification

24 classes recognized by Linnaeus in his *Species Plantarum* (1753) on the basis of stamens.

No.	Classes	Characters
1	Monandria	stamen one
2	Diandria	stamens two
3	Triandria	stamens three
4	Tetrandria	stamens four
5	Pentandria	stamens five
	up to 24th class Cryptogamia	flowerless plants

Carolus Linnaeus (1707 -1778) was a great Swedish Botanist and said to be the "**Father of Taxonomy**." He outlined an artificial system of classification in "***Species Plantarum***" in 1753, wherein he listed and described 7,300 species and arranged in 24 classes mostly on the basis of number, union (adhesion and cohesion), length, and distribution of stamens. The classes were further subdivided on the basis of carpel characteristics into orders. Hence the system of classification is also known as **sexual system of classification**.

Figure 5.4: Carolus Linnaeus

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

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

1. Totally unrelated plants were kept in a single group, whereas closely related plants were placed in widely separated groups. Example:
   a. Zingiberaceae of monocotyledons and Anacardiaceae of dicotyledonous were placed under the class **Monandria** since these possess single stamens.
   b. *Prunus* was classified along with *Cactus* because of the same number of stamens.

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

5.10.2 Natural system

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

Bentham and Hooker system of classification

Figure 5.5: George Bentham and J.D. Hooker

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

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

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

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

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

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

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

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

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

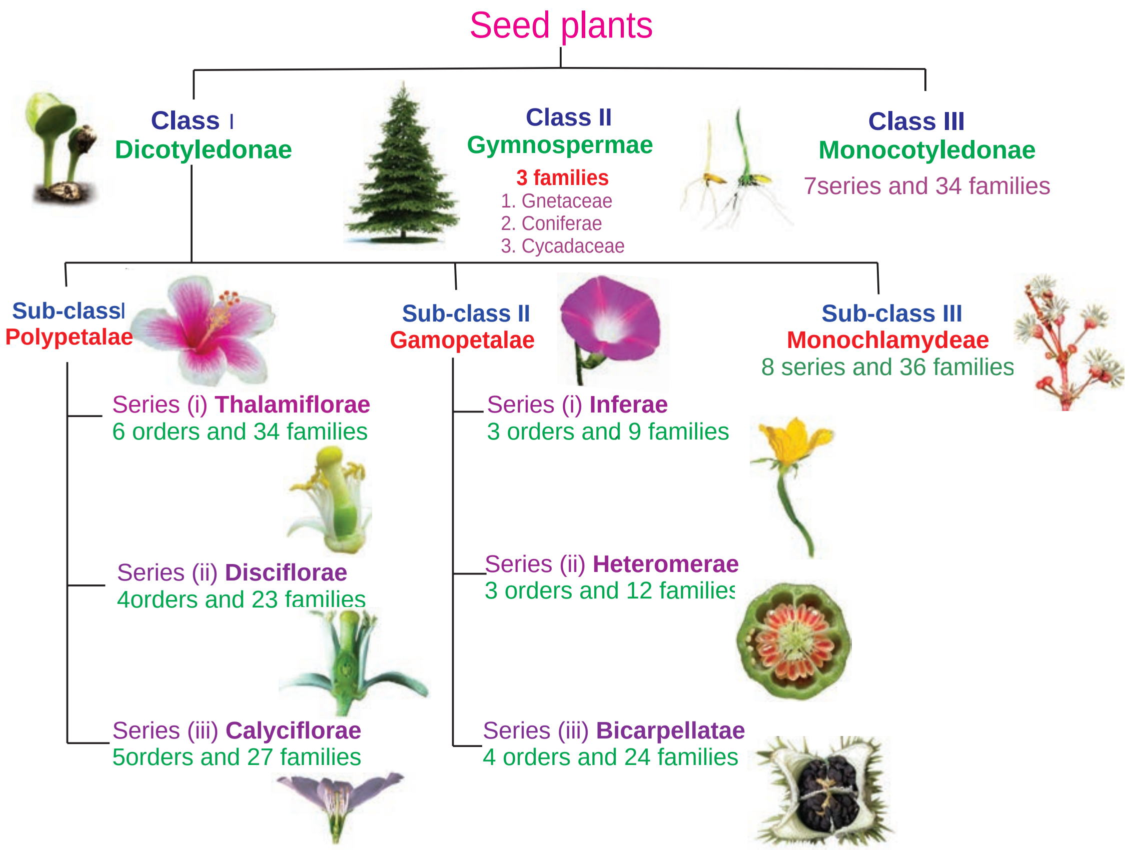


Figure 5.6: Bentham and Hooker system of classification

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

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

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

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

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

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

Though it is a natural system, this system was not intended to be phylogenetic.

5.10.3 Phylogenetic system of classification

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

I Adolph Engler and Karl A Prantl system of classification

Figure 5.7: Adolph Engler and Karl A Prantl

One of the earliest phylogenetic system of classification of the entire plant Kingdom was jointly proposed by two German botanists **Adolph Engler** (1844 -1930) and **Karl A Prantl** (1849 - 1893). They published their classification in a monumental work "***Die Naturelichen Pflanzen Familien***" in 23 volumes (1887-1915)

In this system of classification the plant kingdom was divided into 13 divisions. The first 11 divisions are Thallophytes, twelfth division is **Embryophyta Asiphonogama** (plants with embryos but no pollen tubes; Bryophytes and Pteridophytes) and the thirteenth division is **Embryophyta Siphonogama** (plants with embryos and pollen tubes) which includes seed plants.

II Arthur Cronquist system of classification

Arthur Cronquist (1919 - 1992) an eminent American taxonomist proposed phylogenetic classification of flowering plants based on a wide range of taxonomic characters including anatomical and phytochemical characters of phylogenetic importance. He has presented his classification in 1968 in his book titled "**The evolution and classification of flowering plants.**" His classification is broadly based on the Principles of phylogeny that finds acceptance with major contemporary authors.

Figure 5.9: Arthur Cronquist

Cronquist classified the angiosperms into two main classes **Magnoliopsida** (=dicotyledons) and **Liliopsida** (= monocotyledons). There are 6 subclasses, 64 orders, 320 families and about 165,000 species in Magnoliopsida, whereas in Liliopsida there are 5 sub classes, 19 orders, 66 families and about 50,000 species.

Cronquist system of classification also could not persist for a long time because, the system is not very useful for identification and cannot be adopted in herbaria due to its high phylogenetic nature.

5.10.4 Angiosperm phylogeny group (APG) classification

The most recent classification of flowering plants based on **phylogenetic data** was set in the last decade of twentieth century. Four versions of Angiosperm Phylogenetic Group classification (APG I, APG II, APG III & APG IV) have been published in 1998, 2003, 2009 and 2016 respectively. Each version supplants the previous version. Recognition of **monophyletic** group based on the information received from various disciplines such as gross morphology, anatomy, embryology, palynology, karyology, phytochemistry and more strongly on molecular data with respect to DNA sequences of two chloroplast

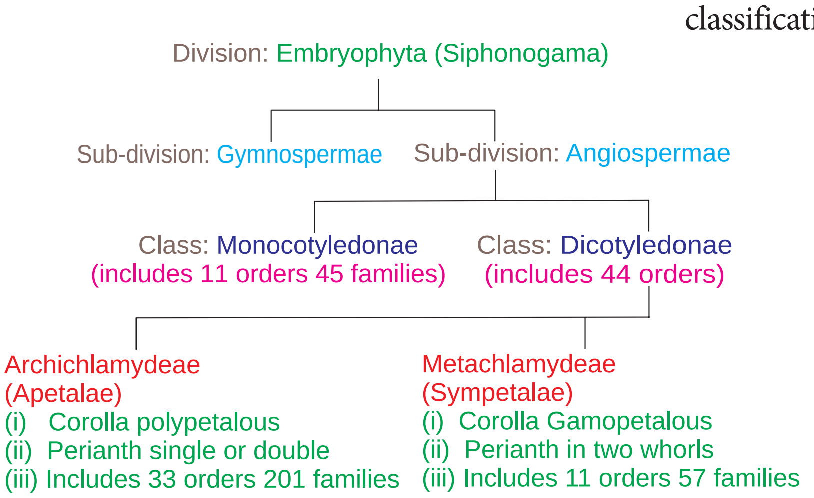


Figure 5.8: Outline of Engler and Prantl classification

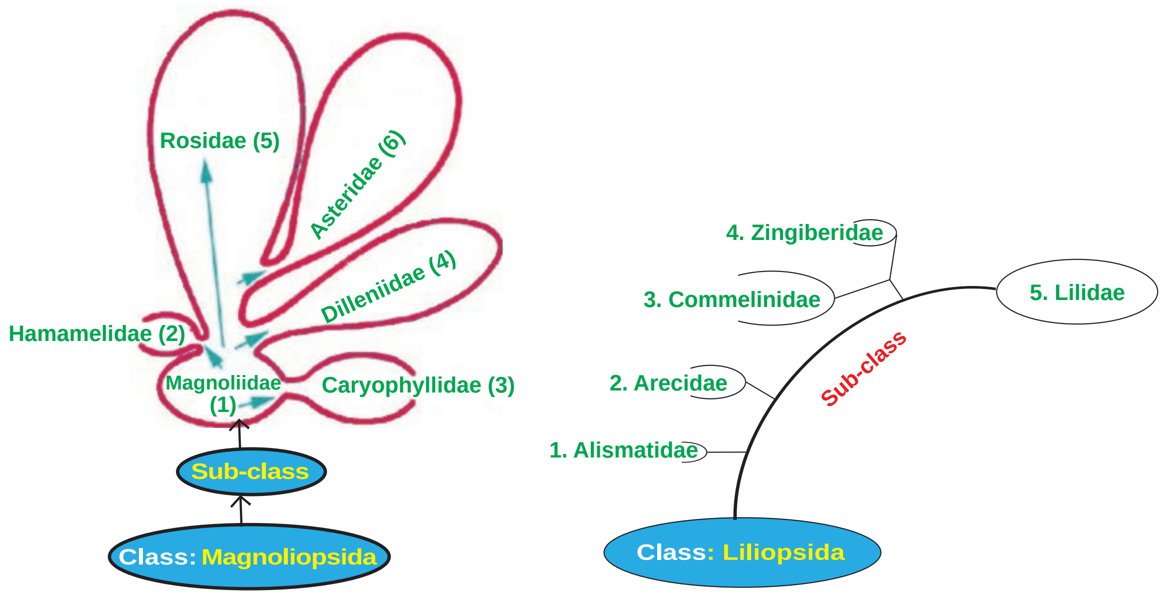


Figure 5.10: Diagramatic representation of class Magnoliopsida and Liliopsida.

genes (*atp*B and *rbc*L) and one nuclear gene (nuclear ribosomal 18s DNA).

The most recent updated version, APG IV (2016) recognised 64 orders and 416 families. Of these, 416 families 259 are represented in India.

The outline of APG IV classification is given below.

Angiosperms are classified into three clades early angiosperms, monocots and eudicots. Early angiosperms are classified into **8 orders** and **26 families** (**ANA**-clade + magnoliids + Chloranthales)

Amborellales
Nymphaeales
Austrobaileyales

- Seeds generally always with two cotyledons.
- Presence of ethereal oils.
- Leaves are always simple net-veined.
- Each floral whorls with many parts.
- Perianth usually spirally arranged or parts in threes.
- Stamens with broad filaments.
- Anthers tetrasporangiate.
- Pollen monosulcate.
- Nectaries are rare.
- Carpels usually free and
- Embryo very small.

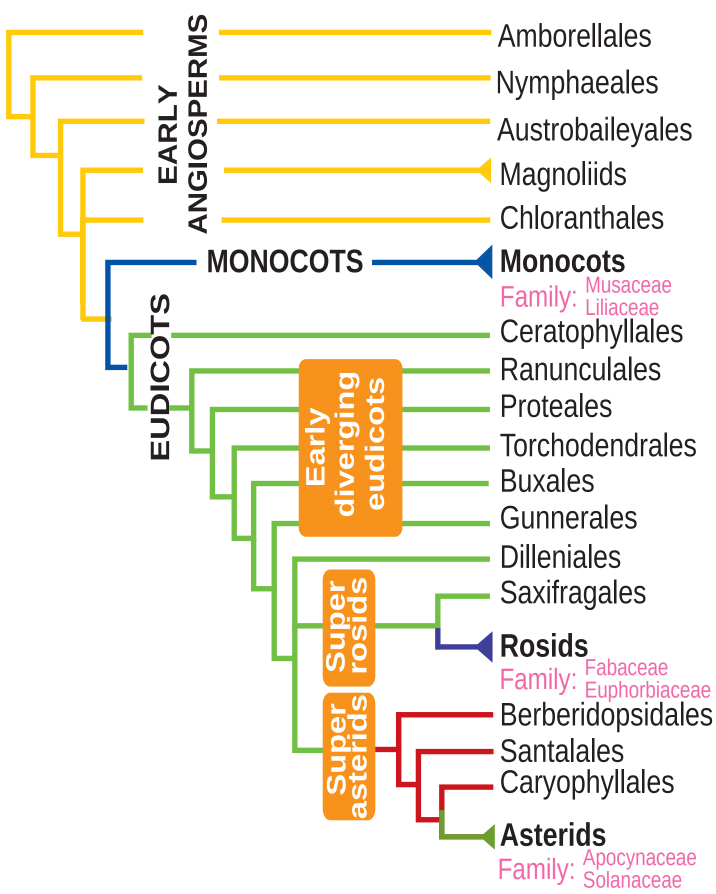


Figure 5.11: Simplified version of APG IV
(Source: Plant Gateway's The Global Flora, Vol. I January 2018)

Monocots are classified into 11 orders and 77 families (basal monocots + lilioids + commelinids)

- Seeds with single cotyledon.
- Primary root short-lived.

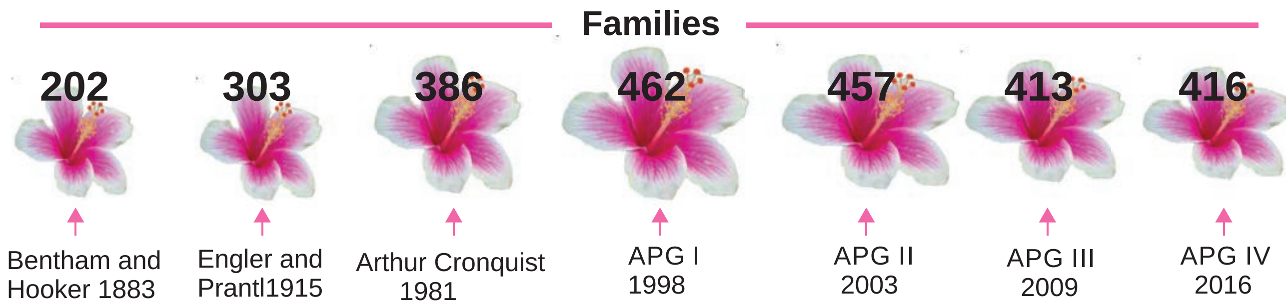


Figure 5.12: A timeline showing the history of classifying flowering plants into families. (Source: Royal Botanic Gardens Kew State of World's Plant 2017)

- Single adaxial prophyll.
- Ethereal oils rarely present.
- Mostly herbaceous, absence of vascular cambium.
- Vascular bundles are scattered in the stem.
- Leaf simple with parallel-veined.
- Floral parts usually in threes.
- Perianth often composed of tepals.
- Pollen monosulcate.
- Styles normally hollow and
- Successive microsporogenesis.

Eudicots are divided into 45 orders and 313 families (early diverging eudicots + super rosids + super asterids).

- Seeds with always two cotyledons.
- Nodes trilacunar with three leaf traces.
- Stomata anomocytic.
- Ethereal oils rarely present.
- Woody or herbaceous plants.
- Leaves simple or compound, usually net-veined.
- Flower parts mostly in twos, fours or fives.
- Microsporogenesis simultaneous.
- Style solid and
- Pollen tricolpate.

APG system is an evolving system that might undergo change periodically based on the new sets of data from various disciplines of Botany. It is the currently accepted system across the world and followed by all the leading taxonomic institutions and practising taxonomists. However, it is yet to percolate into the Indian botanical curriculum.

Classification reflects the state of our knowledge at a given point of time. It will continue to change as we acquire new information.

DO YOU KNOW?

A significant number of major herbaria, including Kew are changing the order of their collections in accordance with APG.

The influential world checklist of selected plant families (also from kew) is being updated to the APG III system.

A recent photographic survey of the plants of USA and Canada is organized according to the APG III system.

In UK, the latest edition of the standard flora of the British Isles written by Stace is based on the APG III system.

5.11 Modern trends in taxonomy

Taxonomists now accept that, the morphological characters alone should not be considered in systematic classification of plants. The complete knowledge of taxonomy is possible with the principles of various disciplines like Cytology, Genetics, Anatomy, Physiology, Geographical Distribution, Embryology, Ecology, Palynology, Phenology, Bio-Chemistry, Numerical Taxonomy and Transplant Experiments. These have been found to be useful in solving some of the taxonomical problems by providing additional characters. It has changed the face of classification from **alpha** (classical) to **omega** (modern kind). Thus the new systematic has evolved into a better taxonomy.

5.11.1 Chemotaxonomy

Proteins, amino acids, nucleic acids, peptides etc. are the most studied chemicals in chemotaxonomy. Chemotaxonomy is the scientific approach of classification of plants on the basis of their biochemical constituents. As proteins are more closely controlled by genes and less subjected to natural selection, it has been used at all hierarchical levels of classification starting from the rank of 'variety' up to the rank of division in plants.

The chemical characters can be divided into three main categories.

1. Easily visible characters like starch grains, silica.
2. Characters detected by chemical tests like phenolics, oil, fats, waxes.
3. Proteins.

Aims of chemotaxonomy

1. To develop taxonomic characters which may improve existing system of plant classification.
2. To improve present day knowledge of phylogeny of plants.

5.11.2 Biosystematics

Biosystematics is an "Experimental, ecological and cytotaxonomy" through which life forms are studied and their relationships are defined. The term biosystematics was introduced by **Camp** and **Gilly** in 1943. Many authors feel Biosystematics is closer to Cytogenetics and Ecology and much importance given not to classification but to evolution.

Aims of biosystematics

The aims of biosystematics are as follows:

1. To delimit the naturally occurring biotic community of plant species.
2. To establish the evolution of a group of taxa by understanding the evolutionary and phylogenetic trends.
3. To involve any type of data gathering based on modern concepts and not only on morphology and anatomy.
4. To recognize the various groups as separate biosystematic categories such as ecotypes, ecospecies, cenospecies and comparium.

5.11.3 Karyotaxonomy

Chromosomes are the carriers of genetic information. Increased knowledge about the chromosomes have been used for extensive biosystematic studies and resolving many taxonomic problems. Utilization of the characters and phenomena of cytology for the explanation of taxonomic problem is known as **cytotaxonomy** or **karyotaxonomy**. The characters of chromosome such as number, size, morphology and behaviour during meiosis have proved to be of taxonomic value.

5.11.4 Serotaxonomy (Immunotaxonomy)

Systematic serology or serotaxonomy had its origin towards the end of twentieth century with the discovery of serological reactions and development of the discipline of immunology. The classification of very similar plants by means of differences in the proteins they contain, to solve taxonomic problems is called **serotaxonomy**. **Smith** (1976) defined it as "**the study of the origins and properties of antisera**."

Importance of serotaxonomy

It determines the degree of similarity between species, genera, families etc. by comparing the reactions of antigens from various plant taxa with antibodies raised against the antigen of a given taxon.

Example: 1. The assignment of *Phaseolus aureus* and *P. mungo* to the genus *Vigna* is strongly supported by serological evidence by **Chrispeels** and **Gartner**.

5.11.5 Molecular taxonomy (molecular systematics / molecular phylogenetics)

Molecular Taxonomy is the branch of phylogeny that analyses hereditary molecular differences, mainly in DNA sequences, to gain information and to establish genetic relationship between the members of different taxonomic categories. The advent of DNA cloning and sequencing methods have contributed immensely to the development of molecular taxonomy and population genetics over the years. These modern methods have revolutionised the field of molecular taxonomy and population genetics with improved analytical power and precision.

The results of a molecular phylogenetic analysis are expressed in the form of a tree called **phylogenetic tree.** Different molecular markers like allozymes, mitochondrial DNA, microsatellites, RFLP (Restriction Fragment Length Polymorphism), RAPD (Random amplified polymorphic DNA), AFLPs (Amplified Fragment Length Polymorphism), single nucleotide polymorphism- (SNP), microchips or arrays are used in analysis.

Uses of molecular taxonomy

1. Molecular taxonomy helps in establishing the relationship of different plant groups at DNA level.
2. It unlocks the treasure chest of information on evolutionary history of organisms.

RFLP (Restriction Fragment Length Polymorphism)

RFLPs is a molecular method of genetic analysis that allows identification of taxa based on unique patterns of restriction sites in specific regions of DNA. It refers to differences between taxa in restriction sites and therefore the lengths of fragments of DNA following cleavage with restriction enzymes.

Amplified Fragment Length Polymorphism (AFLP)

This method is similar to that of identifying RFLPs in that a restriction enzyme is used to cut DNA into numerous smaller pieces, each of which terminates in a characteristic nucleotide sequence due to the action of restriction enzymes.

AFLP is largely used for population genetics studies, but has been used in studies of closely related species and even in some cases, for higher level cladistic analysis.

Random Amplified Polymorphic DNA (RAPD)

It is a method to identify genetic markers using a randomly synthesized primer that will anneal (recombine (DNA) in the double stranded form) to complementary regions located in various locations of isolated DNA. If another complementary site is present on the opposing DNA strand at a distance that is not too great (within the limits of PCR) then the reaction will amplify this region of DNA.

RAPDs like microsatellites may often be used for genetic studies within species but may also be successfully employed in phylogenetic studies to address relationships within a species or between closely related species. However RAPD analysis has the major disadvantage that results are difficult to replicate and in that the homology of similar bands in different taxa may be nuclear.

Significance of Molecular Taxonomy

1. It helps to identify a very large number of species of plants and animals by the use of conserved molecular sequences.
2. Using DNA data evolutionary patterns of biodiversity are now investigated.
3. DNA taxonomy plays a vital role in phytogeography, which ultimately helps in genome mapping and biodiversity conservation.
4. DNA- based molecular markers used for designing DNA based molecular probes, have also been developed under the branch of molecular systematics.

5.11.6 DNA Barcoding

Have you seen how scanners are used in supermarkets to distinguish the **Universal**

Product Code (UPC)? In the same way we can also distinguish one species from another. DNA barcoding is a taxonomic method that uses a very short genetic sequence from a standard part of a genome. The genetic sequence used to identify a plant is known as "**DNA tags**" or "**DNA barcodes**". **Paul Hebert** in 2003 proposed '**DNA barcoding**' and he is considered as 'Father of barcoding'.

The gene region that is being used as an effective barcode in plants is present in two genes of the chloroplast, **matK** and **rbcL**, and have been approved as the barcode regions for plants.

Sequence of unknown species can be matched from submitted sequence in GenBank using Blast (web-programme for searching the closely related sequence).

Significance of DNA barcoding

1. DNA barcoding greatly helps in identification and classification of organism.
2. It aids in mapping the extent of biodiversity.

DNA barcoding techniques require a large database of sequences for comparison and prior knowledge of the barcoding region.

However, DNA barcoding is a helpful tool to determine the authenticity of botanical material in whole, cut or powdered form.

5.11.7 Differences between classical and modern taxonomy

Classical Taxonomy	Modern Taxonomy
It is called old systematics or Alpha (ὰ) taxonomy or Taxonomy	It is called Neosystematics or Biosystematics or Omega (Ω) taxonomy
It is pre Darwinean	It is post Darwinean
Species is considered as basic unit and is static	species is considered as dynamic entity and ever changing
Classification is mainly based on morphological characters	Classification is based on morphological, reproductive characters and phylogenetic (evolutionary) relationship of the organism
This system is based on the observation of a few samples/ individuals	This system is based on the observation of large number of samples/individuals

5.12 Cladistics

Analysis of the taxonomic data, and the types of characters that are used in classification have changed from time to time. Plants have been classified based on the morphology before the advancement of microscopes, which help in the inclusions of **sub microscopic** and **microscopic** features. A closer study is necessary while classifying closely related plants. Discovery of new finer molecular analytical techniques coupled with advanced software and computers has ushered in a new era of modern or phylogenetic classification.

The method of classifying organisms into monophyletic group of a common ancestor based on shared apomorphic characters is called **cladistics** (from Greek, *klados*- branch).

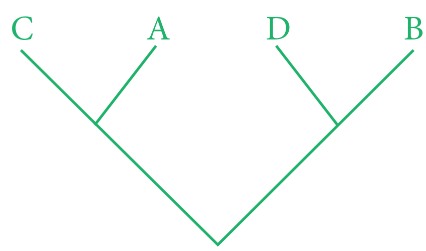
The outcome of a cladistic analysis is a **cladogram**, a tree-shaped diagram that represent the best hypothesis of phylogenetic relationships. Earlier generated cladograms were largely on the basis of morphological characters, but now genetic sequencing data and computational softwares are commonly used in phylogenetic analysis.

Cladistic analysis

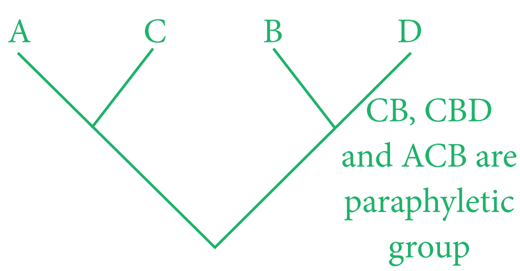
Cladistics is one of the primary methods of constructing phylogenies, or evolutionary histories. Cladistics uses shared, derived characters to group organisms into clades. These clades have atleast one shared, derived character found in their most recent common ancestor that is not found in other groups hence they are considered more closely related to each other. These shared characters can be morphological such as, leaf, flower, fruit, seed and so on; behavioural, like opening of flowers nocturnal/diurnal; molecular like, DNA or protein sequence and more.

Cladistics accept only **monophyletic groups**. **Paraphyletic** and **polyphyletic** taxa are occasionally considered when such taxa conveniently treated as one group for practical purposes. Example: dicots, sterculiaceae. Polyphyletic groups are rejected by cladistics.

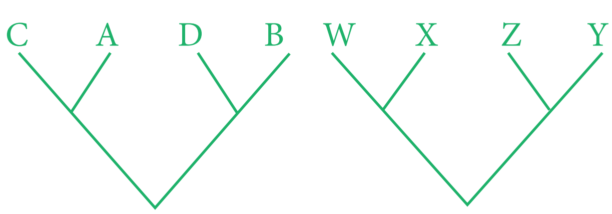
i. **Monophyletic group;** Taxa comprising all the descendants of a common ancestor.



ii. **Paraphyletic group;** Taxon that includes an ancestor but not all of the descendants of that ancestor.



iii. **Polyphyletic group;** Taxa that includes members from two different lineages.



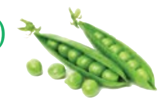
Need for cladistics

1. Cladistics is now the most commonly used and accepted method for creating phylogenetic system of classifications.
2. Cladistics produces a hypothesis about the relationship of organisms to predict the phylogeny
3. Cladistics helps to elucidate mechanism of evolution.

5.13 Selected Families of Angiosperms

Dicot Families

5.13.1 Family: Fabaceae (Pea family)



Systematic position

APG classification		**Bentham and Hooker classification**	
Kingdom	Plantae	Kingdom	Plantae
Clade	Angio-sperms	Class	Dicotyledonae
Clade	Eudicots	Sub-class	Polypetalae
Clade	Rosids	Series	Calyciflorae
Order	Fabales	Order	Rosales
Family	Fabaceae	Family	Fabaceae

General characters

Distribution: Fabaceae includes about 741 genera and more than 20,200 species. The members are cosmopolitan in distribution but abundant in tropical and subtropical regions.

Habit: All types of habits are represented in this family. Mostly herbs (*Crotalaria*), prostrate (*Indigofera enneaphylla)* erect (*Crotalaria verrucosa*), shrubs (*Cajanus cajan*), small trees (*Sesbania*), climbers (*Clitoria*), large tree (*Pongamia, Dalbergia*), woody climber (*Mucuna*), hydrophyte (*Aeschynomene aspera*) commonly called **pith plant.**

Root: Tap root system, roots are nodulated, have tubercles containing

Root nodule

nitrogen – fixing bacteria (*Rhizobium leguminosarum)*

Stem: Aerial, herbaceous, woody (*Dalbergia*) twining or climbing (*Clitoria*).

Leaf: Leaf simple or unifoliate (*Desmodium gangeticum*) bifoliate (*Zornia diphylla,*), Trifoliate (*Lablab purpureus*), alternate, stipulate, leaf base, **pulvinate**, reticulate venation terminal leaflet modifies into a **tendril** in *Pisum sativum*.

Inflorescence: Raceme (*Crotalaria verrucosa*), panicle (*Dalbergia latifolia*) axillary solitary (*Clitoria ternatea*)

Flowers: Bracteate, bracteolate, pedicellete, complete, bisexual, pentamerous, heterochlamydeous, zygomorphic hypogynous or sometimes perigynous.

Calyx: Sepals 5, green, synsepalous, more or less united in a tube and persistant, valvate or imbricate, odd sepal is anterior in position.

Corolla: Petals 5, apopetalous, unequal and **papilionaceous**, **vexillary** or **descendingly imbricate** aestivation, all petals have claw at the base. The outer most petal is large called **standard petal** or **vexillum**, Lateral 2 petals are lanceolate and curved. They are called **wing petals** or **alae**. Anterior two petals are partly fused and are called **keel petals** or **carina** which encloses the stamens and pistil.

Androecium: Stamens 10, diadelphous, usually 9+1 (*Clitoria ternatea*). The odd stamen is posterior in position. In *Aeschynomene aspera*, the stamens are fused to form two bundles each containing five stamens (5)+(5). Stamens are **monadelphous** and **dimorphic** ie. 5 stamens have longer filaments and other 5 stamens have shorter filaments thus the stamens are found at two levels and the shape of anthers also varies in (*Crotalaria verrucosa*). (5 anthers are long and lanceolate, and the other 5 anthers are short and blunt). Anthers are dithecous, basifixed and dehiscing longitudinally.

Gynoecium: Monocarpellary, unilocular, ovary superior, with two alternating rows of ovules on marginal placentation. Style simple and bent, stigma flattened or feathery.

Fruit: The characteristic fruit of Fabaceae is a legume (*Pisum sativum*), sometimes indehiscent and rarely a lomentum (*Desmodium*). In *Arachis hypogea* the fruit is ***geocarpic*** (fruits develops and matures under the soil). After fertilization the stipe of the ovary becomes meristematic and grows down into the soil. This ovary gets buried into the soil and develops into fruit.

Seed: Endospermic or non-endospermic (*Pisum sativum*), mostly **reniform**.

Botanical description of *Clitoria ternatea* (Sangu pushpam)

Habit: Twining climber

Root: Branched tap root system having nodules.

Stem: Aerial, weak stem and a twiner

Leaf: Imparipinnately compound, alternate, stipulate showing reticulate venation. Leaflets are stipellate. Petiolate and stipels are pulvinated.

Inflorescence: Solitary and axillary

Flower: Bracteate, bracteolate, bracteoles usually large, pedicellate, heterochlamydeous, complete, bisexual, pentamerous, zygomorphic and hypogynous.

Calyx: Sepals 5, synsepalous, green showing valvate aestivation. Odd sepal is anterior in position.

Corolla: Petals 5, white or blue apopetalous, irregular papilionaceous corolla showing descendingly imbricate aestivation.

Androecium: Stamens 10, diadelphous (9)+1, nine stamens fused to form a bundle and the tenth stamen is free. Anthers are dithecous, basifixed, introse and dechiscing by longitudinal slits.

Gynoecium: Monocarpellary, unilocular, with many ovules on mariginal placentation, ovary superior, style simple and incurved with feathery stigma.

Fruit: Legume

Seed: Non-endospermous, reniform.

Floral Formula:

Dt0Dtn0' .⚥.''M$_{*7+}$.E$_{7}$.C$_{*;+3}$.$\underline{I}_{3}$

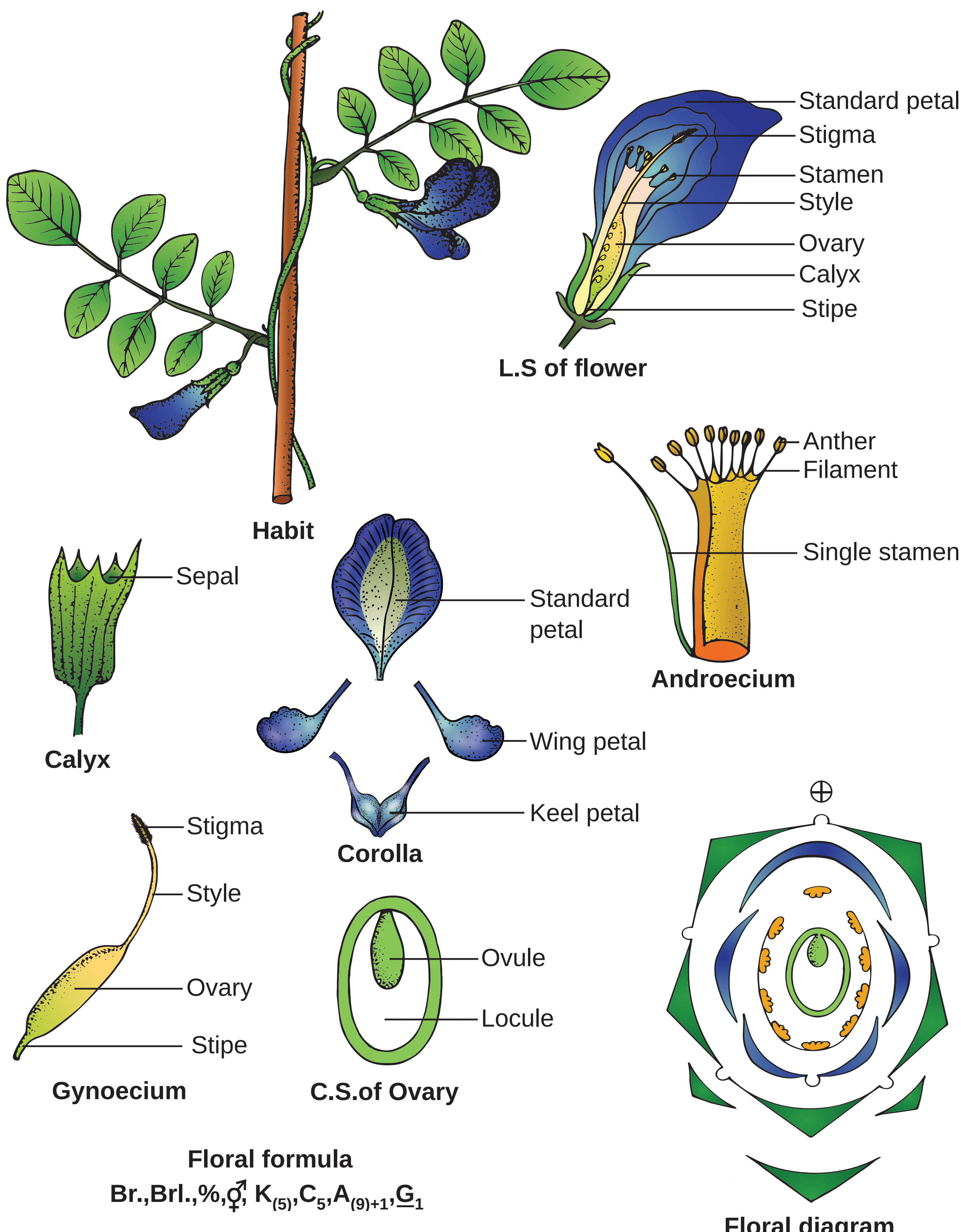


Figure 5.13: *Clitoria ternatea*

Economic Importance

Economic importance	Binomial	Useful part	Uses
Pulses	*Cajanus cajan* (Pigeon Pea) *Phaseolus vulgaris* (French bean) *Cicer arietinum* (Chick pea / Channa / கொண்டைக்கடலை) *Vigna mungo* (black gram / உளுந்து) *Vigna radiata* (green gram / பாசிப்பயறு) *Vigna unguiculata* (cow pea / தட்டைப்பயறு) *Glycine max* (soya bean) *Macrotyloma uniflorum* (Horse gram / கொள்ளு)	Seeds	Sources of protein and starch of our food.
Food plants	*Lablab purpureus* (field bean) *Sesbania grandiflora* (agathi) *Cyamopsis tetragonoloba* (cluster bean)	Tender fruits Leaves Tender fruits	Vegetable Greens Vegetable
Oil Plants	*Arachis hypogea* (ground nut) *Pongamia pinnata* (pungam)	Seeds Seeds	Oil extracted from the seeds is edible and used for cooking. Pongam oil has medicinal value and is used in the preparation of soap.
Timber Plants	*Dalbergia latifolia* (rose wood) *Pterocarpus santalinus* (red sandalwood) *P.marsupium* (வேங்கை)	Timber	Timber is used for making furniture, cabinet articles and as building materials.
Medicinal Plants	*Crotalaria albida* *Psoralea corylifolia* (கார்போக அரிசி) *Glycyrrhiza glabra* (Licorice root / அதிமதுரம்) *Mucuna pruriens* (பூனைக்காலி)	Roots Seeds Roots Seeds	Used as purgative Used in leprosy and leucoderma Immuno modulater Neurological remedy
Fibre Plants	*Crotalaria juncea* (sunhemp / சணப்பை) *Sesbania* sesban *(aegyptiaca)*	Stem fibres (Bast)	Used for making ropes.
Pith Plant	*Aeschynomene aspera*	Stem pith	Used for packing, handicraft and fishing floats
Dye Plants	*Indigofera tinctoria* (Avuri) *Clitoria ternatea* *Butea monosperma*	Leaves Flowers and seeds Flowers	Indigo dye obtained from leaves is used to colour printing and in paints. Blue dye is obtained Natural dye

Economic importance	Binomial	Useful part	Uses
Ornamental Plants	*Butea frondosa* (Flame of the forest), *Clitoria ternatea*, *Lathyrus odoratus* (Sweet pea) and *Lupinus hirsutus* (Lupin)	Entire plant	Grown as ornamental plants.

Diabetes Remedy

The aerial parts of *Galega officinalis* (Fabaceae) contains Metformin (dimethyl biguanide). It is now reputed to be the most widely prescribed agent in the treatment of diabetes all over the world.

The attractive seeds of *Adenanthera pavonina* (Family: Caesalpiniaceae) have been used as units of weight for the measures of gold throughout India.

The seeds of *Abrus precatorius* are used in necklaces and rosaries, but are extremely poisonous and can be fatal if ingested.

2016
INTERNATIONAL YEAR OF PULSES

The Food and Agriculture Organization (FAO) of the United Nations has been declared 2016 as the year for pulses, to make people more aware of the nutritional value of pulses.

5.13.2 Family: Solanaceae (Potato Family / Night shade family)

Systematic Position

APG system of classification		Bentham and Hooker system of classification	
Kingdom	Plantae	Kingdom	Plantae
Clade	Angiosperms	Class	Dicotyledonae
Clade	Eudicot	Subclass	Gamopetalae
Clade	Asterids	Series	Bicarpellatae
Clade	Solanales	Order	Polemoniales
Family	Solanaceae	Family	Solanaceae

General Characters

Distribution:

Family Solanaceae includes about 88 genera and about 2650 species, of these *Solanum* is the largest genus of the family with about 1500 species. Plants are worldwide in distribution but more abundant in South America.

Habit: Mostly annual herbs, shrubs, small trees (*Solanum violaceum*) lianas with prickles (*Solanum trilobatum*)

Root: Branched tap root system.

Stem: Herbaceous or woody; erect or twining, or creeping; sometimes modified into tubers (*Solanum tuberosum*) it is covered with Spines (*Solanum tuberosum)*

Leaves: Alternate, simple, rarely pinnately compound (*Solanum tuberosum* and *Lycopersicon esculentum*, exstipulate, opposite or sub-opposite in upper part, unicostate reticulate venation. Yellowish verbs present in *Solanum tuberosum*

Inflorescence: Generally axillary or terminal cymose (*Solanum*) or solitary flowers (*Datura stramonium*). Extra axillary scorpiod cyme called **rhiphidium** (*Solanum americanum*) solitary and axillary (*Datura* and *Nicotiana*) umbellate cyme (*Withania somnifera*).

Flowers: Bracteate or ebracteate, pedicellate, bisexual, heterochlamydeous, pentamerous actinomorphic or weakly zygomorphic due to oblique position of ovary, hypogynous.

Calyx: Sepals 5, Synsepalous, valvate persistent (*Solanum americanum*), often accrescent. (*Physalis*)

Corolla: Petals 5, sympetalous, rotate, tubular (*Solanum*) or bell- shaped (*Atropa*) or infundibuliform (*Petunia*) usually alternate with sepals; rarely bilipped and zygomorphic (*Schizanthus*) usually valvate, sometimes convolute (*Datura*).

Androecium: Stamens 5, epipetalous, filaments usually unequal in length, stamens only 2 in *Schizanthus* (others 3 are reduced to staminode), Anthers dithecous, dehisce longitudinally or poricidal.

Gynoecium: Bicarpellary, syncarpous obliquely placed, ovary superior, bilocular but looks tetralocular due to the formation of false septa, numerous ovules in each locule on axile placentation.

Fruit: A capsule or berry. (*Datura & Petunia, Lycopersicon esculentum, Capsicum*)

Seed: Endospermous.

Botanical description of *Datura metel*

Habit: Large, erect and stout herb.

Root: Branched tap root system.

Stem: Stem is hollow, green and herbaceous with strong odour.

Leaf: Simple, alternate, petiolate, entire or deeply lobed, glabrous exstipulate showing unicostate reticulate venation.

Inflorescence: Solitary and axillary cyme.

Flower: Flowers are large, greenish white, bracteate, ebracteolate, pedicellate, complete, heterochlamydeous, pentamerous, regular, actinomorphic, bisexual and hypogynous.

Calyx: Sepals 5, green synsepalous showing valvate aestivation. Calyx is mostly persistent, odd sepal is posterior in position.

Corolla: petals 5, greenish white, sympetalous, plicate (folded like a fan) showing twisted aestivation, funnel shaped with wide mouth and 10 lobed.

Androecium: Stamens 5, free from one another, epipetalous, alternipetalous and are inserted in the middle of the corolla tube. Anthers are basifixed, dithecous, with long filament, introse and longitudinally dehiscent.

Gynoecium: Ovary bicarpellary, syncarpous superior ovary, basically bilocular but tetralocular due to the formation of false septum. Carpels are obliquely placed and ovules on swollen axile placentation. Style simple long and filiform, stigma two lobed.

Fruit: Spinescent capsule opening by four apical valves with persistent calyx.

Seed: Endospermous.

Floral Formula:

Dt0Gdtn0⊕.⚥.M_{*7+}.$\overset{\frown}{E_{*7+}.C_{7}}$.$\underline{I}_{*4+}$

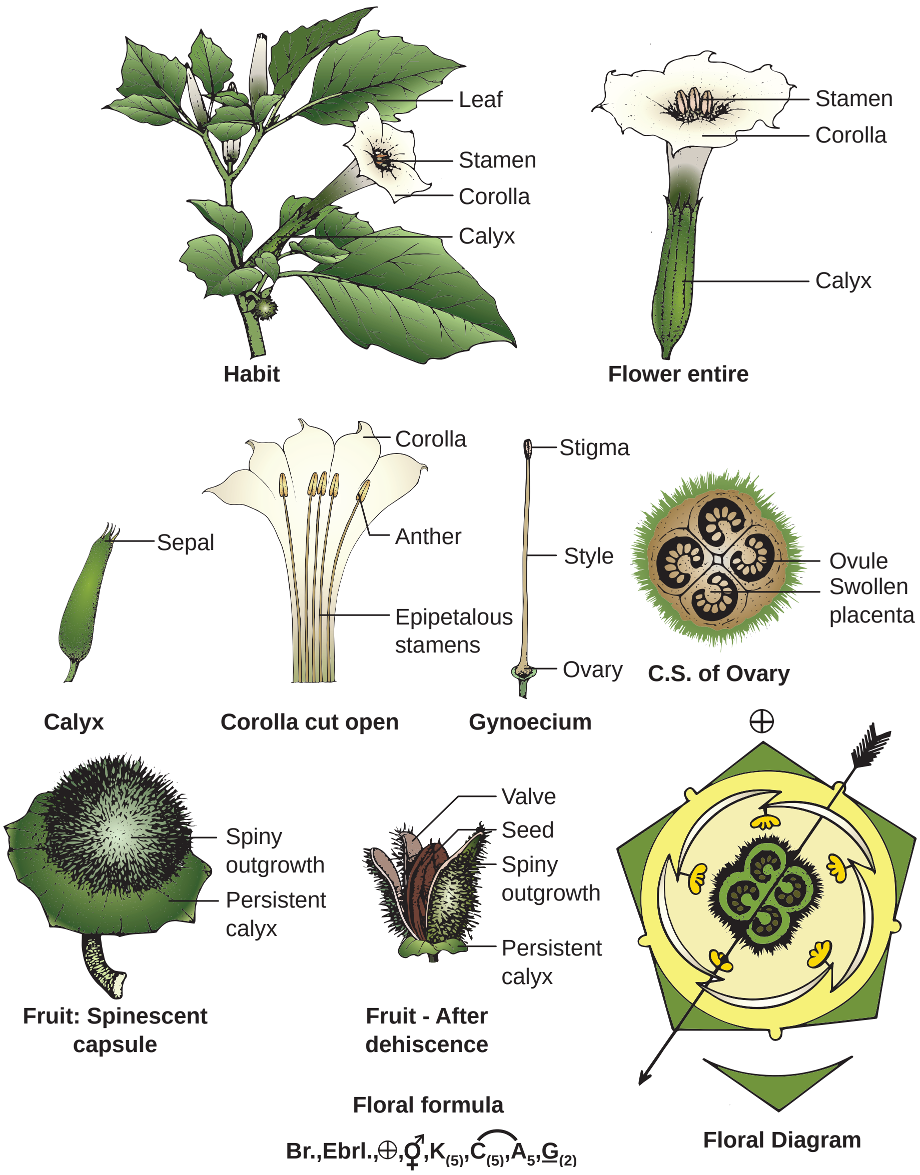


Figure 5.14: *Datura Metel*

Economic importance

Economic importance of the family solanaceae				
S.No.	**Economic importance**	**Binomial**	**Useful part**	**Uses**
1.	Food plant	*Solanum tuberosum* (potato)	Underground stem tubers	Used as vegetables and also used for the production of starch.
		Lycopersicon esculentum (tomato)	Ripened fruits	Used as delicious vegetable and eaten raw.
		Solanum melongena (brinjal)	Tender fruits	Cooked and eaten as vegetable.
		Capsicum annuum (bell peppers & chilli papers) *C. frutescens* (மிளகாய்)	Fruits	Used as vegetables and powdered chilli is the dried pulverized fruit which is used as spice to add pungency or piquancy and flavour to dishes.
		Physalis peruviana (cape gooseberry / சொடக்கு தக்காளி)	Fruit	Used as delicious fruit.

Economic importance of the family solanaceae				
S.No.	**Economic importance**	**Binomial**	**Useful part**	**Uses**
2.	Medicinal plant	*Atropa belladonna* (deadly nightshade) *Datura stramonium* (ஊமத்தை) *Solanum trilobatum* (தூதுவளை) *Withania somnifera* (Ashwagandha / அமுக்காரா)	Roots Leaves and roots Leaves, flowers and berries Roots	A powerful alkaloid 'atropine' obtained from root is used in belladonna plasters, tinctures etc. for relieving pain and also for dialating pupils of eyes for eye –testing. Stramonium drug obtained from the leaves and roots of this is used to treat asthma and whooping cough. Used to treat cough. Used in curing cough and rheumatism.
3.	Tobacco	*Nicotiana tabaccum* (tobacco / புகையிலை)	Leaves are dried and made into tobacco.	Used in cigarette, beedi, hukkah, pipes as well as for chewing and snuffing, alkaloids like nicotine, nornicotine and anabasin are present in tobacco.
4.	Ornamental plants	*Cestrum diurnum* (Day Jasmine) *Cestrum nocturnum* (Night Jasmine) *Nicotiana alata* *Petunia hybrida*, *Schizanthus pinnatus*	Plant	Grown in garden as ornamental plants for their aesthetic nature. Do tomatoes come from a tree?  Solanum betaceum (Tree tomato)

5.13.3 Family: Liliaceae (Lily Family)

Systematic position

APG Classification		Bentham and Hooker Classification	
Kingdom	Plantae	Kingdom	Plantae
Clade	Angiosperms	Class	Monocotyledons
Clade	Monocots	Series	Coronarieae
Order	Liliales	Order	Liliales
Family	Liliaceae	Family	Liliaceae

Note: Liliaceae of Bentham and Hooker included *Allium, Gloriosa, Smilax, Asparagus, Scilla, Aloe, Dracaena* etc. Now under APG, it includes only ***Lilium*** and ***Tulipa***. All others are placed under different families.

General Characters

Distribution: Liliaceae are fairly large family comprising about 15 genera and 550 species. Members of this family are widely distributed over most part of the world.

Habit: Mostly perennial herbs persisting by means of a sympodial rhizome (*Polygonatum)*, by a bulb (*Lilium*) corm (*Colchicum*), shrubby or tree like (*Yucca* and *Dracaena*). Woody climbers, climbing with the help of stipular tendrils in *Smilax*. Trees in (*Xanthorrhoea),* succulents (*Aloe)*.

Root: Adventitious and fibrous, and typically contractile.

Stem: Stems usually bulbous, rhizomatous in some, aerial, erect (*Dracaena*) or climbing (*Smilax)* in *Ruscus* the ultimate branches are modified into phylloclades, In *Asparagus* stem is modified into cladodes and the leaves are reduced to scales.

Leaf: Leaves are radical (*Lilium*) or **cauline** (*Dracaena*), usually alternate, opposite (*Gloriosa*), sometimes fleshy and hollow, reduced to scales (*Ruscus* and *Asparagus*). The venation is parallel but in species of *Smilax* it is reticulate. Leaves are usually exstipulate, but in *Smilax*, two tendrils arise from the base of the leaf, which are considered modified stipules.

Inflorescence: Flowers are usually borne in simple or branched racemes (*Asphodelus*) spikes in *Aloe*, huge terminal panicle in *Yucca*, solitary and axillary in *Gloriosa*, solitary and terminal in *Tulipa.*

Flowers: Flowers are often showy, pedicellate, bracteate, ebracteolate, except *Dianella* and *Lilium*, bisexual, actinomorphic, trimerous, hypogynous, rarely unisexual (*Smilax*) and are dioecious, rarely tetramerous (*Maianthemum*), slightly zygomorphic (*Lilium*) and hypogynous.

Perianth: Tepals 6 biseriate arranged in two whorls of 3 each, apotepalous or rarely syntepalous as in *Aloe.* Usually petaloid or sometimes sepaloid, odd tepal of the outer whorl is anterior in position, valvate or imbricate, tepals more than six in *Paris quadrifolia*.

Androecium: Stamens 6, arranged in 2 whorls of 3 each, rarely stamens are 3 (*Ruscus*), 4 in *Maianthemum,* or up to 12, apostamenous, opposite to the tepals, sometimes epitepalous; filaments distinct or connate, anthers dithecous, basifixed or versatile, extrose, or introse, dehiscing usually by vertical slit and sometimes by terminal pores; rarely **synstamenous** (*Ruscus*).

Gynoecium: Tricarpallary, syncarpous, the odd carpel usually anterior, ovary superior, trilocular, with 2 rows of numerous ovules on axile placextation; rarely unilocular with parietal placentation, style usually one; stigmas 1 or 3; rarely the ovary is inferior (*Haemodorum*), nectar – secreting **septal glands** are present in the ovary.

Fruit: Fruit usually a septicidal or loculicidal capsule or a berry as in *Asparagus* and *Smilax.*

Botanical description of *Allium cepa*

(In APG classification, *Allium cepa* is placed under the family Amaryllidaceae)

Habit: Perennial herb with bulb.

Root: Fibrous adventitious root system

Stem: Underground bulb

Leaf: A cluster of radical leaves emerges from the underground bulb, cylindrical and fleshy having sheathy leaf bases with parallel venation.

Inflorescence: **Scapigerous** i.e. the inflorescence axis (peduncle) arising from the ground bearing a cluster of flowers at its apex. Pedicels are of equal length, arising from the apex of the peduncle which brings all flowers at the same level.

Flower: Small, white, bracteate, ebracteolate, pedicellate, complete, trimerous, actinomorphic and hypogynous. Flowers are protandrous.

Perianth: Tepals 6, white, arranged in two whorls of three each, syntepalous showing valvate aestivation.

Androecium: Stamens 6, arranged in two whorls of three each, epitepalous, apostamenous /free and opposite to tepals.

Anthers dithecous, basifixed, introse, and dehiscing longitudinally.

Gynoecium: Tricarpellary and syncarpous. Ovary superior, trilocular with two ovules in each locule on axile placentation. Style simple, slender with simple stigma.

Fruit: A loculicidal capsule.

Seed: Endospermous

Floral Formula:

Br.,Ebrl.,$\oplus$,⚥,$\overset{\frown}{P_{(3+3)}\ A_{3+3}}$,$\underline{G}_{(3)}$

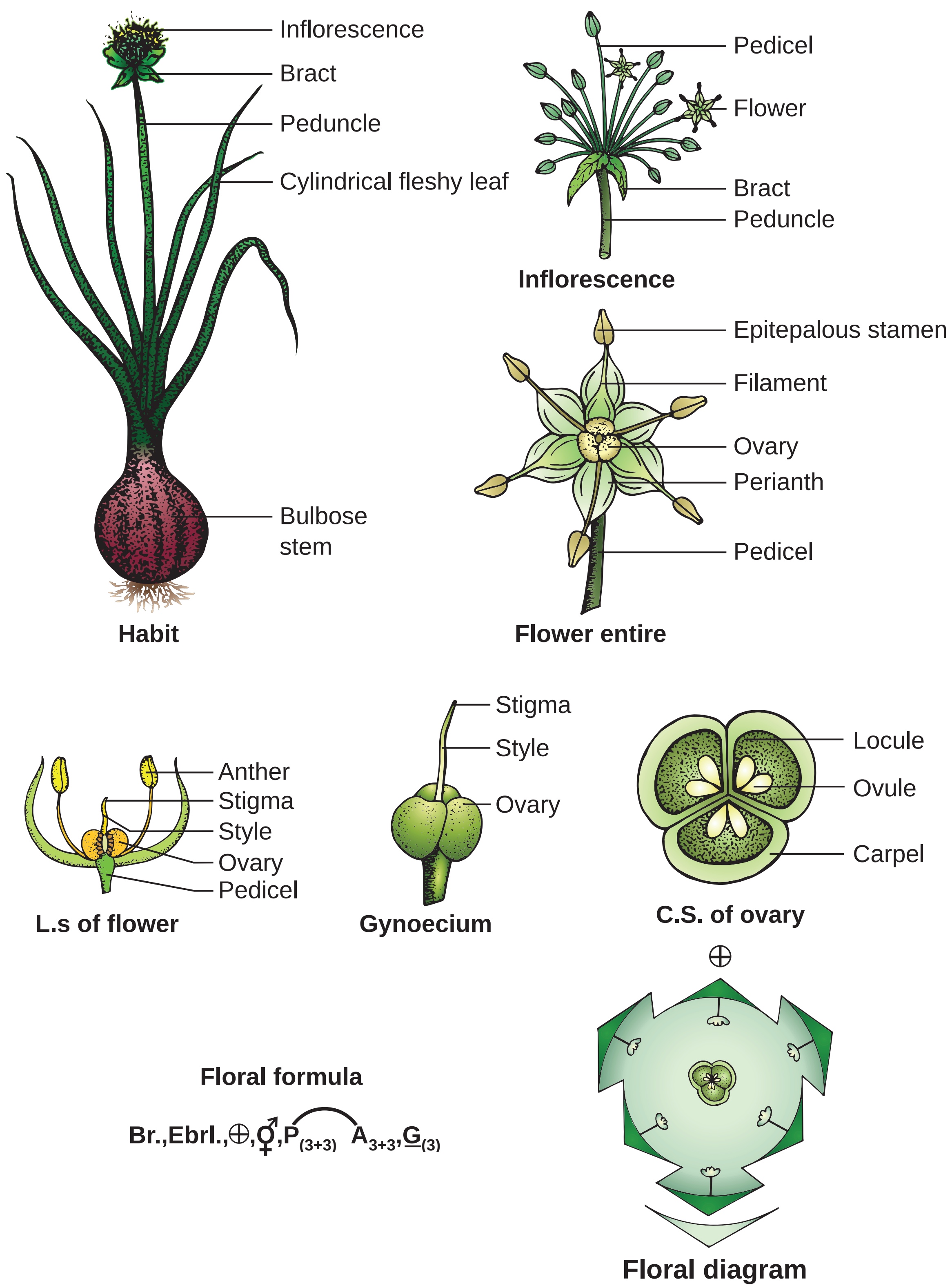


Figure 5.15: *Allium cepa*

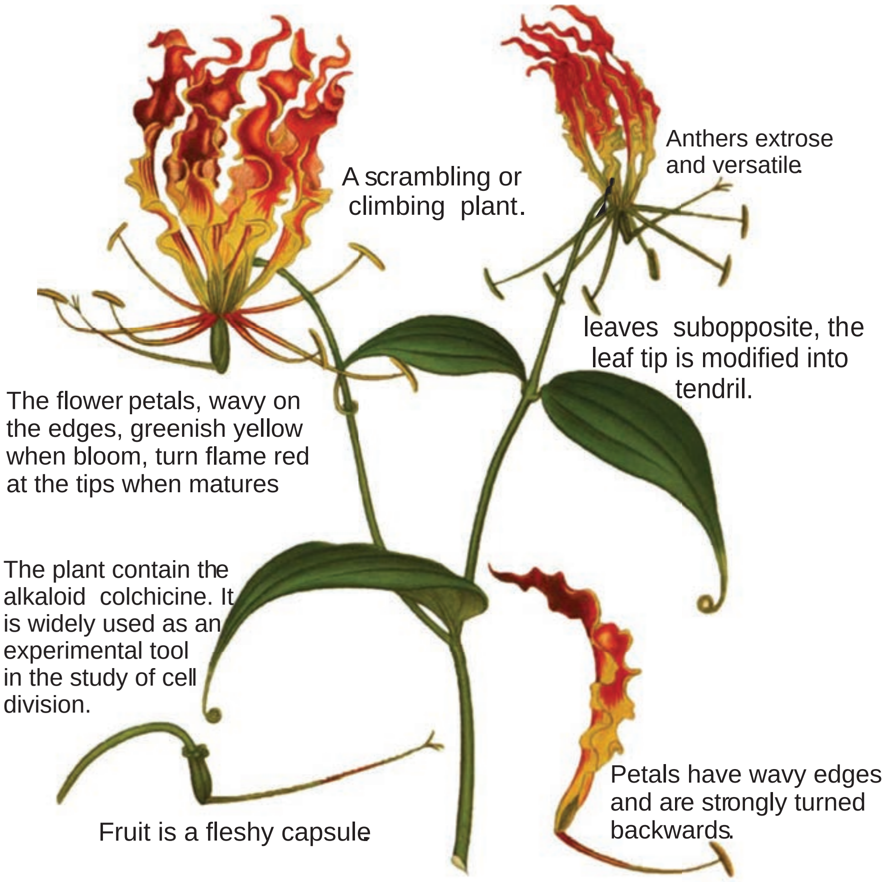
Economic importance of the family Liliaceae

S.No	Economic importance	Binomial	Useful part	Uses
1	Food plant	*Allium cepa*	Bulbs	Used as vegetable, stimulative, diuretic, expectorant with bactericidal properties.
		Allium sativum	Bulbs	Used as condiment and also good for heart.
		Asparagus officinalis	Fleshy shoots	Used as vegetables.
2.	Medicinal plant	*Aloe vera*	Leaves	Gelatinous glycoside called aloin from succulent leaves are used in soothing lotions, piles and inflammations, hemorrhoidal salves and shampoos.
		Asparagus racemosus	Roots	Medicinal oil is prepared from the root is used for nervous and rheumatic complaints and also in skin diseases.
		Colchichum luteum	Roots	Used in the treatment of gout and rheumatism.
		Gloriosa superba	Tubers	Tubers helpful in promoting labour pains in women.
3.	Fibre yielding plant	*Phormium tenax*	Fibre	Used for cordage, fishing net, mattings, twines.
4.	Raticides	*Urginea indica*	Bulbs	Used for killing rats.
	Insecticides	*Veratrum album*	Bulbs	Used as insecticide.
5.	Polyploidy	*Colchicum luteum*	Corm	Colchicine (alkaloid) used to induce polyploidy.
6.	Ornamental plants	*Agapanthus africanus* (African Lily) *Gloriosa superba* (Malabar glory lily) *Lilium giganteum* *Ruscus aculeatus* (Butchers Broom) *Yucca alcifolia* and *Y.gloriosa*	Plant	Some of the well known garden ornamentals. **Can you identify this?** a. Name the family. b. Write the binomial. c. List the economic uses. 

DO YOU KNOW?

In *Yucca* the cross-pollination is carried out by special moth, *Pronuba yuccasella*. Fully opened flowers emit perfumes and are visited by the female moth, especially during nights. This moth collects a lot of pollen grains from one flower and visits another flower. Life history of this moth is intimately associated with the pollination mechanism in *Yucca*.

State Flower of Tamil Nadu
Gloriosa superba



The name of *Gloriosa superba* is composed of two greek words Gloriosa means full of glory, superba means superb. This plant was placed earlier in Liliaceae.

Summary

Taxonomy deals with the identification, naming and classification of plants. But systematics deals with evolutionary relationship between the organisms in addition to taxonomy. Taxonomic hierarchy was introduced by Carolus Linnaeus. It also includes ranks. Species is the fundamental unit of taxonomic classification. Species concept can be classified into two groups based on the process of evolution and product of evolution. There are three types of species, morphological, biological and phylogenetic species. Taxonomic aids are the tools for the taxonomic study such as keys, flora, revisions, catalogues, botanical gardens and herbaria. Botanical gardens serve different purposes. They have aesthetic value, offers scope for botanical research, conservation of rare species and propagation of many species. Botanical survey of India explores and documents biodiversity all over India. It has 11 regional centres in India. Herbarium preparation includes plant collection, documentation of field data, preparation of plant specimens, mounting and labelling. There are several national and international herbaria. National herbaria include MH, PCM, CAL etc. Kew herbarium is the world's largest one.

Classification is the basis for cataloguing and retrieving information about the tremendous diversity of flora. It helps us to know about different varieties, their phylogenetic relationship and exact position. Some important systems of classification are fall in to three types; artificial, natural and phylogenetic. Carolus Linnaeus outlined an artificial system of classification in "*Species Plantarum*" in 1753. The first scheme of classification based on overall similarities was presented by Antoine Laurent De Jessieu in 1789. A widely followed natural system of classification was proposed by George Bentham

(1800 - 1884) and Joseph Dalton Hooker. This system was not intended to be phylogenetic. One of the earliest phylogenetic systems of classification was jointly proposed by Adolf Engler and Karl A Prantl in a monumental work "***Die Naturelichen Pflanzen Familien***". Arthur Cronquist proposed phylogenetic classification of flowering plants based on a wide range of taxonomic characters including anatomical and phytochemical of phylogenetic importance in his book titled "The evolution and classification of flowering plants." Angiosperm phylogeny group (APG) classification is the most recent classification of flowering plants based on phylogenetic data. APG system is an evolving and currently accepted system across the world and followed by all the leading taxonomic institutions and practising taxonomists.

Cladistics is the methodology, used to classify organisms into monophyletic groups, consisting of all the descents of the common ancestors. The outcome of a cladistic analysis is a cladogram and is constructed to represent the best hypothesis of phylogenetic relationships. Chemotaxonomy is the scientific approach of classification of plants on the basis of their biochemical constituents in them. Utilization of the characters of chromosome for the taxonomic inference is known as karyotaxonomy. The application of serology in solving taxonomic problems is called serotaxonomy. Molecular Taxonomy is the branch of phylogeny that analyses hereditary molecular differences, mainly in DNA nuclear and chloroplast sequences, to gain information and to establish genetic relationship between the members of different taxonomic categories. Different molecular markers like allozymes, mitochondrial DNA, microsatellites, RAPDs, AFLPs, single nucleotide polymorphism-(SNP), microchips or arrays are used in analysis. Molecular Taxonomy unlocks the treasure chest of information on evolutionary history of organisms. It plays a vital role in phytogeography, which ultimately helps in genome mapping and biodiversity conservation. DNA barcoding is a taxonomic method that uses a very short genetic sequence from a standard part of a genome. It helps in identification of organisms.

Evaluation

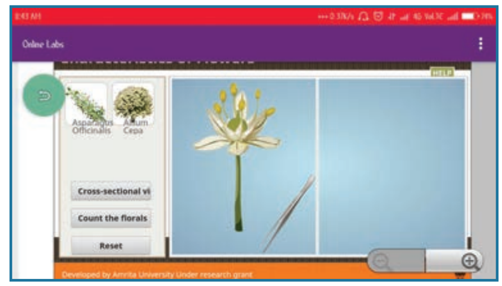
5QIV5Y

1. Phylogenetic classification is the most favoured classification because it reflects
   a. Comparative Anatomy
   b. Number of flowers produced
   c. Comparative cytology
   d. Evolutionary relationships
2. The taxonomy which involves the similarities and dissimilarities among the immune system of different taxa is termed as
   a. Chemotaxonomy
   b. Molecular systematics
   c. Serotaxonomy
   d. Numerical taxonomy
3. Which of the following is a flowering plant with nodules containing filamentous nitrogen fixing micro - organisms?
   a. *Crotalaria juncea*
   b. *Cycas revoluta*
   c. *Cicer arietinum*
   d. *Casuarina equisetifolia*
4. Flowers are zygomorphic in
   a. *Ceropegia* b. *Thevetia*
   c. *Datura* d. *Solanum*
5. What is the role of national gardens in conserving biodiversity – discuss
6. Where will you place the plants which contain two cotyledons with cup shaped thalamus?
7. Give the floral characters of *Clitoria ternatea*.
8. How will you distinguish Solanaceae members from Liliaceae members?

ICT Corner

Characteristics of flowers

Look inside the **Flower.** →

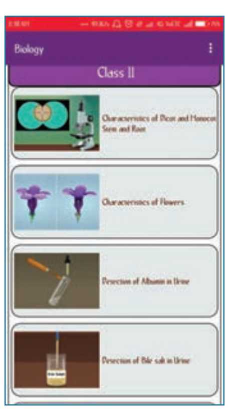


Steps

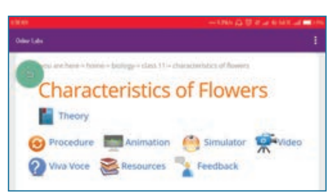
- Scan the QR code or go to google play store
- Type online labs and install it.
- Select biology and select Character of flower
- Click theory to know the basic about Character of flower
- Register yourself with mail-id and create password to access online lab simulations

Activity

- Select simulation and dissect the different flowers
- Record your observations



Step 1



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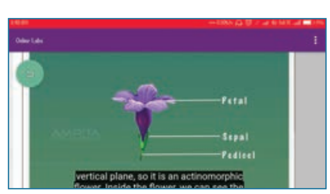

Step 3

Step 4

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* Pictures are indicative only