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DIRECTORATE OF DISTANCE EDUCATION

M.Sc., Botany

Paper – II

Taxonomy of Angiosperms and Economic Botany

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6046

PBOT02

Printed At Gokul Agencies

Copies – 500 Fresh Print -2014

Paper II: TAXONOMY OF ANGIOSAPERMS AND ECONOMIC BOTANY

Angiosperm taxonomy: Principles- Classification- (a) Artificial – Linnaeus, (b) Natural- Bentham and Hooker, (c) phylogenetic – Engler and Prantl. Taxonomic hierarchy- species concept – Binomial nomenclature: Principles of ICBN – Typification- Principles of Priority – Effective and valid publication – citation – Retention and Rejection of names – chemotaxonomy – Numerical taxonomy – Molecular taxonomy- Molecular taxonomy – Computer applications in systematic- Role of herbaria and Flora.

Study of the polypetalae families: mangnoliaceae, manispermaceae, papaveraceae, polygalaceae, Tiliaceae, Geramiaceae, Mimosaceae, Myrtaceae, Meliaceae and Sapindaceae.

Study of the Gamopetalae families: Sapotaceae, Rubiaceae, Asteraceae, Apocynaceae, Convolvulaceae, Biognoniaceae, Scrophulariaceae and Verbenaceae, Dioscoreaceae, Arecaceae and Cyperaceae.

Study of the Monochlamydeae families: Polygonaceae, Amaranthaceae, Aristolochiaceae, and loranthaceae study of the Monocotyledons: Hydrocharitaceae, Dioscoreaceae, arecaceae and Cyperaceae.

Economic Botany: General account on economic Botany – cultivation and utilization of selected crop plants- spices and condiments, commercial crops: Fiber, Timbers, oils and drug yielding plants-tribals: Ethnobotany.

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Paper II

TAXONOMY OF ANGIOSPERMS AND ECONOMIC BOTANY

ANGIOPSERMS TAXONOMY

INTRODCUTION

Taxonomy is a branch of natural science basically concerned with the classification of organisms. Before attempting to classify the various organisms, it is necessary to identify and name them. A particular group of individuals, unique in several respects, is assigned to a species. These species are grouped into genera; genera into families; families into orders; and the process continue till all the species have been arranged under a single largest, most inclusive group. When the primitive man distinguished the plants that he ate safely, from this he cannot, he laid the foundation of taxonomy. Plants are man's prime companions in this universe. It is being the source of food and energy, shelter and cloth, drugs and beverages, dyes and colours, oxygen and aesthetic environment. The characterizing, the naming, the classifying, and the identifying of all organisms, whether actually or potentially useful to man or not is one duty of the taxonomist or systematist.

Plant taxonomy is certainly a relevant field of inquiry for modern man. For a long time this subject was considered as the science of identifying, naming and classifying plants (Lawrence, 1951). The duties of the taxonomist are never-ending. It was recognized as a formal major field of study only during the latter half of twentieth century, the term 'systematics' had been in use for a considerable period. Derived from the Latin word *systema* (= organized whole), forming with title of Linnaeus famous work *Systema naturae* (1735). Different authors at various times tried to describe the subject in different titles, but the broader definition was given by Stace (1980), taxonomy is to coincide with systematics, it recognize the study and description of variations in organisms, this variation would produce a system of classification.

What is taxonomy?

Taxonomy is the science of naming, describing and classifying organisms and includes all plants, animals and microorganisms of the world. Using morphological, behavioural, genetic and biochemical observations, taxonomists identify, describe and arrange species into classifications, including those that are new to science. Taxonomy identifies and enumerates the components of biological diversity providing basic knowledge underpinning management and implementation of the Convention on Biological Diversity. The term **taxonomy** is derived from Greek words *taxis* = arrangement; *nomous* = law or rule, which means lawful arrangement or arrangement by rules. The term taxonomy was first introduced to plant science by A.P. de Candolle in 1813. This term is based on the word 'taxon', it was first used to mention the individual by German biologist Adolf Meyer in 1926.

Principles of Taxonomy

The main objective of the taxonomy is directed towards the single goal of constructing an ideal system of classification that necessitates the procedures of identification, description, nomenclature and constructing affinities. According to Davis (1963), there are four distinct phases in plant taxonomy as exploratory or pioneer phase, consolidation or systematic phase, experimental or biosynthetic phase and encylopaedic or holotaxonomic phase. These four phases covered modern day taxonomy also. The first two phases, which are mainly descriptive and based on gross morphological features, it is called 'alpha' taxonomy (Turrill, 1938) and last two phases are correspond to the 'omega' taxonomy.

Identification

Identification or determination is recognizing an unknown taxon or individual with known one, and assigning a correct rank and position in an extant classification. It involves finding a correct name for an unknown specimen in practice. This may be achieved by visiting herbarium and comparing unknown specimen with duely identified specimens sorted in the herbarium. Identification can also be achieved by using various types of pertinent literature such as Floras,

Monographs or Manuals and making use of identification keys provided in these resources. Over the recent years an aid with computer involves taking a photograph of the plant and it parts, uploading this picture on the website and informing the members of the appropriate electronic Lists or newsgroups, who can see the photograph at the website and send their comments to the enquirer. The electronic or digital plant identification is much efficient now days for user groups in faster way.

Description

The description of the taxon involves listing of its features by recording the appropriate characters states. The precise description of a taxon is consisting of only those taxonomic characters which help in separating a taxon from other closely related taxa. It forms the diagnostic characters are termed 'key characters'. The diagnostic or key characters for a taxon determine its circumscription. The description is recorded in a set pattern (habit, root, stem, leaves, flowers, sepals, petals, stamens, carpels, etc.). For each character, an appropriate chatacter-state is listed. The description is recorded in semi-technical language using specific terms for each character state to enable a proper documentation of data.

Nomenclature

Nomenclature is the determination of the correct name of a taxon with proper systematic treatment. There are different sets of rules for different groups of organisms promulgated by eminent groups of scientists in different times. Nomenclature of plants is governed by the **International Code of Botanical Nomenclature (ICBN)** through the rules and recommendations. The code was updated every six years and so on. The Botanical code helps to determine a single correct name of a taxon out of numerous scientific names available for a same taxon with a particular circumscription, position and rank. To avoid inconvenient name changes for a taxon, a list of conserved names are provide in the code. Recently in Melbourne (July 2011), the 18th International Botanical Congress was held and decided the changes in the title of ICBN to **International**

Code of Nomenclature for Algae, Fungi and Plants (ICN). Cultivated plants are governed by the **International Code of Nomenclature for Cultivated Plants (ICNCP)**, slightly modified from and largely based on the Botanical Code.

Classification

Classification is an arrangement of organisms into recognizable groups on the basis of similarities and differences. Each group are placed to assemble into more inclusive groups with fixed taxonomic hierarchy of categories such as species, genus, family, order, class and division, the final and definite arrangement constituting a system of classification. Once established a classification provides an important mechanism of information storage, retrieval and usage. Taxonomic entities are classified in different fashions since the past. There are three major types of plant classification appeared so far from the Linnaean era. 1. **Artificial classification**: It is based on arbitrary, easily observable morphologic characters such as habit, colour of the flowers, number of stamen or similar features. The sexual system of Linnaeus, the famous example for artificial system of plant classification, it utilized the number of stamens for basic construction feature of classification of the flowering plants. 2. **Natural classification**: This classification utilized the overall similarity in grouping of taxa mainly based on morphological characters. Bentham and Hooker classification is an example for natural system but the concept was originally drafted by M. Anderson in early eighteenth century. 3. **Phylogenetic classification**: This classification is based on the evolutionary descent of a group of organisms, the relationship depicted either through **phylogram, phylogenetic trees** or a **cladogram**. Now the trend is newly emerged to classify the organisms based on their DNA or RNA or protein sequence information called **molecular taxonomy**. Based on the molecular biosystematics, now the classification of flowering plants as Angiosperm Phylogeny Group III (APG III) is uploaded and updated in the website.

Linnaeus system of Artificial Classification

(*Carolus Linnaeus* 1707 – 1778)

Carolus Linnaeus is regarded as father of modern taxonomic botany and zoology. Linnaeus was born in Rashault in Sweden. He was educated at the University of Uppsala and eventually obtained his M.D. degree at the University of Harderwijk in Netherlands. He was impressed by the discovery of Rudolf Camerarius who discovered the sexuality in plants. Linnaeus considered male and female sex organs (stamens and gynoecium) as important for classification of plants. He arranged all the plants based on the sexual characters and hence his classification is known as sexual system. He proposed his sexual system of classification in *Genera Plantarum* (1737) where he gave descriptions of 935 genera and it is published with five editions and two supplements in a total of 1,336 genera were diagnosed. Linnaeus did not stop his work and continuously work on many species, finally altogether pooled in his famous '*Species Plantarum*' published in May 1753. This book marks the first consistent use of binomial nomenclature for about 6000 species and 1000 genera. It has subsequently been adopted by the botanical community as the starting point for modern botanical nomenclature.

Linnaeus recognized 24 classes, which are based on number, union and length of stamens in plants. These classes were subdivided into orders on the basis of number of styles and unisexuality. All the non-flowering plants were lumped together in a single class, the Cryptogamia. Although this system is highly artificial, it was accepted at that time because it provided a very easy means of identification.

Linnaeus' sexual system of classification (*Species Plantarum*, 1753)

	Class	Example of species
I.	Monandria (Stamens one)	*Canna indica*
II.	Diandria (Stamens two)	*Jasminum sambac*
III.	Triandria (Stamens three)	*Triticum aestivum*
IV.	Tetrandria (Stamens four)	*Plantago major*
V.	Pentandria (Stamens five)	*Coriandrum sativum*
VI.	Hexandria (Stamens six)	*Oryza sativa*
VII.	Heptandria (Stamens seven)	*Aesculus pavia*
VIII.	Octandria (Stamens eight)	*Polygonum persicaria*
IX.	Enneandria (Stamens nine)	*Rheum rhaponticum*
X.	Decandria (Stamens ten)	*Oxalis corniculata*
XI.	Dodecandria (Stamens 12 – 19)	*Glinus lotoides*
XII.	Icosandria (Stamens >19, attached to calyx)	*Pyrus communis*
XIII.	Polyandria (Stamens >19 attached to receptacle	*Capparis spinosa*
XIV.	Didynamia (Stamens didynamous)	*Ajuga raptans*
XV.	Tetradynamia (Stamens tetradynamous)	*Draba verna*
XVI.	Monoadelphia (Stamens in one bundle)	*Waltheria indica*
XVII.	Diadelphia (Stamens in two bundles)	*Polygala chinensis*
XVIII.	Polyadelphia (Stamens in several bundles)	*Citrus limeta*
XIX.	Syngenesia (Stamens with united anthers)	*Artemisia annua*
XX.	Gynandria (Stamens adnate to pistil)	*Passiflora edulis*
XXI.	Monoecia (Plant's monoecious)	*Urtica diocia*
XXII.	Dioecia (Plant's dioecious)	*Smilax lanceolata*
XXIII.	Polygamia (Plant's polygamous)	*Celtis occidentalis*
XXIV.	Cryptogamia (Flowers concealed)	*Algae,Fungi,Musci* etc.

Bentham and Hooker's natural system of classification (*Genera Plantarum* 1862 – 1883)

George Bentham (1800 – 1884) and Joseph Dalton Hooker (1817 – 1911) jointly published their 3 volumes of work *Genera Plantarum* in Latin at intervals between 1862 and 1883. This monumental work comprised the names and descriptions of about 97,205 species of seed plants then known, classified according to their own system. They have divided all the seed plants into 3 classes, 3 subclasses, 21 series, 25 orders and 202 families. The system was accepted throughout the British Empire and in the United States and was adapted to a lesser extent by some continental botanists. Many of the Indian Herbaria

have been arranged according to Bentham and Hooker's system with modifications to incorporate recent changes. Many Indian Universities still follow this system although it is obsolete. The system is given below in detail.

Class I. Dicotyledons
Subclass: Polypetalae
Series: Thalamiflorae
Order: Ranales
Families: Ranunculaceae, Dilleniaceae, Calycanthaceae, Magnoliaceae, Annonaceae, Menispermaceae, Berberidaceae, Nymphaeaceae
Order: Parietales
Families: Sarraceniaceae, Papaveraceae, Cruciferae, Capparidaceae, Resedaceae, Cistineaceae,Violaceae, Canellaceae, Bixaceae
Order: Polygalineae
Families: Pittosporaceae, Tremandreaceae, Polygalaceae,Vochysiacae
Order: Caryophyllineae
Families: Frankeniaceae, Caryophyllaceae, Portulacaceae, Tamaricaceae
Order: Guttiferales
Families:Elatinaceae, Hypericaceae, Guttiferae, Trenstromiaceae, Dipterocarpacae, Chlaenaceae
Order: Malvales
Families: Malvaceae, Sterculiaceae , Tiliaceae
Series: Disciflorae
Order: Geraniales
Families: Linaceae, Humiriaceae, Malpighiaceae, Zygophyllaceae, Geraniaceae, Rutaceae, Simarubaceae, Ochnaceae, Burseraceae, Meliaceae, Chailletiaceae
Order: Olacales
Families: Olacaceae, Iliciaceae, Cyrillaceae
Order: Celastrales
Families: Celastraceae, Stackhousiaceae, Rhamnaceae, Ampelidaceae
Order: Sapindales
Families: Sapindaceae, Sabiaceae, Anacardiaceae
Series: Calyciflorae
Order: Rosales
Families: Connaraceae, Leguminsae, Rosaceae,Saxifragaceae, Crassulaceae, Droseraceae, Hamamelidaceae, Bruniaceae, Haloragaceae
Order: Myrtales
Families: Rhizophoraceae, Combretaceae, Myrtaceae, Melastomataceae, Lythraceae, Ongaraceae

Order: Passiflorales
Families: Samydaceae, Loasaceae, Tuneraceae, Passifloraceae, Cucurbitaceae, Begoniaceae, Datiscaceae
Order: Ficoidales
Families: Cactaceae, Ficodeae
Order: Umbellales
Families: Umbelliferae, Araliaceae, Cornaceae
Subclass: Gamopetalae
Series: Infreae
Order: Rubiales
Families: Caprifoliaceae, Rubiaceae
Order: Asterales
Families: Valerianaceae, Dipsacaceae, Calyceraceae, Compositae
Order: Campanales
Families: Stylidaceae, Goodenovieae, Campanulaceae
Series: Heteromerae
Order: Ericales
Families: Ericaceae, Vaccinieae, Monotropeae, Epacrideae, Diapensiaceae, Lennoaceae
Order: Primulales
Families: Plumbagineae, Primulaceae, Myrsinaceae
Order: Ebenales
Families: Sapotaceae, Ebenaceae, Styraceae
Series: Bicarpellatae
Order: Gentianales
Families: Oleaceae, Salvadoraceae, Apocynaceae, Asclepiadaceae, Loganiaceae, Gentianacae

Order: Polemoniales
Families: Polemoniaceae, Hydrophyllaceae, Boraginaceae, Convolvulaceae, Solanaceae
Order: Personales
Families: Scrophulariaceae, Orobanchaceae, Lentibulariaceae, Columelliaceae, Gesneriaceae, Bignoniaceae, Pedaliaceae, Acanthaceae
Order: Lamiales
Families:Myoporinae, Selaginae, Verbenaceae,Labiatae

Merits

1. Every species and genus was studied originally from the material of British and continental herbaria.
2. Full and complete descriptions were prepared from studied and dissections of plants themselves and did not represent a compilation made from literature.
3. The system has great practical value for identification of plants.
4. The description of families and genera precise. Key to the identification are very useful.

Demerits

1. Placing Gymnosperms between Dicotyledons and Monocotyledons.
2. The Monochlamydeae is an unnatural assemblage. Keeping the families with single whorl of perianth and families without perianth, although they are showing similarity with polypetalous families, is unjustified.
3. Liliaceae and Amaryllidaceae have been separated on the basis of superior or inferior ovary and are kept in different series, although they show similarities.
4. Elimination or orders in Monochlamydeae and Monocotyledons.
5. The system was proposed after Darwin's theory of evolution, but it was not followed evolutionary or phylogenetic sequence.
6. Unisexuales is a loose assemblage of diverse families, which are share only one major character that is unisexual flowers.

Engler and Prantl's Phylogenetic classification (*Die Naturlichen Pflanzen familien*, 1897 – 1915)

This is a system of phylogenetic classification of the entire plant kingdom, proposed jointly by two German botanists: Adolph Engler (1844 – 1930) and Karl A.E. Prantl (1849 – 1893). It was published in a monumental work *Die NAturlichen Pflanzenfamilien* in 23 volumes (1849 – 1893). This system, often considered the beginning in phylogenetic schemes, was not strictly phylogenetic in modern sense. It was an arrangement of linear sequence starting with simplest groups and arranged in the order of progressing complexity.

An outline of Engler and Prantl's system of Classification

Plant kingdom

Division: 1 .....}

} Thallophyta

Division : 11.....}

Division: 12. Embryophyta Asiphonogama

Subdivision: 1. Bryophyta

Subdivision: 2. Pteridophyta

Division: 13. Embryophyta Siphonogama

Subdivision: 1. Gymnosperma

Subdivision: 2. Angiosperma

Class: 1. Monocotyledoneae – 11 orders, 45 families.

Order: 1. Pandanales (first family Pandanaceae)

.....

Order: 11. Microspermae (last family Orchidaceae)

Class: 2. Dicotyledoneae – 44 orders, 258 families.

Subclass: 1. Archichlamydeae – 35 orders, 201 families.

Order: 1. Verticillatae (family Casuarinaceae only)

.....

Order: 33. Umbelliflorae (last family Cornaceae)

Subclass: 2. Metachlamydeae – 11 orders, 57 families.

Order: 34. Diapensiales (Family Diapensiaceae)

.....

Order: 44. Campanulatae (last family Compositae)

Merits

1. It is a phylogenetic system.
2. The classification covers entire plant kingdom and provides description and identification keys down to the level of the family, genus and even species.
3. Compositae and Orchidaceae are considered as advanced families.
4. Merger of Polypetale and Monochlamydeae into a single subclass Archichlamydeae.

Demerits

1. Monocotyledons are placed before Dicotyledons.

2. Simplicity is considered more primitive.
3. Amentiferae regarded as primitive group of flowering plants.
4. Angiosperms were considered as monophyletic phylogenetic groups.
5. Derivation of free central placentation from parietal placentation, and of the latter from axile placentation is contrary to the evidence from floral anatomy. Free central placentation is now believed to have evolved from axile placnetation through the disappearance of septa.

Comparison of Bentham & Hooker's and Engler & Prantl's systems of classification.

Betnam and Hooker's system	Engler and Prantl's system
1. Publihsed in *Genera Plantarum* in 3 volumes (1862 -1883)	Published in *Die Naturlichen Pflanzenfamilien* in 23 volumes (1887 – 1915).
2. Includes only seed plants.	Includes the entire plant kingdom.
3. Gymnosperms placed in between Dicotyledons and Monocotyledons.	Gymnosperms separated and placed before the Angiosperms.
4. Dicotyledons placed before the Monocotyledons.	Dicotyledons placed after the Monocotyledons.
5. Dicotyledons divided into 3 subclasses: Polypetalae, Gamopetalae and Monochlamydeae.	Dicotyledons divided into 2 subclasses: Archichlamydeae and Metachlamydeae.
6. Subclasses are further divided into series, order and families.	Subclasses are divided into orders and families, series not recognized.
7. Monocotyledons include 7 series and 34 families.	Monocotyledons include 11 orders and 45 families.
8. Pre-Darwinian in concept.	Post-Darwinian in concept.
9. Dicotyledons starts with Ranales having bisexual flowers.	Dicotyledons starts with Verticillatae with unisexual flowers.
10. Monocotyledons starts with Microspermae including Orchidaceae.	Monocotyldeons starts with Pandanales. Microspermae placed end of the Monocotyledons.
11. Closely related families	

Caryophyllacae, Ilecebraceae and Chenopodiaceae are kept apart, the first under Polypetalae and the other two in Monochlamydeae.	Family Ilecebraceae is merged with Caryophyllaceae. Chenopodiaceae and Caryophyllaceae are placed under same order Centrospermae.
12. Closely related families Amaryllidaceae and Liliaceae placed iin separate series Epigynae and Coronariae respectively.	Liliaceae and Amaryllidaceae placed in the same order Lilliflorae.
13. Many larger families e.g. Urticaceae, Saxifragaceae and Euphorbiaceae are unnatural heterogeneous group.	Several larger families of Bentham and Hooker's split into smaller homogeneous families, Urticaceae split into Urticaceae, Ulmaceae and Moraceae.

History of Botanical Nomenclature

For several centuries, the scientific names of plants appeared as polynomial – long descriptive phrases, often very difficult to remember. For example, *Sida cordifolia* L. (1753) was named as '*Althaea maderaspatana subrotundo folio molli & hirsute multiplis*' by Plukenet (1692). Casper Bauhin (1623) introduced the concept of **Bionomial nomenclature** under which the name of a species consists of two parts, the first the name of the **genus** to which it belongs and the second the **specific epithet**. Mango is thus appropriately named *Mangifera indica*, *Mangifera* being the generic name and *indica* the specific epithet. However, Bauhin did not use binomial for all the plant species and it was left to Carolus Linnaeus to firmly establish this binomial system of nomenclature in his *Species Plantarum* (1753). The rules of nomenclature were set forth by Linnaeus in his *Fundamenta Botanica* (1736), *Critica Botanica* (1737) and further elaborated his principles and rules of amplified nomenclature in his *Philosophia Botanica* (1751). A.P. de Candolle, in his *Theorie elementaire de la botanique* (1813), gave explicit instructions on nomenclatural procedures, mainly taken from Linnaeus and Steudal in *Nomenclator Botanicus* (1821).

Binomial nomenclature

Binomial nomenclature is a formal system of naming plant species by giving each a name composed of two parts, both of which use Latin grammatical forms, although they can be based on words from other languages. Such a name is called a **binomial name** or a **scientific name**; more informally it is also called a **Latin name**. The first part of the name identifies the genus to which the species belongs; the second part identifies the species within the genus. The formal introduction of this system of naming species is fully employed by Carl Linnaeus his *Species Plantarum* in 1753. The application of binomial nomenclature is now governed by various internationally agreed codes of rules, of which the most important are the **International Code of Zoological Nomenclature** (ICZN) for animals and the **International Code of Nomenclature for algae, fungi, and plants** (ICN) for plants. Although the general principles underlying binomial nomenclature are common to these two codes, there are some differences, both in the terminology they use and in their precise rules.

In modern usage, the first letter of the genus name is always capitalized in writing, while that of the second part is not, even when derived from a proper noun such as the name of a person or place. The first part of the name is capitalized, and the second part has a lower case. The binomial name is written in italicized when printed and underlined when handwritten. The author citation is written with end of the species with abbreviated letters or full forms, but it should not be underlined or italicized. For example *Capparis rheedii* DC.

Species concept

In biology, a **species** is one of the basic units of biological classification and a taxonomic rank. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring. While in many cases this definition is adequate, the difficulty of defining species is known as the species problem. Differing measures are often used, such as similarity of DNA, morphology or ecological niche. Presence of specific locally adapted traits may further

subdivide species into "infraspecific taxa" such as subspecies, varieties, subvarieties, and forma. A usable definition of the word "species" and reliable methods of identifying particular species is essential for stating and testing biological theories and for measuring biodiversity. Traditionally, multiple examples of a proposed species must be studied for unifying characters before it can be regarded as a species. It is generally difficult to give precise taxonomic rankings to extinct species known only from fossils.

The biological species concept was first developed by Mayr (1942) who defined species as group of actually or potentially inbreeding natural populations, which are reproductively isolated from other such groups. The words 'actually or potentially' are meaningless. The concept has several advantages: It is objective and the same criterion is used for the group of plants. It has a scientific basis as the population showing reproductive isolation do not intermix and the morphological differences are maintained even if the species grow the same area. The concept is based on the analysis of features and does not need experience to put it into practice. Stebbins (1950) proposed a new species concept stated that species must be consist of systems of population that area separated from each other by complete or at least sharp discontinuities in the variation pattern, and that these discontinuities must have a genetic basis.

Taxonomic hierarchy

Taxon refers to a taxonomic group belonging to any rank of classification. The system of nomenclature provides a hierarchical arrangement of ranks. Every plant is treated as belonging to number of taxa, each assigned a particular taxonomic rank. Mustard thus belongs to *Brassica juncea* L. (species rank), *Brassica* (genus rank), *Brassicaceae* (family rank) and so on. The seven principal obligatory ranks of taxa in descending sequence are: **Kingdom** (regnum), **Division** or **Phylum** (divisio, phylum), **Class** (classis), **Order** (ordo), **family** (familia), **genus** (genus), and **species** (species). The ending of the name indicates

its rank; ending **–bionta** denotes a kingdom, - **phyta** a division, - **phytina** a subdivision, - **opsida** a class, **-opsidae** or – **idea** a subclass, - **ales** an order, - **ineae** a suborder and – **aceae** a family. The detailed hierarchy of ranks and endings with examples is given in Table 2.

Table 2. The Ranks of Taxa and endings provided by ICN.

Ranks	Endings	Examples
Regnum	-ile	Vegetabile
Division	-phyta	Magnoliophyta
	-mycota (Fungi)	Eumycota
Subdivision	-phytina	Pterophytina
	-mycotina (Fungi)	Eumycotina
Class	-opsida	Magnoliopsida
	-phyceae (Algae)	Chlorophyceae
	-mycetes (Fungi)	Ascomycetes
Subclass	-opsidae	Pteropsidae
	-idae (seed plants)	Astridae
	-physidae (Algae)	Cyanophysidae
	-mycetidae (Fungi)	Basidiomycetidae
Order	- ales	Magnoliales
Suborder	-ineae	Rosineae
Family	- aceae	Magnoliaceae
Subfamily	-oideae	Mimosoideae
Tribe	- eae	Heliantheae

Subtribe	- inae	Rosinae
Genus	- us, -um, -is, -a, -on	*Pyrus,Solanum,Arabis, Ruta,Heteropogon*

Principles of ICBN

The International Code of Botanical Nomenclature is based on the following set of six principles, which are the philosophical basis of the Code and provide guidelines for the taxonomists who propose amendments or deliberate on the suggestion for modification of the Code:

1. 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.
2. The application of names of taxonomic groups is determined by means of nomenclatural types.
3. The nomenclature of a taxonomic group is based upon priority of publication.
4. 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.
5. Scientific names of taxonomic groups are treated as Latin regardless of their derivation.
6. The Rules of nomenclature are retroactive unless expressly limited.

Typification

The application of name of taxonomic group is determined by means of nomenclatural types. The Code lays great emphasis on typification of various taxa in order to active stabilization of names. A nomenclatural type is that constituent element of a taxon to which the name of the taxon is permanently attached, whether as a correct name or as a synonym.

1. Holotype: A holotype is the one specimen or illustration used by the author or designated by him as the nomenclatural type. As long as holotype is extant, it automatically fixes the application of the name concerned. 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.

2. Isotype: A specimen which is a duplicate of the holotype collected from the same place, at the same time and by the same person. Often collection number is also the same, differentiated as a, b, c, tc.

3. Syntype: A syntype is any one of two or more specimen cited by the author when no holotype was designated, or any one of two or more specimens simultaneously designated as types.

4. Paratype: A paratype is a specimen cited in the protologue that is neither the holotype nor an isotype, nor one of the syntypes of two or more specimens were simultaneously designated as types. If a new taxon is described based on one or more than one gathering made at different times, the author will designate one gathering as holotype and isotype(s). The rest of the gathering bearing different field numbers from the paratypes.

5. Lectotype: A lectotype 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. When two or more specimens have been designated as types by the author of a specific or intraspecific name, the lectotype must be chosen from among them. Designation of lectotype should be undertaken only in the light of an understanding of the group concerned.

6. Neotype: A specimen or illustration selected to serve as nomenclatural type as long as all of the material on which the name of the taxon was based is missing.

A specimen or an illustration selected when no holotype, isotype, paratype or syntype exists.

7. Epitype: A specimen or illustration selected to serve as an interpretative type when the holotype, lectotype or previously designated neotype, or all original material associated with a validly published name, is demonstrably ambiguous and cannot be critically identified for purpose of the precise application of the name of a taxon. When an epitype is designated, the holotype, lectotype or neotype that the epitype supports must be explicitly cited.

Principle of Priority

The principle of priority is concerned with the selection of single correct name for a taxonomic group. After identifying legitimate and illegitimate names, and rejecting the latte, a correct name has to be selected from among the legitimate ones. If more than one legitimate names are available for a taxon, the correct name is the earliest legitimate name in the same rank. The first published legitimate name is basionym, and latter names are called synonyms, rendering it illegitimate. For example, the common name of apple was first described by Linnaeus under the name *Pyrus malus* in 1753. The species subsequently transferred to the genus *Malus* but the combination *Malus malus* (L.) Britt., 1888cannot be taken as the correct name since it becomes a tautonym. Two other binomials under *Malus* available for apple include *Malus pumila* Mill., 1768 and *Malus domestica* Borkh, 1803; former being the earlier for of two is selected as the correct name and the citation written as:

Malus pumila Mill., 1768. *Pyrus malus* L., 1753. *M. domestica* Borkh., 1803.

M. malus (L.) Britt., 1888 – (Tautonym; Generic name exactly repeats in specific epithet).

Although the earliest name *Pyrus malus* is perfectly illegitimate, but since the species is now placed in the genus *Malus* it cannot be served as basionym for the correct name since *Malus malus* is a tautonym.

Limitations to the principle of priority: For higher plants, the principle of priority starts with the *Species Plantatrum* of Linnaeus published 1-5-1753. The starting dates for different groups include:

Seed plants, Pteridophyta, Sphanaceae, Hepaticae, most Algae, slime moulds and lichens ---------- 1-5-1753.

Mosses (excluding sphagnaceae) ----------1-1-1801.

Fungi ----------31-12-1801.

Fossils ----------21-12-1801.

Algae (Nostacaceae) ----------1-1-1886.

Algae (Odedogoniaceae) ----------1-1-1900.

The publications before these dates for respective groups are ignored while deciding the priority. By adhering strictly to the Principle of Priority, several changes were brought about in the current names of the plants. In order to avoid disadvantageous changes in the nomenclature of species, genera, families and intertaxa, the code provides lists of names that are conserved. These names are conserved due to their very long usage in botanical publications and in the interest of nomenclatural stability.

Nomina conservanda (abbreviated as ***nom.cons.***): Strict application of the principle of priority has resulted in numerous name changes. To avoid name changes of well known failies or genera – especially those containing many species – a list of conserved generic and family names has been prepared and publishd in the Code with relevant changes. Such **nomina conservanda** are to be used as correct names replacing the earlier legitimate names, which are rejected and constitute **nomina rejicienda** (abbreviated as ***nom.rejic.***). The family name

Theaceae D.Don, 1825 is thus conserved against Ternstromiaceae Mirbe, 1813. The genus *Desmodium* Desv., 1813 conserved against *Meibomia* Heist, 1759 and *Pleurolobus* Hilare, 1812.

Effective and valid publication

The name must be published in the medium appropriate to the code and the names should be published according to the provisions of the code. These are known as effective and valid publication respectively. Publication is effected under the code, only by distribution of perinted matter trough sale, exchange or gift to the general public or at least to botanical institutions with libraries accessible to botanists generally. It is not effected by communication of new names at a public meeting or by placing name in collections or gardens open to public or by the issue of microfilm made from manuscript, type-scripts or other unpublished material. But more recently the Code has accepted the online publication of new taxa.

The name of a taxon when published must fuifill a number conditions for valid publication. The name of a taxon must be accompanied by a description or diagnosis of the taxon or by a reference to a previously and effectively published diagnosis or description. A name of a new taxon of plants published on or after 1-1-1935 must be accompanied by Latin description or diagnosis, but last International Botanical Conference at Melbourne (Melbourne Code 2011) has relaxed the rule, taxon diagnosis or description in English is also accepted for valid publication.

Publication of the names f a new taxon of the rank of family or below on or after 1-1-1958 is valid only when the nomenclatural type is indicated. The place where the type specimen is permanently conserved also should be indicated. New names or combinations published on or after 1-1-1953 are not validly published without a clear indication of the rank of the taxon. It should be clearly indicated whether it is new genus (*gen.nov.*), new species (*sp.nov.*) or a new combination (*comb.nov.*) etc.

Registration of new names in Kew Index will have to be subsequently registered all validly published names of taxon. The name must be submitted for registration after publication have to be met several conditions. The coordinating centre new name registry is the Secretariat of IAPT, currently at the Botanical Garden and Botanical Museum, Berlin-Dahlem, Germany.

Citation

For the indication of the name of the taxon to be accurate and complete, and in order that the date may be readily verified. It is necessary to cite the name of the author(s) who first validly published the name concerned e.g. Annonaceae Juss., *Annona* L., *Annona squamosa* L.

Authors' name put after the names of plants may be abbreviated, unless they are very short e.g. L. for Linnaeus, DC. for de Candolle, H.B.K. for Humboldt, Hook or Hk. for Hooker. If son's name is to be abbreviated letter 'f' (for filial) is added after abbreviation e.g. Hook.f. or Hk.f. for son Hooker, L.f. for son Linnaeus. When name is published jointly by two authors, the names of both are connected by *et* or by and ampersand (&). It is wrong to use 'and' between the authors name since the name of the plant is in Latin and this includes the authors name also.

e.g. *Curcuma vamana* Sabu *et* Mangaly

When a name is published jointly by more than two authors, the citation shouldbe restricted to that of the first one followed by et al. (i.e. and others).

e.g. *Ceropegia pullaiahii* Kullayiswamy, Karuppusamy & Sandhiyarani. This should not be cited as *Ceropegia pullaiahii* Kullayiswamy *et al.*

Retention and Rejection of names

When a genus is divided into two or more genera, the original generic name must be retained for one of them. Similarly when a species is divided into two or more species, the specific epithet must be retained for one of them. When a subdivision of a genus is transferred to another genus without changes of rank, its epithet must be retained.

e.g. *Uvaria longifolia* Sonner when transferred to *Polyalthia* it becomes *Polyalthia longifolia* (Sonner) Thwaites. The specific epithet '*longifolia*' is a basionym, it should be retained when the genus may be transferred to another.

Rejection of names: A legitimate name or epithet should not be rejected simply because it is inappropriate or disagreeable or because of another is preferable or better known or because it has lost its original meaning. The name *Scilla peruviana* L. is not to be rejected because of the species does not grow in Peru. Any one or more of the following reasons leads to the rejection of a name:

a) **Nomem nudum** (abbreviated ***nom.nud.***) The names which are contrary to the Code and published without a accompanying description are called **nomem nudum**. Thus many names published by Roxburgh in his '*Hortus Bengalensis*' and by Wallich in '*Wallich's Catalogue*' are *nomina nuda.*

e.g. *Odina wodier* Roxb.

Erigeron asteroids Roxb.

Centranthera humifusa Wall.

b) Name not effectively published, not properly formulated, lacking typification or without a Latin diagnosis.

c) **Tautonym**: Usually tautonym are not allowed according to the Code in Botanical Nomenclature. The generic name exactly repeats in specific epithet is a tautonym e.g. *Malus malus, Linaria linaria, Alfalfa alfalafa* etc. these names are rejected automatically and are illegitimate. But some names such as *Sesbania sesban, Cajanus cajan* are legitimate and are not tautonyms. Sometimes the specific name repeates when the species is divided onto more infraspecific taxa, for recognizing more subspecies or varieties under a species, the original species name automatically erected to a basic subspecies or variety such name is called **autonym.** But the autonyms should not have author citation usually for example *Acacial nilotica* ssp. *nilotica.*

d) The code similarly does not allow to use the same name for two different species, such names area called **homonyms**. For example *Zizyphus jujuba* Lamk, 1789 has long been used and later homonym *Z. jujuba* Mill., 1768. But both

name was rejected and correct binomial for identified for the same species later *Zizyphus mauritiana* Lamk. 1789. The last one is legitimate and valid, the first two are illegitimate homonyms for the same taxa.

e) **Nomem superfloum** (abbreviated ***nom.superfl.***): A name is illegitimate and must be rejected if it was nomenclaturally superfluous when published. For example, the generic name *Elaeodendron* Jacq. (1782) is illegitimate because it was superfluous name for *Cassine* L. (1753); the two genera had precisely same circumscription. Hence the name *Elaeodendron* Jacq. is a superfluous name published at a later date is to be rejected.

Chemotaxonomy

The application of chemical characters in plants to problems of classification and phylogeny is known as Chemotaxonomy. This rapidly expanding discipline of plant taxonomy has been variously called as chemotaxonomy, chemosystematics, biochemical systematic or phytochemistry. This field has make rapid progress in the last 50 years because of new instruments and newer techniques invented time to time for updating chemical knowledge in plant systems. Chromatography, Electrophoresis and Thermocycler have made the analysis of plants much quicker and simpler. Botanists of late have come to the conclusion that evidence for discussing the relationship and phylogeny must be taken from as many source as possible.

The first successful attempt to combine chemical and morphological evidence in the study of single genus was presented by Baker and Smith (1920) on the essential oil of *Eucalyptus*. This study revealed that about 176 Eucalyptus species correlated the morphology and essential oil constituent data arrange definite variations within these species and also divided various phylogenetic groups based on chemical evolution within that. It gives the new ideas in plant taxonomy, plants continuously evolve new defensive mechanisms to save themselves from predators, and animals evolve methods to overcome these defences. In the process, some plant species have developed animal hormones,

thus disturbing the hormonal levels of animls if ingested. This evolution is called co-evolution.

A large variety of chemical compounds are found in plants and quit often the biosynthetic pathways producing these compounds differ in various plant groups. Based on the origin and size of phytomolecules which are useful in taxonomic evidence area:

Micromolecules: compounds with low molecular weight (less than 1000μg).

Primary metabolites: Compounds involved in vital metabolite pathways – citric acid, aconitic acid, proteins, amino acids etc.

Secondary metabolites: Compounds which are produced by secondary metabolism often perform non-vital functions – phenolic compounds, alkaloids, glycosides, terpenes, glucosinolates etc.

Macromolecules: Compounds with high molecular weight (more than 1000μg).

Non-semantide molecules: compounds not involved in information transfer – Starch, cellulose etc.

Semantides: Information carrying molecules – DNA, RNA and proteins.

Compounds useful in Plant Taxonomy: Theoritically all the plant chemical compounds are potentially valuable to plant taxonomists to solve some taxonomic problems. In practice, some sorts of molecules are much useful than others such as secondary metabolites and semantides. Secondary metabolites perform non-vital functions and are widespread in plants. It is of course restricted occurrence among certain plant groups which rendered the valuable taxonomic information. The most well known secondary metabolites are alkaloids, phenolics, glucosinolates, terpenoids, oils and waxes etc. For example, flavonoid groups are more extensively used in plant taxonomy based on flavonoid ring containing Carobon three open or closed structures. Common flavonoids are flavonols, insoflavones, malvadins, and anthocynidins. In plant system, anthocynins plays important role in pigmentation and colouration of leaves, floral petals and fruit epicarps. It provides pigments on in the cell sap of petals providing red, blue (anthocynins), and yellow (anthoxanthins) colours in large

number of families. These pigments are absent in some families and replaced by highly different compounds, betacyanins and betaxanthins (together known as betalains), which consist of heterocyclic nitrogen-containing rings and having quit distinct metabolic pathways.

Engler and Prantl recognized a special group Centrospermae based on the concentration of betalains in the plants groups include eleven families such as Basellaceae, Caryophyllaceae, Cactaceae, Dideriaceae, Aizoaceae, Amaranthaceae, Chenopodiaceae, Molluginaceae, Cacataceae, Phytolacaceae, Portulacaceae and Nyctaginaceae. Previously these families are placed in different position in various remote places by Bentham and Hooker. Traditional Centrospermae included Gyrostemonaceae, Caryophyllaceae and molluginaceae which lack betalains and contain anthocyanins instead. Mabry *et al.* (1963) on the basis of separate structure and metabolic pathways, suggested the placement of only betalain- containing families in Centrospermae, thus advocating the inclusion of Cactaceae and Didieraceae and exclusion of Caryophyllaceae and Molluginaceae.

The special value of the chemotaxonomic approach can be seen when chemical characters correlate well with data obtainable from other sources. To take just one example, the fact that chemical discontinuity among the families of the order Rhoeadales as defined by Wettstein (1935), it has been used by modern taxonomists as a reason for dividing this assemblage of six or seven families into tow orders, the Capparales and the Papaverales.

Examples from Semantides: Serotaxonomy: A biological science deals with the nature and interactions of antigenic material and antibodies known as **serology**. This science also deals with immunochemical reactions between, serum antibodies and antigens (Klaus, 1971). It has provided valuable taxonomic information because its techniques help to detect homologous proteins. Boyden (1967) and Fairbrothers (1977) have discussed the importance of this type of study in plant systematic. Serological studies using crude plant extracts have been widely used in estimating phylogenetic relationships and elucidating the

taxonomy of a wide variety of taxa. Based on serological studies the genus *Liriodendron* had been found to be quite distinct from other members of the family Magnoliaceae, and the genera *Magnolia* and *Michelia* displayed closest affinity within the family (Johnston and Fairbrothers, 1965).

In addition to DNA and RNA are coming unde non-semantides, which will be dealt under molecular systematic in recent years. In this macromolecules include proteins, and the complex of polysaccharides such as starches and celluloses. Starches are commonly found in the form of grains which may be concentric (*Triticum, Zea*) or eccentric (*Solanum tuberosum*) and present anatomical characteristics which can be seen under a microscope. Detailed studies of starch grains under scanning electron microscope also hold promise for taxonomic significance.

Numerical taxonomy

Numerical taxonomy is a classification system in biological systematics which deals with the grouping by numerical methods of taxonomic units based on their character states. It aims to create a taxonomy using numeric algorithms like cluster analysis rather than using subjective evaluation of their properties. Numerical Taxonomy may be defined as numerical evaluation of the apparent (phonetic) similarity among the groups of organisms and ordering them into higher ranking taxa (Heywood, 1967). The branch of botany concerned with numerical approaches towards taxonomy has been variously termed Numerical Systematics, Mathematical Taxonomy, Taxometrics, Taximetrics and Numerical Taxonomy. Michel Adanson (1763) for the first time pointed out that equal weightage should be given for all the characters while classifying plants. These principles called Adanson principles. It has been received great support since 1960s and have developed a new methods in taxonomy included under a general term numerical taxonomy. The concept was developed latter by Robert R. Sokal & Peter H. A. Sneath in 1963.

Principles of Numerical Taxonomy: The philosophy of modern methods of numerical taxonomy is based on ideas of Michel Adanson (1763). The modern numerical taxonomy is based on Sokal and Sneath interpretations, hence these principles are called **neo-Adansonian principles**. These are: 1. A priori, every character is of equal weight in creating natural taxa. 2. Overall similarity between any two entities is a function of their individual similarities in each of the many characters in which they are being compared. 3. Distinct taxa can be recognized because correlation of characters differs in the group of organisms under study. 4. Phylogenetic inference can be made from the taxonomic structures of a group and also from character correlations, given certain assumptions about evolutionary pathways and mechanisms. 5. Taxonomy is viewed and practiced as an empirical science, hence classification are based on phonetic similarity.

Construction of Taxonomic Groups: The methodology of numerical taxonomy involves the selection of operational units (populations, genera, species, etc., from which the information is collected) and characters. The designing natural system of classification, two major bases have been recommended; first one phonetic and second one phylogenetic (cladistic). It aims at determining phonetic relationships between organisms or taxa. The phonetic relationship as similarity based on a set of phenotypic characters of the subjected taxa. It is distinct from cladistic relationship, which is expression of the recency of common ancestry and is represented by a branching network of ancestor or decendant relationships. Whereas the phonetic relationship is represented by a **phenogram**, the cladistic relationship is depicted thorugh **cladogram**.

Operational Taxonomic Unit (OTU): The basic unit of Numerical Taxonomy is known as operational taxonomic unit (OTU). It can be and individual, species, genus, family, orders, or class. When the OTU is supra-individual (above the level of an individual), there should be adequate representation of various polymorphic forms i.e. when genera are compared they should be represented by different species, when families are compared, they should be represented by

different genera and so on. The comparison of OTUs of equal rank is made equally for all characters in numerical taxonomy.

Unit characters: The characters employed in numerical taxonomy are known as Unit characters. A unit character is that cannot be sub-divided logically. There are two types of unit characters: 1. Those unit characters which exist in two sets. They are called binary or two state characters. This is simplest form of coding where character are divided into + and – or as 1 and 0. The positive characters are recorded as + or 1 and negative characters as – or 0. In case organ possessing a character is missing in the organism, the character must be scored NC, which means No Comparison. The example for two state character is the presence or absence of stipule. 2. Those unit characters which exist in more than two state are called multivariate characters. It may be qualitative such as the colour of the flower, it could be states – white, red, yellow, violet, etc. or quantitative such as length of leaf, it could be in any number of states – 1 cm, 2 cm, 3 cm and so on. The multistate characters can be converted into two state characters like flowers white versus coloured, leaf long versus short. It may be noted that character is an attribute that exists in abstract form, while the character state is an expression of the character in the correct form.

Measurement of resemblances: There are three methods of estimating phenetic resemblance between the taxonomic groups, namely **coefficients of association, coefficients of correlation** and **measurement of taxonomic distance. Cluster analysis**: Different OTUs are grouped together on the basis of degree of similarity. These groups are termed clusters. There are several techniques to describe structure in matrices of similarity coefficients. One of the common method is shading of the similarity matrix. In this method, each of these classes are represented by different degrees of shading in the squares of half matrix. The highest value usually showed darkest and lowest value the lightest as in Fig. 1. Finally percentage of similarity can be calculated from analysis of all the squares and its values.

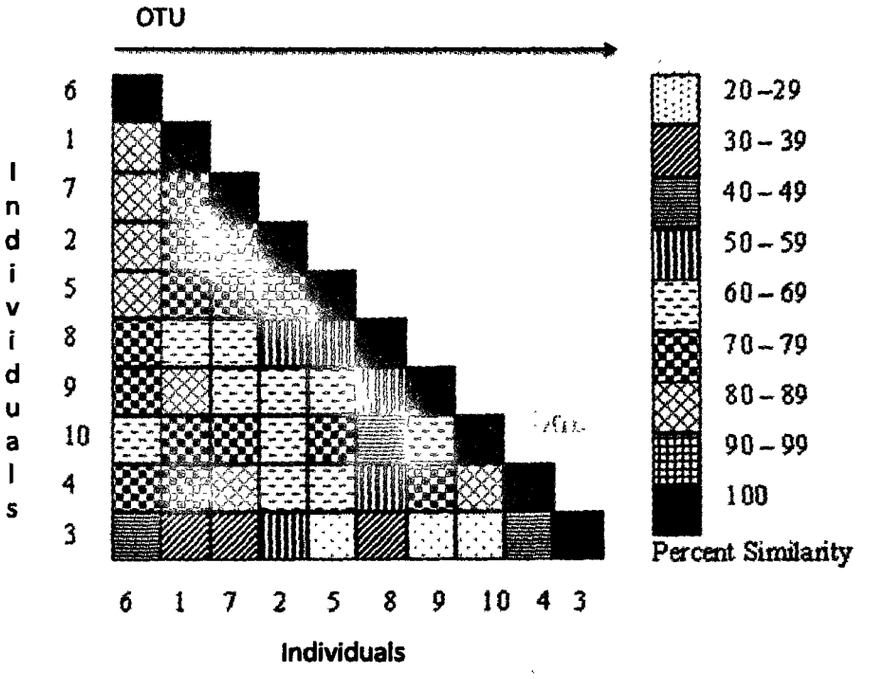

Fig. 1. Shaded similarity matrix and percentage of similarity of individuals.

The groups of similar organisms organized in this manner are termed **phenons.** The clusters of phenons are then rearranged in a dendrogram, which summarizes the main features of cluster analysis. The second way of clustering is by dendrograms. In this case, the mutually most similar taxa are paired. The pairs are successively joined by the average similarity. The process is continued till all units have been joined together. It results in a tree like **dendrogram** with taxa at tips of branches. The horizontal (phenon line) interesting the vertical lines of the dendrogram gives number of clusters. The delimitation of phenons is done by drawing a horizontal line across the dendrogram (Fig. 2) at a similarly value. A line at 80% for example creates six phenons. Such as dendrogram will have a reference to a given taxon and cannot be transferred to any other study. In the present dendrogram, It the OTUs 1 to 10 had been species, an 80-phenon line could indicate 6 subgenera and a 65-phenon line two genera.

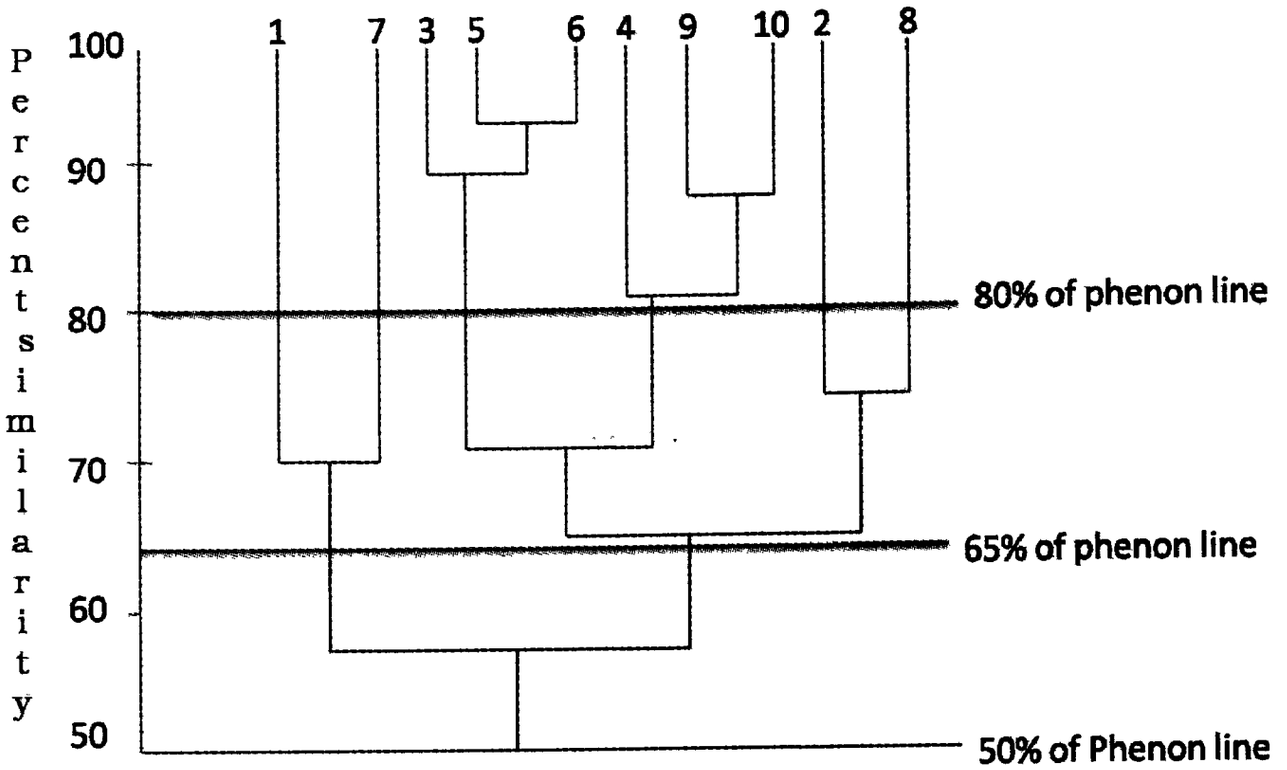

Fig. 2. Dendrogram to show formation of phenons and clusters.

Discrimination: If taxonomic groups chosen for the study show overlapping of characters, discrimination should be used to select them. Various techniques, such as discriminant analysis, have been advised for such purposes. The best methods for delimiting taxa are based on the utilization of maximum number of characters with similar weightage given to them.

Nomenclature and Numerical Taxonomy: Modern nomenclature does not concern itself with the problems of delimitation of taxa. It serves only as a reference point to the taxonomic names. The limits are debatable subjective and forever changeable. Numerical taxonomy, on the other hand, is very useful in delimitation of taxa by exact estimation of affinities (although phonetic). Thus, there is no scope for personal opinion or decision of taxonomists. The limits may be objective, utilitarian, permanent and fixed by common consent.

Molecular Taxonomy

In recent years, the study of identification and classification of plants as become much more precise due to refined techniques using its genetic material called DNA or RNA. These are of particular importance when interpretations of data from sources such as morphology, anatomy and palynology conflict. DNA or

RNA of the plants help us to resolve such conflict, and lead to a clear definition of relationship among angiosperms. This in turn, provides a better understanding of the evolution of plant structures and breeding systems. To construct evolutionary history of plants, analysis of gene sequences and molecular markers can be used to answer to specific biological questions, for instance evolutionary aspects of biogeography, morphology, development and ecology of plants. It also provides the phylogenetic data that underpin molecular systematic.

Molecular evolution: During the past decade, molecular genetics has taken a dominant role in enabling us to understand speciation of evolution clearly. Differences through nucleotides sequences area quantitative and can be analyzed using mathematical principles, utilizing the help of computer programs. Evolutionary changes at the DNA level can be objectively compared among different species to establish evolutionary relationships. In plants, both Mitochondria and Chlorplast DNA have proved very useful for making inferences concerning the relationship of different taxa ranging from the species level to reorganization of the kingdom of plant life. Analysis of restriction site variation in Chloroplast DNA is the method of choice and remains a good way to assess relationship among the plant taxa. In particularly chloroplast gene *rbc*L , is encoded the large subunit of the photosynthetic enzyme ribulose-1, 5 diphosphate carboxylase/oxygenase (RubisCO).which is a major carbon acceptor in all green plants and photosynthetic bacteria. Now it is a universal marker gene for assessing the evolutionary relationship in green plants. Some other chloroplast genes are also great potential taxonomic value in molecular systematic are *ndh*F, *trn*K, *rpo*A and *rpo*C2.

Another group of genes from Ribosomes that are the only nuclear genes with a high copy number for easy study. They are arranged in tandem arrays of several hundred to several thousand copies. A smaller (5.8S) gene separates the small subunit (18S) and large subunit (26S) gene, and the whole set of genes is transcribed as a single unit. There are short transcribed spacers (ITS) between the three genes. Each set of three genes is separated from the following set by a

larger spacer referred as intergenic spacer (IGS), extragenic spacer (EGS) or nontranscribed spacer (NTS). The last is a misnomer, in that some of the sequence immediately upstream of the 18S gene and downstream of the 28S is actually transcribed area called external transcribed spacers (ETS). The middle portion is the spacer is not transcribed, and is made up of variable numbers of short repeated sequence (100 – 300 bp each). The 5S rRNA genes are in tandem arrays of several thousand copies and are separated by nontranscribed spacers. Such highly repetitive sequences undergo homogenization processes known as concerted evolution. Other nuclear genes for phylogeny reconstruction are those of the phytochromes, the small heat shock proteins and glutamine synthetase. Before such genes can be used reliably forphylogenetic studies, considerable data must be acquired to determine the taxonomic level at which the genes vary, the copy number of the genes and whether the copies tend to correct each other.

Molecular methods available: The techniques of handling molecular data have great advancements over past few decades, starting with comparison of whole DNA molecules. It is now possible to break DNA at specific sites, generate maps of individual genes, determine sequencing of genes, and make multiple copies a DNA through Polymerase chain reaction (PCR) technique. These help in generating enough molecular data for comparison. These complete array of techniques used for analysis of DNA, RNA or protein can be applied to the classification of angiosperms. It may be divided into those that molecular marker method and those based upon the comparison of gene sequence at specific loci.

The types of molecular methods used to measure genetic differences being assessed in table 2.

Table 2. Molecular methods suitable for various level of comparison.

Higher lever		Population – Phylogenetic analysis			
	Individual	Variety	Species	Genus	Family
1.	SSR	**	***	*	*
2.	RAPD	**	***	**	
3.	RFLP				*
4.	Nuclear genes	**	***	**	*
5.	Mitochondrial gene*		**	**	
6.	Chloroplast gene	**	***	**	
7.	ITS	**	***	**	
8.	Ribosomal genes	**	***	**	*
9.	Conserved proteins	*	**	***	*****

*Asterisks indicate increasing use of the method.

Techniques such as RAPD analysis may be useful for distinguishing different genotypes within a plant cultivar while sequence analysis of the ribosomal genes may allow species or higher taxonomic level. The three most common markers are protein based, hybridization based and PCR based markers. Each marker has its own advantages and disadvantages over the other than in different levels of the taxonomic hierarchy as individual, variety, species, genus and family so on.

The following marker techniques are widely applied in molecular systematic:

1. Restriction Fragment Length Polymorphism (RFLP)
2. Variable Number of Tandem Repeats (VNTRs)
3. Multiple Arbitrary Amplicon Profiling (MAAP)
4. Random Amplified Polymorphic DNA (RAPD)
5. Arbitrary Primed PCR (AP-PCR)
6. DNA Amplification Fingerprinting (DAF)
7. Amplified Fragment Length Polymorphism (AFLP)
8. Sequence Tagged Sites (STS)
9. Sequence Tagged Microsatellites (STMS)
10. Single Primer Amplification Reactions (SPAR)

11. Inter Simple Sequence Repeats (ISSR)
12. Sequence Characterized Amplified Regions (SCAR)
13. Cleaved Amplified Polymorphic Sequence (CAPS)

Gene sequencing: DNA sequencing of genes, parts of genes or noncoding regions is becoming more and more common and is now widely used in systematic. Sequencing determines the precise order of nucleosides – adenine (A), cytosine (C), guanine (G), and Thymine (T) – in a stretch of DNA. This rapid method has allowed systematists to study the same region in many species of a particular group. One disadvantage of PCR is that the polymerase itself introduces occasional errors, which could in theory affect an estimate of phylogeny, particularly if the sequence being compared extremely similar. Direct sequencing of the PCR product will not generally reveal minor variants of the sequence if they are present. This is sometimes a problem with highly repetitive sequence genes such as ribosomal genes, for which the many copies often are not identical. Now most of the systematic laboratories have commercial sequencing facilities to high through put technologies to fast enough the sequencing and systematic analysis facilities in all over the world.

Interpretation and analysis of molecular data: The analysis of data and their interpretation in the measurement of genetic relationships between different taxa is more complex. All methods require certain basic assumptions and have strengths and weakness. Mathematical methods have been developed to allow corrections for the errors in estimation of genetic distance associated with the scoring of complex gels and with the difficulty of reproducing then DNA extraction and amplification.

The resulting data may be of two types, discrete characters and similarities. Discrete characters include data on sequence differences while similarity data is an estimation of distance between two individual taaxa. Analysis of sequence data requires alignment of sequence and this may require the insertion of gaps. This allows the identification of positional homologies. Algorithms are available to allow computerized alignment of sequence.

Construction of molecular trees: The construction of trees based upon molecular distance can be generated using an unweighted pair group method with arithmetic mean analysis (UPGMA) and is usually conducted using NT-SYS computer software, the neighbor –joining or maximum likelyhood calculated using PHYLIP (Phyygenetic Inferences Package) or for character data using Wagner Parismony with PAUP (Phylogenetic Analysis Using Parismony) or Mac Clade software. This attempts to recreate true phylogeny by identifying individuals with shared characters. These individuals can be considered as a clade arising from a common ancestor. The tree with the smallest number of steps is considered the most likely to represent the true phylogeny. A consensus tree retaining the most common branches may be selected from most parsimonious trees. Statistical tests such as bootstrapping or jack-knifing may also be used to evaluate the results. Bootstrapping involves random resample from the original data set and analysis of the data 100 to 1000 times to establish that the result is robust. Jack-knifing is resample data by dropping out different samples and reanalyzing.

Molecular Systematics of Angiosperms: All molecular systematic studies used appropriate gene markers and out groups, and the data are analyzed by phonetic or cladistic procedures as appropriate. Morphological and molecular data are analyzed singly and together to provide estimates of taxonomic boundaries and relationships. In many cases, molecular data have supported the monophyly of groups that were recognized on morphological basis (e.g. Fabaceae, Rosaceae, Poaceae). The trees based on *rbc*L data support many ideas that were accepted based on morphology. The Caryophillidae, for example, are monophyletic. The groups that Cronquist called Rosidae and Dilleniidae are largely intermingled, as had been suspected by anyone who had tried to tech according Cronquist's system. Several well known family pairs (e.g. Asclepiadaceae/Apocynaceae, Araliaceae/Apiaceae, Brassicaceae/Capparaceae) here united to preserve monophyly with supported by *rbc*L data, although the exact relationships between members of the pairs differ. Families long suspected of being

polyphyletic (e.g. Saxifragaceae, Caprifoliaceae) appear polyphyletic based on *rbc*L data. APG III classification published for the entire plant kingdom based on the selected gene markers with possible phylogenetic relationships. It has been provided a numbered list to 413 of the 415 currently accepted families in those Apodanthaceae and Cynomoriaceae were not included.

Molecular taxonomy and DNA barcoding: DNA barcoding is a taxonomic method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species. It differs from molecular phylogeny in that the main goal is not to determine classification but to identify an unknown sample in terms of a known classification. Although barcodes are sometimes used in an effort to identify unknown species or assess whether species should be combined or separated, the utility of DNA barcoding for these purposes is subject to debate. Applications include, for example, identifying plant leaves even when flowers or fruit are not available and identifying products in commerce (for example, herbal supplements or wood).

Thus, molecular tools are used increasingly for understanding the patterns and processes in biodiversity, and this toolbox grows as molecular technologies advance. In plant molecular systematic is both truly molecular, in that detailed knowledge of plant molecular biology is now essential data, and truly organismal, in that understanding plant diversity requires in depth study of whole and their place in nature.

Computer applications in systematics

The green plants area a clade, at least one billion years old constitutes the biggest branches of tree of life with more than half million species. Their morphological and chemical diversity, ecological dominance and importance in human affairs for food, shelter and medicines are paramount among life's lineages. An improved understanding of their phylogeny allows the intellectual satisfaction of discovering the roots of this major component of the world's biotic diversity, but also has important practical benefits as well. At present, users worldwide will be able to verify the scientific name, status and

classification of any known species through species checklist data drawn from an array of participating database using appropriate software. This includes methods of collecting and analyzing data, as well as interpretations of those results as new biological information only with advancement of computer.

Computer-aided manipulation and management of taxonomic descriptive data has a relatively long and well-documented history. Indeed a standard coding system has been available and widely adopted for nearly thirty years and has seen many changes over that time. The availability of information technology and advances in taxonomy will open up new avenues for biological world. Today's World Wide Web (WWW) presents an everdiversified experience of multimedia, programming languages and real time communication. Now many software and databases were designed to fulfill these requirements with reliable information on species names and their hierarchical plant classification.

As access to the Internet has become more widespread, much taxonomy and systematics related information resources could be accessed using online resources. It means that anyone with minimum technical soft skill and access to a host computer can get all the information about plant taxonomy and systemactics. Other hand one of the most efficient ways of conducting research on the Internet is to use the World Wide Web. Since the Web includes most Internet protocols, it offers access to a great deal of what is available on the internet. More recent times, most of the scientific publications, journals and magazines published online, it can be accessed very fast to the user groups.

The voluminous taxonomic data generated in the past will help us to understand the real features of many know plants as well in computer. This can be achieved only with help of suitable software and high throughput databases, which cater fast access and retrieval through the web. Software facilitates biodiversity documentation and species identification. It is an innovative multifunctional research tool for systematic and biodiversity researchers. It supports the creation of taxonomic databases, optimizes the construction of easy-to-use identification

keys, expedites the display and comparison of distribution patterns and promotes the use of taxonomic data for biodiversity studies.

There are invaluable computer programs for generation of taxonomic monographs like DELTA and DELIA. The DELTA format (Description Language for Taxonomy) is a flexible method for encoding taxonomic descriptions for computer processing. The international Taxonomic Databases Working Group (TDWG) has adopted it as a standard for data exchange. DELIA format can be used to produce natural language descriptions, interactive or conventional keys, cladistic ro phonetic classifications, and information retrieval systems. More than 50 different softwares are available in internet for taxonomic and systematic analysis and data retrieval purposes.

The World Taxonomist Database offers online taxonomists directory service for access anytime data transfer or knowledge transfer, it is only because of computer. The taxonomic databases look somewhat like an electronic file card system displaying an overview picture of the species and an abstract description. From this point, it is easy to click through the detailed information of the species stored in various fields of the database, varying from taxonomic description and diagnosis, reproduction, ecology, practical importance, biochemical data and additional multimedia files as photographs, drawings, sounds, videos etc. if you click www.plantsystematics.co.uk/alpha_taxonomy.html web site, can get different heads in online such as Monographs & Revisions, Floras & Check lists, Identification keys, Online keys, Virtual Herbaria & Herbaria databases, Virtual Libraries & other literature sources, Morphometrics & Statistical Analysis, GIS & Georeferencing, etc.

Role of Herbaria in Taxonomy

A collection of pressed and dried plants arranged in some order and available for reference or study is known as a herbarium (plural, Herbaria). Many large research and educated institutions serving as basic resources for systematic botany had their beginning as gardens which include herbaria. A herbarium may contain a few hundred specimens collected locally or millions of gradually

accumulated specimens which document the flora of one or more continents. To overall goal of herbarium management is to collect and preserve plant specimens with adequate label notes and to collect literature of taxonomy in the herbarium library. *Herbarium News*, a valuable monthly news letter published by the Missouri Botanical Garden, Communicates current events in the herbarium community.

Now there are many herbaria located throughout the world that are of great value to botanists and other workers who need information regarding plants. A detailed index of the world herbaria (*Index Herbariorum*) has been compiled by Holmgren *et al.* (1990) wherein about 950 institutions including 50 major herbaria have been reported. Most of these have long names and for the sake of brevity and convenience their names have been abbreviated. Some of the more important herbaria in India are Central National Herbarium (CNH), Culcutta; Madras Herbarium (MH), Botanical Survey of India, Coimbatore; Blatter Herbarium (BH), St. Xavier College, Bombay etc. The herbaria can be classified into regional herbaria, local herbaria including personal collections and herbaria of educational institutions such as Universities, Colleges and Schools. They also can help in the dissemination of scientific information to the needy public. In India, only a few Universities have maintained herbaria with proper care namely Anantapur, Bangalore, Baroda, Calicut, Delhi, Marathwada, Mysore and Trivandrum and a few other Universities where herbaria of some kind have been maintained.

Herbaria are the repository of 'original documents' – that is, specimens upon which all our knowledge of the taxonomy, evolution, distribution, and so on of the flora rests. All manuals, monographs, and wild flower books eventually stem from herbarium resources. The role of herbaria is categorized as follows:

1. Providing a standard reference collection for verifying the identification of newly collected plants.
2. Serving as a reference collection for plant taxonomy and other botany resources.
3. Training graduate and undergraduate students in herbarium practices.

4. Documenting the presence of a species at particular locations and providing data on its geographical range. It is often possible to go back to the exact spot where a plant was originally collected and to find again the plant material.
5. Providing samples of the flora of an area. For example, it is possible for an ecologist to go to the herbarium and put together a series of specimens that represent the major vegetative components of a region. By studying these specimens, much time may be saved which in the field.
6. When writing the floristic work by taxonomists of a region would go through the herbarium to ascertain which species are represented in the floristic area.
7. Pointing out the existence of classification problems. A preliminary examination of herbarium specimens may indicate that a species contains plants that do not combine the characters normally listed in manuals, therefore suggesting the need for additional studies.
8. Providing plant material for analysis. Data are available in the form of vegetative and reproductive morphology; pollen samples; leaf samples for chemical analysis; anatomical samples; data for distribution maps; plant samples for DNA analysis and phylogenetic studies; and ecological, economic, and ethnobotanical data from the labels.
9. Providing type specimens and serving as a repository of chromosome, chemosystematic, and experimental vouchers. Examination of type material allows a researcher to determine which plant was described by the original author and to find out the exact specimen associated with the name.
10. Modern taxonomic literature is documented by reference to individual plant specimens according to herbarium, collector, and collection number. If a mistake is made in the identification of a plant used for chromosome counts, the mistake may later be corrected if a voucher was prepared and deposited in a herbarium. It is now impossible to publish chromosome counts or chemosynthetic data without reference to a deposited voucher.

Systematic collection of plants in herbaria provide a permanent record of the earth's flora and its diversity. They are vital for a wide range of basic activities

and play irreplaceable roles in sustaining society. The collections provide information for identification services, conservation and land-use planning, education, national defense, medicine and public health, business and industry, and agriculture and forestry.

Flora

Flora is the basic literature of plant systematics and is one of the oldest and most complicated literatures of the plant sciences. Plants have been named and described in innumerable books and periodicals in many languages. Taxonomists must have a thorough knowledge of the literature and bibliographic aids, because these tools are an essential part of identification, nomenclature and revisonary studies. **Flora** is precisely defined as a systematic enumeration of plant species occurring in a given region and ideally provides keys, descriptions and often illustrations. This helps in the determination of plant species described in the flora. It may cover any suitable area from a small patch of forest to a taluk, city, district, state, province, country or even a continent.

The word 'flora' is also referred to the plants of an area. In other form of Flora is 'manual' and is a book that provides keys and descriptions to aid in identifying plants. Floristic documents cover a wide range of formats from the most comprehensive, almost monographic approach, to the barest of species checklists. Of the hundreds of Floras and manuals that have prepared, varying degrees of exhaustiveness and authoritativeness may be found. A typical Flora or manual will normally contain description to the families, genera, and species. Much additional information is usually provided for each species, including the accepted scientific name, followed by author(s) citation, major synonyms; information on infraspecific taxa if any; ecological and distributional data; common vernacular name and local names; illustration and photographs, and distribution maps.

Indian Floras: As early as 1565, Garcia d'Orta published the first account of Indian Plants in the Portuguese language which was later translated in Latin by Clusius. The work entitled *Coloquios da Simples e Drogas da Inidia* became

the basis of attraction of the European botanists to India. Subsequently, Hendrick von Rheede's (1670-1703) *Hortus Malabaricus*; Burmann's (1768) *Flora Inidica*; Roxburgh's (1795-1819) *The Plants of Coast Coramandel* and (1820-1824) *Flora Indica* appeared. Several other explorers including Wallich (1830-1832) *Plantae Asiaticae Rariores*; Robert Wight (1838-1853) *Icones Plantarum Inidae Orientalis* and a few others also contributed to Indian botany. The most comprehensive flora ever written is that of Sir J.D. Hooker (1872-1897) *The Flora of British India* in seven volumes. Hooker's flora has provided the basis for the subsequent regional and stare Floras of this country. The Botanical Survey of India (BSI) has recently been taken up the series of publications of *Flora of India*.

Successful original research depends largely on personal curiosity and excitement of the taxonomic investigator. For those interested in the how-to-do floristic works see Gamble (1914-1927) – *Flora of Presidency of Madras* (3 vols.); Fr. K.M. Matthew's (1983- 1999) *Flora of Carnatic Tamilnadu* (3 vols.) and *Flora of Palni hills* (3 vols.); Pullaiah et al. (1999-2009) *Flora of Eastern Ghats* (4 vols.). These Floras provide excellent information for taxonomic researchers in India. In addition, there are hundreds of excellent Floristic accounts published in taxonomic journals and periodicals such as Bulletin of Botanical Survey of India, Rheedea, Blumea, Rhodora, Brittania, Systematic Botany and many other journals.

Floras today's standards, require much attention to detail and documentation of the taxa by means of herbarium specimens deposited in recognized herbaria. Standard Floras help in immense way to identify precisely all the available plant species from an area with elaborate biogeographic sketches of each. Floras are the basic literature for plant taxonomy researchers and user groups.

MAGNOLIACEAE

Systematic Position (According to Bentham &Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Serier: Thalamiflorae

Order: Ranales

Family: Magnoliaceae

Selected Indian Genera: *Magnolia, Michelia, Liriodendron, Aclimandra, Talauma, Maglietia* and *Schizandra.*

Distribution: 12 genera and 230 species according to Rendle 18 genera and 300 species distributed mainly in the tropical and subtropical regions.

Vegetative characters: Deciduous to evergreen shrubs and trees e.g. *Liriodendrin, Michelia* and *Magnolia. Schizandra* and *Kadsura* are climbing shrubs. Root is taproot system. Stem erect, woody contains oil glands. Leaves simple, alternate, stipulate but exstipulate in *Illicium* and *Kadsura.* In many genera of Illicioideae vessels are absent in the secondary wood (eg. *Drimys*) and the wood resemble coniferous wood.

Floral characters: Flowers are usually solitary, axillary (*Michelia*), terminal (*Magnolia*). Flowers crowded near the tips of the branches (*Illicium*). Usually flowers are large, showy, bracteates (*Magnolia, Michelia*), ebracteate, pedicellate, bisexual but rarely unisexual in *Drimys* and *Kmeria.*

Perianth: Except in *Illicium* and some species of *Magnolia, Michelia* and *Drimys*, the perianth is undifferentiated into calyx and corolla. Perianth consists of 3 whorls of perianth arranged in 3+3+3 manner. *Drimys* sepals fused but petals free 9-12 perianth lobes, in *Magnolia* 6-15, in *Michelia.* In *Euptela* perianth is absent.Valvate (*Michelia*) or imbricate in aestivation.

Androecium: Stamens are numerous, free, spirally arranged on the basal part of floral axis in thalamus. Anthers long, dithecous, basifixed or adnate in *Liriodendron* , dehiscence longitudinal, connective prolonged.


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Michelia champaca

Gynoecium: Carples numerous, apocarpous (free carples), the carpels arranged spirally on the floral axis above the stamens. Superior ovary, unilocular, one or more ovules, marginal or parietal placentation. Style short, simple, stigma in *Zygogynum* and *Pachylarnax*, the carpels are syncarpous (united).

Fruits: Follicle (*Magnolia*), samara (*Liriodendron*) and rarely berry (*Schizandra*). Seeds minute, embryo with more endosperm (endospermic).

Pollination: Entomophilous, seed dispersal by birds and monkeys etc.

Economic importance: Timber woods: *Talauma phellocarpa, Magnolia hookeri, Pachylarnax* and *Aclimandra* provides good furniture woods. White wood or yellow poplar wood is obtained from *Liriodendron* species used for making musical instruments, toys, etc. The fruits of *Schizandra grandiflora* are edible. *Drimys winteri* bark is used as an astringent and stimulant. *Illicium verum* yields an oil useful in colic disorders. The fruit of *Illicium* is used as spice. *Magnolia* species are commonly cultivated in gardens such as *M. grandiflora, M. fuscata, M. campbelli, M. stellata. Michelia champaca* (Shenbagam0 is a common garden ornamental plant or in temples *M. nilagirica, M. alba, M. fuscata* are other ornamental species with sweet-scented flowers.

Systematics and Phylogeny: Bentham and Hooker considered Magnoliaceae as primitive and so placed under Ranales at the beginning of their classification. Magnoliaceae is divided into 3 tribes in Wintereae, Magnolieae and Schiandreae by Bentham and Hooker. Rendles (1938) classified in to 3 families Magnolioideae, Illicioideae and Schizandraoideae. Jones and Luchsonger (1987) divided this family into two tribes that is MAgnolieae and Liriodendreae.

Several taxonomists treated for many sub-families such as Eupteleaceae, Illiciaceae, Schizandraceae, Trochodendraceae and Winteraceae as belonging to family Magnoliaceae. But Hutchinson (1959) has treated them as independent families except Eupteleaceae, which was merged by him under Schizandraceae. Takhtajan (1969) also treated them as independent families the flower of

Magnolia is compared to the strobilus of Bennettitales of Gymnosperms from which Angiosperms are supposed to have been derived.

The presence of tracheids with bordered pits show that this family is closely related to Gymnosperms. The Magnoliaceae is considered to be primitive due to the acyclic flowers, leafy perianth, infinite stamens and carpels spiral attangement on the elongated thalamus. Takhtajan (1969), Hutchinson (1973), Cronquist (1981) and several other taxonomists considered that Magnoliaceae is most primitive family of Angiosperms.

MENISPERMACEAE

Systematic position (according to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Thalamiflorae

Order: Ranales

Family: Menispermaceae

Selected Indian Genera: *Anamirta, Cocculus, Menispermum, Pachygone, Tiliacora* and *Tinospora.*

Distribution: 70 genera and 400 species mostly found in the Pantropical regions.

Vegetative characters: Usually herbs, shrubs, small trees and woody climbers. Mostly herbs and climbers with tap root system and aerial roots in *Tinospora.* Leaves simple, alternate, with palmate venation. Stipules are absent. *Anamirta* is a woody climber.

Floral characters: Inflorescence is axillary cymes, panicles or solitary clusters. Flowers small, regular, unisexual (commonly dioecious), superior ovary. Calyx minute, usually 6 in two whorls (3+3), distinct. Corolla 6, in 2 whorls, usually succulent.

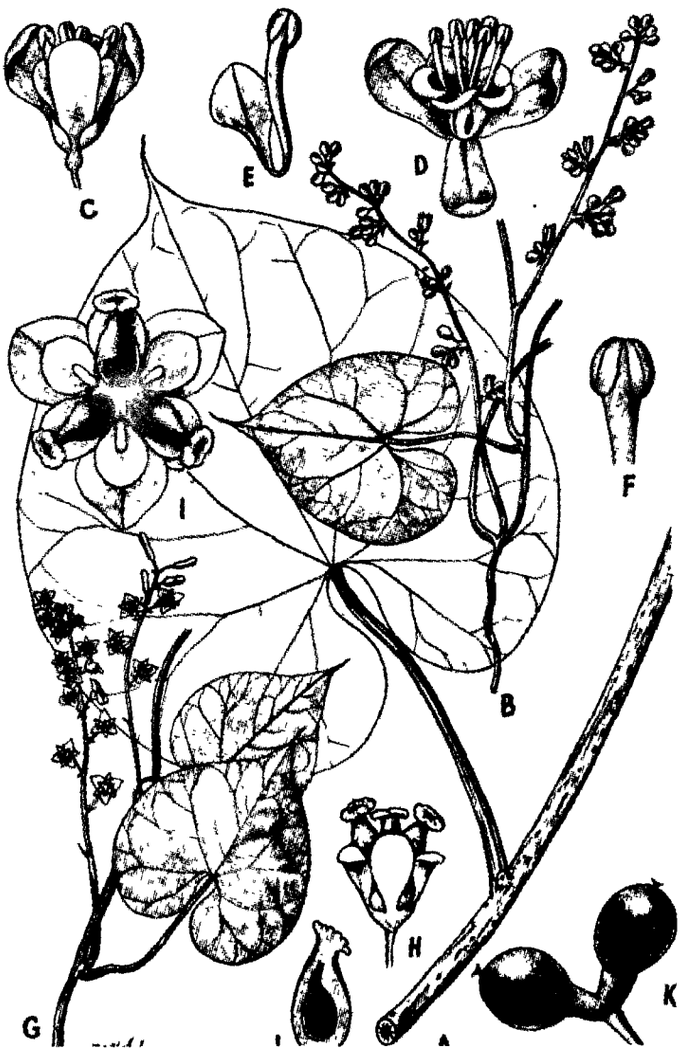
Androecium: The staminate flowers having 6 stamens to 40, found opposite to the petal.

Gynoecium: The pistillate flowers usually with superior ovary, unilocular with parietal placentation, 3-6 carpels, apocarpous, ovules 2 but one is sterile and the other one is functional. Style 1 or absent.

Fruit: Drupe or achene. Seeds and embryo usually curves or horseshoe-shaped. Endosperm present or absent.

Economic importance: Economically this family is of little importance. A few species are cultivated as ornamentals. *Chondrodendron tomentosum* is the sources of curare (tubocurarine chloride) which is used as muscle relaxant during neurosurgical operations. *Tinospora cordifolia* is used for heart tonic preparation. This plant is also used as stimulant and diuretic.

Systematic and Phylogeny: This family placed under Ranales alongwith other 7 families by Bentham and Hooker. But the position of Menispermaceae is presently debated by taxonomists and is unsettled.



Tinospora malabarica

POLYGALACEAE

Systematic position (according to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Thalamiflorae

Order: Polygalineae

Family: Polygalaceae

Selected Indian Genera: *Polygala* and *Xanthophyllum* .

Distribution: 12-17 genera about 1000 species with cosmopolitan in distribution. The largest genus is *Polygala* (about 500 sp.), the flowers superficially look like members of the bean family is Fabaceae.

Vegetative characters: Mostly herbs and rarely woody shrubs (*Polygala arillata*). Leaves simple, alternate or reduced to scales. Stipules present as scales or absent.

Floral characters: Inflorescence is axillary or terminal raceme or spikes. Sometimes cleistogamous flowers produced. Flowers very minute, bracteolate, bisexual, slightly irregular, due to petals, hypogynous. Calyx 5 sepals, distinct, lower 2 sepals are connate or petal like. Corolla 3-5, lower petals coomonly fringed and saucer shaped and resembling Fabaceae petals.

Androecium: Stamens 8 (rarely 3-10) in 2 whorls, filament connate into a tube, split on one side and adnate to the base of the corolla. Anthers opening by a short slit or apical pore. Nectary disc found between the stamens.

Gynoecium: Carpels 2-5, syncarpous, hypogynous, style single, stigma capitate, ovary bilocular, axile placentation.

Fruit: Capsule, nut or samara. Seed is straight and endosperm present or absent.

Polygala chinensis

Economic importance: This family is of minor economic importance. *Polygala senega* is used for treating snake bite. Some *Polygala* are used to as dye yielding purposes. *Polygala butyracea* produces a strong fiber.

Systematic and Phylogeny: Bentham and Hooker placed this family under Thalamiflorae. The position of this family is not clear.

PAPAVERACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Thalamiflorae

Order: Parietales

Family: Papaveraceae

Selected Indian Genera: *Argemone, Eschscholizia* and *Papaver.*

Distribution: 26 genera and 280 species distributed mainly in northern hemisphere. The *Meconopsis* about 26 species grow wild in some parts of Himalayas. *Argemone Mexicana* is a common weed.

Vegetative characters: Mostly annual or perennial herbs with milky or coloured latex (yellow latex in *Argemone*), woody shrubs (*Dendromecon*), tree (*Bocconia arborea*). Roots are tap root system with extremely branched. Sometimes roots are tuberous (*Corydalis*) or bulbs (*Dicentra*) Leaves simple or variously divided, alternate, spiny in *Argemone*, with variously coloured latex (white in *Papaver*, yellow in *Argemone*, orange in *Cheliodonium*, orange red in *Sanguinaria*).

Floral characters: Flowers in solitary and showy usually, cyme in *Meconopsis*, racemose panicles in *Bocconia*, umbellate clusters in *Chelidonium*. Flowers ebracteolate, pedicellate, bisexual, actinomorphic, complete, hypogynous. Calyx 2-4, free, but fused in *Eschscholzia*. They are caduceus in early fall off, imbricate in aestivation. Corolla 4-6 or more, arranged in two whorls, bright coloured, yellow in *Argemone*. In *Macleaya* and *Bocconia* corolla is absent. Spurred petals are found in *Corydalis* and *Fumaria*.

Androecium: Stamens infinite, polyandrous, alternating in several whorls (*Papaver, Argemone*). Stamens 4 in *Hypecoum*, free, filaments slender with erect anthers, basifixed.

Gynoecium: Carpels 2, bicarpellary, halfinferior in *Eschscholzia* but generally superior, parietal placentation, style short, stigma 2. In *Eschcholzia* ovary is

multilocular, due to false septum occur between. Style reduced, stigma as many as carpels. *Bocconia* rarely only one basal ovule is present.

Fruit: Fruit is a capsule, opened by valves (*Argemone*) or by pores (*Papaver*). Seeds numerous, endospermous with small embryo.

Papaver somniferum

Economic importance: Opium is obtained from fruits of *Papaver somniferum* which is used for sedative and pain killer etc. The seeds are useful in food preparation. An emetic drug "Sanguinarine" is obtained from the rhizome and roots of *Saguinaria canadensis.* It is used for dyspepsia in indigestion. An non-edible oil obtained from the seeds of *Argemone mexicana* is used as an illuminant and in skin infections. Some genera are used for common ornamental purposes due its large showy flowers such as *Papaver,Eschcholzia, Rhoeas, Mecanopsis, Dicentra* etc.

Systematics and phylogeny: Bentham and Hooker placed under Parietales along with Brassicaceae. Engler and Prantl place under Rhoeadales. This family shows close affinities with Ranunculaceae mainly due to hemicyclic flowers, numerous stamens and numerous carpels. Papaveraceae has close affinity with Brassicaceae in possessing syncarpous, unilocular ovary and parietal placentation. Flowers of platystemoe establish a link between Papaveraceae and Nymphaeaceae.

TILIACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Thalamiflorae

Order: Malvales

Family: Tiliaceae

Selected Indian Genera: *Tilia, Corchorus,Microcos, Triumfetta, Grewia, Elaeocarpus.*

Distribution: About 50 genera and 550 species distributed in tropical and temperate regions.

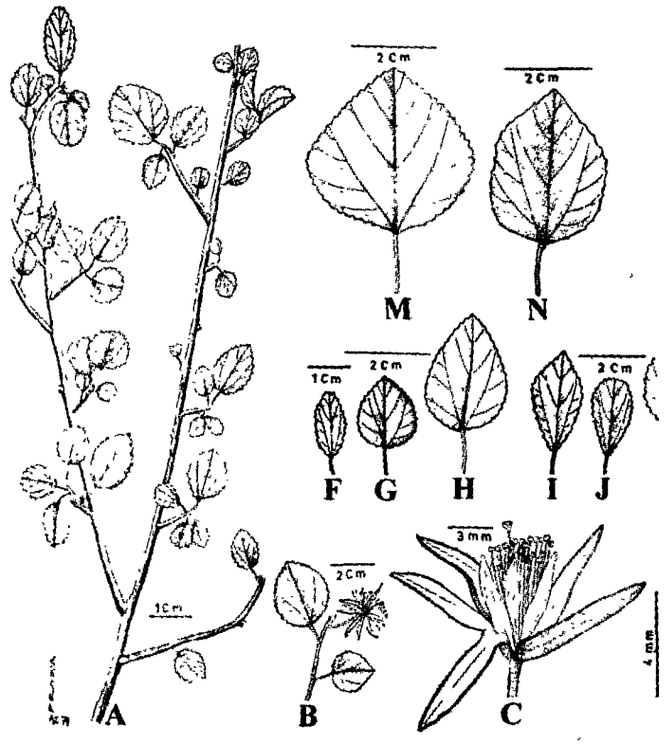
Vegetative characters: Usually trees (*Tilia, Elaeocarpus*), shrubs (*Grewia, Microcos*), herbs (*Triumfetta*) and rarely climbers (*Plagiopteron*). Roots are tap roots with highly branched. Stem is cylindrical or angular, mucilage canal present, stellate hairs present. Leaves simple, stipulate, alternate, rarely opposite, stipules are caduceus (*Tilia*).

Floral characters: Inflorescence is cymose, racemose in *Elaeocarpus*, dichasial cyme in *Corchorus*. Flowers are bracteates, bracteolate (resembling epicalyx), pedicellate, complete, bisexual, very rarely unisexual, hypogynous, pentamerous, but tetramerous in *Sparmannia*. Sometimes androgynophore is found in *Grewia* and *Duboscia*. Calyx 5-sepals, rarely 3 or 4, polysepalous but gamosepalous in *Chartacalyx,* nectar secreting glands found at the base of the sepals in *Tilia*. Corolla polypetalous, petals 5, imbricate, usually yellow coloured but rarely sepaloid (*Elaeocarpus*), often glandular at the base.

Androecium: Stamens infinite, free, often united at the base, 5-10 bundles (Polyadelphous). Petaloid staminodes (sterile stamens) found in *Pentace*. Dehiscence by longitudinal slits or apical pores In *Grewia* androgynophore is present.

Gynoecium: Carpels 2-many, syncarpous, superior, 2 to many loculed, axile placentation. Style dividing as many as stigmas as number of carpels. In *Elaeocarpus* septa is dissolved to make it unilocular.

Fruit: Capsule (*Corchorus*) or Schizocarps. Seeds with straight embryo and with more endosperm. Pollination entamophilous, seed dispersal through animals.



Grewia tenax

Economic importance: Jute fiber is obtained from the bast fiber or phloem fiber of *Corchorus capsularis* and *C. olitorius* which are cultivated in West Bengal. *Tilia* species are grown for their timber value in temperate regions. Species of *Berraya, Grewia, Elaeocarpus* are also grown in tropical regions for timbers. *Grewia microcos* used against eczema and *Grewia villosa* used to treat diarrhea. *Triumfetta* used against gonorrhea. Many *Grewia* species fruits are edible. Some *Grewia* species leaves are used as fodder. Some plants are grown as ornamental and avenue trees eg. *Tilia* species, *Muntingia calabura, Sparmannia Africana* etc.

Systematics and Phylogeny: According to Bentham and Hooker, it is coming under Malvales along with Malvaceae and Sterculiaceae. Tiliaceae differs from

Malvaceae and sterculiaceae mainly by anther characters. Tiliaceae is allied to some genera of Euphorbiaceae.

GERANIACEAE

Systematic position (according to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Disciflorae

Order: Geraniales

Family: Geraniaceae

Selected Indian Genera: *Geranium* and *Pelargonium.*

Distribution: About 21 genera and 2010 species distributed over temperate and tropical regions. *Geranium* alone have more than 400 species.

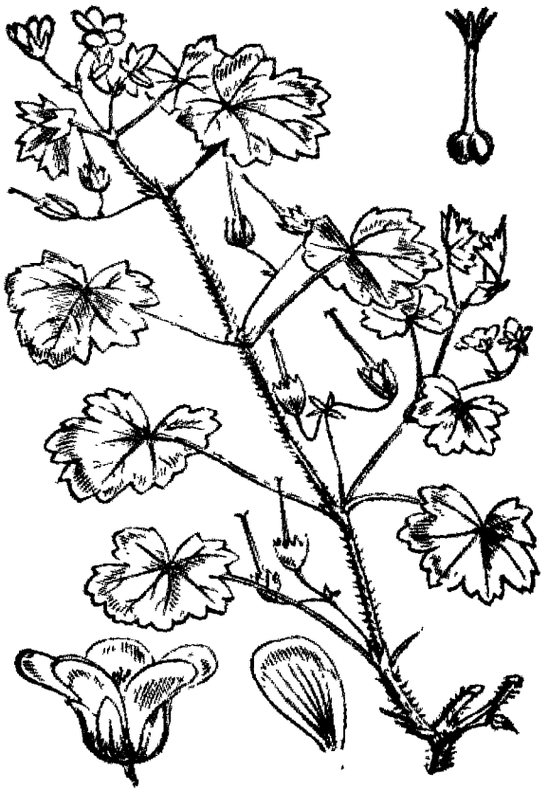
Vegetative characters: Mostly aromatic herbs, undershrubs. Stem often fleshy (*Pelargonium*). Leaves simple, lobed or dissected, stipulate, palmately veined.

Floral characters: Inflorescence is usually cymose, sometimes umbellate (*Pelargonium*). Flowers bracteates, bracteolate, bisexual, actinomorphic, but zygomorphic in *Pelargonium*, hypogynous, pentamerous. Calyx 5-sepals, free, or nearly united, sepals 4 and united in *Vivania*. In *Dirachma* it is persistent. In some members sepal is spurred and the spur is adnate to the pedicel. Corolla 5-petals, free, alternate with sepals, and nectariferous glands., imbricate in aestivation.

Androecium: Stamens 10, obdiplostaminous, monoadelphous, arranged in two rows that is 5+5. In *Erodium* only 5 stamens are present and stamens of one whorl is suppressed or reduced into scales. In *Pelargonium* only 2-4 stamens are fertile. In *Monsonia* there are 15 stamens and 5 bundles of 3 each. A nectary disc is present at the base of each stamens of inner whorl in *Geranium.*

Gynoecium: Carpels 5, pentacarpellary, pentalocular, syncarpous, superior ovary, one to two ovules in each locule, axile placentation. Styles 3-5, stigmas 3-5.

Fruit: Capsule or schizocarp. Seeds many with straight embryo, endospermous.



Geranium rotundifolium

Economic importance: Geranium oil is extracted from *Pelargonium odoratissimum*. It is used in perfumery industries. Roots and leaves of *Geranium robertianum* is medicinally important for treating diarrhea and eye troubles. Many of them are cultivated for ornamental purposes such as *Pelargonium, Geranium, Erodium* etc.

Systematics and Phylogeny: Geraniaceae belongs to Geraniales and placed along with Oxalidaceae, Balsaminaceae and Tropaeolaceae. Usually Geraniales are considered to have derived from Ranales. Takhtajan (1969) stated that Geraniales are 'clearly connected with Rutales especially with Rutaceae'.

MELIACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Disciflorae

Order: Geraniales

Family: Meliaceae

Selected Indian Genera: *Azadirachta, Melia, Toona, Cedrela* and *Chloroxylon.*

Distribution: 50 genera and 1400 species distributed exclusively in tropical regions. *Xylocarpus* is grown in Mangrove ecosystem.

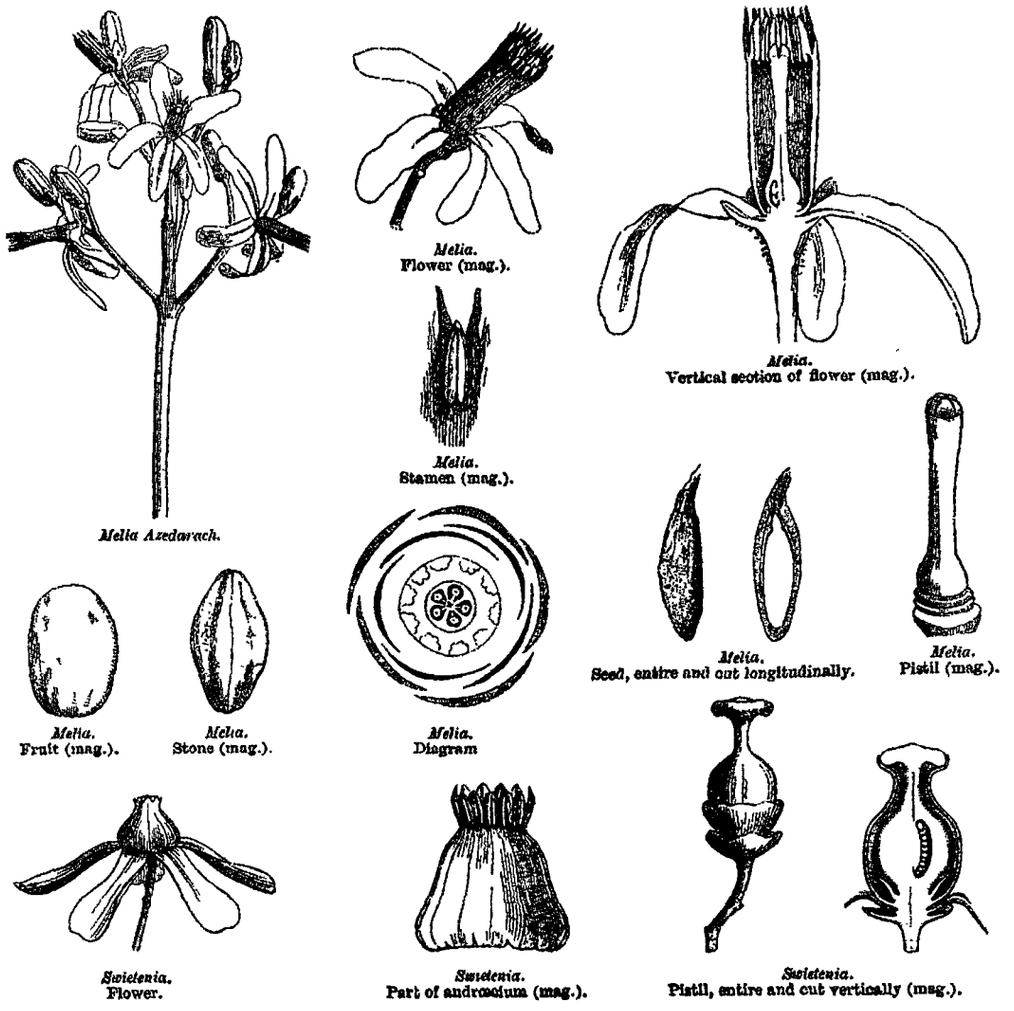
Vegetative characters: Mostly trees and shrubs. Stem solid, woody, branched and hard. Leaves pinnately compound, alternate, exstipulate, leaflets with serrate margins, bicompound in *Melia.*

Floral characters: Inflorescence is axillary panicle or cymose. Flowers bracteate, bracteolate, bisexual, but *Aphanamixis* is an unisexual, dioecious, actinomorphic, hypogynous, usually with an annular or tubular disc present between ovary and stamens. Calyx 4-5 sepals, free, imbricate aestivation. Corolla 4-5 petals, free, twisted or valvate aestivation.

Androecium: Stamens 8-10, united to form a columnar tube (monoadelphous), free in *Toona* and *Cedrela*, stamens 4 in *Aglaia*, 5 in *Aphanamixis*. The female flowers stamens are absent. A disc is usually present between androecium and gynoecium.

Gynoecium: Carpels 2-5, syncarpous, superior, locule as many as carples, in *Swietenia* 12 locules are present. Axile placentation, *Agalaia* and *Walsura* 3 carples, *Azadirachta, Naringamia, Melia* are having 4 ccarples. Style short, stigma capitate.

Fruit: Fruit is a berry, capsule or rarely a drupe, with or without endosperms, rarely arillate (*Aphanamixis*). Seeds usually winged in *Toona* and *Khaya.* Pollination is generally entamophilous, seed dispersal mainly by birds or other animals.



Economic importance: Many trees are yielding high value timbers namely *Azadirachta indica* (neem tree), ***Melia azedarach, Swietenia mahogany*** (Mahogany wood), ***Khaya senegalensis*** (Africal mahogany), *Cedrela odorata* (ceder wood), *C. toona*, and ***Dysoxylum malabaricum*** (White ceder). Some are medicinal example for margosa oil and soap is prepared from *Azadirachta indica*, *Melia azedarach* leaf juice for denque fever, *Agalaia odorata* used to cure leprosy. Red dye is obtained from *Chukrassia* sp. Cederwood oil is used in Microscopy.

Systematics and Phylogeny: Bentham and Hooker placed Meliaceae under Geraniales. This family is related to Rutaceae, Burseraceae and Simaroubaceae. Engler and Prantl believed that it is originated from Malvales. Hallier opined that Meliaceae derived from Rutaceae. Hutchinson put under the order Meliales.

SAPINDACEAE

Systematic position (according to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Disciflorae

Order: Sapindales

Family: Sapindaceae

Selected Indian Genera: *Dodonaea, Sapindus, Acer, Aesculus, Schleichera* and *Litchi.*

Distribution: 158 genera and 2,230 species distributed in tropical and subtropical regions.

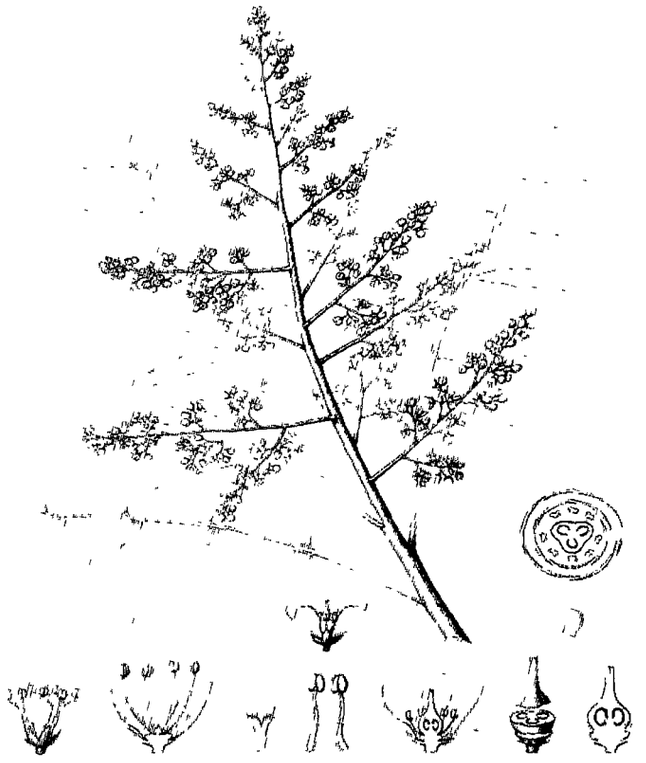
Vegetative characters: Mostly trees or shrubs. Tendril climbers (*Cardiospermum*) and woody lianas (*Serjania* and *Paullinia*). Leaves are alternate, opposite in *Acer*, usually compound, pari or imparipinnate, stipule present in climbing species.

Floral characters: Inflorescence is cymose type, cymes arranged in racemes. Biparous cyme in *Cardiospermum*. Flowers minute, bracteates, ebracteolate, bisexual or unisexual, actinomorphic (*Litchi, Aphania, Sapindus*), obliquely zygomorphic (*Cardiospermum, Eroglossum*), pentamerous or rarely tetramerous, hypogynous. Calyx 4 or 5 seplas, free or connate, valvate or imbricate in bud. Corolla 4 or 5 petals, free, sometimes 3, even absent in *Schleichera*, polypetalous, valvate (*Acer*), imbricate (*Sapindus*). The corona in the form of scaly structure or hair-tuffs is present in nectarines.

Androecium: Stamens 10 (*Acer* and *Sapindus*), 5 in *Turpinia* and infinite in *Deinbollia*, free, and uniseriate inside a prominent receptacular or extrastaminal disc, basified. In between petals and stamens is often present an annular disc.

Gynoecium: Carpels 3, tricarpellary, trilocular, superior, ovules on axile placentation, rarely parietal. Style simple or divided, single ovule in each locule (*Nephelium* and *Sapindus*).

Fruit: Various types may be a capsule, nut, berry, drupe, samara or schizocarp. Seeds have aril (*Litchi*), non-endospermic with curved embryo.



Sapindus laurifolius

Economic importance: Several members are yielding edible fruits such as *Litchi chinensis* (Litchi), *Nephelium lappaceum* (Rambuan), the edible part is sweet pulpy aril which surrounds the seeds. *Acer hippocastanum* (horse chestnut) fruits are given to horses as well as used for manufacturing starch. *Acer saccharium* (sugar maple) is source of maple sugar and timber. *Acer indica, Schelichera oleosa* and *Dodonaea viscosa* are used for rearing Lac insects. *Sapindus laurifolius* (Indian soapnut tree) fruits are used as a substitute for soap. The chemical saponin is used in the preparation of soaps, tooth paste, shampoos as well as some insecticides.

Systematics and Phylogeny: Bentham and Hooker placed this family under Celastrales before Rosales. Rendle (1925) placed Sapindales between Rutales and Rhamnales. Sapindaceae is related to Anacardiaceae in habit and general floral structure but flowers are irregular in Sapindaceae. In the characters such as the presence of on ovule in each locule,tricarpellary ovary, often unisexual

flowers and arillate seeds family Sapindaceae resembles Euphorbiaceae. Sapindaceae are generally thought to be evolved parallel to Rutales and Meliales.

MIMOSACEAE (or) MIMOSOIDEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Calyciflorae

Order: Rosales

Family: Leguminosae

Subfamily: Mimosae or Mimosoideae

Selected Indian Genera: *Acacia, Albizia, Leucaena, Mimosa, Prosopis,* and *Parkia.*

Distribution: 56 genera and 2,800 species are distributed in tropical and subtropical regions, absent in colder regions of the world.

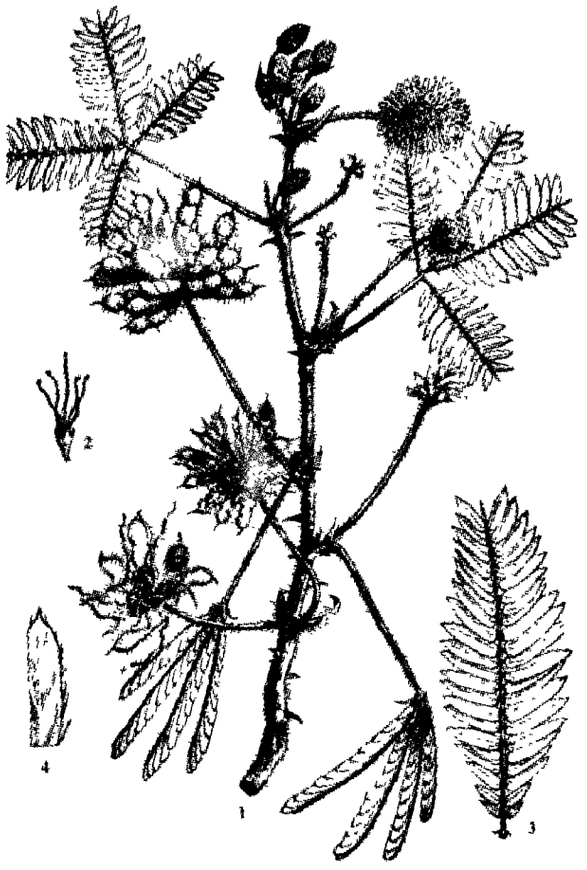
Vegetative characters: Mostly medium sized trees, shrubs (*Acacia*), herbs (*Neptunia*) and woody climbers (*Entada*). Roots are tap root system and usually associated with *Rhizobium* a nodule forming bacteria. Leaves mostly compound, uni or bipinnate, phyllodes are present, stipules often modified into thorns (*Acacia*), sleep movement found in *Mimosa pudica* and *Neptunia oleracea.*

Floral characters: Inflorescence is often grouped in clusters or racemose head. Spike found in *Prospis.* Flowers are bracteate, actinomorphic, bisexual, pentamerous, hypogynous rarely perigynous. Calyx 5 sepals, very minute, 4 in *Mimosa.* Corollaa 5, fused in *Acacia* and *Albizia,* free in *Parkia* and *Mimosa.* Usually valve aestivation.

Androecium: Stamens 4 – many. 4 in *Mimosa,* monoadelphous in Albizia, dithecous and basifixed.

Gynoecium: Monocarpellay, unilocular with marginal placentation. Stigma and style are simple.

Fruit: Fruit is a legume. Seeds with straight embryo and scanty endospermic.



Mimosa pudica

Economic importance: Gum is obtained from *Acacia senegal* is used as medicine, confectionary and textile industries. Tannins extracted from several species of *Acacia* which is used in tannery industries (*A.catechu, A. decurrens, A. dealbata, A. leucophloea*). Several species are yielding good timber woods such as *Acacia nilotica, A. ferruginea, Albizia amara, A. lebbeck, A. procera, Adeananthera pavoniana, Xylia xylocarpa* etc. Some members of the family are sued as garden ornamentals and hedge plants are of *Acacia melanoxylon, Lecaena leucocephala, Enterolobium saman, Parkia biglandulosa* etc. *Acacia concinna* fruit pods are using to hair cleaning purposes. *Albizia amara* leaves are used to clean hairs and against skin diseases. Fodder yield by *Leucaena leucocephala, Acacia nilotica* etc. *Acacia planifrons, Dichrostachys cinerea* are good fuel woods. Fruits of *Pithecellobium dulce*, the aril portion is edible and have more starch sources. *Entada* fruits are also edible and medicinal.

Systematics and Phylogeny: Bentham and Hooker place three families under the family Leguminosae – Papilionaceae, Caesalpninaceae and Mimosaceae. However majority of recent taxonomists (Hutchinson, 1973; Takhtajan, 1980; Cronquist, 1981) treat all these three as three separate families (Mimosaceae, Caesalpiniaceae and Fabaceae) under te order Fabales (Takhajan, 1980) and Leguminales (Hutchinson, 1973).

MYRTACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Polypetalae

Series: Calyciflorae

Order: Myrtales

Family: Myrtaceae

Selected Indian Genera: *Eucalyptus, Psidium, Syzygium, Eugenia, Callistemon*, etc.

Distribution: About 140 genera and 3,400 species distributed mainly in tropical and subtropical regions of the world. Eucalyptus is a largest genus and trees are known to world's tallest Angiosperms.

Vegetative characters: Usually trees and shrubs. *Eucalyptus* of Australia is reaching to a towering height of 300-400 feet. Lysigenous cavities contains ethereal oils in young stems, leaves, floral parts and fruits. Root is tap root system. Stem erect, woody and branched, bark peel off in patches of bicollateral vascular bundles. Leaves simple, alternate or opposite, heterophylly condition found in *Eucalyptus*. The margin is entire, prominent, intramarginal venation is present. Leaves are gland dotted.

Floral characters: Inflorescence is solitary as in *Psidium* and *Myrtus*, cymes in *Rhodomyrtus*, much branched cymes in *Eugenia*, multichasial cyme in *Eucalyptus*, spikes in *Callistemon*. Flowers are bracteates, often with 2 bracteoles, actinomorphic, bisexual, inferior ovary(epigynous) or semionferior (perigynous in *Tristania*). The floral receptacle unites with the gynoecium at the

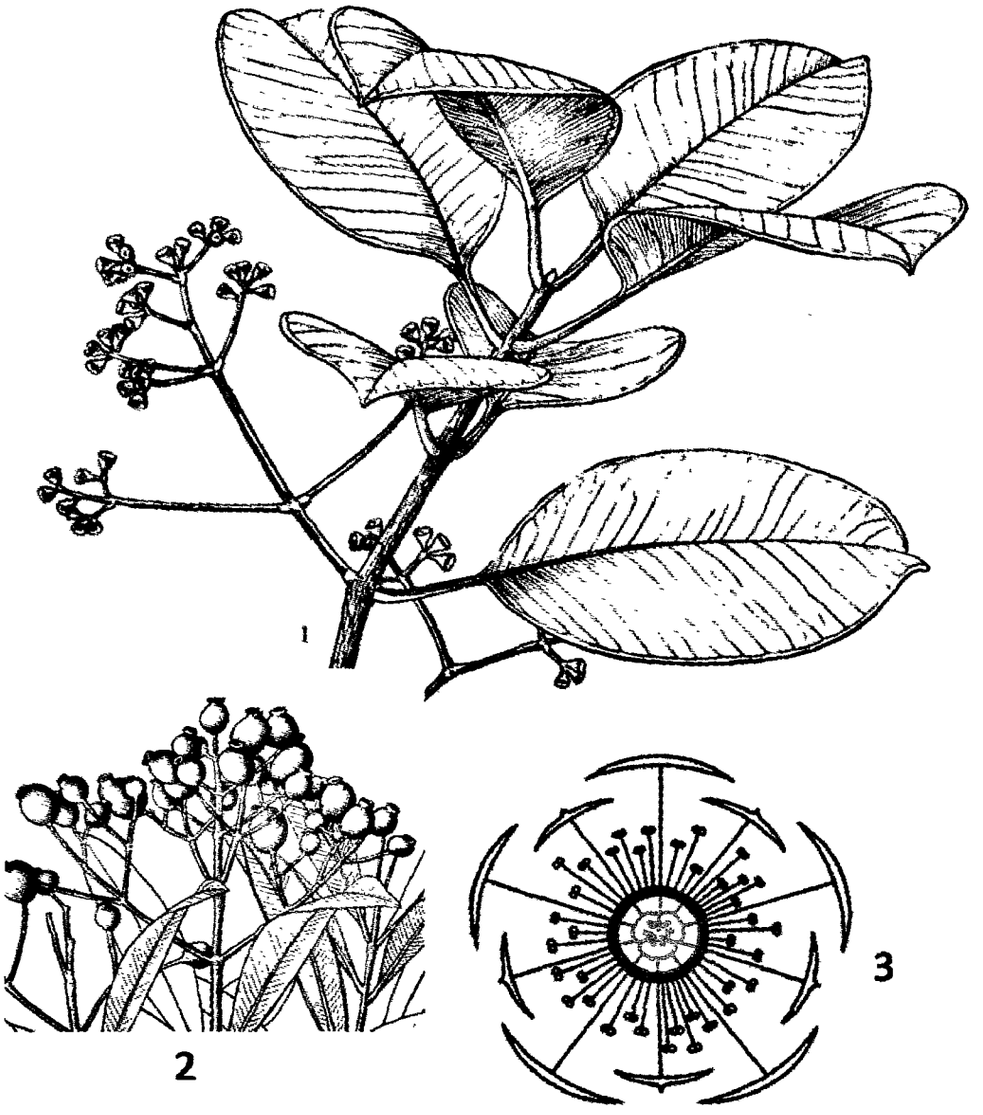
base and often prolonged in to a hybanthium. Calyx 4 or 5 sepals, free or united (*Eucalyptus*), valvate or quincuncial. Sepals united in *Eucalyptus* and thrown off unopened as a lid, sepals contains oil glands. Corolla 4 or 5 petals, free or united (*Eucalyptus*), form cup-like structure called operculum. Some *Eugenia* species are without petals.

Androecium: Stamens many, free, arranged on the rim of its receptacle in several whorls. They may reduced in a single whorl and opposite to petals that is obdiplostaminous in *Melaleuca*. Anthers are dithecous, versatile, the characteristic features is the inward bent filament in the bud.

Gynoecium: Carple 2-5, syncarpous, ovary epi- or perigynous (*Tristania* and *Callistemon*), 2-5 locules, 2 in *Eugenia* and 5 in *Psidium*, axile placentation or rarely parietal (*Rhodmania*), style is one, long and stigma is capitate.

Fruit: Fleshy berry (*Psidium, Eugenia*), capsule (*Eucalyptus* and *Callistemon*). Seeds with little or no endosperm. Pollination is by entamophilous. Seeds are dispersed by wind, birds, and other animals.

Economic importance: Psidium guajava, Syzygium cumini and Rhodomyrtus tomentosa are yielding edible fruits. Eucalyptus oil is obtained from *E. globulus, E. camadulensis*. The dried unopened floral buds of *Eugenia caryophyllata* is used as aromatic spice. *Eucalyptus, Eugenia,* and *Coreya* are yielding quality timber woods. Mainly *Eucalyptus* wood is used for paper industries. Valuable gum is obtained from *Eucalyptus globulus* (Blue gum), *E. robusta* (red gum). Some members are cultivated in garden ornamentals as *Callistemon, Melaleuca, Tristania*, and some *Eucalyptus* sp.



Syzygium cumini

Sysematics and Phylogeny: Almost all taxonomists placed Myrtaceae under order Myrtales. Myrtaceae is allied to Rhizophoraceae, Lythraceae, Combretaceae and Onagraceae. Myrtaceae is divided into 2 subfamilies i.e. Myrtoideae (fruit berry, leaves opposite) and Leptospermoideae (fruit dry and leaves alternate).

RUBIACEAE
CLASS: Dicotyledons
SUB CLASS: Gamopetalae
SERIES: Inferae
COHORT: Rubiales
Family: Rubiaceae

SELECTED INDIAN GENERA: *Coffea, Cinchona, Ixora, Gardenia, Oldenlandia.* **DISTRIBUTION:** 500 genera/6500 species.Rubiaceae are mainly distributed in tropics.

VEGETATIVE CHARACTERS OF THE FAMILY

HABIT: Trees (*Cinchona officinalis*), Shrubs (*Coffea, Mussaenda*), Herbs (*Galium, Oldenlandia*), hook climber (*Uncaria*), Twiner (*Manettia*) Epiphyte (*Myrmecodia).*

LEAVES: Simple, entire, opposite, decussate, stipulate usually interpetiolar and rarely intrapetiolar.

INFLORESCENCE: Dichasial cyme, Dichasia sometimes grouped into globose head (*Adina, Nauclea*) rarely flowers are solitary (*Gardenia,Randia*) Helicoidcyme- (*Hamelia*)

FLOWERS: Bracteole, sometimes Bracteolate, Bisexual, usually actinomorphic rarely slightly zygomorphic, penta- or tetramerous, inferior ovary (epigynous), only rarely Perigynous (synaptautha), very rarely hypogynous (Gaertnera & pagamea), zygomorphic in *Henriquezia.*

CALYX: K(4-5) united, gamosepalous. Highly reduced in *Morinda.* In *Mussaenda* one of the sepals is enlarged and highly attractive and bright coloured. In *Alberta* the sepals persists and helps in fruit dispersal.

COROLLA: C (4-5) united gamopetalous. Valvate or twisted usually salverform. In *Henriquezia,* it is bilabiate.

ANDROECIUM: A (4-5) Stamens, Epipetalous, inserted in the mouth of corolla. Alternate with corolla lobes. Anthers-2 celled, introse, dehiscing longitudinally.

GYNOECIUM: G(2) Inferior, bicarpellary, syncarpous, bilocular ovules are few to many on axile placentation, In *Gardenia* it is unilocular with parietal placentation.

FRUIT: Fleshy berry (*coffea*), capsule (*Oldenlandia)* Multiple fruit (Morinda,) and Schizocarp (Galium).

SEEDS: very small & endospermous.

GENERAL FLORAL FORMULA: Br, K(4-5) C(4-5) A(4-5) $G_{(2)}$

ECONOMIC IMPORTANCE

Coffee: the most popular non-alcoholic, caffeine-containing beverage, obtained from roasted and powdered seeds of Coffea arabica. Other coffee producing species are C.liberia & C.robusta.

Quinine: this malarial drug comes from the bark of several species of *chinchona* mainly *chinchona offcinalis.*

Other medicinal plants:-

Ipecac: obtained from the roots of *Cephaelis ipecachuanha* used against amoebic dysentery and pyorrhea.

Randia tinctoria fruit pulp is emetic and anthelmintic

Gardenia gummifera: the plant yields a gum-resin. It is used as carminative and stimulant and also given in dyspepsia.

Timber: useful timber is obtained from *Adina cordifolia, Anthocephalus cadamba, Morinta tingtoria.*

Ornamentals: *Galium sp, Hamelia patens, Ixora sp, Musssaenda sp, Pentas lanceolala, Anthocephalus cadamba.*

Sacred plant: *Anthocephalus cadamba* (kadamba maram) is a sacred plant of Madurai .

SYSTEMATICS AND PHYLOGENY

B&H treated Rubiaceae under order Rubiales while Takhtajan(1969) and Throne(1983) discussed it under Gentianales.

Affinities of Rubiaceae are controversial. Similar type of alkaloids bring Rubiaceae close to Loganiaceae. But in Loganiaceae ovary is superior but in Rubiaceae ovary is inferior. In possessing opposite leaves, cymose inflorescence and inferior ovary Rubiaceae comes closer to caprifoliaceae. However, leaves are exstipulate in Caprifoliaceae. In possessing epigynous flower, cymose inflorescence, epigynous disc and bicarpellate ovary, Rubiaceae comes closer to umbelliferae and cornaceae.

ASTERACEAE

CLASS: Dicotyledons

SUB CLASS: Gamopetalae

SERIES: Inferae

COHORT: Asterales

Family: Asteraceae or Compositae

SELECTED INDIAN GENERA: *Aster, Chrysanthemum, Dahlia, Eclipta, Helianthus, Cichorzium, Pyrethrum carthamus, Xanthium & Helichrysum.*

DISTRIBUTION: Asteraceae is one of the largest families of flowering plants 1100 genera/20,000 species. Cosmopolitan in distribution *ie* Growing in all parts of the world.

VEGETATIVE CHARACTERS:-

GENERAL HABIT: Usually annual or perennial herbs. Few are climbers (*Mikania & Mutisia).* Trees are rare *Vernonia travancorica, V. shervaroyensis.*

Senecio, the largest genus of the family include all habits.--

HERB: *Senecio vulgaris* SHRUB*: S. magnificus* TREE: *S. cruentus Climber S.scandens,* WOODY CLIMBER: *S. calcadensis.*

XEROPHYTE: *Holophyllum, Proustia & Baccharis*

LEAVES: Simple or compound, Alternate rarely opposite, whorled in some cases (*Eupatorium). Launaea, Taraxacun* - radical or rosette leaves. In *Corymbium* parallel venation is found. In *Holophyllum* the leaves are modified into spines.

Stem tubers are found in *Helianthus tuberosus* [poinsous plant]

INFLORESCENCE: The primary inflorescence is a head a Capitulum with many florets borne on a conical flat receptacle. Each floret is often subtended by a bract called pale or chaff, the receptacle is often subtended by a involucre of bracts called Phyllaries.

In *Echinops* the head contains only one flower. The head may be Heterogamous or Homogamous.

HETEROGAMOUS INFLORESCENCE: Eg – *Helianthus*, the central florets are disc florets which are bisexual and actinomorphic and theouter Ray florets are ligulate, --female and zygomorphic.

HOMOGAMOUS INFLORESCENCE: Eg- All florets are similar usually bisexual, Eg., *Vernonia* --Actinomorphic – lot of variations occur in this type.

CALYX: Represented by pappus hairs [or] bristles or scales.

COROLLA: C (5) united gamopetalous, valvate represented by three basic types 1) 5 lobed & tubular 2) Ligulate with 3 to 5 leeth 3) bilabiate with 3 lobes in upper lip and 2 lobes in lower lip. In Mutisia all florets are bilabiate While *Cichorium* is ligulate.

ANDROECIUM: A(5) Epipetalous, syngenesious condition *ie* anthers are united but filaments are free.

GYNOECIUM: Bicarpellary, syncarpous, inferior ovary, unilocular, only one ovule, basal placentation, style 1 usually 2 branched- bifid stigma.

FRUIT: Cypsela which is dispersed by pappus hairs.

POLLINATION: Entornophilous – insects attracted by ray florets.

GENERAL FLORAL FORMULA: Br, K() C(4-5) A(4-5) G(2)

ECONOMIC IMPORTANCE:-

OIL: *Helianthus annuus* , the seed is useful for the extraction of sunflower oil.

MEDICINAL: *Artemisia cina* - flower heads provide the drug santonin and antidote against intestinal worms.

Blumea balsamifera – leaves are used against insomnia.

Inula belium – leaves are effective against tuberculosis.

Lectuca virosa – leaves have sedative properties.

Sphaeranthus indicus – heads are used for curing stomach ache and piles.

Eclipta alba – hair tonic

Taraxacum officinale – roots and rhizome provide the drug "*Taraxacum*" used a mild laxative.

INSECTICIDES: The insecticide "Pyrethrum" is got from the dried leaves of *chrysanthemum cinerariaefolium & pyrethrum cinerarifolium* also used in preparing of insecticides.

EDIBLE: *Lactuca sativa* – used for salad preparation.

Taraxacum officinale – roasted seeds are used in the place of coffee.

DYE: A red dye obtained from petals of *Carthamus tinctorius* [Saff flower] is used for colouring candles, and liquors.

CHICORY POWDER: Chicory powder is got by roasting roots of *Cichorium intybus* and the powder is used in mixing with coffee for aroma.

ORNAMENTALS: Well known ornamental species found in the family *ie* the species of *Aster, Calendula Dahlia, Gynura, Helichrysum , Zinnia elegams, Chrysanthemum, Tagetes, Coreopsis& cosmos.*

Launeaea - Herb common in sandy tracts. Good soil binder

Parthenium argentatum –Guayule rubber plant

Parthenium hysteriophoeus- congress weed

SYSTEMATIC POSITION AND PHYLOGENY:- This family is divided into 13 tribes.

1.Heliantheae (*Helianthus),* 2) Astereae (*Aster*) 3) Anthemideae (*Chrysanthemum*) 4) Arctotideae (*Arctotis*) 5) Inuleae (*Inula)* 6) Senecioneae (*senecio)* 7) Calenduleae (*Calendula*) 8) Eupatorieae (*Eupatorium*) 9) Vernoniae (*Vernonia),* 10) Cynareae (*Carthamus*) 11) Mutitsieae (*Mutisia*) 12) Liabeae (*Liabum*) 13) Lactuceae (*Lactuca).*

In possessing pentamerous flowers, syngenesious anthers and inferior ovary Asteraceae is related to Campanulaceae and Goodeniaceae.

In possessing inferior bilocular ovary Asteraceae also comes near to Rubiaceae. The characters such as dense inflorescence and inferior ovary also trace the affinity of Asteraceae with Dipsacaceae and Valerianaceae.

It is presumed that Asteraceae might have been originated from Rubiaceae.

SAPOTACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Gamopetalae

Series: Heteromerae

Order: Ebenales

Family: Sapotaceae

Selected Indian Genera: *Achras, Madhuca, Mimusops, Manilkara, Palaquim.*

Distribution: About 40 genera and 800 species distributed mainly in tropical regions of the world.

Vegetative characters: Mostly trees or shrubs with milky sap present in the laticiferous ducts. Leaves simple, alternate, petiolate, exstipulate, rarely stipulate in *Madhuca*, sometime crowded in the tip of the branches.

Floral characters: Inflorescence is solitary cymose clusters on leaf axiles, cauliflorous in *Dichopsis*. Flowers bracteate or ebaracteate (*Achras*), superior ovary. Calyx 4-8 sepals, in two whorls (*Chrysophyllum*), or 4+4 in two whorls (*Mimusops*) or 3+3 in *Achras*. Corolla 6-8 petals, free are short appendages are present. In *Mimusops* the outer whorl is 16 and inner whorl has 8 petals. In *Achras* 6 petals area present in one whorl. Imbricate aestivation. In *Bassia* corolla is fleshy and deciduous.

Androecium: Stamens 6 or 8 or many, fused with petals i.e.epipetalous condition. One or two whorls, in *Mimusops* there are 8 fertile stamens and 8 sub-petaloid staminodes occurring on the involucral of petals. The fertile stamens are

alternate with staminodes. In *Achras sapota* there 6 fertile stamens and 6 petaloid staminodes on the same whorl. In *Chrysophyllum* staminodes are absent. In *Palaquim* stamens 2 or 3 times the number of petals and all of them are fertile.

Gynoecium: Carpels 1 or 4 or 14, superior, syncarpous, usually with as many locules as the number of carpels, each locule is uniovuled, axile placentation, style is one with lobed stigma.

Fruit: Berry with 1-8 seeds, endospermic. Pollination is entamophilous. Seed dispersal is by animals.

Economic importance: Ripened fruits of *Achras sapota* are delicious. The latex of *Palaquim* and *Mimusops* are useful for the manufacture of a rubber known as Guttapercha. Chickle gum obtained from *Achras sapota* is used dental surgery. Seeds and dried fruits of Mimusops are highly effective in curing piles. Oil from seeds if *Madhuca indica* effective for skin problems and rheumatism. An oil extracted from seeds of *Madhuca indica* and *Diploknema butyracea* is used in the manufacture if soaps and candles. The corolla of *Bassia latifolia* flowers are utilized in the distillation of cheap alcohol. The wood of *Sideroxylon* is used as timber and is commonly known as Iron wood.

Systematics and Phylogeny: Sapotaceae is usually divided into 2 tribes namely Palaquiae (Petal lobes without appendages) and Mimusopae (petal lobes with appendages).

CONVOVULACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Gamopetalae

Series: Bicarpellatae

Order: Polemoniales

Family: Convolvulaceae

Selected Indian Genera: *Ipomoea, Convolvulus, Cuscuta, Evolvulus.*

Distribution: 55genera and 1,650 species distributed in both tropical and temperate regions.

Vegetative characters: Usually annual or perennial herbs, shrubs or rarely trees (some species of *Erycibe*),climbers (*Ipomoea*), leafless parasite (*Cuscuta*), runner (*Merremia*), prostrate herb (*Evolvulus*), some are hydrophytes (*Ipomoea aquatica*), xerophytes (*Hildebrandtia*). Root is normal tap root system, root tubers present in *Ipomoea batata* (sweet potato). In *Cuscuta* roots are modified into haustoria. Leaves simple, alternate, exstipulate, entire or variously lobed, palmately dissected (*Ipomoea palmata*), pinnately dissected (*Quamoclit pinnata*), greatly reduced into small scales (*Cuscuta*).

Floral characters: Inflorescence is an axillary cyme. Solitary flowers in *Evovulus, Merremia,* etc. Panicle in *Porana*. Flowers are bracteates, bracteolate, bisexual, pentamerous, actinomorphic, hypogynous, rarely unisexual and tetramerous in *Hildebrandtia* and dioecious. Calyx 5 sepals, free, persistent, quincuncial (*Convolvulus*) or fused and valvate (*Cuscuta*), 4 sepals in *Hildebrandtia*. Corolla 5 petals, gamopetalous, valvate or twisted, *Cuscuta* is imbricate, 4 petals in *Hildebrandtia*, salviform or infundibuliform (*Convolvulus* and *Porana*).

Androecium: Stamens 5, epipetalous, inserted towards the base of corolla tube, basifixed, sagittate in Ipomoea, 4 stamens in *Hildebrandtia*, filaments are usually of different length i.e. heterodynamous.

Gynoecium: Carpel 2, bicarpellary, syncarpous, superior, usually 2 locule (rarely 4 locules formed by false septum), pentacarpellary in *Erycibe*, axile placentation, stigma bifid with hairy appendages.

Fruit: Capsule (*Ipomoea*), seeds with straight or curved embryo.

Economic importance: Root tubers are edible in *Ipomoea batata* and leafy vegetable as *Ipomoea aquatica*. *Evovulus alsinoides* used as bitter tonic, *Exogonum purga* is used as purgative. *Ipomoea violacea* seeds contains lysergic acid and are hallucinogenic. Many of them are ornamental as *Argyreia speciosa, Ipomoea carica, I. quamoclit, I. tuberosa, I. violacea, Porana paniculata.*

Systematics and Phylogeny: The family is divided into 2 sub families Convolvulaceae and Cuscutaceae, however Bentham and Hooker divided into

five tribes. Several axonomists place Cuscuta under a separate family Cuscutaceae. Convovulaceae is related closely to Solanaceae and also to some extent to Hydrophyllaceae and Nolanaceae. Cronquist (1981) and Thorne (1985) have treated it under Solanales.

APOCYNACEAE
CLASS: Dicotyledons
SUBCLASS: Gamopetalae
SERIES: Bicarpellate
COHORT: Gentianales
Family: Apocynaceae

SELECTED INDIAN GENERA: *Allamanda, Alstonia, Vinca, Nerium, Plumeria, Rauwolfia.*

DISTRIBUTION: 300 Genera/1300 species. The plants are cosmopolitan in distribution but mainly found in tropical regions.

HABIT: Herbs(*vinca rosea*) shrub*(Thevetia, Nerium,)* climbers *(Beaumontia, Valleris & Allamanda*) Trees (*Alstonia, Plumeria, Holarrhena*)

LEAVES: Opposite – whorled as in *Rauwolfia, Allamanda, Alstonia,* exstipulate but in *Ervatamia* intrapetiolar stipules are present. In *Thevetia* is alternate. In the tropical African genus *Adenium* the stem is thick fleshy and also the leaves are succulent xerophytes.

INFLORESCENCE: In *Vinca* solitary, axillary or terminal cymes.

FLORAL: Br, Brl, Bisexual, actinomorphic, hypogynous, pentamerous
CALYX: K 5, gamosepalous appearing to be poly often with gland at the base – quincuncial.

COROLLA:C 5 Big showy, gamopetalous with prominent throat tube and lobes. Funnel *(Nerium)* & Salvar (*Ervatamia*) are the common types seen. In *Allamanda* it is bell shaped. Almost all the members are provided with appendage but vary in quantity. In *Thevetia* & *Vinca* hairy. In *Nerium,& Wrightia* coronal appendages twisted to the left or right.

ANDROECIUM: A 5 -Equal to the number of petals and alternate to them. Attached to the throat and included in the tube, filaments short, Epipetalous, introrse free or adherent by viscid exudates to the stigma. Each anther is dithecous and each theca is 2 celled both may be equal the inner may be shorter. The outer may from empty basal projections. Thus the anther becomes sagittate. Pollen grains spherical, powdery and simple but in *Condylocarpus* grains united in tetrads. Disc hypogynous great variation. Annular bowl shaped as in *Nerium* – 5 scales – 2 glands in *Vinca.*

GYNOECIUM: G[2] Nrmally 2carpels very rarely 3 to 5. The carpels are most frequently free apocarpous. Rarely united. *Vinca* free, *Nerium, Allamanda* united(syncarpous). Even if the carpels happen to be free they have a common terminal style. Normally bilocular with axile or marginal placentation. In *Plumeria* ovary is partly inferior(sub-inferior). The stigma is characteristic of the family. It is ellipsoidal or "hour glass" shaped. It is also known as "Clavuncle". The top bilobed and receptive surface confined to the base. Ovules – axile, marginal or parietal placentation.

FRUIT : Common type is follicle – pair of follicle from apocarpous ovary is called conceptaculum. The fruit of *cerbera* is drupaceous, mesocarp is fibrous, endocarp hard. Transported by sea. *Aspidosperma and Allamanda* – capsule, *Landolphia* – berry like. Condylocarpous fruit seperates at maturity into one seeded joints. *Cameraria* mericarps winged (2 wings) aggregate of samara.

SEEDS: Winged or hairy *Plumeria, Allalmanda* – winged, hairy – tuft at one end or both end. *Strophanthers*, embryo large cotyledon, copious endosperm.

POLLINATION: Herkogamy

GENERAL FLORAL FORMULA: Br, K(4-5) C(4-5) A(4-5) G(2)

ECONOMIC IMPORTANCE:-

Allamanda: woody climber, Ls – whorled, flowers yellow or pink. A.eathartica garden plant

Carissa: false dicfotomy. Thorns are modified buds. C.carandus – used for pickles *C. spinarum.*

Rauwolfia: Ls anisophyllous 3 or 4 at a node. Ovules 2 in each carpel. *R. canescens* wild *R.serpentina* – good for blood pressure and hot diseases.

Vinca rosea: periwinkle opposite flowers solitary or in groups pink , white or violet. Disc two glands. *Vinca rosea* very common waste land plant. *V. pusilla* poisonous to cattle weed in fields.

Alstonia scholaris: tree branches whorled. Ls whorled 5 – 7.
the wood is soft close grained used for making boxes. Common in Thenmalai and courtallum.

Holarrhena antidysenterica: A small tree, wood white soft, used for carving. The plant is medicinal and poisonous.

Ervatamia: tall shrub wild and cultivated, stipulate. *E. coronaria* medicinal (eye disease).**Vallaris solanacea :** woody creeper wheel shaped corolla mistaken for solanaceae.

Wrightia tinctoria tree: coralline corona 2 series, plants yield dye. *W. tomentosa*. tree in dry hilly countries.

BIGNONIACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons
Subclass: Gamopetalae
Series: Bicarpellatae
Order: Personales
Family: Bignoniaceae

Selected Indian Genera: *Tecoma, Oroxylon, Millingtonia, Kigelia, Tabebuia, Spathodia,* and *Crescentia.*

Distribution: About 120 genera and 800 species distributed mainly in tropical regions. Only a few taxa are temperate climates. The largest genus *Tabebuia* (100 species) found in the south American countries.

Vegetative characters: Mostly trees and shrubs. *Campsis radicans* is climber with aerial roots. *Tecoma, Pandorea* and *Pyrostegia* are twiners. Leaves are pinnately compound, opposite, terminal leaflet modified into tendril. Leaves whorled in *Diplanthera,* exstipulate but glands present at the base if petiole.

Floral characters: Inflorescence is a dichasial cyme. Flowers bracteates, bracteolate, complete, bisexual, irregular (zygomorphic), hypogynous, pentamerous. Calyx 5-sepals, gamosepalous, 5-toothed, often campanulate, valvate aestivation. Corolla 5-petals, gamopetalous, campanulate, lobed or bilabiate (bilipped), 2/3 with the upper lip of 2 petals and lower lip of 3 petals, i.e. irregular petals (zygomorphic).

Androecium: Stamens 4, epipetalous, didynomous (out of 4 stamens, outer 2 are longer and inner two are smaller in size). Stamens 5 in *Oroxylum* and *Tecoma*, 2 in *Catalpa* and it has two staminodes. Anthers dithecous, longitudinally dehisce.

Gynoecium: Carple 2, bicarpellary, syncarpous, bilocular, numerous ovules are attached in each locule on axile placentation, unilocular with parietal placentation in *Kigelia* and *Eccremocarpus*. Style simple, stigma bilobed. A hypogynous nectar secreting disc is present.

Fruit: Loculicidal capsule or berry. Seeds often winged, non-endospermic. Embryo straight.

Economic importance: *Oroxylum indicum* the bark of the tree is useful in stomach cancer. An inferior quality cork is prepared from the bark of *Millingtonia hortensis* (Indian Cork tree). Many trees are yielding timber woods such as *Catalpa, Stereospermum, Dolichandron, Haplophragma,* etc. Some members of the family are ornamental trees and shrubs namely *Spathodea campanulata, Tabebuia spectabilis, Kigelia pinnata, Jacaranda mimosaefolia, Millingtonia hortensis, Tecoma stans, Tecomaria undulata, Bignonia biloba, Pyrostegia venusta* and *Crescentia alata.*

Systematics and Phylogeny: Bentham and Hooker placed under Personales. Hutchinson placed under Bignoniales. Takhtajan and Cronquist placed under Scrophulariales. The family has been divided into 4 tribes i.e. Bignonieae, Tecomeae, Eccremocarpae, and Crescentieae by Schumann. In possessing didynamous stamens, bicarpellary ovary, zygomorphic flowers and capsular fruits, Bignoniaceae is closely allied to Scrophulariceae. It is also allied to Acanthaceae and Pedaliaceae.

SCROPHULARIACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons
Subclass: Gamopetalae
Series: Bicarpellatae
Order: Personales
Family: Scrophulariaceae

Selected Indian Genera: *Antirrhinum, Digitalis, Veronica, Limnophila, Russelia, Striga.*

Distribution: 220 genera and 3,500 species distributed all over the world.

Vegetative characters: Mostly herbs, shrubs (*Veronica*), tree (*Paulownia*), climbers (*Maurandia*), parasites (*Striga*). Leaves simple, alternate (*Verbascum*), opposite or whorled (*Russelia*), heterophylly (*Limnophila*). *Veronica* if Newzealand have dimorphic leaves i.e scale leaves and normal leaves.

Floral characters: Inflorescence is racemose (*Mazus*), cymose (*Verbascum*), solitary (*Linaria*), spike (*Digitalis*), panicle (*Scrophularia*). Flowers bracteate, bracteolate, complete, bisexual, medianly zygomorphic but actinomorphic in *Verbascum.* All the petals of Antirrhinum produce spurs so that regular symmetry is achieved. Brightly coloured bracts are found in *Castilleja.* Calyx 5-sepals, quincuncial or valvate, sepals 4 in *Veronica* and *Scoparia*, sometimes 2 anterior sepals are united (*Calceolaria*). Corolla 5-petals, gamopetalous, often bilipped, 2/3, 4 petals are found in *Veronica.* Frequently the anterior petals are spurred (*Linaria*) or with a gibbous (*Antirrhinum*). In *Verascum* all 5 petals are equal.

Androecium: Stamens 2-4, 2 in *Veronica*, 4 in *Mazus,* all five fertile in *Verbascum.* Stamens are alternate with corolla, dithecous, dehiscence mostly longitudinal slit.

Gynoecium: Carpel 2, bicarpellary, syncarpous, ovules many in each locule, axile placentation, stigma bilobed, nectar secreting disc is present below the ovary.

Fruits: Capsule, rarely a berry (*Leucocarpus*), seeds many with curved embryo. Pollination is entamophilous, seed dispersal by water, birds or animals.

Economic importance: Many of the members are medicinally important herbs as *Bacopa monnieri* used in epilepsy and insanity. *Digitalis purpurea* (fox glove) used in heart failure, *Scoparia dulcis* used in common cold, fever and cough. Several species are grown in garden ornamental as *Angelonia, Antirrhinum, Calceolaria, Collinsa, Paulownia, Veronica,* and *Torenia.*

Systematics and Phylogeny: Bentham and Hooker and Hutchinson placed under Personales, Wettstein divided the family into 3 subfamilies as Verbascoideae, Scrophulariodeae and Rhinanthodeae. Scrophulariaceae is closely allied with Solanaceae and Convolvulaceae. This is also related to Biognoniaceae having zygomorphic flowers, exstipulate leaves and hypogynous disc. In several characters Scrophulariaceae is closely allied to Lamiaceae and Acnathaceae.

VERBENACEAE

Systematic position (According to Bentham and Hooker)

Class: Dicotyledons

Subclass: Gamopetalae

Series: Bicarpellatae

Order: Lamiales

Family: Verbenaceae

Selected Indian Genera: *Tectona, Lippia, Vitex, Duranta, Lantana, Clerodendrum, Avicennia.*

Distribution: 99 genera and 3,151 species distributed mainly in tropics and subtropics.

Vegetative characters: Mostly mesophytes but *Avicennia* is a mangrove shrub. Mostly shrubs (Lantana, Vitex), trees (*Tectona*), Climbers (*Petrea* and *Holmskioldia*), herbs (*Verbena* and *Lippia*). Leaves simple or sometimes pinnately compound (*Peronema*), palmately compound (*Vitex*), usually opposite, highly reduced in xerophytic species (*Verbena*) and exstipulate.

Floral characters: Inflorescence is racemose (*Duranta*) or umbel (*Lantana*), dichasial cyme (*Clerodendrum*), spike (*Lippia*). Flowers bracteate, bracteolate, complete, bisexual, zygomorphic (rarely actinomorphic, *Physopis*), pentamerous, hypogynous. Calyx 5-sepals, gamosepalous, persistent, valvate. Corolla 5-petals, gamopetalous, unequal, often bilipped with a narrow tube, imbricate.

Ardroecium: Stamens 4, didynamous condition, epipetalous, in *Tectona* 5 stamens are present. In *Oxera* stamens 5 (2+3), 2 fertile and 3 staminodes are present. In *Stachytarpheta* only 2 fertile stamens are present. Anthers dithecous, longitudinally dehisce.

Gynoecium: Carple 2, syncarpous, ovary superior, originally bilocular but divided into 4 locules by the formation of false septum in each locule. Carpel 5 in *Geunsia* and 4 in *Duranta*. In *Lippia* and *Lantana* posterior carple is abortive, ovules in axile placentation, style simple with forked stigma.

Fruit: Capsule (*Avicennia*), nutlets (*Verbena*) and drupe (*Lantana*). Seed without endosperm at maturity, non-endospermic. Calyx is persistent and form a bladdery structure in *Tectona*. Pollination is mainly by butterflies and bees. Seeds dispersed by birds and animals.

Economic importance: *Tectona grandis* one of the most famous timber yielding tree of the world. Other timber wood trees are *Gmelina arborea, Premna latifolia, Vitex altissima, Callicarpa tomentosa. Verbena officinalis* leaves (verbena oil) used in curing various eye diseases. *Vitex negundo* leaves are used in steambath method to cure common cold. *Lantana indica* leaves are used as an antidote for snake bite. Some species are used in perfumery industries e.g. *Aloysia triphylla*. Many of them are grown in ornamental such as *Duranta repens, Lantana camera, Clerodendrum inerme, C. neerifolim, Holskioldea saguinea, Petera volubilis* and *Verbena officnalis*.

Systematics and Phylogeny: Verbenaceae was placed under Lamiales by majority of taxonomists including Bentham and Hooker, Takhtajan, Cronquist and Throne. Hutchinson placed it under Verbenales, Briquet divided Verbenaceae in 7 tribes (Stilbeae, Verbeneae, Chiloantheae, Viliceae, Caryopteriae, Symphoremeae and Avicenniae). Verbenaceae is closely allied to Labiatae and to some extent to Boragincaeae and Scrophulariaceae. However Hutchinson opined that Verbenaceae and Labiatae are not at all related.

POLYGONACEAE (Buckwheat family)

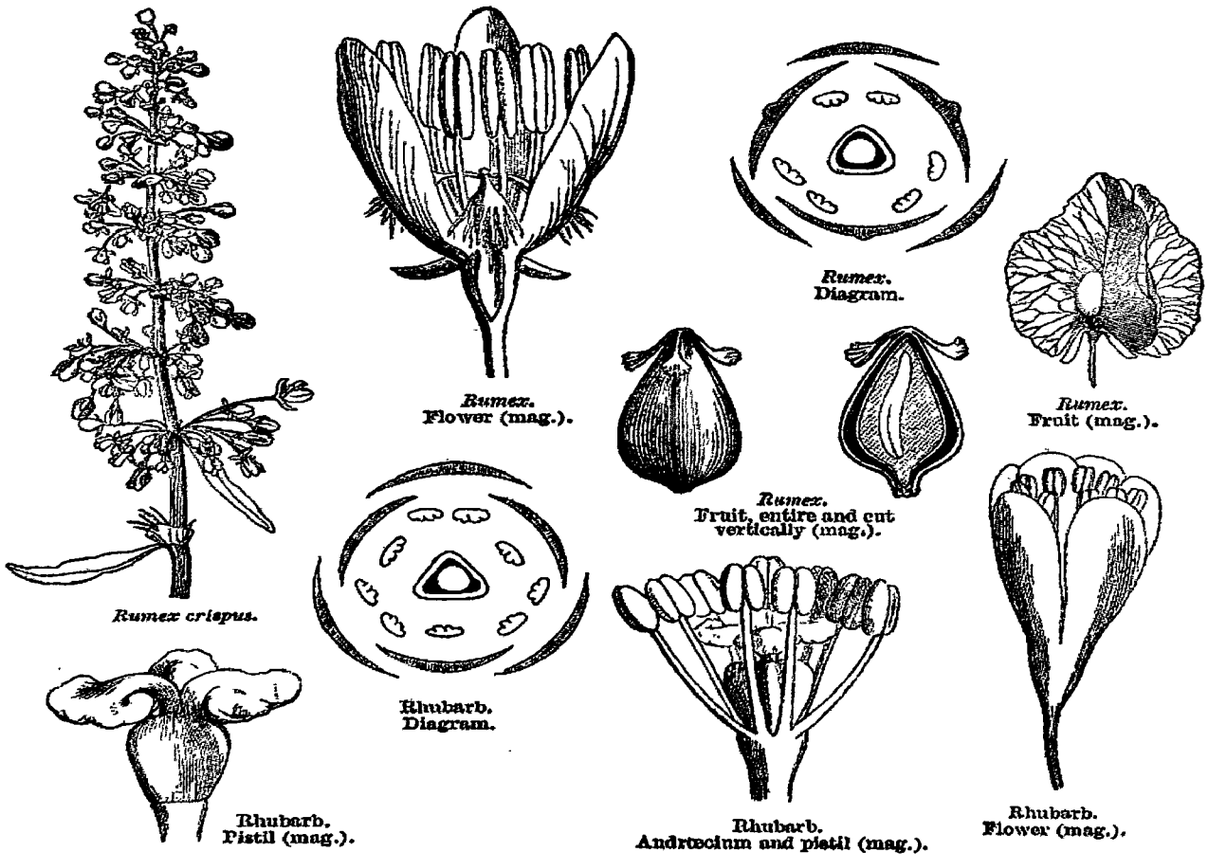
Distribution: The Polygonaceae comprise about 1,200 species distributed into about 50 genera. The largest genera are *Eriogonum* (240 species), *Rumex* (200 species), *Coccoloba* (120 species), *Persicaria* (100 species) and *Calligonum* (80 species). The family is present worldwide, but is most diverse in the North Temperate Zone.

Vegetative characters: Habit varied from prostrate herbaceous annual plants under 5 cm high, others erect herbaceous perennial plants growing to 3–4 m tall, and yet others perennial woody vines growing to 20–30 m high in trees. Several are aquatic, growing as floating plants in ponds. The smooth-edged leaves range from 1–30 cm long, and vary in shape between species from narrow lanceolate to oval, broad triangular, heart-shaped, or arrowhead forms. The stems are often reddish or red-speckled. The small flowers are, pink, white, or greenish, forming in summer in dense clusters from the leaf joints or stem apices.

Leaves minute to large; alternate (nearly always), or opposite (*Pterostegia*); usually spiral; 'herbaceous', or membranous (when reduced); petiolate, or subsessile; sheathing. Leaf sheaths not tubular; with free margins. Leaves gland-dotted, or not gland-dotted; simple; sometimes almost peltate, or not peltate; epulvinate. Lamina entire; pinnately veined; cross-venulate; auriculate at the base, or cordate, or hastate, or sagittate, or attenuate at the base, or cuneate at the

base, or rounded at the base. Leaves stipulate (usually), or exstipulate (*Eriogoneae*). **Stipules** intrapetiolar or concrescent or ochreate or scaly. Margins entire (or crisped), or crenate; revolute (when young).

Floral characters: Plants bisexual or monoecious, or polygamomonoecious, or dioecious. **Inflorescences** terminal or axillary; racemes, corymbs, spikes and heads; with or without involucral bracts; often conspicuously ochreolate. Flowers small, regular, 2 merous or 3 merous or 5 merous, cyclic to partially acyclic. Free hypanthium present, or absent. Hypogynous disk present (or nectaries present between the androecial members), annular. **Perianth** ambiguously with distinct calyx and corolla, or sepaline, or petaline, 2–6, free to joined, 1 whorled or 2 whorled (or spiralled), when biseriate, similar in the two whorls, or different in the two whorls; fleshy (sometimes) or non-fleshy, persistent, accrescent or non-accrescent.



Androecium branched (e.g. *Rheum*), or unbranched; free of the perianth, or adnate (usually more or less perigynous); all equal or markedly unequal; free of one another, or coherent (sometimes filaments basally connate); when cyclic, 2 whorled (3+3, or spiralled). Androecium exclusively of fertile stamens. Stamens (2–) 6 (–9); alternisepalous, or oppositisepalous. Anthers dorsifixed, or basifixed; versatile, or non-versatile; dehiscing via longitudinal slits; introrse, or extrorse and introrse, or latrorse; tetrasporangiate.

Gynoecium (2–) 3 (–4) carpelled. Carpels isomerous with the perianth. The pistil 1 celled or 3 celled. Gynoecium syncarpous; synovarious to synstylovarious; superior. Locules secondarily divided by false septa (rarely, incompletely) or without false septa. Styles (2–)3(–4), free to partially joined; apical. Placentation basal. Ovules in the single cavity 1; funicled, or sessile; ascending; non-arillate.

Fruit non-fleshy, indehiscent, a nut or achene-like, enclosed in the fleshy hypanthium, or enclosed in the fleshy perianth, or without fleshy investment; 1 seeded. Seeds endospermic. Endosperm ruminate (*Coccoloba*), or not ruminate; oily. Seeds with starch.

Important genera: *Afrobrunnichia*, *Antigonon*, *Aristocapsa*, *Atraphaxis*, *Brunnichia*, *Calligonum*, *Centrostegia*, *Chorizanthe*, *Coccoloba*, *Dedeckera*, *Dodecahema*, *Emex*, *Eriogonum*, *Fagopyrum*, *Fallopia*, *Gilmania*, *Goodmania*, *Gymnopodium*, *Harfordia*, *Hollisteria*, *Knorringia*, *Koenigia*, *Lastarriaea*, *Leptogonum*, *Muconea*, *Muehlenbeckia*, *Nemacaulis*, *Neomillspaughia*, *Oxygonum*, *Oxyria*, *Oxytheca*, *Parapteropyrum*, *Persicaria*, *Podopterus*, *Polygonella*, *Polygonum*, *Pteropyrum*, *Pterostegia*, *Rheum*, *Rumex*, *Ruprechtia*, *Stenogonum*, *Symmeria*, *Systenotheca*, *Triplaris*.

Economic uses: Foodstuffs from *Fagopyrum* (buckwheat) and *Rheum* (rhubarb); many noxious weeds, and some ornamentals.

AMARANTHACEAE (Amaranth family)

Distribution: This family comprised about 50 genera and 1000 species world over. They are mostly annual or perennial herbs or shrubs. Many of them are mesophytes. A few species of *Aerva* are xerophytes, species of *Alternanthera* inhabit damp localities.

Vegetative characters: Usually plants area herbaceous, stem branching monopoidal or sympodial (*Achyranthes*). The leaves are simple, opposite (*Alternanthera* and *Achyranthes*), alternate (*Aerva*). They are exstipulate, sometimes variegated (*Irisine*).

Floral characters: Inflorescence is terminal or axillary. It is a spike in *Achyranthes*, faciated in *Celosia*. Normally development of cymose type but condensation of the axis, it appears as a globose head (*Comphrena*). In *Pupalia*, the lateral flowers are sterile, whereas the central flowers alone fertile.

The **flowers** are bisexual, rarely unisexual (Amaranthus), sometimes polygamous (*Celosia*). They are actinomorphic, hypogynous, monochlamydous, bracteates, and bracteolate. Bracts and bracteoles are sometimes brightly coloured. The calys consists of 5 sepals, free and persistent. The sepals are membranous, and petaloid. Aestivation is quincuncial. Usually corolla is absent.

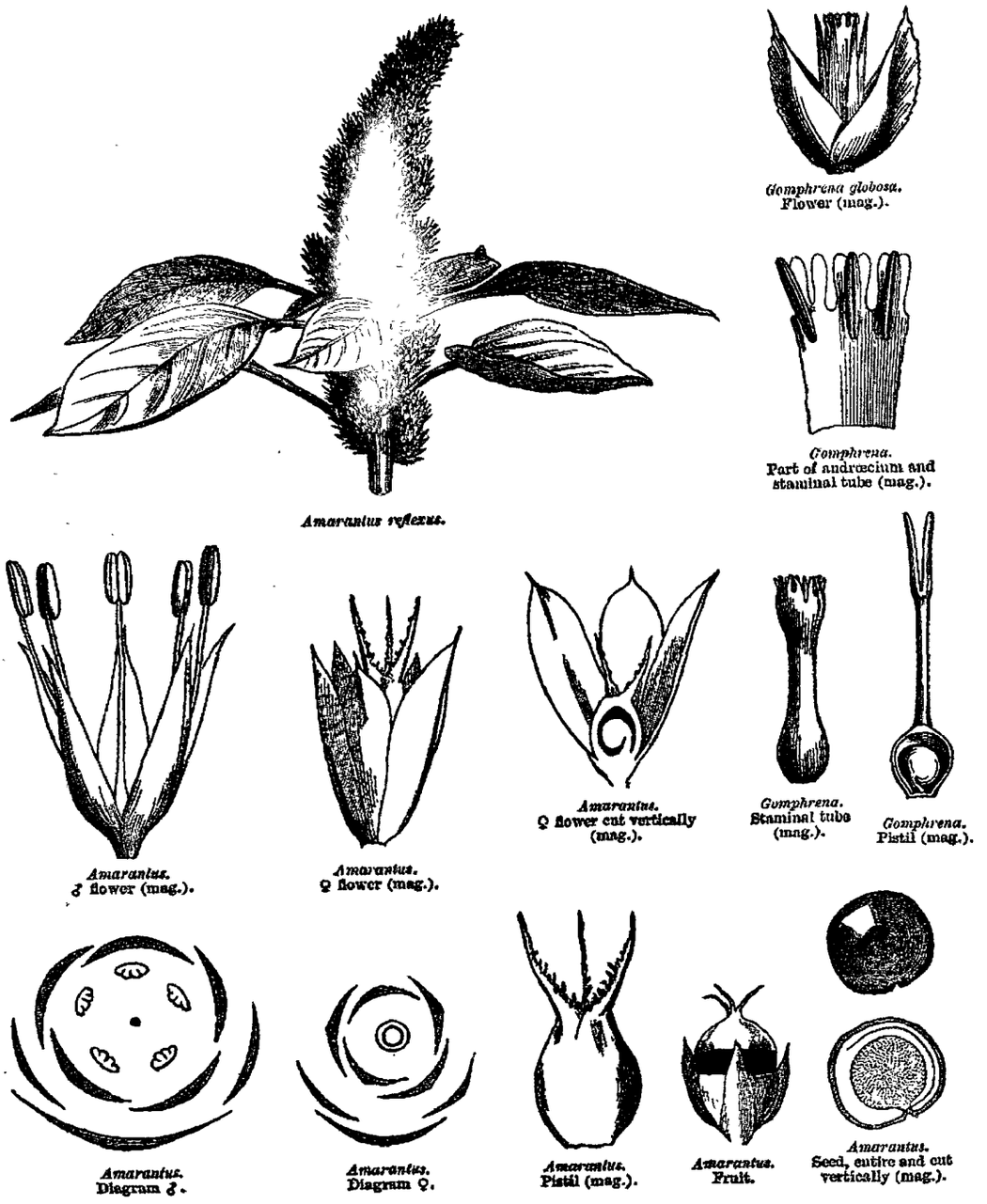
Androecium consists of 5 stamens that are opposite to the sepals. Usually they are united by filaments to form a tube around the gynoecium. In *Achyranthes*, alternating with the fertile stamens, are fringed scaly structures which are taken to represent stamens in second whorl. The anthers are dithecous, introrse, dehiscing by longitudinal slits.

Gynoecium is 2 or 3-carpellary, syncarpous, unilocular, hypogynous with terminal style and 2 or 3 lobed stigma. The solitary ovule is campylotropous with long funicle, placentation usually basal. In *Celosia*, ovules are many.

Fruit is usually an achene,or rarely a nut. It is a circum scissile capsule in *Celosia*. The seeds are endospermic.

Economic importance: Several of the members are of ornamental value: *Gomphrena globosa* (Bachelor's button), *Celosia cristata* (Cocks comb) with remarkable faciated flowers. *Telanthera ficoidea* is grown for decorative purpose. Some members are used for culinary and leafy vegetable purpose – *Amaranthus, Alternanthera, Pupalia, Allmania,* etc. *Amaranthus caudatus* and *A. verticillatus* seeds are edible.

Some important local plants: *Acyranthes aspera, Aerva lanata, Allmania nodiflora, Alternanthera sessilis, Amaranthus viridis, Celosia argentea, Digera muricata, Gomphrena globisa, Pupalia lappacea*, and *Psilotrichum nudum.*



ARISTOLOCHIACEAE (Birthwort family)

Distribution: Aristolochiaceae represented 7 genera about 400 species in tropical regions of the world. In India, *Aristolochia* and *Thottea* are common genera.

Vegetative characters: Mostly shrubs, or lianas, or herbs; stem woody, climbing, or self supporting, or twining. **Leaves** alternate, spiral, flat, and membranous; petiolate, aromatic, simple. Lamina entire or dissected, when dissected, palmatifid (trilobed); palmately veined, or pinnately veined; often cordate. Leaves usually exstipulate.

Floral characters: Flowers solitary, or aggregated in cymes, or in racemes, or in spikes. The ultimate inflorescence unit cymose, or racemose, terminal, or axillary. Flowers small to large; often malodorous (smelling of carrion), or odourless , regular to very irregular; cyclic; tricyclic to pentacyclic. ***Perianth*** with distinct calyx and corolla, or petaline; 3, or 6; joined; 1 whorled, or 2 whorled (the corolla whorl conspicuous and well developed only in *Saruma*); when two-whorled, isomerous. Calyx 3; 1 whorled; gamosepalous; entire, or blunt-lobed; campanulate, or tubular (the tube often S-shaped); unequal but not bilabiate, or bilabiate, or regular; persistent, or not persistent; valvate (or valvate-induplicate). Corolla when present, 3 (usually reduced or absent); 1 whorled.

Androecium: Stamens 4, or 6, or 12(–36); isomerous with the perianth to polystemonous; filantherous, or with sessile anthers. Anthers cohering, or separate from one another; basifixed, or adnate; non-versatile; dehiscing via longitudinal slits; extrorse, or extrorse and introrse (*Heterotropa*); tetrasporangiate; appendaged (apically, with the expanded connective assuming stigmatic functions in association with the gynostemium), or unappendaged.

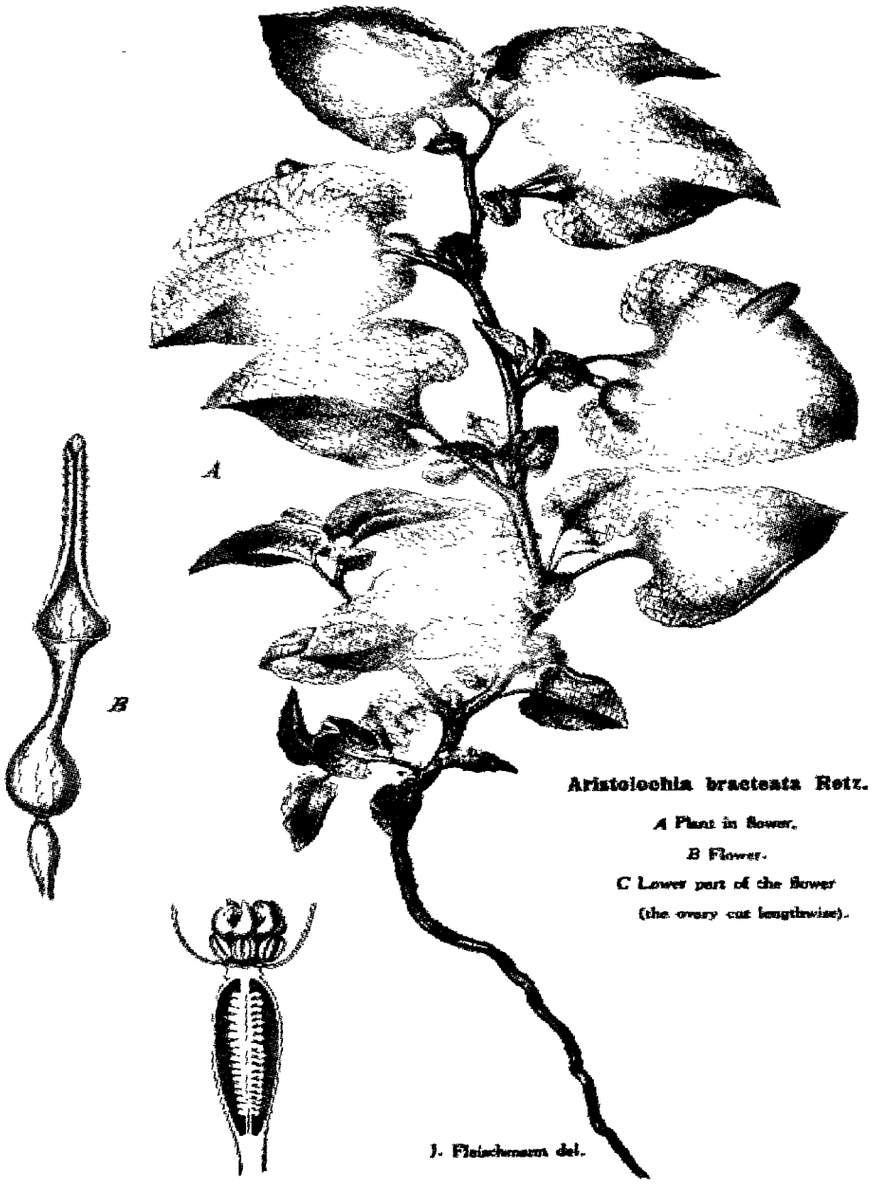
Gynoecium 4–6 carpelled. Carpels isomerous with the perianth to increased in number relative to the perianth. The pistil 1 celled, or 4–6 celled. Gynoecium syncarpous, synovarious (*Hexastylis*), or synstylovarious, or eu-syncarpous; partly inferior (sometimes), or inferior (usually). Ovary 4–6 locular, or 1 locular (the septa sometimes incompletely intruded). Epigynous disk present, or absent. Gynoecium stylate. Styles 1, or 4–6; free, or partially joined; apical. Stigmas dry type (mostly), or wet type, papillate; Placentation when unilocular, parietal; when plurilocular, axile. Ovules in the single cavity when unilocular, 50–100; when plurilocular, 20–50 per locule.

Fruit non-fleshy (usually), or fleshy (sometimes with a fleshy endocarp); dehiscent (usually), or indehiscent (rarely), or a schizocarp (*Saruma*). Mericarps in *Saruma*, 4–6; comprising follicles (*Thottea*). Fruit a capsule (usually), or a berry, or a nut. Capsules when dehiscent, septicidal and valvular (usually basally,

rarely at the top), or splitting irregularly. Seeds endospermic, endosperm ruminate, or non-ruminate; oily.

Important genera; *Apama, Aristolochia, Asarum, Euglypha, Holostylis, Saruma, Thottea.*

Economic uses: A few *Aristolochia* and *Asarum* spp. cultivated as ornamentals.



LORANTHACEAE (Mistletoe family)

Distribution: It consists of about 75 genera and 1,000 species of woody plants, many of them hemi-parasites, all of them except three having the mistletoe habit. The three terrestrial species are *Nuytsia floribunda* - the Western Australian Christmas tree, *Atkinsonia ligustrina* - a rare shrub of the Blue

Mountains of Australia, and the Central to South American species of *Gaiadendron punctatum*.

Vegetative characters: This is an interesting family of semiparasitic shrubs which obtain their nourishment from the host with the help of specially modified roots, called suckers on haustoria. Stem growth conspicuously sympodial. Mesophytic, or xerophytic. Leaves are simple, opposite, sometime alternate, rarely whorled; entire, leathery and exstipulate. In some species of *Viscum*, leaves are scaly and the stem is green and photosynthetic (cladode). Nodes are usually swollen.

Floral characters: Inflorescence is usually terminal, sometime axillary cymes, in racemes, in spikes, in fascicles, and in umbels. The ultimate inflorescence unit cymose (the flowers often in threes). Flowers bracteolate (the two bracteoles adnate to form a 'calyculus' external to the calyx); regular to somewhat irregular. The floral irregularity involving the perianth. Flowers cyclic; tetracyclic. Floral receptacle markedly hollowed, free hypanthium absent. In *Phoradendron*, flowers sunken into axile depressions. *Perianth* with distinct calyx and corolla, or petaline (the calyx much reduced, often to a mere rim), or absent in *Amyema*; usually dimeous, or trimerosu in *Viscum*. It consists of 5 lobes in *Loranthus;* polypetalous, or gamopetalous; valvate; often tubular (the tube often bent and split down one side); unequal but not bilabiate, or bilabiate, or regular; often yellow, or orange, or red.

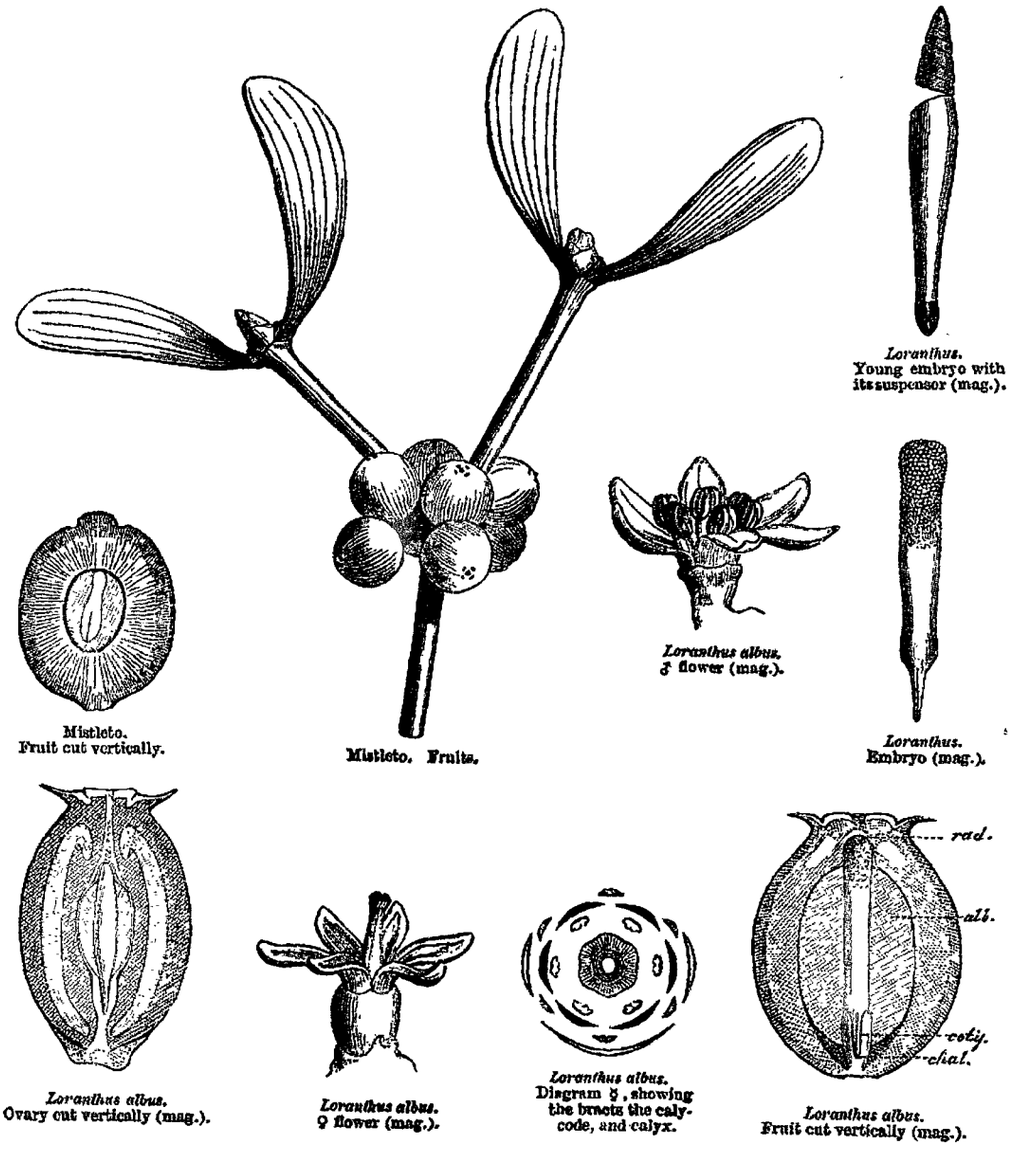
Androecium consists of stamens equal in number to the perianth lobes and opposite to them. Sometimes they attached, or completely fused with perianth lobes (*Viscum*). Anthers are dithecous, introrse or sometimes with numerous chambers. Dehiscence is by longitudinal or transverse slits or by pores. Pistillode is commonly seen in the male flower.

Gynoecium is 3-carpelled, or 4-carpelled. The pistil 1 celled. Gynoecium syncarpous; synstylovarious, or eu-syncarpous; inferior. Ovary 1 locular. Placentation basal. Ovules not differentiated; in the single cavity 4–12; sessile;

non-arillate; not clearly differentiated from the placenta; without integuments; without obvious nucellus.

Fruit is fleshy, or non-fleshy (rarely, e.g. *Nuytsia*); indehiscent; usually a berry, or a drupe (the fleshy part being receptacular), or a nut (*Nuytsia*). Seeds copiously endospermic. Endosperm oily. Seeds covered with viscous material; without a testa.

Important genera; *Elytranthe*, *Erianthemum*, *Helicanthes*, *Helixanthera*, *Loranthus*, *Loxanthera*, *Macrosolen*, *Nuytsia*, *Oliverella*, *Oryctanthus*, *Oryctina*, *Panamanthus*, *Papuanthes*, *Pedistylis*, *Peraxilla*, *Phragmanthera*, *Phthirusa*, *Plicosepalus*, *Psittacanthus*, *Scurrula*, *Septulina*, *Socratina*, *Sogerianthe*, *Spragueanella*, *Struthanthus*, *Tapinanthus*, *Taxillus*, *Tetradyas*, *Thaumasianthes*, *Tolypanthus*, *Trithecanthera*, *Tupeia*, *Vanwykia*.



HYDROCHARITACEAE (Tape grass family)

Distribution: This family comprises 16 genera and nearly 100 species. All of them are hydrophytes, indigenous to the waters of the warmer parts of the world. 3 genera are marine (*Ehnalus, Halophila* and *Thalassia*) while the fresh water forms are seen in tropical regions, extending into temperate zones.

Vegetative characters: Mostly perennial aquatic herbs; with a basal aggregation of leaves, or with neither basal nor terminal aggregations of leaves. Leaves submerged, or emergent, or floating, or submerged and emergent, or submerged and floating. Leaves alternate, or opposite, or whorled; spiral, or distichous; petiolate, or sessile, sheathing to non-sheathing. Lamina entire; linear, or oblong to orbicular (usually with ribbonlike submerged leaves); one-veined, or

pinnately veined, or palmately veined, or parallel-veined, stipulate, or exstipulate.

Floral characters: Inflorescence is scapiflorous, or not scapiflorous; axillary; few flowered cymes; spatheate (the spathe formed of (1-)2 connate bracts). **Flowers** small; regular, or somewhat irregular (*Vallisneria*). The floral irregularity involving the perianth. Flowers 3 merous; partially acyclic. The gynoecium acyclic. Perigone tube present, or absent. Perianth with distinct calyx and corolla, or of tepals; 6, or (2–)3; free, or joined; 2 whorled; isomerous; if not resolvable into calyx and corolla, sepaloid, or petaloid; similar in the two whorls (then semipetaloid), or different in the two whorls; white, or yellow, or red, or purple, or blue. Calyx (2–)3; 1 whorled; polysepalous (sometimes from a hypanthium); regular. Corolla when present, 3; 1 whorled; polypetalous (attached to the gynoecium or to the perigone tube). Petals clawed, or sessile.

Androecium consists of exclusively fertile stamens, 2 -25, or including staminodes (the innermost or outermost members often constituting staminodal nectaries). Staminodes external to the fertile stamens, or internal to the fertile stamens. Anthers dehiscing via short slits; generally extrorse; bisporangiate, or tetrasporangiate.

Gynoecium is (2–)3–6(–20) carpelled. The pistil 1–6(–20) celled, syncarpous; synovarious to synstylovarious; inferior. Ovary 1 locular (but often with deeply intruding partial partitions). Locules partially secondarily divided by false septa, or without false septa. Styles (2–)3–6(–20) (but often individually bifurcated, and then seeming to be twice as many as the carpels); partially joined; apical. Stigmas dry type; non-papillate; Placentation laminar-dispersed, or basal (e.g. *Elodea*). Ovules in the single cavity 12–100 , pendulous to ascending; non-arillate; orthotropous (rarely), or hemianatropous to anatropous; bitegmic; crassinucellate.

Fruit is fleshy, or non-fleshy; dehiscent, or indehiscent (often opening by decay); a capsule, or capsular-indehiscent. Capsules splitting irregularly

(underwater). Dispersal by water. Seeds scantily endospermic (*Otelia*), or non-endospermic (usually). Seeds with starch.

Important genera: *Apalanthe*, *Appertiella*, *Blyxa*, *Egeria*, *Elodea*, *Enhalus*, *Halophila*, *Hydrilla*, *Hydrocharis*, *Lagarosiphon*, *Limnobium*, *Maidenia*, *Nechamandra*, *Ottelia*, *Stratiotes*, *Thalassia*, *Vallisneria*.

Economic importance: This family is not much of economic importance. Leaves of *Vallisneria* are used in refining sugar. *Limnobium* is an aquarium plant in water gardens.

DIOSCOREACEAE (Yam family)

Distribution: Dioscoreaceae is a family of monocotyledonous flowering plants, with about 750 species in 9 genera distributed in tropical zones of the world. The best-known member of the family is the Yam (*Dioscorea*).

Vegetatice characters: Mostly shrubs, or herbs, or lianas, rhizomatous, or tuberous (the tubers giving rise to annual stems). Climbing (usully), or self supporting (rarely); mostly stem twiners, or scrambling (or trailing); *Tamus* twining clockwise. Leaves alternate, or opposite (rarely); usually spiral; petiolate; sheathing to non-sheathing; simple, or compound; when compound, palmate (with three to six or more leaflets). Lamina entire, or dissected (occasionally); when incised, palmatifid; basically palmately veined; cross-venulate; often cordate, or sagittate, stipulate, or exstipulate.

Floral characters: Flowers aggregated in inflorescences, in panicles, in racemes, and in spikes. The ultimate inflorescence unit racemose, usually axillary. Flowers bracteate; bracteolate (one bracteole, rarely two); small (generally inconspicuous); regular; 3 merous. Perigone tube usually present (short).Perianth of tepals, 6; joined; 2 whorled; isomerous; sepaloid, or petaloid; similar in the two whorls, or different in the two whorls.

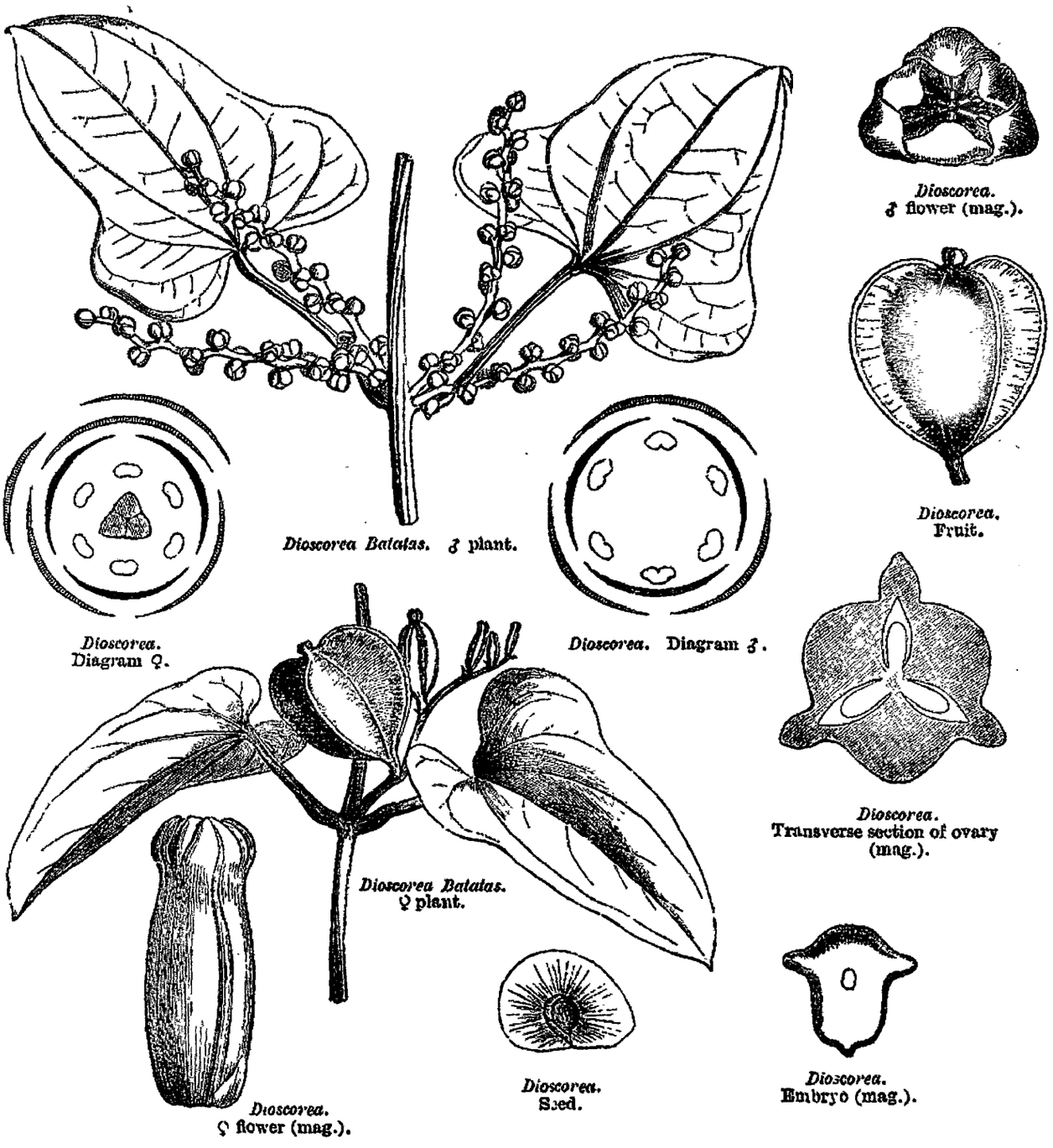
Androecium stamens usually 6, or 3 (the inner whorl sometimes missing); free of one another, or coherent; when cohering 1 adelphous (the filaments connate into a tube); 2 whorled (usually), or 1 whorled (by reduction). Staminodes when present,

3; internal to the fertile stamens, isomerous with the perianth, or diplostemonous. Anthers dorsifixed, or adnate; dehiscing via longitudinal slits; extrorse, or introrse; appendaged, or unappendaged.

Gynoecium is 3 carpelled. The pistil 3 celled. Gynoecium syncarpous; synovarious to synstylovarious; inferior. Ovary 3 locular. Gynoecium stylate. Styles 1, or 3; free, or partially joined; apical. Stylar canal present. Stigmas dry type; non-papillate; Placentation axile. Ovules 2 per locule (usually), or 3–50 per locule, pendulous; superposed; non-arillate; anatropous; bitegmic; crassinucellate.

Fruit is fleshy, or non-fleshy; dehiscent, or indehiscent; a capsule, or a berry (*Tamus*), or a samara (*Rajania*). Capsules loculicidal. Seeds endospermic. Endosperm oily. Seeds winged (e.g. *Dioscorea*), or wingless. Seeds without starch.

Economic importance: Several members are important food plants, notably yams (*Dioscorea*).



ARECACEAE (Palm family)

Distribution: The family comprises 150 genera and 1,200 species which are exclusively tropical in distribution.

Vegetative characters: They form a feature of vegetation, mostly attaining the size of trees. While *Cocos* (coconut) and others are found along the coastal regions, *Nipha* forms a member of esturial flora of Sundarbans of our country. The stem is usually an unbranched erect one with a crown of leaves at the top. Branched condition is exceptional in many forms, but it is a common in *Hyphaene*. The internodes are short but in the stem of *Calamus*, internodes are

thin and long. It shows the straggling habit hold of support by means of recurved spines in the terminal part of rachis that is whip like. The stem is normally straight with broad leaf-scars or persistent leaf bases on the older part of stem. Leaves forms crown at the tip of the stem. They are compactly arranged leaf base with leaf sheaths. The petiole is long with blade that is incised in various degrees in a palmate or pinnate manner, accordingly the plants are called fan plams or feather plams respectively. They are bipinnately deeply dissected in *Corypha* and *Caryota*. Leaves are coriaceous and xerophytic. The venation is parallel.

Floral characters: Inflorescence is usually axillary, but in monocarpic forms like *Corypha umbraculifera* and *Metroxylon rumphii* it is terminal. It is usually covered by one or several, broad, leathery bracts that are called spathes. They enclose and protected the simple or much branched inflorescence axis in the young condition. The sessile flowers are sometimes embedded in the axis.

Flowers are sessile, usually unisexual, monoecious (*Cocos*) or dioecious (*Borassus* and *Phoenix*). They are bisexual in *Pritchardia* and polygamous in *Chamaerops*. Flowers are usually small, trimerous, hypogynous, and actinomorphic. Sterile structures are seen in the flowers of the opposite sex.

Perianth is in 2 trimerous whorls. The perianth lobes may be distinguished into sepals and petals by their size alone. They are usually leathery but scaly in *Phytelephas*. The perianth lobes are free or united showing valvate or imbricate aestivation. It is persistent in female flowers.

Androecium consists of 6 stamens. They are in 2 trimerous whorls, but in *Areca* in one whorl. They are free with dithecous, introrse, versatile anthers that dehisce by longitudinal slits. In the female flowers of *Cocos* and *Borassus*, the staminodes are represent as a ring with six teeth.

Gynoecium is 3-carpellary (bicarpellary in *Corypha*), syncarpous (apocarpous in *Phoenix*). The ovary is superior, style is short and stigma is capitates. There is one ovule in each chamber and usually only one carpel is functional. The placentation is axile or basal.

Fruit is berry in *Phoenix* and a fibrous drupe in *Cocos*. The seed is monocotyledonous and endospermic. Endosperm is oily in *Cocos*, cellulose in *Phytelephas*, ruminate in *Areaca*.

Important plants: *Areca catechu, Arenga wightii, Borassus flabellifer, Caryota urens, Cocos nucifera, Calamus rotung, Corypha umbraculifera, Elaeis guineensis, Lodoicea maldevica, Nipha fruticans, Phoenix dactylifera.*

Economic importance: The woods of *Borassus* and *Cocos* are used for poles and rafters. The reedy stem of *Calamus rotung*, cane is used for making baskets, caskets, cradles, chairs etc. Sugar containing sap (toddy) is obtained by tapping the inflorescence of *Mauritia vinifera, Borassus flabellifer, Phoenix sylvestris, Cocos nucifera, Arenga wightii*. Fibers are obtained from the leaf bases, blade of leaves, or mesocarp of the fruits of *Borassus flabellifer, Leopoldenia piassaba, Attalea, Cocos*. The fibers are used in coir-pith industry and also in the making of mats, baskets, hats etc. Wax is obtained by scraping the leaves of *Copornicia cerfera*, the stem of *Ceroxylon andicolum*. It is used in the making of gramophone discs and candles. The fruits of *Cocos* and *Borassus* are edible. Oil is obtained from the fruits of *Elaeis guineensis* and *Cocos nucifera*. The endosperm of *Phytelephas* is vegetable ivory. Young buds of *Euterpe, Cocos, Phoenix*, and *Attalea* are used as cabbage.

CYPERACEAE (Sedge family)

Distribution: Cyperaceae are a family of monocotyledonous graminoid flowering plants known as sedges, which superficially resemble grasses or rushes. The family is large, with some 5,500 species described in about 109 genera world over.

Vegetative characters: Usually marshy herbs, sometimes with the principal photosynthesizing function transferred to stems. Annual, or biennial, or perennial; with a basal aggregation of leaves, or with neither basal nor terminal aggregations of leaves. Young stems not breaking easily at the nodes, rhizomatous, or tuberous.

Hydrophytic, or helophytic, or mesophytic, or xerophytic (rarely, e.g. *Caustis*); when hydrophytic, free floating, or rooted. Leaves of aquatics submerged and emergent. Leaves simple, alternate; spiral, or distichous (often), or tristichous (usually); flat, or folded (and occasionally plicate), or rolled, or terete; sessile, or petiolate (occasionally); sheathing. Lamina entire; setaceous, or acicular, or linear to obovate; parallel-veined; cross-venulate, or without cross-venules. Vernation conduplicate, or plicate, or involute, or revolute, or convolute.

Floral characters: Inflorescences with the spikelets often numerous, in branched, paniculate inflorescences. Flowers bracteate, or ebracteate; bracteolate (each borne in the axil of a 'glume'); usually small, or minute. Perigone tube absent. Hypogynous disk absent (usually), or present (in a few genera). Perianth of tepals, or vestigial (represented by bristles or hairs), or absent; when present, often 6; free; sometimes more or less sepaloid.

Androecium: Stamens 1–3, or 4–6(–22). Anthers filamentous, basifixed; introrse, or latrorse; tetrasporangiate; appendaged (via prolongation of the connective into an apiculus), or unappendaged.

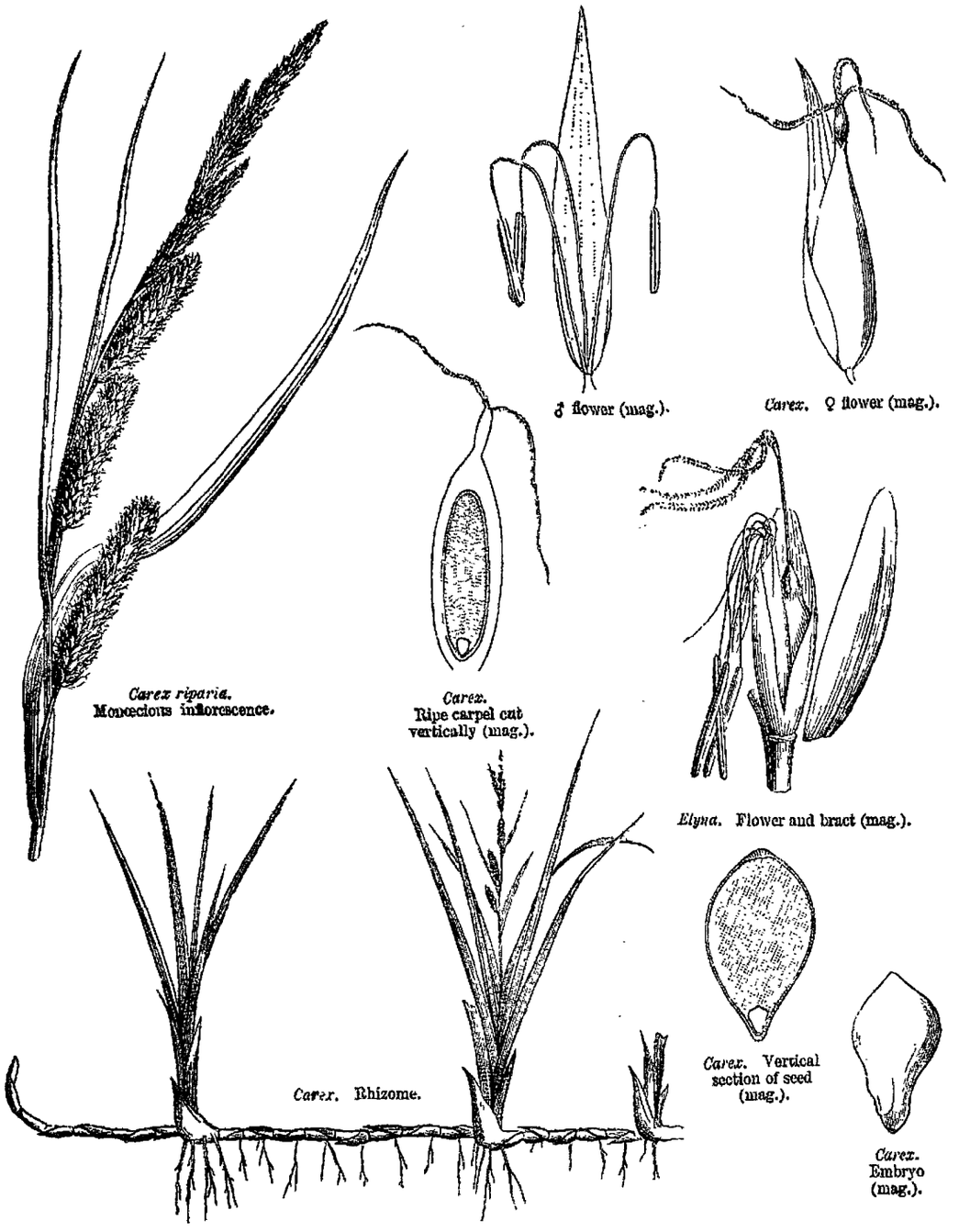
Gynoecium is 2 carpelled, or 3(–4) carpelled, 1 celled. Gynoecium syncarpous; synovarious to synstylovarious; superior. Ovary 1 locular. Styles 2–3; free to partially joined. Stigmas (1–)2, or 3(–15); dry type; papillate, or non-papillate; Placentation basal. Ovules in the single cavity 1; non-arillate; anatropous; bitegmic; crassinucellate.

Fruit is non-fleshy; indehiscent; achene-like, or a drupe (very rarely). The drupes with one stone. Fruit 1 seeded. Seeds endospermic.

Important genera; *Bulbostylis*, *Carex*, *Chrysitrix*, *Courtoisina*, *Crosslandia*, *Cyathochaeta*, *Cyperus*, *Desmoschoenus*, *Didymiandrum*, *Diplacrum*, *Diplasia*, *Dulichium*, *Egleria*, *Eleocharis*, *Eriophorum*, *Erioscirpus*, *EFimbristylis*, *Fuirena*,

Gahnia, *Gymnoschoenus*, *Hellmuthia*, *Hemicarpha*, *Hymenochaeta*, *Hypolytrum*, *Isolepis*, *Kobresia*, *Kyllinga*, *Kyllingiella*, *Lagenocarpus*, *Lepidosperma*, *Lepironia*, *Lipocarpha*, *Lophoschoenus*, *Machaerina*, *Mapania*, *Mapaniopsis*, *Mariscus*, *Paramapania*, *Phylloscirpus*, *Pleurostachys*, *Principina*, *Pseudoschoenus*, *Ptilanthelium*, *Pycreus*, *Reedia*, *Schoenoplectus*, *Schoenoxiphium*, *Schoenoides*, *Schoenus*, *Scirpodendron*, *Scirpoides*, *Scirpus*, *Scleria*, *Tetraria*, *Tetrariopsis*, *Thoracostachyum*, *Torulinium*, *Trachystylis*, *Trianoptiles*, *Trichoschoenus*, *Tricostularia*, *Trilepis*, *Tylocarya*, *Uncinia*, *Vesicarex*, *Volkiella*, *Websteria*.

Economic importance: Some noxious weeds, otherwise of little economic importance - *Cyperus papyrus* is of historical interest in connection with papermaking, and that genus furnishes a few watergarden ornamentals; *Cyperus esculentus* has edible rhizomes.



ECONOMIC BOTANY

Economic botany usually deals with the all pervading plants in relation to human welfare as food, clothing, shelter, medicine etc., either directly or indirectly. Plants bring about economy to the country at large and it is a fact that the wealth of any country largely depends upon its agriculture and plant products. Hence economic botany embodies many disciplines of science other than botany. This science has wide scope to study include crop plants, timber woods, medicinal plants, spice and condiments, oil yielding plants and medicinal plants.

Crop plants: A crop is a cultivated plant whose product is harvested by man at some point of its growth stage. Major crops include sugarcane, maize, rice, wheat, brinjal, potatoes, soy beans, cucurbits, cassava, cotton, etc.

Classification Based on growing season:

1. **Kharif/Rainy/Monsoon crops:** The crops grown in monsoon months from June to Oct-Nov, Require warm, wet weather at major period of crop growth, also required short day length for flowering. E.g. Cotton, Rice, Jowar, etc.
2. **Rabi/winter/cold seasons crops:** require winter season to grow well from Oct to March month. Crops grow well in cold and dry weather. Require longer day length for flowering. E.g. Wheat, gram, sunflower etc.
3. **Summer crops:** crops grown in summer month from March to June. Require warm day weather for major growth period and longer any length for flowering. E.g. Groundnuts, Watermelon, Pumpkins, Gourds.

Agronomic classification:

1. **Grain crops:** Cereals and millets are the cultivated grasses grown for their edible starchy grains. The larger grain used as staple food is cereals. E.g. rice, Jowar, wheat, maize, barley, and millets are the small grained cereals which are of minor importance as food. E.g. Bajara.
2. **Pulse/legume crops:** Seeds of leguminous crops plant used as food. On splitting they produced dal which is rich in protein. E.g. green gram, black gram, soybean, pea, cowpea etc.
3. **Oil seeds crops:** Crop seeds are rich in fatty acids, are used to extract vegetable oil to meet various requirements. E.g. Groundnut, Mustard, Sunflower, Sesamum, linseed etc.
4. **Forage Crop:** It refers to vegetative matter fresh as preserved utilized as food for animals. Crop cultivated and used for fickler, hay, silage. E.g. sorghum, elephant grass, guinea grass, etc.

5. **Fiber crops:** Grown for fiber yield. Fiber may be obtained from seed. E.g. Cotton, sun hemp and flax.
6. **Roots crops:** Roots are the economic produce in root crop. E.g. sweet, potato, sugar beet, carrot, turnip etc.
7. **Tuber crop**: Crop whose edible portion is not a root but a short thickened underground stem. E.g. Potato, elephant yam.
8. **Sugar crops:** The two important crops are sugarcane and sugar beet cultivated for production for sugar.
9. **Starch crops:** Grown for the production of starch. E.g. tapioca, potato, sweet potato.
10. **Drug crop:** Used for preparation for medicines. E.g. tobacco, mint, pyrethrum.
11. **Spices & condiments:** Crop plants as their products are used to flavor taste and sometime color the fresh preserved food. E.g. ginger, garlic, cumin, onion, coriander, cardamom, pepper, turmeric etc.
12. **Vegetables crops:** May be leafy as fruity vegetables. E.g. Palak, mentha, brinjal, tomato.
13. **Green manure crop:** Grown and incorporated into soil to increase fertility of soil. E.g. sun hemp.
14. **Medicinal & aromatic crops:** Medicinal plants includes cinchona, opium poppy, senna, belladonna, raufofia, lycorice and aromatic plants such as lemon grass, citronella grass, palmorsa, Japanese mint, peppermint, rose geranium, jasmine, henna etc.

Classification based on life of crops/duration of crops:

1. **Seasonal crops:** A crop completes its life cycle in one season-Karin, Rabi. summer. E.g. rice, Jowar, wheat etc.
2. **Two seasonal crops:** Crops complete its life in two seasons. E.g. Cotton, turmeric, ginger.
3. **Annual crops:** Crops require one full year to complete its life in cycle. E.g. sugarcane.

4. **Biennial crops:** Crop which grows in one year and flowers, fructifies & perishes the next year. E.g. Banana, Papaya.
5. **Perennial crops:** crops live for several years. E.g. Fruit crops, mango, guava etc.

Classification based on cultural method/water:

1. **Rain fed:** crops grow only on rain water. E.g. Jowar, Bajara, Mung etc.
2. **Irrigated crops:** Crops grows with the help of irrigation water. E.g. Chili, sugarcane, Banana, papaya etc.

Classification based on root system:

1. Tap root system: The main root goes deep into the soil. E.g. Tur, Grape, Cotton etc.

2. Adventitious/Fiber rooted: The crops whose roots are fibrous shallow & spreading into the soil. E.g. Cereal crops, wheat, rice etc.

Classification based on economic importance:

Cash crop: Grown for earning money. E.g. Sugarcane, cotton.

Food crops: Grown for raising food grain for the population and & fodder for cattle. E.g. Jowar, wheat, rice etc.

Cultivation and utilization of selected crops

Rice: *Oryza sativa* (Poaceae)

Rice is one of the chief grains of India. Moreover, this country has the biggest area under rice cultivation, as it is one of the principal food crops. It is in fact the dominant crop of the country. India is one of the leading producers of this crop. Rice is the basic food crop and being a tropical plant, it flourishes comfortably in hot and humid climate. Rice is mainly grown in rain fed areas that receive heavy annual rainfall. That is why it is fundamentally a kharif crop in India. It demands temperature of around 25 degree Celsius and above and rainfall of more than 100 cm. Rice is also grown through irrigation in those areas that receives comparatively less rainfall. Rice is the staple food of eastern and southern parts

of India. Winter rice crop is a long duration crop and summer rice crop is a short duration crop. At some places in the eastern and southern parts of India, rice crop of short duration is followed by the rice crop of long duration. Winter rice crop is raised preferably in low lying areas that remain flooded mainly during the rainy season.

Uses of Rice:

Staple food: Rice is used as a staple food by more than 60 percent of world population. Cooking of rice is a most popular way of eating.

Starch: Rice starch is used in making ice cream, custard powder, puddings, gel, distillation of potable alcohol, etc.

Rice bran: It is used in confectionery products like bread, snacks, cookies and biscuits. The defatted bran is also used as cattle feed, organic fertilizer (compost), and medicinal purpose and in wax making.

Rice bran oil: Rice bran oil is used as edible oil, in soap and fatty acids manufacturing. It is also used in cosmetics, synthetic fibers, detergents and emulsifiers. It is nutritionally superior and provides better protection to heart.

Flaked rice: It is made from parboiled rice and used in many preparations.

Puffed rice: It is made from paddy and used as whole for eating.

Parched rice: It is made from parboiled rice and is easily digestible.

Rice husk: It is used as a fuel, in board and paper manufacturing, packing and building materials and as an insulator. It is also used for compost making and chemical derivatives.

Rice broken: It is used for making food item like breakfast cereals, baby foods, rice flour, noodles, rice cakes, etc. and also used as a poultry feed.

Rice straw: Mainly used as animal feed, fuel, mushroom bed, for mulching in horticultural crops and in preparation of paper and compost.

Maize: *Zea mays* (Poaceae)

The maize plant is often 2.5 m (meters) (8 ft) in height, though some natural strains can grow 10 m. The stem has the appearance of a bamboo cane and is commonly composed of 20 internodes of 18 cm length. The apex of the stem ends in the tassel, an inflorescence of male flowers. When the tassel is mature and conditions are suitably warm and dry, anthers on the tassel dehisce and release pollen. Elongated stigmas, called silks, emerge from the whorl of husk leaves at the end of the ear. They are often pale yellow and 178 mm in length, like tufts of hair in appearance. At the end of each is a carpel, which may develop into a "kernel" if fertilized by a pollen grain. The pericarp of the fruit is fused with the seed coat referred to as "caryopsis", typical of the grasses, and the entire kernel is often referred to as the "seed". The cob is close to a multiple fruit in structure, except that the individual fruits (the kernels) never fuse into a single mass. The grains are about the size of peas, and adhere in regular rows around a white, pithy substance, which forms the ear

Many forms of maize are used for food, sometimes classified as various subspecies related to the amount of starch each has:

- Flour corn — *Zea mays* var. *amylacea*
- Popcorn — *Zea mays* var. *everta*
- Dent corn — *Zea mays* var. *indentata*
- Flint corn — *Zea mays* var. *indurata*
- Sweet corn — *Zea mays* var. *saccharata* and *Zea mays* var. *rugosa*
- Waxy corn — *Zea mays* var. *ceratina*
- Amylomaize — *Zea mays*
- Pod corn — *Zea mays* var. *tunicata*
- Striped maize — *Zea mays* var. *japonica*

Spice and condiments

A spice is a dried seed, fruit, root, bark or vegetative substance primarily used for flavoring, coloring or preserving food. Sometimes a spice is used to hide other flavours. It is also used for medicine, pharmaceuticals, perfumery and cosmaceuticals. Many spices have antimicrobial properties which suppress the growth of microbes in food items. Spice may be used for other purposes like medicinal, religious and rituals, cosmetic and perfumes or as a vegetable. For example, turmeric rhizomes are consumed as vegetable and garlic as an antibiotic. A condiment is an edible supplement substance which is used to be added to some foods to impart a particular flavor or enhance its flavor or in some culture, to complement the dish.

Important spices and flavoring materials.

Sl. No.	Plant species	Family	Parts used
1.	*Angelica archangelica*	Apiaceae	Roots and fruits
2.	*Alipinia galanga*	Zingiberaceae	Rhizome
3.	*Armoracia lepathifolia*	Brassicaceae	Roots
4.	*Curcuma amada*	Zingiberaceae	Rhizome
5.	*Ferula asafetida*	Apiaceae	Resin from root
6.	*Allium sativum*	Liliaceae	Bulb
7.	*Crocus sativus*	Iridaceae	Stigmas and style
8.	*Capparis spinosa*	Capparidaceae	Flower buds
9.	*Carum carvi*	Apiaceae	Fruits
10.	*Cuminum cyminum*	Apiaceae	Fruits
11.	*Apium graveolens*	Apiaceae	Fruits
12.	*Piper longum*	Piperaceae	Fruits
13.	*Illicium verum*	Illiciaceae	Fruits
14.	*Vanilla planifolia*	Orchidaceae	Fruits
15.	*Elettaria cardamomum*	Zingiberaceae	Fruits
16.	*Trigonella foenum-graecum*	Fabaceae	Seeds

17.	*Brassica juncea*	Brassicaceae	Seeds
18.	*Myristica fragrans*	Myristicaceae	Seeds and aril
19.	*Nigella sativa*	Ranunculaceae	Seeds
20.	*Mentha piperita*	Lamiaceae	Leaves
21.	*Gaultheria fragrantissima*	Ericaceae	Leaves
22.	*Ruta graveolens*	Rutaceae	Leaves
23.	*Murrya koenigii*	Rutaceae	Leaves
24.	*Ocimum basilicum*	Lamiaceae	Leaves
25.	*Origanum vulgare*	Lamiaceae	Leaves

Cultivation of spices and condiments

Turmeric: *Curcuma longa*

Family: Zingiberaceae

Uses of Turmeric: Used as a conditioner. Useful as a dye wife varied uses in drug and cosmetic industries. Used medicinally for external application and consumed as a stimulant.

Area and Production: India is the largest producer of turmeric with a annual production of 3.49 lakh tones (1991-92) and 4.35 lakh tones (96-97). The turmeric export-stands at 18.95 thousand, tones (92-93) and 25 M thousand tones (96-97). The major producing states are Tamil Nadu, Andhra Pradesh and Orissa.

Soil: Different kinds of soils such as sandy loam to clay loam or alluvial soils are suitable. Well-drained loamy soils are the best. Soil should be rich in organic matter and uniform in texture. Turmeric cannot withstand water stagnation or alkalinity.

Cultivation of Turmeric: Seed Material: Seed of turmeric consists of rhizomes. Both mother and finger rhizomes are used. The fingers are cut into pieces, each 4-5 cm long with 1-2 buds. Mother rhizomes are planted as such or split into two, each having one sound bud. Mother rhizomes are preferred since they give 50% more yields than the finger rhizome and also give good growth. Large sized, plumy and healthy mother rhizomes at least 100 g in weight should be used.

Method of Planting: On Flat Beds: (25 x 2.5 cm) in each direction. On ridges and furrows: 40-60 x 25 cm. Rhizomes are planted at 1/3rd height of ridge on broad ridge.

Manuring and Fertilization: Turmeric is a heavy feeder crop. In Maharashtra, on the basis of experiments conducted at Turmeric Research Station, Digraj recommended fertilizer dose is; 25-31 ton FYM, 120 kg N, 50 kg P205 and 50 kg K20/ha.

Harvesting: Harvesting is starting from February and continues till April. Rhizomes are ready for harvest in 7-9 months after planting. Usually Longa type - 9 months, Amada type - 8 months and Aromatica type - 7 months time for maturity. Turmeric is harvested when leaves start yellowing and ultimately the stem dries down. The aerial plant parts are cut close to the ground. The crop is irrigated lightly for easy digging. Harvesting consists of digging of underground clumps of rhizomes with pick axe or digging fork. Fingers are separated from mother rhizomes.

Cardamom: *Elettaria cordamomum* (Zingiberaceae)

The natural habitat of small cardamom is the evergreen forests of Western Ghats. It is grown in the area where the annual rainfall ranges from 1500-4000 mm, with a temperature of 10-35 ^{0}C and an altitude 600 – 1200 m (MSL). Cardamom is generally grown in forest loamy soils, which are usually acidic in nature with a pH range of 5.0 to 6.5.

Plant material: *E. cardamomum* var. *major* consisting of wild indigenous types and var. *minor* comprising cultivar types available in Horticulture Research Stations at Mysore, Malabar and Vazhukka. The types identified mainly based on the nature of panicle and shape of fruits.

Planting: 18 month old seedlings are used for planting in the main field. Before planting the seedling, land preparation is important, it consists of clearing all under growth and thinning out excess shade trees or branches in order to have an even overhead canopy. Pits into 45 x 45x 30 cm size may be dug in April-May

and filled with a mixture of top soil and compost or well rotten farm yard manure. Close planting 2 m x 1 m is advisable along the contour.

Cultural Practices: A regular schedule of cultural practices consisting of weeding, mulching, trashing, shad regulation, fertilizer application and irrigation are to be taken up from time to time.

Harvesting: The harvested fresh cardamom contains 72-85% moisture. The colour of the small cardamom at the time of maturity appeared dull green to yellowish green. The mature capsules are manually collected from the long parallel grown inflorescence. Further collected capsules, shade drying for removing the moisture content reduce to 10-15%. The dried capsule is yellowish green in colour, it shows the quality of oil content and flavor.

Fiber crops

Hemp: *Cannabis sativa* (Cannabinaceae)

It grows well in a wild humid and warm climate. It requires an annual rainfall of 30-35 cm, fertile humus rich loamy soil gives a very good yield of hemp.

Uses: The fiber obtained from the stem is used in the manufacture of cordage (ropes and twines), sacking, carpets, tarpaulins, thread, binder twine, bags and webbing etc. Fine quality fiber is used in the manufacture of coarse fabrics which look like a coarse linen cloth.

Cotton fiber: *Gossypium* spp. (Malvaceae)

Cotton is the most important fiber in the world. The fiber is obtained from the seed hairs (lint) of a few of the several species (about 20) of *Gossypium*. The cultivated and wild species are either diploid or tetraploid which haploid chromosomes of 13 and 26, respectively. The tetraploids include only the new world cottons, whereas all other species are dipliod.

Uses: Cotton alone or mixed with other fibers are used in the manufacture of various types of textiles. Absorbent cotton consisting of thoroughly cleaned fibers, which are almost pure cellulose, are basic raw materials for a number of cellulose industries. It is used in the manufacture of rubber-tire fabrics, in plastic reinforcing, carpeting and cordage. Unspun cotton is commonly used for stuffing

purposes. The stalks of the cotton plant can be used as a fuel. They also yield a fiber which can be used in paper making..

Timbers

Wooden logs cut for use usually called 'lumber'. Large sized lumber fit for heavy construction or carpentary is called 'timber. Timber may be used for number of purposes. **Structural purposes**: Sawed timbers obtained from large sized lumbers of preferably soft woods are used for the construction of residential and other buildings, bridges, and other types of heavy constructions. **Planning-mill products**: Big lumber is recut into smaller size for constructing doors, blinds, window frames, and interior finishing like baseboards, columns, stairwork, grills, etc. **Crating**: Timber is very widely used for manufacturing crates, boxes, baskets etc., for vegetables, canned goods, farm products, cosmetics, tea packets and instruments transport. Manufactured products: A number of items are manufactured from wood. They include furniture, railway wagons, vehicles, boats, musical instruments, matches, toys, picture frames, agriculture implements, and numerous other items.

Teak wood.

Morphology: It is a large deciduous tree. The branches are four-sided. Leaves are opposite, large, broad, ellipsoidal, rough, and glabrous. The plant bears small white flowers on branched paniculate inflorescence.

Quality and uses of teak wood: Teak is the most durable of the commercial timbers of the tropics. In Burma, the tree is usually seasoned by a girdling process in which a deep circular cut is made through the brown-grey bark, the sapwood, and the heart wood. The girdled tree dies after a few days. It is allowed to stand for one or two even more years for seasoning. An outstanding quality of a seasoned teak timber is that it dies not split, crack, shrink, warp or alter its shape. The wood contains an aromatic oil which is believed to be responsible for the great durability of the teak wood. It works easily and takes a fine polish. It does not corrode in contact with metal.

Uses of teak wood: It is used for ship building, boats, masts etc. It is widely used in construction of houses, pit porps in coal mine, railway wagons, and carriages. The wood is prized for high quality furniture, cabinet work, ornamental veneers, bowls, toys, musical instruments and numerous other things.

Dalbergia latifolia (Fabaceae)

Morphology: It is native of Peninsular India distributed throughout Indian subcontinent and Sri Lanka. It is large deciduous tree attaining a height of 60 ft and more. It has a trunk of 6 – 12 ft diameter. It bears compound leaves, each leaves have 6-12 leaflets. Yellowish white flowers are borne in axillary and terminal panicles.

Quality and uses: *Dalbergia* wood is well known for strength and elasticity. It is widely used for following purposes: It is very much used in building of boats, carts, carriages, agricultural implements etc. It is used in construction of buildings, doors and window frames. It is also a very good wood for furniture, interior decoration, cabinet works, and various carpentary works. The wood is also used for making toys, articles for decoration purposes, combs, sports items, drums, etc.

Sal wood: *Shorea robusta* (Dipterocarpaceae)

Morphology: It is a large branched tree distributed largely in northern India to southern Peninsula. Leaves are glabrous, long petioled, and broad-ovate lamina. It bears yellow flowers in racemes in large branched panicles.

Quality and uses: The sap wood is not durable but the heart wood is very strong, heavy and tough. It has cross-grained structure. The uses are: the timber is widely used for pit-props, bridge construction, railway sleepers, piles, boat building, mats, oars etc. Sal wood is also used for manufacturing interior quality furniture. It yields charcoal which is used by blacksmith. The bark of wood is used as tannin material.

Oils

Oils, fats and waxes have been in use by man since very ancient times. Chinese and Hindus were known to extract vegetable oils from oil bearing materials since pre-historic times. Vegetable oils and fats are triglycerides of complex organic fatty acids and they have very low percentage of oxygen. Oils, fats and waxes are very similar in their chemical composition. Oils are liquid at ordinary room temperatures, whereas fats are solid or nearly solid. Coconut oil, palm oil, cocoa butter are example for fats. Waxes are fatty acid esters of monohydroxy alcohols. They are found as protective coverings on the surfaces of leaves and stems which help in checking transpiration.

Vegetable oils differ from essential oils in the following respects: They do not volatize at room temperature, cannot be distilled without being decomposed, have a permanent greasy stain on paper, they form soaps with alkali, lack strong odour and become rancid after long exposure to air.

Major vegetable oils

	Name of oil	Plant source	Family	Extracted from
1.	Coconut oil	*Cocos nucifera*	Areacaceae	Seed kernel
2.	Corn oil	*Zea maize*	Poaceae	Seeds
3.	Cotton seed oil	*Gossypium* sp.	Malvaceae	Seeds
4.	Olive oil	*Olea europea*	Oleaceae	Seeds
5.	Plam oil	*Elaeis guieensis*	Arecaceae	Seed kernel
6.	Peanut oil	*Arachis hypogaea*	Fabaceae	Seeds
7.	Rapseed oil	*Brassica napus*	Brassicaceae	Seeds
8.	Safflower oil	*Carthamus tinctorius*	Asteraceae	Seeds
9.	Soybean oil	*Glycine max*	Fabaceae	Seeds
10.	Sesame oil	*Sesamum indicum*	Pedaliaceae	Seeds
11.	Sunflower oil	*Helianthus annuus*	Asteraceae	Seeds
12.	Castor oil	*Ricinus communis*	Euphorbiaceae	Seeds

These oils make up significant fraction of worldwide edible oil production and also used as fuels.

Oil palm: *Elaeis guineensis* (Arecaceae)

Morphology: The oil palm tree has stocky stem with crown of 20-40 large leaves at the top. It grows up to a height of 50 – 60 ft. Thick stem covered with leaf bases and stem has permanent leaf scar. The flowers are unisexual and the plant is monoecious. The lower leaves bears spadix of female flowers and the upper leaves produce spadix of male flowers. It bears as many as 200 -2000 fruits in a bunch. They formed twice in a year in the rainy season as well as in the dry season till the plant is about 40 years old.

Uses: Palm oil is widely used as a cooking medium. It is a source of Vitamin-A and also used for manufacture of candles, soaps and lubricants. Palm kernel oil is used for manufacture of shampoos, soaps, glycerine etc. It is also used in bakeries for preparing cakes, biscuits, butter like preparations etc.

Linseed oil: *Linum usitatissimum* (Linaceae)

Morphology: Linseed of flax is a source of an oil and fiber. It is a herbaceous annual herb reaching a height of 1-4 ft. The leaves are small, narrow and blunt at the apex. The inflorescence is terminal panicle of small white or blue flowers. The fruit is a capsule which is commonly known as the 'seed ball'. The seeds are quite small and flattened.

Uses: Linseed oil is a common carrier in oil paints, varnishes etc. It can also be used as a painting medium, making oil paints more fluid, transparent and glossy. The oil is used in the preparation of linoleum for floor covering. It is also used in food and nutritional supplements.

Castor oil: *Ricinus communis* (Euphorbiaceae)

Morphology: The plant is coarse and erect annual shrub. It grows several feet height and developed tap root system. The stem is hollow and branched all over its height. The leaves are large with long hollow petioled, lamina broad and palmately lobed. It bears terminal inflorescence and has unisexual flowers. The fruits are globular, spiny and with three seeded.

Uses: Castor is of medicinal value and also can be used as fuel and lubricant for machineries. It also has a number of industrial uses, used to manufacture soaps, inks, plastics, imitation leather, linoleum, oil cloth, nylon etc. The oil is also used for water proof in many articles. It is medium for some paints industries.

DRUG YIELDING PLANTS

Medicinal plants were known to man since the time immemorial. The history of drug plants is as old as the history of these civilizations. The Chinese are reported to have used drug plants as early as 5000-4000BC. The Assyrians, Babylonians, Hebrews, and Egyptians knew many drug plants in about 1600Bc. The works of Greek *viz.* Aristotle (384-322BC), Hippocrates (460-370BC), Pythagoras and Theophrastus (370-287BC) have numerous references of many of the present day drugs. In 77BC, a Roman physician Dioscorides work 'De Materia Medica' which described the nature and properties of all the 500 medicinal plants known at that time. His book was considered to be the most authentic work on medicinal plants for the next 16 centuries or so. After introduction of printing in Europe in the 15th century, many persons published 'herbals' which contained many information on medicinal drugs. In the present times, medicinal science has paid great attention to the study of drug plants. The branch of medicinal science which deals with the drug plants is called phramacognosy, whereas the study of te action of drug is called pharmacology.

Medicinal drugs

Aconite: *Aconitum napellus* (Ranunculaceae)

It is an herbaceous rhizomatous perennial plant growing to 1 m tall, with hairless stems and leaves. The leaves are rounded, 5–10 cm diameter, palmately divided into five to seven deeply lobed segments. The flowers are dark purple to bluish-purple, narrow oblong helmet-shaped, 1–2 cm tall.

Uses: Tuberous roots are the useful part of this plant. Aconite produced from the roots of a number of different species of *Aconitum* is used ethnomedically in traditional Indian and Chinese medicine, to treat "coldness", general debility, and Yang deficiency. Misuse of the medicinal ingredients contained in this plant can negatively affect the cardiovascular and central nervous systems, thus resulting in death. Aconites have been used more recently in characterized Chemical alkaloids aconitine, mesaconitine, hypaconitine and jesaconitine, which are highly toxic.

Ashwagandha: *Withania somnifera* (Solanaceae)

It grows as a woody herb (35–75 cm) with a central stem from which branches extend radially in a star pattern (stellate) and covered with a dense matte of wooly hairs (tomentose). The flowers are small and green, while the ripe fruit is orange-red and has milk-coagulating properties. The plant's long, brown, tuberous roots are used for medicinal purposes.

Uses: In Ayurveda, the berries and leaves of *W. somnifera* are locally applied to tumors, tubercular glands, carbuncles, and ulcers. The roots of *W. somnifera* are used to prepare the herbal remedy ashwagandha, which has been traditionally used to treat various symptoms and conditions. The main chemical constituents are alkaloids and steroidal lactones. These include tropine and cuscohygrine. The leaves contain the steroidal lactones, withanolides, notably withaferin A, which was the first withanolide to be isolated from *W. somnifera*. Ashwgandha has long been considered as an excellent rejuvenator, a general health tonic and a cure for a

number of health complaints. It is a sedative, diuretic, anti-inflammatory and generally respected for increasing energy, endurance, and acts as an-adaptogen that exerts a strong immunostimulatory and an-anti-stress agent. Ashwagandha is taken for treating cold and coughs, ulcers, emaciation, diabetes, conjunctivitis, epilepsy, insomnia, senile dementia, leprosy, Parkinson's disease, nervous disorders, rheumatism, arthritis, intestinal infections, bronchitis, asthma, impotence and a suppressant in HIV/AIDS patients.

Belladona: *Atropa belladonna* (Solanaceae)

Atropa belladonna is a branching herbaceous perennial, often growing as a subshrub, from a fleshy rootstock. Plants grow to 1.5 metres tall with 18 cm long ovate leaves. The bell-shaped flowers are tyrian purple with green tinges and faintly scented. The fruits are berries, which are green ripening to a shiny black, and approximately 1 cm in diameter.

Uses: The whole plant is considered as medicinal. Drops prepared from the belladonna plant were used to dilate women's pupils, an effect considered attractive Belladonna drops act as an antimuscarinic, blocking receptors in the muscles of the eye that constrict pupil size. Belladonna is currently rarely used cosmetically, as it carries the adverse effects of causing minor visual distortions, inability to focus on near objects, and increased heart rate. Prolonged usage was reputed to cause blindness. Belladonna is used in ointments that are applied to the skin for joint pain (rheumatism), leg pain caused by a disc in the backbone pushing on the sciatic nerve (sciatica), and nerve pain (neuralgia). Belladonna is also used in plasters (medicine-filled gauze applied to the skin) for treating psychiatric disorders, a behavior disorder called hyperkinesis, excessive sweating (hyperhidrosis), and bronchial asthma. The homeopathic uses of *Atropa belladonna* plant, many homeopaths uses this plant for the treatment of fever, common cold, coughs, arthritis, menstrual cramps, headaches, stomach upsets,

nerve pain, inflammation of the brain or spinal cord, depression, insomnia flu, boils and abscesses.

Glory lily: *Gloriosa superba* (Liliaceae)

Gloriosa are perennial herbs that climb or scramble over other plants with the aid of tendrils at the ends of their leaves and can reach 3 meters in height. They have showy flowers, many with distinctive and pronouncedly reflexed petals, like a Turk's cap lily, ranging in colour from a greenish-yellow through yellow, orange, red and sometimes even a deep pinkish-red. The underground rhizome is very characteristic and L-shaped.

Uses: In Ayurveda and Yunani systems of medicine it is a reputed medicine. According to Ayurveda, tuber is pungent, bitter, acrid, heating, anthemirtic, laxative, alexiteric, abortifacient, and useful in ulcers, leprosy, piles, inflammation, abdominal pains, itching and thirst. Seed contain high level of colchicines. Cornigerine, 3-demethyl-N-formyl-N-deacetyl-b-lumicolchicine, 3-demethyl-g-lumicolchicine, 3-demethyl colchicines have been isolated from plant. b-sitosterol, its glucoside, a long chain fatty acid, b and g-lumiccolchicines from fresh tubers and luteolin, colchicines, N-formyldeacetylcolchicines and glucosides of 3-demethylcolchicine have been isolated from flowers.

Sarpagandha: *Rauvolfia serpentina* (Apocynaceae)

Sarpagandha is an erect, evergreen sub-shrub. This plant is 0.2m to 0.6 m tall. The stem has no branch and has irregularly longitudinally fissured, pale brown and corky bark. The taproot of this plant is tuberous, soft, sometimes irregularly nodular and bitter. The leaves are placed in whorls of 3 or 4 and are 5cm to 18 cm long and 1.5 cm to 7 cm wide. They are elliptic-lanceolate or obovate, apex acute or acuminate, base tapering, the surface is dark green and the beneath of the leaf is pale green and the petioles are 0.6cm to 1.4 cm long. The flowers of Sarpagandha are white or violet-tinged. The flowers blossom in abundance at a time and have

corymbose Cymes. The peduncles are 0.5 cm to 12.5 cm long. The pedicels are stout, 0.3cm to 0.6 cm long and bright red in colour.

Uses: Sarpagandha is considered as one of the best-known medicinal plants in the world. The roots contain major Alkaloid constituents, notably Reserpine, Rescin-Namine and Deserpidine, which are used for medical purpose in India. The root of Sarpagandha that carries immense medicinal properties is widely used even in foreign countries, in the treatment of high blood pressure and as a sedative and tranquillising agent. For centuries, Ayurveda and Unani practitioners reckon the root of Sarpagandha as a hypnotic and sedative, for reducing high blood pressure, and for treating various central nervous system disorders, both psychic and motor, including anxiety, psychosis, schizophrenia, epilepsy and insomnia. The tribal inhabitants of southern and eastern Bihar take the powdered roots orally as an antidote to snake venom. Extracts of the roots of Sarpagandha plant are valued for treatment of intestinal disorders, particularly diarrhoea and dysentery, and also as an anthelmintic.

ETHNOBOTANY

Ethnobotany is the study of interaction between plants and people, with a particular emphasis on traditional ethnic culture. It is a new branch of science dealing with use of plants by tribal communities. The word ethnobotany was first time applied by Harshberger (1896) to the study of plants used by primitive and aboriginal people. Ethnobotanists explore how plants are used for such things as food, shelter, medicine, clothing, hunting, and religious ceremonies.

Ethnobotany has its roots in botany, the study of plants. Botany, in turn, originated in part from an interest in finding plants to help fight illness. In fact, medicine and botany have always had close ties. Many of today's drugs have been derived from plant sources. Pharmacognosy is the study of medicinal and toxic products from natural plant sources. At one time, pharmacologists researching drugs were required to understand the natural plant world, and physicians were

schooled in plant-derived remedies. However, as modern medicine and drug research advanced, chemically-synthesized drugs replaced plants as the source of most medicinal agents in industrialized countries. Although research in plant sources continued and plants were still used as the basis for some drug development, the dominant interest (and resulting research funding) shifted to the laboratory.

Ethnobotany was variously named by different scientist. In 1874, Powers coined the term 'aboriginal botany' to describe the use of medicine, food, textile, fabrics, ornaments etc. by tribal communities. Jain (1992) stated that ethnobotany includes the plants collected or cultivated food, fabrics, fodder, and other material and beliefs associated with indigenous cultured communities. In 1962, Schultes described all the aspects of ethnobotanical disciplines, hence he called father of ethnobotany. S.K. Jain covered the ethnobotancial study of Indian region, he is the founder of Indian ethnobotany.

Branches of Ethnobotany

Ethnobotany is an interdisciplinary science comprising of different aspects of anthropology, botany, archaeology, ecology, economics, medicine, linguistics etc. It plays an important role in research and development in resources management, conservation of biodiversity and regional socio-economic development. Ethnomedicobotany is the study of tribal medicinal plants which is sometimes referred to as ethnotherapeutics. It provides a powerful and highly effective strategy for the discovery of clinically useful compounds from tribal medicines.

To discover the practical potential of native plants, an ethnobotanist must be knowledgeable not only in the study of plants themselves, but must understand and be sensitive to the dynamics of how cultures work. Ethnobotanists have helped us to understand the frightening implications which loss of the rain forests would bring not only in terms of consequent loss of knowledge about tropical plants, but the consequent damage brought on by the loss of native cultures in their entirety, as well as the damage to the earth's ecological health.

Tribes of Western Ghats: The hill tribes or Adivasis (original inhabitants) as they are called, account for barely 5% of the area population in the Western Ghats. The tribals have coexisted with nature for centuries in quiet harmony with rich traditional knowledge and cultural life. Before the British opened up the high pastures of the Nilgiris in 1818 to the western civilisation, they were the preserve of four tribes: The Kotas, who gave their name to Kotagiri, made tools and music; the Badagas, who cultivated the land, the forest dwelling Kurumbas who collected honey and wood and also performed sorcery; and the Todas, who with their herds of sacred buffalo, provided milk and ghee. The forest regions of Yelandur, Chamarajnagar, Nanjangud and Kollegal which include Biligiri Rangaswamy and Malai Mahadeshwara hill ranges in the southern part of Karnataka are inhabited by nearly 20,000 indigenous people called Soligas. Halakki Vokkals are confined to the coastal talukas of Uttara Kannada district of Karnataka. The Siddis are the descendants of African Negroes, who were brought to India mainly by Arabs, the Portugese and the Dutch. They are chiefly found in the forest areas of Ankola, Mundgod, Haliyal and Yellapur taluks. They live in small clusters constituting a distinct settlement of a village or independent settlement. The Paniya, a major tribal community in Kerala live in the hills of Wayanad. This is a primitive tribe and the Kattunayakans literally live in jungles and are mainly engaged In collecting forest produce and honey sporadically in southern Western Ghats. Many other tribal communities living in Tamilnadu are Paliyans or Pulayans, Malayalies, Irulas, Muthuvars, Malasar, Paniyar etc. They are all custodians of the forest until now they are living as primitive forest dwellers.

Ethnology of Paliyans of Western Ghats

The Paliyan, or Palaiyar or Pazhaiyarare are Adivasi Dravidian people living in the South Western Ghats montane rain forests in South India, especially in Tamil Nadu. They are traditional nomadic hunter-gatherers, honey hunters and foragers. Yams are their major food source. In the early part of the 20th century the Paliyans dressed scantily and lived in rock crevices and caves. Most have now have transformed to traders of forest products, food cultivators and beekeepers.

Some work intermittently as wage laborers, mostly on plantations. They are included in the List of Scheduled Tribes in India.

Thurston (1909) quoting from the writing of Rev. F. Dahman.(1908) describes Palians as nomadic tribe, who for the most part rove in small parties through the jungle clad gorges (Sholas) that fringe the upper Palnis plateau. Pate (1916) describes Paliyans as a "Very backward caste who live-in small scattered parties amid the jungles of the upper Palnis and the Varrushanadu valley". Paliyans are dark in complexion, short in Stature with an Archaic type of Nose, Square face thick Lips.

The Tamil speaking Pulayan are referred as the Malapulayans, a group categorized as scheduled caste by State government of Tamil Nadu. Their traditional livelihood is foraging yams and small gaming in the nearby forest areas combined with cultivation of several species of minor millets in small plots located near their hamlets to meet their subsistence requirements.

They live in small hamlets in huts and government constructed colonies. The sedentary life started with the construction of group houses by the government in the early sixties. The community is vertically divided into two sub divisions called Koora and Kanni, further subdivided into 47 sub sects. Each sub sect is called Kootams, which regulates certain social events. Each kootam has it own deity, which is common to the entire group and once yearly the members of the same kootam assemble to worship the deity.

Many native tribals in the Palani Hills have partially assimilated modern culture but are marginalized on the fringes of society. Their social, economic and physical survival has become a difficult challenge for them and several public and private agencies. Their ancient culture in this area is well documented.

Plant used by Paliyan tribes

Food plants

Name of the Plant	Family	Tamil Name
Echinochloa frumentacea	Poaceae	Kuthiraovazhli
Eleusine coracana	Poaceae	Ragi, Kezhvaragu
Oryza sativa	Poaceae	Nellu
Setaria italic	Poaceae	Thinai
Panicum miliare	Poaceae	Saamai
Sorghum halepense	Poaceae	Sencholam, Inukkucholam

Wild edibles

Name of the plant	Family	Tamil Name
Dioscorea bulbifera (Tuber)	Dioscoreaceae	Velikizhangu, Vertilaivalli
Dioscorea tomentosa (Tuber)	Dioscoreaceae	Nalvelikizhangu, Salikizhangu
Dioscorea oppositifolia (Tuber)	Dioscoreaceae	Naruvalli
Leafy vegetables *Marselia quadrifolia*	Marseliaceae	Aaraikeerai
Solanum nigrum	Solanaceae	Karunthakeerai, Karunjukkutu
Talinum portulacifolium	Portulacaceae	Basalikeerai
Fruits *Carissa carandas*	Apocynaceae	Kazhakai
Ficus hispida	Moraceae	Kattuaathi
Syzygium lanceolatum	Myrtaceae	Sirunaval
Securinega leucopyrus	Euphorbiaceae	Vetpula
Seeds *Entada pursaetha*	Mimosaceae	Yanaikozhinji
Mucuna pruriens	Fabaceae	Poonaikali
Dunbaria ferruginea	Fabaceae	Sirupoonaikali

Medicinal plants

Name of the plant	Family	Tamil Name	Uses
Andrographis lineate	Acanthaceae	Perianangai	Antidote against all poisonous bites
Lobelia nicotianifolia	Lobeliaceae	Kattupugaiyelai	Powder snuff used to get rid of cold and cough
Glycosmis pentaphylla	Rutaceae	Kuttivila	Fruit juice used to treat stomach pain due to indigestion
Ichnocarpus fruitescens	Apocynaceae	Paravalli	Leaf paste with honey to given for intestinal ulcer.
Celastrus paniculatus	Celastraceae	Valuluvai	Seed extract is orally administered to mental disorder
Helicteres isora	Sterculiaceae	Valamburi	Fruit extract given orally to treat diabetes.
Aristolochia indica	Aristolochiaceae	Eswaramuli, Urikaikodi	Leaf extract is used to treat skin disease.
Memecylon umbellatum	Melastomataceae	Kaya	Flower extract used to remove wound scar.
Plumbago zeylanica	Plumbaginaceae	Chithramulam	Root extract used to abortive.
Mucuna pruriens	Fabaceae	Poonaikali	Seeds used to induce sexual stimulant.