

E-Reading Manual

On

Dendrology

(Course Code: SA-1202) Credits: 3(2+1)

[For B. Sc. (Hons.) Forestry Ist Semester Students]



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E- Reading Manual on Dendrology

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PREFACE

Dendrology (SA-1102) is a compulsory course offered to the students of first Semester B.Sc. (Hons.) Forestry, which includes importance and scope of dendrology, principles and systems of plant classification systems. Detailed study of Bentham and Hooker natural system, its advantages and disadvantages. Plant Nomenclature – objectives, principles and International Code of Botanical Nomenclature. Role of vegetative morphology in identification of woody forest flora. Peculiarities of bole, general form of woody trunk and deviations like buttresses, flutes, etc. Morphology and description of barks of common trees. Characteristics of blaze, bark colour, exudations etc. Morphology of leaf, different types of leaves, colour of young and old leaves in some species as (regular) features of identification. Reproductive morphology of plants with reference to description and identification of reproductive parts. Detailed study of the families- diagnose the features-floral variations–distribution and economic importance-systematic position as per Bentham & Hooker System of classification-Magnoliaceae, Annonaceae, Guttiferae, Dipterocarpaceae, Malvaceae, Sterculiaceae, Tiliaceae, Rutaceae, Meliaceae, Sapindaceae, Anacardiaceae, Leguminosae, Rhizophoraceae, Combretaceae, Myrtaceae, Rubiaceae, Sapotaceae, Apocyanaceae, Bignoniaceae, Lamiaceae, Lauraceae, Euphorbiaceae, Orchidaceae, Palmae and Graminae. Brief description of the families-Bombacaceae, Santalaceae, Casuarinaceae.

The author extends her gratitude to our Hon'ble Vice Chancellor Dr. (Prof.) Narendra Pratap Singh, for his valuable guidance, encouragement and inspiration for preparation of this manual. Dr. A.C. Mishra Director of Research, Dr. A.K. Shrivastva Director P MEC, Dr. Sanjeev Kumar, Dean, College of Forestry for their encouragement and help to write this manual. I hope, this manual will meet the requirement of undergraduate students studying Dendrology.

Kaushal Singh

Date: September 2024

DECLARATION

This E-Reading manual on “**Dendrology** (SA-1102)” is prepared according to the syllabus recommended by the ICAR 5th Dean Committee Report. The course “Dendrology (SA-1102)” is being offered by Department of Silviculture & Agroforestry to the undergraduate students of B.Sc. (Hons) Forestry degree Programme. This study material is prepared by consulting different text books, package of practice manuals, online sources such as University websites, e-documents, e-books, e-data and other available off-line sources. The authors do not claim for originality of work. The purpose of this E-content is just to provide the study material to students of B.Sc. (Hons) Forestry as reference material for easy and better understanding of the course. This is not meant for the commercial use. The multiplication of this content for commercial activity is prohibited.

Authors

CONTENTS

S. N.	Contents	Page No.
1.	Definitions: Dendrology	1
2.	Plant Nomenclature	2
3.	Systems of plant classification	8
4.	Herbarium	26
5.	Morphology of woody plants	31
6.	Detailed study of the family: Magnoliaceae	47
7.	Detailed study of the family: Rubiaceae	48
8.	Detailed study of the family: Annonaceae	50
9.	Detailed study of the family: Sapotaceae	52
10.	Detailed study of the family: Myrtaceae	53
11.	Detailed study of the family: Combretaceae	55
12.	Detailed study of the family: Meliaceae	56
13.	Detailed study of the family: Rutaceae	58
14.	Detailed study of the family: Sapindaceae	59
15.	Detailed study of the family: Anacardiaceae	61
16.	Detailed study of the family: Tiliaceae	62
17.	Detailed study of the family: Malvaceae	63
18.	Detailed study of the family: Sterculiaceae	65
19.	Detailed study of the family: Dipterocarpaceae	66
20.	Detailed study of the family: Guttiferae	67
21.	Detailed study of the family: Rhizophoraceae	69
22.	Detailed study of the family: Fabaceae	70
23.	Detailed study of the family: Euphorbiaceae	72
24.	Detailed study of the family: Bignoniaceae	73
25.	Detailed study of the family: Apocyanaceae	75
26.	Detailed study of the family: Lamiaceae	76
27.	Detailed study of the family: Lauraceae	77
28.	Detailed study of the family: Bombacaceae	78
29.	Detailed study of the family: Casuarinaceae	79
30.	Detailed study of the family: Santalaceae	81
31.	Detailed study of the family: Orchidaceae	82
32.	Detailed study of the family: Poaceae	83
33.	References	85

1. Definition

Dendrology derived from Greek word “*Dendron*” means tree and “*Logos*” means study. Dendrology is a “study of trees or woody plants”. Woody plants means trees, shrubs, lianas or vines and some times undershrubs that have woody structural system. Idzajtich 2019 define the dendrology, as “*Dendrology, is the scientific study of morphological characteristics of woody plants, their relationship, biological characteristics, ecological requirements, variability, distribution and economic importance*”. Dendrology is an important and necessary discipline for the foresters that provide a convenient method of identification and communication by learning basic knowledge of identification, naming, habits and characteristic botanical features of trees. The properly identified specimens can be arranged systematically in herbarium.

A dendrologist study the various aspects of trees like type of leaf, arrangement of leaf, scars of leaf, presence or absence of petiole, type of inflorescence, flower, fruit/cone, types of bark, blaze, branches, twigs, wood and suitability of growth and reproduction for correct identification of any woody plant species.

Objectives and Scope

There are five main objectives of dendrology which are given below:

- Identification by specific features like bark, blaze and buds etc.
- Nomenclature naming the trees according to the ICBN rules
- Classification division of tree species based on botanical arrangement into groups such as families and genus
- Distribution of trees in different types of forest.
- Importance uses of important forest tree species of the country.

It provides the inventory of the woody flora of any area. It is helpful in detection of evolution within woody flora and helpful in developing and revision of forest types of any region. Like other plants woody species also have two types of names, common/vernacular and scientific names. Both types of names have its advantages and disadvantages.

2. Plant Nomenclature

Nomenclature is a system of naming objects, particularly of biological origin. Since ancient times all around the world man named plants in their own regional languages. Often same plant has several common names in different parts of the country or the same common name has been applied for several different plants. Thus, the common names are quite indefinite and are restricted to the people of a particular language or a region. This necessitated the need for assessing scientific names of the plants.

Nomenclature is based on the principles, rules and recommendations formulated and adopted by International Botanical Congress (IBC). These principles, rules and recommendations are listed formally in a code called as International Code of Nomenclature for algae, fungi, and plants (ICN).

Importance of Nomenclature:

1. To fix the names by providing one scientific name to one plant.
2. To avoid or to reject the use of forms and names which may cause error, ambiguity, or through science into confusion.
3. Avoidance of all useless creation of names.
4. Others, such as absolute grammatical correctness, regularity or euphony of names, prevailing custom, regard for persons, etc., notwithstanding their undisputable importance, are relatively accessory.

Binomial Nomenclature

For many centuries, the name of plants were given in polynomials, i.e. very long and descriptive. For example, *Sida acuta* is named as *Chrysophyllum follis oralis superne glabris parallele straitis subtus tomento sonifides*. These polynomials are very difficult to memorise and hinders in classification of taxa. For solving this problem and shortening the names of Taxa, first attempt was made by Gaspar Bauhin in 1623, in his book “Pinax Theatri Botanici”. He first adopted two-name system for each taxon. After that, it was Carl Linnaeus, the great Swedish botanist, who actually methodically device the binomial nomenclature and laid down the first rules of modern nomenclature. Linnaeus adopted this system in his *Species Plantarum* in 1753.

In this system of classification the scientific name of each taxon consist of two Latin or latinised words: First is the generic name or generic epithet and second is the specific epithet or specific epithet.

For example, *Aegle marmelos* is botanical name for Bael tree. In this, the first word *Aegle* represents the genus and the second word *marmelos* represents species.

International Code of Nomenclature for Algae, Fungi, and Plants (ICN)

History of ICN

Linnaeus, the great Swedish botanist. Laid down the first rules of modern nomenclature in 1737 in his *Critica Botanica*. After that in 1751 Linnaeus, publish certain principles of nomenclature in his *Philosophia Botanica*. Then in 1813, A. P. de Candolle gave more detailed rules for plant nomenclature in his *Theorie elementaire de la botanique*.

First International Botanical Congress was convened by Alphonse de Candolle that was held in Paris in 1867. The rules set and adopted for plant nomenclature are popularly known as

de Candolle rules or Candollian Code or Paris code 1867. It superseded the other rules of botanical nomenclature and subsequent meetings of IBC held from time to time. The latest meeting i.e. 19th congress held at Shenzhen, China in 2017.

The Code is consisting of 3 Divisions

1. Principles
2. Rules and Recommendations
3. Provision for the governance of the Code.

Principles: The six principles that are based upon the system of nomenclature governed by this Code includes:

1. Nomenclature of algae, fungi, and plants is independent of zoological and bacteriological nomenclature. This Code applies equally to names of taxonomic groups treated as algae, fungi, or plants, whether or not these groups were originally so treated.
2. Application of names of taxonomic groups is determined by means of nomenclatural types.
3. 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. Rules of nomenclature are retroactive unless expressly limited.

Rules and Recommendations

Rules are mandatory. All the rules are arranged in form of articles and they provide detailed description of all the points connecting with naming of the taxon. Recommendations are not

compulsory to follow. They are often practical application of rules. The object of recommendations is to bring about greater uniformity and clarity.

Major rules and recommendations of plants nomenclature provided by ICN

1. **Taxa and their ranks:** The rank of taxa (taxon is singular) for taxonomic group of any rank. Each taxon is treated as belonging to a number of taxa of different ranks or categories of successively higher rank. The ascending hierarchy of taxa include species, genus, family, order, class and division. There are following ranks and some standardised endings for these ranks.

Taxa	Suffix	Example
Kingdom	Various	Plantae
Division	-phyta	Magnoliophyta
Subdivision	-phytina	Magnoliophytina
Class	-opsida	Magnoliopsida
Subclass	-opsidae	Asteropsidae
Superorder	-anae, [-iflorae]	Asteranae
Order	-ales	Asterales
Suborder	-ineae	Asterineae
Family	-aceae	Asteraceae
Subfamily	-oideae	Asteroideae
Tribe	-eae	Heliantheae
Subtribe	-inae	Helianthinae
Genus	various	<i>Helianthus</i>
Subgenus	various	<i>Helianthus</i>
Section	various	<i>Helianthus</i>
Species	various	<i>Helianthus annuus</i>
Subspecies	various	<i>Helianthus annuus</i> ssp. <i>annuus</i>
Variety	various	<i>Helianthus annuus</i> var. <i>annuus</i>

1. **Priority of names or Principle of priority:** Many times several names are published for the same taxa it becomes essential to assign one correct name out of several names which is earliest name and validly published name. For example: Polygala L. (1753); Poligala Neck. (1768); Polygaloides Agostis (1770); Phylan Nor. (1790), these are

several names published by different taxonomist. According to principle of priority only *Polygala* L. (1753) is the valid name.

Limitation of the principle of priority (publication, starting-points, conservation of names):

A name of a taxonomic group has no status under the Rules, and has no claim to recognition by botanists, unless it is validly published (see Section 6, Art. 37).

Legitimate botanical nomenclature begins for the different groups of plants at the following dates:

(a) Phanerogamae and Pteridophyta, 1753 (Linnams, *Species Plantarum*, ed. I).

(b) Muscineae, 1801 (Hedwig, *Species Muscorum*).

(c) Sphagnaceae and Hepaticae, 1753 (Linnreus, *Species Plantarum*, ed. 1).

(d) Lichenes, 1753 (Linnreus, *Species Plantarum*, ed. 1).

(e) Fungi: Uredinales, Ustilaginales and Gasteromycetes, 1801 (Persoon, *Synopsis methodica Fungorum*).

(f) Fungi creteri, 1821-32 (Fries, *Systema mycologicum*).

(g) Algae, 1753 (Linnaeus, *Species Plantarum*, ed. 1).

(h) Myxomycetes, 1753 (Linnaeus, *Species Plantarum*, ed. 1).

4. Author Citation:

Rules related to author citation are under mentioned:

- i. **Original Author:** The name of a taxon is complete and accurate only when it is followed by full or abbreviated form of the author(s) who first validly published the concerned name, *viz.* *Meliaceae* and *Acacia arabica* are incorrect; the complete names are *Meliaceae* Juss. and *Acacia arabica* L.
- ii. **Joint Author:** When two authors have jointly published the name of a taxon, the names of both the authors should be cited and linked by the words *et* or *&*. *Viz.* *Cuscuta santapau* Banerji *et* S. Das (or *Cuscuta santapau* Banerji *&* S. Das).
- iii. **Name Proposal:** When the name of a taxon is proposed but not validly published by one author and is later on validly published by another, the word *ex* should be used as a connecting link between the name of the former author and the name of the subsequent author, *viz.* *Cuscuta hyalina* Roth *ex* Schult.
- iv. **Rank Alteration:** When a taxon of a lower rank is upgraded in a higher rank but retains its name, the author's name who published it first should be cited in the bracket. It is to be followed by the name of the author who made the alteration, *viz.* Allioni raised the rank of variety *Medicago polymorpha* var. *orbicularis* L. to the species rank, therefore it becomes *Medicago orbicularis* (L.) Allioni.

2. **Alternative names:** Each family or taxon of lower rank with a particular circumscription, position, and rank can bear only one correct name, special exceptions being made for eight families and one subfamily for which alternative names are permitted.

<i>Names according to ICN rules</i>	<i>Alternate Names under usage</i>
Apiaceae	Umbelliferae
Areaceae	Palmae
Asteraceae	Compositae
Brassicaceae	Cruciferae
Clusiaceae	Guttiferae
Fabaceae	Leguminosae
Lamiaceae	Labiatae
Poaceae	Gramineae
Faboideae	Papilionoideae

6. A name has no priority outside the rank in which it is published *viz.* *Magnolia virginiana* var. *foetida* L. (1753) when raised to specific rank is called *Magnolia grandiflora* L. (1759), not *Magnolia foetida* (L.) Sarg. (1889).

7. **Limitation of Principle of Priority:** The principle of priority does not apply above the rank of family.

8. **Latin or English diagnosis:** Earlier it was necessary to provide the diagnosis, details and description of new taxon, e.g., a species, except for names of fossils, published before 1st January, 1955 are accepted by ICN as valid, irrespective of the language. After this date the description of any new taxa would be considered valid only if accompanied by Latin diagnosis. Recently the Nomenclature Section of ICN modified this so that, for names published on or after 1 January 2012, the description and/or diagnosis must be in either English or Latin (Article 39). This will apply to names of new taxa in all groups covered by the Code. It is already the requirement for names of new fossil-taxa published on or after 1 January 1996.

9. **Effective Publication:** Earlier publication of new names and descriptions are effective when the printed matter is distributed to the public or to at least 10 botanical institutions with library accessible to botanists generally. The date of effective publication is the date on which the printed matter became available. Now the Nomenclature Section of ICN permitted electronic publication from 1 January 2012 (Melbourne code, 2011). This means it is no longer necessary for new names of plants, fungi, and algae (and designations of types) to appear in printed matter in order to be effectively published effective publication being a fundamental requirement of

the Code for acceptance of any nomenclatural act; no longer will it be a requirement to deposit some paper copies in libraries. As an alternative, publication online in Portable Document Format (PDF) in a publication with an International Standard Serial Number (ISSN) or International Standard Book Number (ISBN) is permitted. This provision was approved to prevent changes to a particular electronic publication once it is issued, to prevent preliminary versions being effectively published and to make clear the date of publication.

10. Valid Publication: The following are important conditions attached to for valid publication of the names of new taxon.

- i. Publication must be effective as indicated above.
- ii. It should be accompanied by a description or by a reference to a previously and effectively published description.
- iii. It must be accompanied by a Latin or English description or by a reference to a previously published Latin or English description.
- iv. A nomenclatural type is to be indicated for a new taxon of the rank of family or below published on or after 1st January 1958.

11. Synonyms and related definitions:

- i. **Synonym:** A name rejected due to misuse of difference in taxonomic judgement.
- ii. **Basionym:** A specific or intraspecific name which has priority and is retained when transferred to a new taxon.
- iii. **Homonym:** A case in which two or more identical names are based on different types, of which only one can be a legitimate name.
- iv. **Tautonyms:** An illegitimate binomial in which the name of the genus and the name of the species is same. Tautonyms are treated as a legitimate in Zoological nomenclature, viz. *Linaria linaria*.
- v. **Autonym:** An automatically created legitimate tautonym for infraspecific or infrageneric taxa. viz. *Hypericum* subgenus *Hypericum* section *Hypericum*.

3. Systems of plant classification

Classification is the placement of plants, animals and objects into groups and categories for a clear understanding, accurate study and effective organisation. There are millions of animals and plant species known today, many are left to be discovered. It very difficult task to study all these rganisma separately so there is a need to organize all these organisim into various ranks and groups on the basis of the structure, relationship and reproduction.

Classification of Kingdoms

There are various types of system of classification proposed several biologist on the basis of similirties and dissimilarities, which are as follows:

1. Two kingdom system
2. Three kingdom system
3. Four kingdom system
4. Five kingdom system

Various attempts have been made to classify plants from time to time by systematists and these can be categorised in following three categories:

1. Artificial system
2. Natural system
3. Phylogenetic system

1. Artificial system of classification

The artificial systems propounded by earlier herbalist based on habit (viz. trees, shrubs, herbs, etc.) and the Linnaeus' sexual system is based on floral characters (viz. number of stamens and carpels). Theophrastus 370-285 B.C., Pedanion Dioscorides 62-128 A.D., Andrea Caesalpino 1519-1603 A.D., Gaspard Bauhin 1560-1624 A.D., John Ray 1628-1705 A.D., Joseph pitton de Tournefort 1656-1708, Rudolf Camerarius 1665-1721, Carolus Linnaeus 1707-1778 supports the artificial system of classification.

2. Natural systems of classification

The system of classification used as many taxonomic characters as possible to group taxa. The pre- Darwanian systems such as Michel Adanson 1727-1806, Jussieu 1748-1836, Robert Brown 1773-1858, A.P. de Candolle 1778-1841 and his son Alphonse 1806-1893, George Bentham 1800-1884 and Joseph Dalton Hooker, W. Hofmeister 1824-1877 are well known natural systems of classification.

3. Phylogenetic system of classification

The publication of origin of species by Darwin 1859 change the outlook of taxonomy. The classification systems of this period are based on the course of evolutionary descent and reflect

the genetic and phylogenetic relationships. These systems of classification used as many taxonomical characters as possible in addition to phylogenetic interpretations. The most widely known system of this period are those of August Wilhelm Eicher 1839-1887, Adolph Engler 1844-1930 and Karl A. E. Prantl 1849-1893, Charles Edwin Bessey 1845-1915 and Angiosperm Phylogeny Group (APG-IV) 2016. Some important systems of classification are discussed below

Carl Linnaeus 1707-1778 artificial system

A Swedish naturalist, regarded as *father of taxonomy*. The Linnaeus system is an artificial as well as sexual system of classification of plants. In *Systema Naturae* (1735) Linnaeus gave outline of his classification. Then in *Genera Plantarum* (1737), description of several genera were provided by him. After that in his renowned book *Species Plantarum* (1753), he provided detailed description of nearly 1000 genera and 6000 species in 2 volumes. Linnaeus divided all plants into 24 classes, mainly on the basis of number, union and length of stamens as follows:

Monandria (One stamen); e.g. *Lemna*

Diandria (Two stamens); e.g. *Veronica*

Triandria (Three stamens); e.g. *Iris*

Tetrandria (Four stamens); e.g. *Mentha*

Pentandria (Five stamens); e.g. *Primula*

Hexandria (Six stamens); e.g. *Berberis*

Heptandria (Seven stamens); e.g. *Aesculus*

Octandria (Eight stamens); e.g. *Fagopyrum*

Enneandria (Nine stamens); e.g. *Ranunculus*

Decandria (Ten stamens); e.g. *Acer*

Dodecandria (11-19 stamens); e.g. *Euphorbia*

Icasandria (≥ 20 stamens and episepalous); e.g. *Rosa*

Polyandria (≥ 20 stamens and attached to receptacle); e.g. *Papaver*

Didynamia (Didynamous stamens); e.g. *Linaria*

Tetradynamia (Tetra didynamous stamens); e.g. Brassicaceae

Monadelphia (Monadelphous stamens); e.g. Malvaceae

Diadelphia (Diadelphous stamens); e.g. *Lathyrus*

Polyadelphia (Polyadelphous stamens); e.g. *Hypericum*

Syngenesia (Syngenesious stamens); e.g. Asteraceae

Gynandria (Stamens adnate to gynoecium); e.g. *Aristolochia*

Monoecia (Plants monoecious); e.g. Orchidaceae

Dioecia (Plants dioecious); e.g. *Urtica*, *Salix*

Polygamia (Plants polygamous); e.g. *Empetrum*

Cryptogamia (Flower concealed or flowerless); e.g. Algae, fungus, mosses, ferns.

Each class was then sub divided into 7 series or orders on the basis of number of styles or stigmas in flowers:

1. Monogyna
2. Digyna
3. Trigyna
4. Tetragyna
5. Pentagyna
6. Hexagyna
7. Polygyna

Merits and demerits of Linnaeus system

Merits:

1. This sexual system is a good example of artificial system.
2. It is first publication with binomial system of nomenclature.
3. It is very simple and convenient to use.

Demerits:

1. These unrelated taxa are similar in one respect only.
2. It largely depends on the number size and union of stamens i.e. many and unrelated taxa are placed together.

Linnaeus artificial system was dominated for over seven decades until it was replaced by natural system of Jussieu and A. P. de Candolle.

Bentham and Hooker 1862-1883 Natural System:

The most accepted natural system of classification was proposed by George Bentham and Joseph Dalton book in the three volumes of the *Genera Plantarum* published during 1862-1883.

Bentham, a British botanist and Hooker, Director of Royal Botanic Garden at Kew, London, England described 97,205 species belonging to 7,569 genera of 202 families of flowering plants. Bentham and hooker system is supposed to be the best system for practicals and laboratories purpose that is why it is still used and followed in several herbaria of the world. Bentham and Hooker divided all Phanerogams (seed plants) into three classes: Dicotyledons, Gymnosperms and Monocotyledons which are further classified in 21 series and 25 cohorts or orders. His sytem of classification first time appeared in Latin named genera Plantarum, first

part in July 1862 and third in April 1883 with 97205 species of 7569 genera and 200 (+2) natural orders.

The detailed classification of Bentham and hooker is given below:

CLASS 1: DICOTYLEDONAE (Reticulate venation, 2 cotyledons, pentamerous flowers)

SUBCLASS 1: POLYPETALAE (Petals free)

SERIES I: THALAMIFLORAE: Flowers hypogynous, stamens many, disc absent, sepals free from ovary.

Cohort 1: Ranales (Flowers spirocyclic; gynoecium apocarpous)

1. Ranunculaceae
2. Dilleniaceae
3. Calycanthaceae
4. Magnoliaceae
5. Anonaceae
6. Menispermaceae
7. Berberidaceae
8. Nymphaeaceae

Cohort 2: Parietales (Placentation parietal)

9. Sarraceniaceae
10. Papaveraceae
11. Cruciferae
12. Capparidaceae
13. Resedaceae
14. Cistineae
15. Violaceae
16. Canellaceae
17. Bixineae

Cohort 3: Polygalineae (Ovary bilocular, rarely ≥ 1 locular; stamens as many or twice the number of petals)

18. Pittosporeae
19. Tremandreae
20. Polygaleae
21. Vochysiaceae

Cohort 4: Caryophyllineae (Ovary unilocular; placentation free central or axile)

22. Frankeniaceae
23. Caryophyllaceae

24. Portulacaceae

25. Tamariscineae

Cohort 5: Guttiferales (Ovary 3-many locular; sepals imbricate; stamens many)

26. Elatineae

27. Hypericineae

28. Guttiferae

29. Ternstroemiaceae

30. Dipterocarpaceae

31. Chlenaceae

Cohort 6: Malvales (stamens many; monadelphous; sepals valvate)

32. Malvaceae

33. Sterculiaceae

34. Tiliaceae

SERIES 2: DISCIFLORAE (Flowers hypogynous; ovary superior; disc present around the ovary)

Cohort 7: Geraniales (Flowers often irregular; disc usually annular; adnate stamens; androecia obdiplostemonous; ovules pendulous)

35. Lineae

36. Humiriaceae

37. Malpighiaceae

38. Zygophylleae

39. Geraniaceae

40. Rutaceae

41. Simaroubaceae

42. Ochnaceae

43. Burseraceae

44. Meliaceae

45. Chailletiaceae

Cohort 8: Olacales (Flowers regular, bi- or unisexual; disc copular or annular; androecia diplostemonous)

46. Olacineae

47. Ilicineae

48. Cyrillaceae

Cohort 9: Celastrales (Flowers regular, bisexual; disc adnate to base of calyx tube; stamens \leq number of petals)

- 49. Celastrineae
- 50. Stackhousieae
- 51. Rhamneae
- 52. Ampelideae

Cohort 10: Sapindales (Flowers often irregular, unisexual; disc adnate to base of calyx or lining it; stamens definite)

- 53. Sapindaceae
- 54. Sabiaceae
- 55. Anacardiaceae
- 56. Coriariaceae
- 57. Moringeae

SERIES 3: CALYCIFLORAE (Sepals united, flowers peri- or epigynous)

Cohort 11: Rosales: (Stamens many, often twice or more than petals; style distinct)

- 58. Connaraceae
- 59. Leguminosae
- 60. Rosaceae
- 61. Saxifragaceae
- 62. Crassulaceae
- 63. Droseraceae
- 64. Hamamelidaceae
- 65. Bruniaceae
- 66. Haloragaceae

Cohort 12: Myrtales (Styles undivided; stamens definite, rarely indefinite)

- 67. Rhizophoraceae
- 68. Combretaceae
- 69. Myrtaceae
- 70. Melastomaceae
- 71. Lythraceae
- 72. Onagraceae

Cohort 13: Passiflorales: (Ovary inferior, unilocular; placentation parietal)

- 73. Samydaceae
- 74. Loasaceae
- 75. Turneraceae
- 76. Passifloraceae
- 77. Cucurbitaceae

78. Begoniaceae

79. Datisceae

Cohort 14: Ficoidales (Perianth undifferentiated; axile or basal placentation; embryo curved)

80. Cactaceae

81. Ficoideae

Cohort 15: Umbellales: (Ovary inferior; ovules solitary, pendulous in each locule; umbellate inflorescence)

82. Umbelliferae

83. Araliaceae

84. Cornaceae

Subclass II: GAMOPETALAE (Corolla united)

SERIES 4: INFERRAE (Stamen equal to petals & alternating with them, ovary inferior)

Cohort 16: Rubiales (Stamens epipetalous, anthers free, ovary 2-locular, 1-many ovules in each locule)

85. Caprifoliaceae

86. Rubiaceae

Cohort 17: Asterales (Stamens epipetalous, syngenesious, anther united, ovary 1-loculed, 1-ovuled)

87. Valerianeae

88. Dipsacaceae

89. Calycereae

90. Compositae

Cohort 18: Campanales (Flowers irregular; ovary 2-6 locular, with many ovules in each locule)

91. Stylideae

92. Goodenovieae

93. Campanulaceae

SERIES 5: HETEROMERAE (Stamens free or epipetalous, equal or more to corolla lobes, ovary superior, carpels more than 2)

Cohort 19: Ericales (Stamens as many as corolla lobes and alternating to them)

94. Ericaceae

95. Vacciniaceae

96. Monotropeae

97. Epacrideae

98. Diapensiaceae

99. Lennoaceae

Cohort 20: Primulales (Stamens as many as corolla lobes and opposite to them; ovary unilocular; placentation free central or basal; ovules 1 to many)

100. Plumbagineae

101. Primulaceae

102. Myrsineae

Cohort 21: Ebenales (Ovary bi- to multilocular; ovules few)

103. Sapotaceae

104. Ebenaceae

105. Styraceae

SERIES 6: BICAPELLATAE (Stamens equal or less than corolla lobes, alternipetalous; ovary bicarpellary, syncarpous, superior)

Cohort 22: Gentianales (Leaves opposite, corolla actinomorphic, hypogynous; stamens epipetalous)

106. Oleaceae

107. Salvadoraceae

108. Apocynaceae

109. Asclepiadaceae

110. Loganiaceae

111. Gentianaceae

Cohort 23: Polemoniales (Leaves alternate, corolla actinomorphic, ovary 1-5 locular)

112. Polemoniaceae

113. Hydrophyllaceae

114. Boraginaceae

115. Convolvulaceae

116. Solanaceae

Cohort 24: Personales (Corolla zygomorphic, posterior stamen often reduced to staminod, ovules often more than 4)

117. Scrophulariaceae

118. Orobranchaceae

119. Lentibulariaceae

120. Columelliaceae

121. Gesneriaceae

122. Bignoniaceae

123. Pedalineae

124. Acanthaceae

Cohort 25: Lamiales (Corolla 2-lipped, zygomorphic, posterior stamen reduced, ovary 2-4 locular)

125. Myoporineae

126. Selagineae

127. Verbenaceae

128. Labiatae

129. Plantagineae

SUBCLASS 3: MONOCHLAMIDEAE (perianth 1-2 seriate, sepaloid or absent)

SERIES 7. CURVEMBRYEAE (embryo curved, stamens equal to perianth lobes, ovary 1-ovuled)

130. Nyctagineae

131. Illecebraceae

132. Amarantaceae

133. Chenopodiaceae

134. Phytolaccaceae

135. Batideae

136. Polygonaceae

SERIES 8. MULTIOVULATAE AQUATICAE (Aquatic plants with syncarpous ovary; ovules many)

137. Podostemonaceae

SERIES 9. MULTIOVULATAE TERRESTRES (Terrestrial plants with syncarpous ovary; ovules many)

138. Nepenthaceae

139. Cytinaceae

140. Aristolochiaceae

SERIES 10. MICROEMBRYEAE (Embryo minute; ovary syn- or apocarpous; ovule usually 1)

141. Piperaceae

142. Chloranthaceae

143. Myristicaceae

144. Monimiaceae

SERIES 11. DAPHNALES (Ovary unilocular, ovules 1 to few; perianth sepaloid in 1-2 whorls)

145. Laurineae

- 146. Proteaceae
- 147. Thymelaceae
- 148. Penaeaceae
- 149. Elaeaginaceae

SERIES 12. ACHLAMYDOSPOREAE (Ovary unilocular, ovules 1-3; seeds endospermic without testa)

- 150. Loranthaceae
- 151. Santalaceae
- 152. Balanophoreae

SERIES 13. UNISEXUALES (Flowers unisexual or polygamous; perianth sepaloid and reduced or absent)

- 153. Euphorbiaceae
- 154. Balanopseae
- 155. Urticaceae
- 156. Platanaceae
- 157. Leitnerieae
- 158. Juglandaeae
- 159. Myricaceae
- 160. Casuarinaceae
- 161. Cupuliferae

SERIES 14. ORDINES ANOMALI (Flowers unisexual; families of doubted affinities)

- 162. Salicaceae
- 163. Lacistemaceae
- 164. Empetraceae
- 165. Ceratophylleae

CLASS-GYMNOSPERMEAE (Leaves-parallel veined, flowers pentamerous, cotyledon-1, V. B. scattered & closed; ovules or seeds naked i.e. carpel absent)

- 166. Gnetaceae
- 167. Coniferae
- 168. Cycadaceae

CLASS-III: MONOCOTYLEDONS (Parelllel venation; cotyledon 1; trimerous flowers)

SERIES 15. MICROSPERMAE (Inner perianth petaloid, ovary inferior, seeds minute, exalbuminous)

- 169. Hydrocharideae
- 170. Burmanniaceae

171. Orchideae

SERIES 16. EPIGYNAE (Inner perianth partly petaloid, ovule large, few to many, endosperm abundant)

172. Scitamineae

173. Bromeliaceae

174. Haemodoraceae

175. Irideae

176. Amaryllideae

177. Taccaceae

178. Dioscoreaceae

SERIES 17 CORONARIEAE (Inner perianth petaloid, ovary free, superior, endosperm absent)

179. Roxburghiaceae

180. Liliaceae

181. Pontederiaceae

182. Philydraceae

183. Xyridaceae

184. Mayacaceae

185. Commelinaceae

186. Rapateaceae

SERIES 18. CALYCINEAE (Inner perianth sepaloid, rigid or herbaceous; ovary superior)

187. Flagellariaceae

188. Juncaceae

189. Palmae

SERIES 19. NUDIFLOREAE (Perianth absent or reduced; carpels 1 to many; ovary superior; ovules 1 to many; endosperm present)

190. Pandaneae

191. Cyclanthaceae

192. Typhaceae

193. Aroideae

194. Lemnaceae

SERIES 20. APOCARPAE (Perianth in 1-2 whorls or absent, ovary superior, apocarpous; endosperm absent)

195. Triurideae

196. Alismaceae

197. Najadaceae

SERIES 21. GLUMACEAE (Flowers in dense spikelets, subtended by bracts or glumes, perianth reduced, ovary unilocular & 1-ovuled, seeds endospermic)

198. Eriocaulaceae

199. Centrolepideae

200. Restiaceae

201. Cyperaceae

202. Gramineae

Merits and demerits of Bentham and hooker classification

Merits:

1. It is the first and most accepted natural system of classification.
2. It is very easy to follow for all practical purposes and that is why most of the herbaria of the world are arranged according to this system.
3. In this system the monocots are derived from dicots. Several recent taxonomic findings also support this view.
4. The system starts from Ranales, which is now universally considered to be the most primitive living angiosperm.
5. Disputed families are included in *Ordines anomaly*.
6. The larger taxa are divided into smaller subcategories to bring more clarity.
7. It is very handy for the purpose of quick identification of plants in the field.
8. The series Glumaceae with extremely reduced flowers and inflorescence are placed at the end of the flowering plants.

Demerits:

1. Do not give any clue to the evolutionary history of any genus, family or order.
2. Gymnospermae is placed between the Dicotyledonae and Monocotyledonae, which is extremely and anomalous.
3. In monocot series are not properly arranged. Microspermae which is a highly developed, is placed in the beginning.
4. Liliaceae and Amaryllidaceae were kept apart though they are very closely related.
5. Asteraceae is a highly advanced family and placed in Inferae at the beginning of Gamopetalae.
6. The system does not show any phylogenetic relationship between different taxa.

ADOLF ENGLER 1844-1930 AND KARL A. E. PRANTL 1849-1893

Engler and Prantl's system of classification is a phylogenetic system . They published this monumental work *Die Naturalischen Pflanzenfamilien* (1887-1915) in 23 volumes, which

provided a means for identification of plants from algae to angiosperms. In this work, they provided keys and descriptions of all the plant families known to them at that time.

Later the followers of this system published revised classification in several successive editions of *Syllabus der Pflanzenfamilien*.

Engler and Prantl divided the plant Kingdom into 14 divisions:

I. Schizophyta

II. Myxothallophyta

III. Division Flagellatae

IV. Division Dinoflagellatae

V. Division Bacillariophyta

VI. Division Conjugatae

VII. Heterocontae

VII. Division Chlorophyceae

VIII. Division Charophyta

IX. Division Phaeophyceae

X. Division Rhodophyceae

XI. Division Eumycetes

XII. Embryophyta asiphonogama (Subdivisions Bryophyta and Pteridophyta)

XIII. Embryophyta siphonogama (Subdivisions Gymnospermae and Angiospermae)

Outline of the Angiospermic plants is given below with the number of families in each order in parenthesis.

SUBDIVISION: ANGIOSPERMAE

CLASS 1: MONOCOTYLEDONEAE (Cotyledon 1; leaves with parallel venation; flowers trimerous; stem with closed vascular bundles)

Order 1: Pandanales (3)

Order 2: Helobiae (7)

Order 3: Triuridales (1)

Order 4: Glumiflorae (2)

Order 5: Principes (1)

Order 6: Synanthae (1)

Order 7: Spathiflorae (2)

Order 8: Farinosae (13)

Order 9: Liliiflorae (9)

Order 10: Scitamineae (4)

Order 11. Microspermae (2)

CLASS 2: DICOTYLEDONEAE (Cotyledons 2; leaves with reticulate venation; flowers tetra- or pentamerous; stem with open vascular bundles)

SUBCLASS 1: ARCHICHLAMYDEAE (Plants with achlamydeous flower or with 1 or 2 whorls of perianth; inner whorl free)

- Order 1: Verticillatae (1)
- Order 2: Piperales (4)
- Order 3: Hydrostachyales (1)
- Order 4: Salicales (1)
- Order 5: Garryales (1)
- Order 6: Myricales (1)
- Order 7: Balanopsidales (1)
- Order 8: Leitneriales (1)
- Order 9: Juglandales (1)
- Order 10: Julianiales (1)
- Order 11: Batidales (1)
- Order 12: Fagales (2)
- Order 13: Urticales (3)
- Order 14: Podostemonales (1)
- Order 15: Proteales (1)
- Order 16: Santalales (7)
- Order 17: Aristolochiales (3)
- Order 18: Balanophorales (1)
- Order 19: Polygonales (1)
- Order 20: Centrospermae (10)
- Order 21: Ranales (19)
- Order 22: Rhoadales (7)
- Order 23: Sarraceniales (3)
- Order 24: Rosales (17)
- Order 25: Pandales (1)
- Order 26: Geraniales (21)
- Order 27: Sapindales (23)
- Order 28: Rhamnales (2)
- Order 29: Malvales (7)
- Order 30: Parietales (31)

Order 31: Opuntiales (1)

Order 32: Myrtiflorae (23)

Order 33: Umbelliflorae (3)

SUBCLASS 2: SYMPETALAE (Flowers with 2 whorls of floral leaves; inner whorl fused)

Order 1: Diapensiales (1)

Order 2: Ericales (4)

Order 3: Primulales (3)

Order 4: Plumbaginales (1)

Order 5: Ebenales (7)

Order 6: Contortae (6)

Order 7: Tubiflorae (22)

Order 8: Plantaginales (1)

Order 9: Rubiales (5)

Order 10: Cucurbitales (1)

Order 11: Campanulatae (6)

Merits and demerits of Engler and Prantl classification

Merits:

1. The main merit of the system is that it provides the classification of the whole plant kingdom.
2. The description of each family includes a summary of its morphology, anatomy, embryology and geographical distribution.
3. Bentham & Hooker's polypetalae and monochlamydeae were merged into single subclass Archichlamydae.
4. In this classification, families Orchidaceae (Monocot) and Compositae (Dicot) are treated as advanced families.
5. This system is provided with exhaustive keys of families and orders.

Demerits:

1. In this system monocots have been placed before dicots, however, it has been reversed by Melchior (1964) in 12th edition of *Syllabus der Pflanzenfamilien*.
2. Naked, unisexual flowers of Amentiferae have been treated as most primitive group in this system.
3. Order Helobiae, consisting of primitive forms have been placed between 2 advanced orders Glumiflorae and Pandanales.
4. Family Araceae is derived from family Liliaceae but Araceae was placed before Liliaceae in this system.

5. This system failed to recognise the significance of reduction and it merely corresponded simple with primitive.

Arthur Cronquist 1919-1992

He gave a phylogenetic system of classification. He given the complete version of his concepts of classification in *The Evolution and Classification of Flowering Plants* (1968). The latest and detailed version of his system had appeared in *An Integrated System of Classification of Flowering Plants* (1981). With the help of synoptic keys and detailed charts, he grouped all the angiospermic families into orders and subclasses.

Cronquist recognised 2 classes (i.e. Magnoliopsida or Dicotyledons and Liliopsida or Monocotyledons), 11 subclasses, 83 orders and 383 families and about 2,19,300 species among angiosperms.

A brief outline of the classification is mentioned below and which number of families in each order is mention in paranthesis:

DIVISION MAGNOLIOPHYTA

CLASS I: MAGNOLIOPSISIDA (DICOTS)

Subclass 1: Magnoliidae (Mostly basal dicots)

- Order 1. Magnoliales (10)
- Order 2. Laurales (8)
- Order 3. Piperales (3)
- Order 4. Aristolochiales (1)
- Order 5. Illiciales (2)
- Order 6. Nymphaeales (5)
- Order 7. Ranunculales (8)
- Order 8. Papaverales (2)

Subclass 2: Hamamelidae

- Order 9. Trochodendrales (2)
- Order 10. Hamamelidales (5)
- Order 11. Daphniphyllales (1)
- Order 12. Didymelales (1)
- Order 13. Eucommiales (1)
- Order 14. Urticales (6)
- Order 15. Leitneriales (1)
- Order 16. Juglandales (2)
- Order 17. Myricales (1)

Order 18. Fagales (3)

Order 19. Casuarinales (1)

Subclass 3: Caryophyllidae

Order 20. Caryophyllales (12)

Order 21. Polygonales (1)

Order 22. Plumbaginales (1)

Subclass 4: Dilleniidae

Order 23. Dilleniales (2)

Order 24. Theales (18)

Order 25. Malvales (5)

Order 26. Lecythidales (1)

Order 27. Nepenthales (3)

Order 28. Violales (24)

Order 29. Salicales (1)

Order 30. Capparales (5)

Order 31. Batales (2)

Order 32. Ericales (8)

Order 33. Diapensiales (1)

Order 34. Ebenales (5)

Order 35. Primulales (3)

Subclass 5: Rosidae

Order 36. Rosales (24)

Order 37. Fabales (3)

Order 38. Proteales (2)

Order 39. Podostemales (1)

Order 40. Haloragales (2)

Order 41. Myrtales (12)

Order 42. Rhizophorales (1)

Order 43. Cornales (4)

Order 44. Santalales (10)

Order 45. Rafflesiales (3)

Order 46. Celastrales (11)

Order 47. Euphorbiales (4)

Order 48. Rhamnales (3)

Order 49. Linales (5)

Order 50. Polygalales (7)

Order 51. Sapindales (15)

Order 52. Geraniales (5)

Order 53. Apiales (2)

Subclass 6: Asteridae

Order 54. Gentianales (6)

Order 55. Solanales (8)

Order 56. Lamiales (4)

Order 57. Callitrichales (1)

Order 58. Plantaginales (1)

Order 59. Scrophulariales (12)

Order 60. Campanulales (7)

Order 61. Rubiales (2)

Order 62. Dipsacales (4)

Order 63. Calycerales (1)

Order 64. Asterales (1)

CLASS II. LILIOPSIDA (MONOCOTYLEDONS)

Subclass 7: Alismatidae

Order 65. Alismatales (3)

Order 66. Hydrocharitales (1)

Order 67. Najadales (10)

Order 68. Triuridales (2)

Subclass 8: Arecidae

Order 69. Arecales (1)

Order 70. Cyclanthales (1)

Order 71. Pandanales (1)

Order 72. Arales (2)

Subclass 9: Commelinidae

Order 73. Commelinales (4)

Order 74. Eriocaulales (1)

Order 75. Restionales (4)

Order 76. Juncales (2)

Order 77. Cyperales (2)

Order 78. Hydatellales (1)

Order 79. Typhales (2)

Subclass 10: Zingiberidae

Order 80. Bromeliales (1)

Order 81. Zingiberales (8)

Subclass 11: Liliidae

Order 82. Liliales (15)

Order 83. Orchidales (4)

Merits and demerits of Cronquist system

Merits:

1. Placement of dicots before monocots.
2. Anatomy, embryology and other basis of this classification is completely a phylogenetic approach.
3. Significant key for each group up to family level are very useful for identification of plants.
4. Family Cyperaceae is separated from family Juncaceae. \
5. Cactaceae is placed in Caryophyllales.
6. Magnoliales is treated as most primitive family.
7. Orchidaceae placed in last is most advanced family, having highly evolved flowers in monocots.

Demerits:

1. Subclass Dilleniidae includes Paritales in Caparrales.
2. Families Cyperaceae and Poaceae were placed together under order Cyperales, but the studies show that the 2 families are quite distinct.
3. Shows much emphasis on single character like centrifugal stamens and free-central placentation.
4. Submergence of family Amaryllidaceae into Liliales.

4. Herbarium

A herbarium (plural: herbaria) is defined as a collection of plants or plant parts that are usually dried, pressed, mounted on herbarium sheets and which have been identified and classified according to some system of plant classification so that they provide maximum information about the plants concerned. According to Fosberg and Sachet 1965, "A modern herbarium is a great filing system for information about plants both primary in the form of actual specimens and secondary in the form of published information, picture and recorded notes".

Role of Herbaria

- o Confirm the identity of a new plant to the science.
- o Document the concepts of the specialists who have studied the specimens in the past.

- o Provide local data for planning field trips.
- o Provide records for floristic studies.
- o Serve as a repository of old and new collections.
- o Provide data for revisions and monographs.
- o Serve as a secure repository for “type” specimens.
- o Facilitate and promote the exchange of new material among institutions.
- o Allow for the documentation of flowering and fruiting times of plants.
- o Document which plants grew where through time *viz.* invasive species, climate change, habitat destruction, etc.
- o Document which plants grew with which other plants.
- o Provide material for microscopic observations.
- o Serve as a repository for voucher specimens.
- o Provide material for teaching.
- o Provide space and context for accompanying library and other bibliographic resources.
- o Serve as an archive for related material *viz.* field notebooks, letters, reprints, etc.
- o Provide information on common names and local uses of plants.
- o Serve as a means of locating rare or possibly extinct species via recollecting areas listed on label data.

Serve as an educational tool for the students in institutes

Herbarium technique

Herbarium technique is some times considered to be confined merely to preservation of plants for a herbarium. In its wider sense, the herbarium technique shall include also activities, connected with the specimens after they have been preserved in a herbarium such as identification, labelling, etc.

It involves Plant Collection, Pressing, Drying, Poisoning, Preservation, Mounting, Labelling, Identification, Arrangement, Storage, Care and Protection of Herbarium.

FLORA OF UTTAR PRADESH	
District.....	
State.....	
Serial No.....Date.....	
Botanical Name.....	
Local Name.....	
Habit.....Fl.....Fr.....	
Locality.....Alt.....Soil.....	

1. Plant collection:

The plant specimens should be collected from different localities and habits in every stage of their growth and reproduction. A complete specimen possesses all parts of plant including root system. The plant collected should be either pressed on the spot or may be collected in vasculum and may be pressed after sometime. The plant specimen should be usually in flowering or fruiting stage and multiple specimens should be collected for one plant. During the field work specimens collected must be tagged immediately and the record about habit, habitat, local name, flower, phenology, locality, distribution, uses and other significant information must be noted in the field diary.

2. Pressing and drying:

The plant should be pressed in between the sheets of blotting paper. One plant should be arranged on one sheet in a manner that there should be no overlapping of plant parts. The larger specimens may be folded in V, L, W or N shapes. The blotting paper with plant specimen should be placed in field press for about 24 hours to 48 hours. The press is then opened, blotting should be changed and rearrange the plant properly. After it, press should be again closed and again after 2 or 3 days change the blotting paper and dry in sunlight or the plant is put in dryers and pressed till it gets completely dried.

3. Poisoning and preservation:

Poisoning of the specimens must be done as soon as possible after collection of the plant specimens. Poisoning kills the plant and thereby prevents the formation of abscission layer and decay. For poisoning the specimens mercuric chloride, lauryl pentachlorophenate (LPCP), formalin, fumigates (volatile poisonous liquids) like methyl bromide, carbon disulphide, carbon tetrachloride, paradichlorobenzene are suitable.

a. Mercuric chloride: The poisoning is generally done by dipping the whole plant in a saturated solution of mercuric chloride with ethyl alcohol. This solution is prepared by using 9 parts 90% alcohol and 1 part saturated solution of mercuric chloride in 90% alcohol i.e. in ratio of 9:1. The solution is transferred in a tray and the specimen is dipped in the solution with the help of pincers. Dipping fingers in this solution should be avoided and rubber gloves should be used while poisoning. All the parts of the plant are dipped in the solution and left for 15 to 20 seconds, depending upon the thickness of the plant. After dipping, the specimens are again placed on a blotter for drying out the excess solution. If it is not possible to spread out the plants nicely immediately after poisoning, it can be done after few hours of drying in the press. Mercuric chloride solution can be used for poisoning mounted specimens also. This is done with the help of a brush dipped in mercuric chloride solution.

b. Formalin: Poisoning plants during explorations and expeditions involving longer duration. This is also called formalin method. In this method specimens are spread out in ordinary old newspapers and bundled up. Each bundle is then placed in a large polythene bag, 10% formalin is poured over the bundles to get soaked thoroughly, without however leaving excess of formalin in the bags. The bags are then tied air tight, even for over 90 to 120 days. Specimens are then exposed to atmosphere to drive away the excess of formalin fumes.

c. Fumigation: This is done for killing pest in mounted as well specimens. This process involves any one of the volatile poisonous liquids like methyl bromide, carbon disulphide or carbon tetrachloride. Sometimes para dichlorobenzene (PDB) is used. This chemical can also be sprinkled on sheets or in bundles. PDB should not be used along with naphthalene.

4. Mounting of specimens:

After pressing, drawing and poisoning, the specimens must be mounted for permanent record on sheet called mounting papers or herbarium sheets. The herbarium sheet is of standard size that is 11.5" X 16.5" (i.e. 28.5 X 42 cm approx.) and must be heavy and of good quality to support the specimens. Some curators use 100% rag paper, but this is very expensive. The paper of low rag content is more generally used. The specimens are mounted on the sheet with the help of glue, an adhesive gummed strips, quick drying liquid paste or stitching.

5. Labelling of the specimens:

After mounting the specimens on herbarium sheets, it should be properly labeled. A label is glued on the lower right side of the herbarium sheet. Herbarium slip or label is important part of finished specimen. It should be of size 4" X 2.5" (i.e. 10 X 6 cm approx.) and must give the following information:

6. Identification

Identification is the process through which a specimen whose name is not recognized by its character is identified. The next and equally important task is identification by the use of correct nomenclature. The scientific method is to first study the character of the plant, check them with the flora of the region, work through the family, genus and species and compare with full description and illustration, then compared with earlier identified plant of species of that variety.

7. Filing the specimens:

The mounted, identified and accessioned herbarium sheets are sorted out family, genus and species wise. All same species sheets are filled in lighter cover called the "species cover" or folder and all the species with species covers belonging to one genus are placed in one or more folders of thick paper called the "genus cover".

8. Arrangement of specimens:

The specimens are usually arranged in the herbarium according to some accepted system of classification. All the Indian herbaria follow the order, numbering of families and genera according to the system of Bentham and Hooker's *Genera Plantarum*.

9. Storage of herbarium sheets:

The mounted plant specimens or herbarium sheets may be stored in specially constructed herbarium case following some accepted system of classification. Within the family genera should be arranged alphabetically.

10. Care and protection of herbarium sheets:

To protect herbarium sheets from moulds, fungi and insects etc. 2% solution of mercuric chloride should be sprayed. Mothballs or naphthalene flakes may also be placed in shelves of herbarium from time to time.

5. Morphology of woody plants

There are many features by which any plant species may be identify, but the best way is to select the most common morphological as well as general characters like bark colour and splitting pattern, leaf type, leaf arrangement, reproductive characters etc. General characters includes tree size, growth, form, associates, range of distribution, tolerance, site etc.

Herbs

These are soft stem plants which have generally less than 1 m height and it may be annual, biannual or perennial, e.g., *Cassia tora* (Puad), *Cleome viscosa* (Hulhul), *Cyperus rotundus* (Motha) etc.

Shrubs

Shrubs are woody plants which have generally less than 6 m height, many tillers arising from ground level and perennial in nature, e.g., *Calotropis procera* (Madar), *Ziziphus nummularia* (Jhar ber), *Lawsonia inermis* (Mehandi), *Acacia jacquemontii* (Babal), *Calligonum polygonoides* (Fog), *Commiphora wightii* (Guggal), *Grewia tenax* (Gangan) etc.

Trees

It is a woody perennial with a well marked single trunk or bole, more than 6 m height e.g. *Tectona grandis* (Teak), *Azadirachta indica* (Neem), *Cedrus deodara* (Deodar) etc. In forestry there are five stage of growth viz. Recruit, seedling, sapling, pole and tree has been standardized for a tree (Anon, 1966).

Recruit: From germination stage to emergence of 2-3 leaves of the plant.

Seedling: From recruit stage upto height of 1 m of the plant.

Sapling: From seedling stage to the lower branches begin to fall. It is characterized by the dead bark on the stem and its vigorous height growth.

Pole: From the fall of lower branches increase in height starts to fall, crown expansion becomes marked and diameter at breast height is 30 cm.

Tree: After passing the pole stage or more than 30 cm diameter at breast height.

Stem

Stem is developed from the plumule of the seed. It is a main axis of plant bearing leaves with buds in its axils.

Acaulescent: The stem is not visible e.g. Banana

Arborescent: Plant, which has a visible woody stem, e.g. stems of Mango, Neem, Lantana etc.

Caudex: Main stem or bole is unbranched, straight and bearing crown of leaves, e.g. *Cocus nucifera* (Coconut), *Phoenix sylvestris* (Indian date) etc.

Excurrent: Main stem or bole keeps on growing and lateral branches giving a conical shape to the tree due to their arrangement in acropetal order, e.g. *Pinus roxburghii* (Chir), *Cedrus deodara* (Deodar) etc.

Deliquescent: The apical bud of main stem is suppressed and lateral branches became dominant giving a spreading shape to the tree, e.g. *Madhuca indica* (Mahua), *Mangifera indica* (Mango), *Tamarindus indica* (Imli) etc.

Culms: Stem with nodes and internodes like grasses here nodes are solid and internodes are hollow, e.g. Bamboo.

Scape: Unbranched flowering shoot, leafless produced by underground stem, e.g. Canna, Onion, Garlic, Cyperus sp.

Modification of stems

1. **Phylloclade:** When stem become flattened or swollen, fleshy with several nodes and internodes and works and appears leaf like green. Leaves are reduced into scales or modified into spines, *Opuntia* *Euphorbia nerifolia* (Thor) etc.
2. **Cladode:** It is a type of phylloclade with one or two internodes only. It resembles and work like a leaf and leaves are reduced into spines or scales, e.g. Asparagus
3. **Thorn:** Thorn is a modification of branch. It is straight, hard, pointed, deep seated with vascular connections to the stem, e.g. *Balanites aegyptiaca* (Hingot), *Myrtinus emarginata* (Kankera), *Bougainvillea*
4. **Stem-tendrils:** Axillary or terminal bud modified into tendrils for climbing, e.g. Passiflora, Grape vine etc.

Deviations in tree stem

Buttresses

The buttress is the flattened outgrowth or extensions on stem or root of certain tree species. It is a characteristic feature of some mangrove or littoral forest tree species where soil is poor in nutrients. It is arisen for mechanical support to the bole and to increase the area for absorbing the nutrients from the soil. Examples of buttress trees are *Bombex ceiba*, *Terminalia spp.*, *Sterculia alata*, *Ficus spp.*, *Ceiba pentandra* etc.

Crook

Crook is a deviation from the vertical axis in various successive lengths both above and below which the stem is straight or Crook is a tree defect characterized by sharp bend in the main stem.

Flutes

Fluting is a defect caused by insect attack, faulty practices of thinning and regrowth of dormant buds on bole. It is an irregular swelling on the tree trunk just above the base viz. *Lagersroemia parviflora* (Jarul), *Woodfordia fruticosa* (Dhawai), *Azadirachta indica* (Neem)

Bark and blaze

Bark is the covering of stem, mainly the trunk that reduces water loss, prevent pathogen entry and save internal tissues from mechanical injury. It may be smooth, exfoliating (splitting in large sheets), fissured (split or cracked), or ringed (with circular fissures). Economically bark is used in fuel, tannin, dye, fiber and medicine. It is also an important character of identification of woody plants particularly during the leaf-fall season.

Blaze is a slash made on the tree stem by a knife or axe for determination of colour. It is a colour of freshly cut wood. Some examples are given below of various colours, pattern of splitting of bark and blaze of tree and shrub species for example *Aegle marmelos* bears silver grey, shallow fissured, rough bark and pale yellow colour, hard thicken blaze.

Leaf

Green flattened organ arise from the apex of shoot and specialised for photosynthesis. A leaf consists leaf stack (petiole), lamina and leaf apex.

Leaf colour

Generally leaves of any plant are green except some plants viz. *Prunus cerasifera* (Purple leaf plum), *Corylus maxima* var. *perpurea* (Hezelnut) *Iresine* (Bloodleaf), *Amaranthus*, *Acalypha*, *Coleus* etc. In some plants colour of the leaf vary with age of plant, age of leaf and surrounding environment. Colour and surface of a single leaf may vary in lower and upper surfaces. Lower surface of leaf mostly being light green and upper one is dark green. Some plants have different colour leaves in its young stage viz. young leaves of *Syzygium cumini*, *Lannea coromandelica*, *Quercus rubra*, *Ficus religiosa*, *F. lacor*, *Madhuca longifolia*, *Flacourtia indica* are pinkish, those of *Quercus incana*, *Acer platanoides* (Crimson Maple), *Corylus avellana* (Hezelnut) purplish, those of *Indopiptadenia oudhensis* (Gainti). Whereas, in some species leaves undergo a remarkable change in colour before falling from the tree this phenomenon is known as autumn tint. It helps the forester or a horticulturist in recognizing the species viz. before falling the leaves of *Adina cordifolia* (Haldu), *Corylus maxima* (Hezelnut), *Sterculia foetida*, *Lagerstroemia parviflora* (Senj), *Cassine glauca* (Jamrashi), *Morinda coreia* (Aachhi), *Populus ciliata* (Himalayan poplar), *Aesculus indica* (Horse chest nut) turn yellowish, and the leaves of *Terminalia pendula* (Kala dhok), *T. anogeissiana* (Axle wood) dark red or bronze, and *Terminalia catappa*, *Sapium sebiferum* beautiful red and orange.

Phyllotaxy (Arrangement of leaf)

Alternate: One leaf is found on each node usually form a twisting pattern. Mathmatically it is regular arrangement. In $1/2$ distichous phyllotaxy, where third leaf is above the first leaf as in grasses. In $1/3$ tristichous phyllotaxy the fourth leaf lies above the first leaf e. i. sedges. In $2/5$ pentastichous phyllotaxy the sixth leaf found above the first leaf and completing two spirals therefore this is known as $2/5$ phyllotaxy e.i. *Ficus spp.*, *Hibiscus rosa-sinensis* etc. In $3/8$ octastichous phyllotaxy the ninth leaf found above the first leaf as in *Carica papaya*. In parastichous phyllotaxy leaf bases are closely set and internodes are very small making difficult to count the number of rows. It is found in date palm and other palms.

Opposite: At each node bears a pair of leaves. The pairs of successive leaves may be parallel (superposed) as in Guava or at right angles (decussate) as in Teak and Madar.

Whorled (verticillate): In whorled phylotaxy 3 or more then 3 leaves found at each node as in *Alstonia*, *Callicarpa*, *Raulwolfia* etc.

Cauline: When leaves borne on the stem as in Khajur, Palms and initially in Mango, Jamun, Teak, Neem etc.

Ramal: When leaves borne on the branches as in Neem, Peepal, Gular, Ber etc.

Leaf incision

A leaf with a single lamina and incision is so light that does not devide the lamina termed as simple leaf, e.g. Teak, Sal, Gular, Mango, Axlewood tree, Chilbil, Mahua, Galgal (*Cochlospermum religiosum*) Castor etc.

A compound leaf has incision reaching the midrib (or leaf base) so that there are more than one distinct blades called as leaflet or pinnae. It may similarly be pinnate when the leaflets are borne separated along the rachis or palmate when the leaflets arise from a single point at the base. Both types of compound leaves may be further differentiated:

- i. **Unipinnate:** The leaflets are arranged directly along the rachis. Further based upon the number of leaflets these are subdivided as paripinnate leaf (leaflets in pairs) e.g. Salar (*Boswellia serrata*), Amaltash (*Cassia fistula*), kasod (*Senna siamia*), Rohin (*Soymida febrifuga*) and imparipinnate leaf (leaflets unpair) resulting in odd number of leaflets e.g. *Azadirachta indica*, *Millettia extensa*, Cutsagon, medsinghi (*Dolichendron falcata*), Jhingan (*Lannea coromandelica*), Kharpat (*Garuga pinnata*) etc.
- ii. **Bipinnate:** The pinnae are again dived into pinnules, so that the leaflets are borne on the primary branches of the rachis as in Deshi baool, Israeli babul, Khair tree, Drumstic tree, Bakain, Malabar neem, Khejri (*Prosopis cinerarea*), Garunfal tree (*Radermachera xylocarpa*).
- iii. **Tripinnate:** The dissection goes to the third order so that the leaflet are borne on secondary branches of the rachis as in *Moringa*.

- iv. **Decompound:** Here the dissection go beyond the third order, as in Fennel.
- v. **Ternate:** The leaflets are present in groups of three. Leaf may be ternate (pinnate with three leaflets).

Palmate compound leaf does not have a rachis and the leaflets arise from the top of the petiole:

- i. **Unifoliate:** A modified situation in commonly a trifoliate leaf when the lower tow leaflet are reduced and the terminal leaflet look like a simple leaf but has a distinct joint at base, as seen in *Citrus* plant.
- ii. **Bifoliate:** A leaf with two leaflets, as found in *Hardwickia* binate, *Balanites aegyptiaca* and *Bignonia sp.* etc.
- iii. **Trifoliate:** A leaf with three leaflets as in *Butea monosperma*, *Aegle marmelos*, *Crataeva nurvala*, *Vitex peduncularis* and *Rhus mysorensis* etc.
- iv. **Quadrifolia:** A lesf with four leaflets, as in *Oxalis*, *Marselia*.
- v. **Multifoliate:** A leaf with more than four leaflets, as in *Bombax ceiba*, *Alstonia scholaris*, *Ceiba pentendra* etc.

Leaf duration

Leaves may attached and function for many years to very few days mostly depending upon climatic conditions and adaptation.

Caducuous: These type of leaves shed off within few days after formation, as in *Capparis decidua* and *Opuntia sp.* etc.

Deciduous: Leaves falls at the end of growing season mostly in winter season. In tropical climate of Central and south India, the tree may be leafless for very short period. *Cassia fistula*, *Zizypus mauritiana*, *Mangifera indica*, *Populous spp.* etc.

Evergreen: Leaves remains attached roundoff the year, falling regularly so that tree is never leafless, as in *Abies pindrow* (Fir), *Euonymus pendulus* (Kath kumkum), *Cryptomeria japonica*, *Cupressus torulosa*, *Magnolia grandiflora*, *Quercus sp.* etc.

Stipules: An outgrowth from the leaf base for the protection of leafbud in initial stage. Leaves with stipules are termed stipulate and those without stipules as exstipulate.

Leaf shape

Various types of shapes of lamina of leaf is found in the plant species as given below:

Apicular: Like needle long thin and pointed as in pine (Fig. 3).

Cordate: Lamina is heart shaped, with a deep notch at base, as in *Tinospora cordifolia*.

Cuneate: Lamina snake hood-shaped, tapering towards the base, as in *Pistia*.

Elliptical: Lamina is oval shaped; usually length is more than breadth, as in *Psidium guajava*.

Hastate: Lamina is arrowhead shaped with two basal lobes directed outwards, as in *Typhonium* and *Ipomoea* also referring to hastate leaf base.

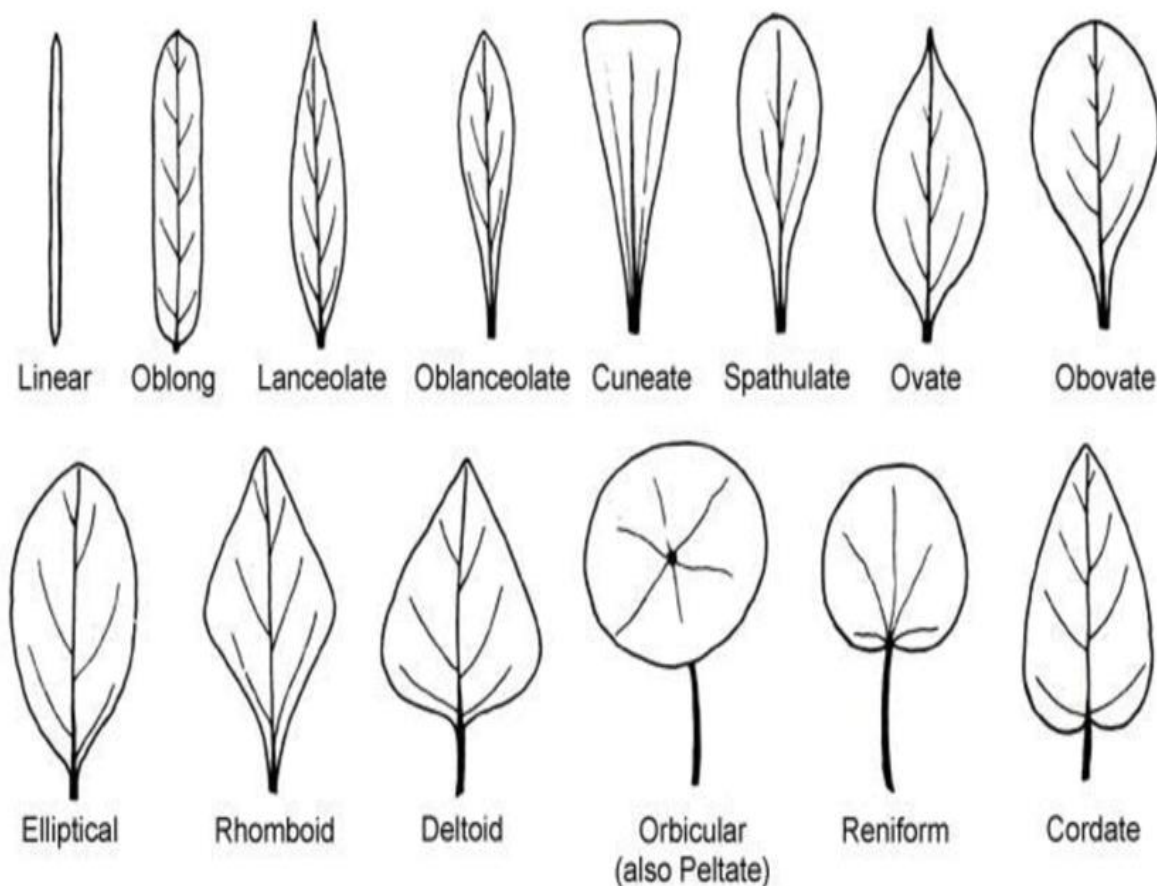


Fig. 3 Shape of leaf

Lanceolate: Lamina is lens shaped, tapering from a broad base towards the apex, as in *Callistemon lanceolatus*, *Nerium indicum*, *Dendrocalamus strictus* etc.

Linear: Lamina is long and narrow with nearly parallel sides as in most of grasses and onion.

Lunate: Lamina like half-moon, as in *Dryopteris sp.* and *Passiflora lunata*.

Lyrate: Lamina is lyra-shaped as in *Brassica compestris*.

Obcordate: Lamina is like cordate but with broadest part near apex as in *Bauhinia sp.*

Oblong: Lamina is uniformly broad along the whole length as in Banana.

Obovate: Lamina is like inverted egg as in *Terminalia catappa*, *Prunus amygdalus* etc.

Ovate: Lamina is egg-shaped broad part near the base, as in *Sida ovata*, *Ficus religiosa*, *Hibiscus rosa-sinensis* etc.

Orbicular: Lamina is circular in outline as in *Nelumbo nucifera* and *Nasturtium sp.* is orbicular in outline.

Reniform: Lamina is kidney shaped as in *Centella asiatica*.

Spathulate: Lamina is like a spatula, broadest rounded in near the apex, gradually narrowed towards the base as in *Euphorbia nerifolia*.

Margins of leaf

The edge of a Lamina is known as margin and may show any of the following type:

Entire: Lamina margins are smooth, without any indentation as in Mango, Jamun, Eucalyptus etc

Spinous: When lamina margins teeth with pointed ends as in Quercus, Pineapple, Argemone etc

Crenate: When margins have rounded ends of teeth as in *Flacourtia indica*, *Kalanchoe*, *Aegel marmelos*, *Garuga pinnata*, *Ailanthus excelsa* etc.

Dentate: Margin of lamina with sharp teeth pointing outwards as in *Cordia monoica*, *Broussonetia papyrifera*, *Xanthium strumarium* etc.

Serrate: Lamina margins with sharp teeth pointing downward like saw, as seen in Rose, Neem, Oak etc.

Serrulate: Margins of leaf blade minutely serrate as in *Putranjiva roxburghii*.

Biserrate: The serrations of lamina margins are again serrate similarly as in *Helecteres*, *Ulmus* etc.

Undulate: This is also known as sinuate or wavy in this type of lamina margins winding gradually up and down as in *Polyalthia*, *Kydia*, *Ficus benjamina*, *Dalbergia latifolia* etc.

Leaf base

Leaf base helps to the leaf in adhering to the stem or branch. Various plants have various types of leaf bases which are given below:

Pulvinus: This type of leaf base is found in most of the tree species in which base is swollen and attached to the stem or branch as in *Vachellia nilotica*, *V. catechu*, *Mangifera indica*, *Butea monosperma*, *Pongamia pinnata* etc.

Amplicaul: When leaf base completely clasps and surround the stem as in *Tamarix dioica*, *Polygonum* etc.

Sheathing: This type of leaf base is found in monocots which is broad and encloses a a stem above the node as in *Musa paradisiaca*, *Zea mays*, *Triticum*, *Hordium* etc.

Auriculate: When leaf base is expended surrounding the stem and looks like ear as in *Calotropis*.

Decurrent: Petiole and base become broad, winged and extends down the stem and ensheath the node as in *Crotolaria*, *Laggera* etc.

Perfoliate: When basal lobes of the leaf united as to appear, the stem is passed through the leaf, as in *Aloe perfoliata* and *Swertia* etc.

Apex of leaf

Apex of leaf is of the following types:

Acute: Apex is pointed with sides forming acute angle, as in Mango, China-rose, Jamun etc.

Acuminate or caudate: Leaf apex gradually taper and make a tail like structure as in *Ficus religiosa*.

Cirrhose: When the apex of lamina end in a thin and coiled structure as in *Flagellaria indica*, *Gloriosa superba*.

Cuspidate: When apex of lamina abruptly narrowed into sharp spiny tip as in Pineapple.

Emarginate: When a notch present at the apex becomes deep and divide the lamina in to two lobes as in *Bauhinia*.

Mucronate: Apex is broad and round with a small point, as in *Ixora parviflora*, *Cassia javanica*, *Desmodium triflorum* and *Catharanthus roseus* etc.

Obtuse: Apex is round and broad with two sides forming more than 90-degree angle as in *Ficus bengalensis*.

Retuse: Apex ends with a slight notch as in *Clitoria* and *Pistia*.

Truncate: Apex seems as cut straight across, as in *Paris polyphylla*.

Leaf surface

Leaf surface characteristics are important in diagnosis of several taxa. Leaf surface may be covered by trichomes arranged variously.

Glabrous: If there is no hairs or any other ornamentation present on surface of lamina as in Semal, Mango, Jamun, Ashok, Mahagony, Toon etc.

Glaucous: Surface of leaf blade with waxy coating, which easily rubs off as in genus *Citrus*, *Eucalyptus*, *Trichillia connaroides* etc.

Glutinous: Surface of leaf blade coated with sticky exudation as in *Tobacco nicotiana*.

Hispid: Leaf blade is covered with stiff hairs as in *Arnebia hispidissima*, *Ficus hispida*.

Lanatus: When covered with long, intertwined and wooly hairs as in *Verbascum thapsus*

Pilose: Lamina is covered with straight and sparse hairs as in *Indigofera astragalina*, lower surface of *Dalbergia lanceolaria* etc.

Pubescent: Leaf blade is covered with straight, soft and short hairs as in *Flacourtia indica*, *Terminalia coronata*, *Cocculus hirsutus*, *Averrhoa carambola*, *Kydia calycina*, *Indigofera hamiltonii* etc.

Rugose: Surface have reticulated lines with convex space between the line as in *Plecteranthus rugosu* (Upper surface), *Euonymus tingens* etc.

Scabrous: Surface of lamina feels tough due to short rough points as in *Streblus asper*, *Helecteris isora*, *Tectona grandis*, *Nyctanthes arbor tristis* etc.

Sericeous: Leaf blade is covered with fine, soft and silky hairs as in *Desmodium brachystachyum* (Lower surfacea), *Anogeissus acuminata* (Lower surfacea),

Stellate: Lamina is covered with branched star-shaped hairsas in *Grewia abutifolia*, *Deutzia scabra* etc.

Leaf texture

Texture is the overall appearance of the leaf. Generally, four types of leaf texture is observed in leaves of woody plants as:

Succulent: Fleshy and juicy leaf as in *Aloe*, *Ardisia*, *Saxifrega*, *Paperomia*, *Bryophyllum* etc.

Coriaceous: Tough and thick leaf which is very common as in Guava, Kadam, Madar, Mango, *Dillenia auria*, *Pterocarpus marsupium*, *Terminalia alata*, *Butea monosperma*, *Bauhinia variegata*, *Shorea robusta* etc.

Scarious: Non-green thin and dry leaf as in *Asparagus*

Membranous: Membrane like thin and pliable leaf as in *Delonix elata*, *Solanum nigrum*

Chartaceous: Papery and thick as in *Dillenia indica*, *Passiflora foetida*, *Elangium salvifolium* etc.

Venation

The arrangement of veins in leaf is known as venation. Dicots shows a network of veins; whereas monocots usually have parallel veins.

Reticulate: Veins makes net like structure in lamina, e.g., in lamina of most of dicots. It is of two type:

- i. **Unicostate:** Centre of lamina have one midrib which is known as central or principal vein, lateral veins arise from this central or principal vein and again these veins produce new veinlets as in *Ficus religiosa*, *Bridelia retusa*, *Holoptelia integrifolia* etc.
- ii. **Multicostate:** There is no principal vein, many veins arise from the base of leaf and run towards the upperside and if these veins meet at the apex and known as **convergent** as in Ber, Tejpat and if diverting without meeting then known as **divergent** e. g. Papaya.

Parallel: When all veins parallel to each other from base to tip of leaf as in most of monocots. It is of two types:

Unicostate: Leaf blade has a principal vein in centre. Lateral veins originat from principal vein and run perpendicular to the midrib as in Banana, Canna etc.

Multicostate: In this type there is no single principal vein, many veins arise from the leaf base and converge towards the apex as in grasses, Bamboo etc known as convergent venation. If all the veins running towards the apex, diverge towards the leaf margins known as divergent venation as in Palmyra palm.

Inflorescence

The flower is found singly on the terminal part of branch is known as solitary terminal flower as in Papaver. If the flowers are present in the axile of leaf then it is known as solitary axillary China rose, Guava etc. Mostly the flowers are produced in groups in a some definite arrangement. This arrangement of flower on the plant axis is known as inflorescence. There are two principle type of inflorescence are found i.e. racemose and cymose.

Racemose (Indefinite)

Peduncle has an indefinite growth and flowers are arranged in acropetal manner (oldest flowers near the base and youngest near growing point). These are of the following types:

Raceme: Inflorescence with single axis bearing flowers as in *Brassica campestris*, *Cassia fistula* etc.

Panicle: Branched raceme, the flower being borne on the branches of the main axis, as in Mango, Chironji.

Spike: Raceme with sessile flowers, as in *Adhatoda vasica*.

Spadix: The axis is fleshy and the flowers are covered by a large bract known as spathe, as in *Alocasia* and Arum.

Corymb: Flat-topped racemose with longer lower pedicels and all flower at the same level as in *Iberis amara*.

Catkin: Spike like with reduced unisexual flowers as in *Morus alba*.

Umbel: Flowers arising from one point due to condensation of axis as in the family Apiaceae.

Head: Flat-topped axis bearing crowded sessile flowers as in *Acacia* and *Mimosa*.

Capitulum: Flat-topped with distinct ray and disc florets as in *Vernonia*, *Ageratum*, *Conyza* etc.

Cymose (Definite)

The peduncle terminates (definite growth) in a flower and does not elongate further. The flowers are arranged in centripetal manner (oldest flowers in centre and youngest towards the periphery). These are of the following types:

Monochasial (Uniperous) cyme: Single branch arise from the peduncle of old flower and further terminate in to flower. Monochasial can be two types:

- (i) **Helicoid cyme:** Successive branches are borne in one side forming a sort of helix as in Drosera, *Myosotis*

(ii) **Scorpioid cyme:** Lateral branches arise on alternate sides (Fig. 4) as in *Heliotropium Solanum nigrum* etc.

Dichasial (Biparous) cyme: Two lateral branches arise below the apical flower at each level so that the flower is between the fork of two branches, as in *Dianthus, Spargula* etc.

Polychasial (multiparous) cyme: More than two lateral branches arise at a node below the terminal flower as in *Ixora, Calotropis* etc.

Cymose head: In this type of inflorescence flowers make a compact group of flowers arising from a condensed peduncle as in *Vachellia nilotica, Vachellia leucophloea, Albizia amara* etc.

Scapigerous head: In this type of inflorescence many cymose groups are covered by bracts. The flowering axis is known as scape as in *Urginea indica, Allium cepa* etc.

Specialized type

Cyathium: This is a complex type of inflorescence found in genus *Euphorbia*, having a cup-shaped involucre with five nectaries along the rim and enclosing many male flowers encloses a single female flower in the centre as in *Euphorbia nerifolia, E. caducifolia, E. nivulica* etc.

Verticillaster: It consists a series of nodes each node bears two opposite clusters of condensation dichasial cyme, subsequently becoming monochasial as a number of flowers in each clusters exceeds three as in family Lamiaceae.

Hypanthodium: A flesh receptacle with a small opening at the top and bearing flowers along the inner wall of the cavity as in *Ficus racemosa, F. religiosa, F. carica, F. benghalensis* etc.

Thyrse: With main axis indeterminate growth but lateral axis determinate growth as in grape vine, lilac etc.

Flower

A flower is modified shoot bearing specific floral leaves. Following terms are generally used in flower description:

Bract: Reduced leaf like structure found on the base of peduncle.

Bracteate: Bract is present as in *Anogeissus acuminata, Vachellia farnesiana, Maytenus senegalensis, Justicia vasica* etc.

Ebracteate: Bracts absent as in *Murraya koenigii, Annona squamosa, Artabotrys hexapetalus, Polyalthia longifolia* etc.

Bracteolate: Bracteoles are present on pedicel as in *Cinchona, Oldenlandia, Coffea, Ixora, Mussaenda, Morinda* etc.

Pedicel: Floral axis attached to the flower.

Pedicellate: Distinct pedicel present as in *Cananga, Rosa, Hibiscus, Melia, Miliusa* etc.

Subsessile: Pedicel is very reduced often shorter than flower

Sessile: Pedicel absent as in *Adhatoda vasica, Avena sativa, Bambusa* etc.

Complete: When four floral whorls are present as in *Muntingia calabura*, *Grewia tiliaefolia*, *Litchi sinensis*, *Scheichera oleosa*, *Acer saccharinum* *Dodonaea viscosa* etc.

Incomplete: When one or more floral whorl is absent as in *Litsea chinensis* *Machilus macrantha* *Persea Americana* (Avocado), *Sassafras albidum* etc.

Symmetry: Relative shape and size of sepal in calyx whorl and relative shape and size of petal in the corolla whorl.

Actinomorphic: A flower that can be divided into equal halves when cut along any vertical plane as in *Michelia champaca*, *Adina cordifolia*, *Anthocephalus cadamba* syn. *Anthocephalus chinensis*, *Mitragyna parviflora* and *Randia spinosa* etc.

Zygomorphic: Flower that can be divided into equal halves by one or more but not all vertical planes as in *Dictamnus*, *Galipea*, *Alnicida*, *Schleichera* and *Dodonaea* etc.

Irregular: *Moringa oleifera*, *Canna indica*,

Position of Floral organs on Thalamus

Hypogynous: A flower in which ovary is superior and other floral whorls inferior as in *Magnolia*, *Michelia*, *Annona squamosa*, *Polyalthia longifolia* etc.

Perigynous: Having sepal, petal, stamens, round the gynoecium, hapanthium present; ovary half superior as in *Rosa*, *Prunus* etc.

Epigynous: Having the various whorls (petals, sepals & stamens) above the ovary, inferior ovary, e.g., *Treminalia arjuan*, *Psidium guajava*, *Myrtus* etc.

Calyx:

The first whorl of sepals.

Sepal: One individual part of calyx.

Petaloid: When sepals are colourful like petal.

Polysepalous: When sepals are free or distinct as in *Rosa*.

Gamosepalous: When sepals are fused as in *Cinchona officinalis*, *Adina*, *Morinda* etc.

Aestivation: Arrangement of sepals in bud. Following types of arrangement of sepals found in flower buds:

- (i) **Valvate:** Edges of sepal meet without overlapping as in *Morinda*, *Mussaenda*, *Ola* etc.
- (ii) **Twisted:** Overlapping in regular with one margin of each sepal overlapping and other being overlapped.
- (iii) **Imbricate:** One sepal completely internal, one completely external and the remaining sepals are partly internal and partly external as in *Zanthoxylum*, *Toddalia*, *Sweitenia*, *Lannea* etc.

- (iv) **Quincuncial:** Out of five sepals, two are external, two internal and the fifth partly internal, partly external as in *Dianthus*.

Corolla

Corolla is a second whorl of petals.

Petals: One of the individual part of corolla usually colourful.

Polypetalous: When petals are free as in *Rosa*, *Plumeria*, *Brassica* etc.

Gamopetalous: When petals are jointed as in *Ipomoea*, *Catunaregam spinosa* *Mitragyna parvifolia*, *Morinda tinctoria* etc.

Astivation: Arrangement of petals in the flower bud.

- (i) **Valvate:** Sepal lobes not overlapping as in *Ixora*, *Mussaenda*, *Solanum* etc (Fig 4.5).
- (ii) **Twisted:** Overlapping in regular pattern, with one margin of each sepal overlapping and other being overlapped as in *Wrightia tinctoria*, *Thevetia peruviana*, *Plumaria rubra*, *Tabernaemontana divaricata* etc.
- (iii) **Imbricate:** Irregular overlapping of petals, one completely internal, one completely external and the remaining three partly internal and partly external as in *Rondeletia*, *Madhuca*, *Mimusops*, *Zanthoxylum*, *Punica granatum* etc.
- (iv) **Quincuncial:** Out of five petals, two are external, two internal and the fifth partly internal and partly external as in etc.
- (v) **Vexillary:** Out of the five petals the posterior one (standard) is the largest and covered two lateral petals (wing), and the lateral petals overlap the two anterior and smallest petals (keel) as in family Papilionaceae.

Shape of corolla

Cruciform: Four free petals arranged in the form of a cross; each one is differentiated into a claw and limb as in family Brassicaceae

Caryophyllaceous: Five free petals with long claw and limbs placed at right angles to the claws as in *Arenaria*, *Dianthus*, *Oxalis* etc.

Rosaceous: Five or more free petals not differentiated into limb and claws as in *Rosa*.

Campanulate: Bell shaped five joined petals as in *Ipomoea*, *Celastrus* (Malkangni), *Withania somnifera* (Ashwagandha), *Catunaregam spinosa* etc.

Infundibuliform: Funnel-shaped corolla as in *Ipomoea*, *Thevetia* (Paras peepal), *Mitragyna* (Krishna kadam), *Morinda* (Aal), *Petunia* etc

Salver-shaped: Petals jointed with a long tube and horizontal limb as in *Ixora*, *Mussaenda*, *Tabernaemontana divericata* (Chandni) etc.

Rotate: Wheel-shaped jointed corolla with a flat and circular limb at right angles to the short tube as in *Nerium*, *Nyctanthes*, *Solanum* etc.

Papilionaceous: Corolla with one large posterior standard, two lateral wings and two innermost and smallest keels as in *Delonix regia*, *Butea monosperma*, *Dalbergia sissoo*, *Pongamia pinnata* etc.

Bilabiate: Two lipped zygomorphic with jointed petals as in members of family Lamiaceae; *Justicia vasica* (Aadusa), *Leucas cephalotus* (Gumma) *Ocimum sanctum* (Tulsi) etc.

Personate: It is also known as masked in which corolla is zygomorphic, fused and bilabiate as in *Lindernbergia muraria* (Patthar chatti), *Antirrhinum majus* (Dog flower)

Ligulate: Strape shaped. It is a zygomorphic tube like corolla forming a ligule-like structure as in members of family Asteraceae *Sonchus arvensis*, *Tagetes erectus*, *Conyza bonariensis* etc.

Perianth

When there is no differentiation in calyx and corolla. In this condition, both sepals and petals are green.

Tepal: Tepal is the unit of perianth.

Polytepalous: When petals are free as in *Phyllanthus*, *Gloriosa*, *Polygonum* etc.

Gamopetalous: When tepals are fused.

Sepaloid: When tepals are green and look like sepals as in *Phienix sylvestris* (Khajoor).

Petaloid: When tepals are colored and look like petals as in *Asphodelous*, *Allium* etc.

Androecium

Androecium: Androecium is a group of stamens, which makes third whorl of the flower.

Stamens: An individual part of androecium that consists filaments and anthers.

Staminiode: Sterile stamens, which do not bear fertile pollen as in *Stellaria*

Polyandrous: When stamens are free from each othre as in Poppy.

Monadelphous: When the filaments of all the stamens are united into one bundle and anthers are free as in memebers of family Malvaceae.

Diadelphous: When filaments of all the stamens are united in to two bundles with free anthers as in members of family Fabaceae *Butea monosperma*, *Delonix regia* etc.

Polyadelphous: When filaments of all the stamens are united in to more then two bundles with free anthers as in *Bombax ceiba*, *Ricinus communis* (Castor) etc.

Syngenesious: When the anthers are cohering and filaments free as in family Asteraceae.

Synandrous: When stamens are united throughout the lenth of filament and anther as in family Cucurbitaceae

Epipetalous: When stamens are attached to the petals as in *Datura*, *Helianthus* etc.

Epitepalous: When stemens are attached to tepal as in *Asphodalous*, *Allium* etc.

Gynandrous: When stemens are atteched with carpels as in *Calotropis*,

Diplostemonous: When stamens are found in two alternating whorls and that of the outer whorl alternate to the petals as in *Murraya*.

Obdiplostemonous: When stamens are found in two alternating whorls and that of the outer whorl opposite to the petals as in *Geranium*.

Tetradynamous: Out of six stamens, four stamens are long in inner whorl and two are short in outer whorl as in family Brassicaceae.

Didynamous: A condition when two stamens are long and two short as in family Lamiaceae.

Gynoecium

Female reproductive part of a flower, made up of one or more carples.

Carpel: Unit of a pistil that bears the ovule on margins.

Pistil: The female organ of a flower, that consist of ovary, style and stigma.

Monocarpellary: When gynoecium have only one carpel as in

Multicarpellary: When gynoecium have two or more carpels as in if they are free known as **apocarpous** and if fused it is known as **syncarpous** as in *Melia*.

Superior: When ovary situated above the attachment of all other floral parts; hypogynous ovary as in *Brassica*.

Placentation: The arrangement of placenta in an ovary is called placentation. It is of six types (a) parietal; (b) axile; (c) freecentral; (d) marginal; (e) Basal; (superficial) (f) lamellate.

Fruit

Fruit is a developed ovary of a flower that consists of seeds.

Achene: A small dry indehiscent fruit develop from the monocarpellary, superior ovary, the pericarp not attached to the seed coat as in *Fagopyrum*, *Clematis*, *Nelumbo*, *Naravelia* etc.

Cypsela: A one seeded dry indehiscent fruit develop from bicarpellary, syncarpous, inferior, ovary with the pericarp not attached to seed coat as in *Sonchus*, *Cosmos*, *Helianthus* etc.

Nut: It develops from a syncarpous, bi or multilycarpellary, superior ovary, with the pericarp hard and stony single seeded fruit as in *Quercus*, *Anacardium*, *Trapa* etc.

Samara: A dry indehiscent fruit develops from bicarpellary syncarpous superior ovary with wing. Here persistence sepal is modified in to wing as in *Holoptelia*, *Acer*, *Hiptage* etc.

Caryopsis: Dry indehiscent single seeded fruit develop from a monocarpellary and superior ovary. Pericarp fused with seed coat as in family Poaceae.

Lomentum: Dry indehiscent fruit develops from monocarpellary and superior ovary having one locule as in *Acacia*, *Tamarindus* etc.

Cremocarp: A two locular develops from bicarpillary, syncarpous inferior ovary. On maturation, seed divide with caryophore in to two mericarp as in family Apiaceae

Regma: Develops from multicarpellary, syncarpous, superior ovary with axile placentation, as in *Geranium*, *Ricinus*.

Carcerulus: Develops from a bicarpellary, syncarpous, superior ovary. It becomes four locular due to formation of two false septa; as in Labiatae and Boraginaceae.

Double samara: Develops from bicarpellary, syncarpous and superior ovary. Pericarp develops in two wings as in Sapindaceae.

Legume: Dry fruit develops from monocarpellary, superior ovary and opening along both sutures as in family Fabaceae.

Follicle: A dry dehiscent fruit develops from monocarpellary, unilocular, superior ovary and reaptured by only one suture as in *Michelia*, *Pentatropis*, *Calotropis*, *Pergularia* etc.

Siliqua: Dry dehiscent develops from bicarpillary, syncarpous and superior ovary with parietal placentation. Unilocular in initial stage but becomes bilocular in later stage due to false septum as in family Brassicaceae.

Silicula: A fruit is small and flattened with parietal placentation and replum as in *Iberis*, *Capsella* etc.

Capsule: Many seeded fruit develops from multicarpellary, syncarpous, superior ovary and multilocular as in *Eucalyptus*, *Datura*, Bottle brush, Bhindi etc.

Drupe: Single seeded fleshy fruit develops from monocarpellary syncarpous ovary. Epicarp is tough and fibrous mesocarp such as Mango, Peach, Cherry, Almond etc.

Berry: These fruit develop from multicarpellary, superior, syncarpous ovary many or few seeded such as Sapota, Supari, Guava, Date palm, Tomato, Brinjal etc.

Pepo: A fleshy, many seeded fruit like berry develops from an inferior tricarpillary with periatial placentation such as Cucumber, Muskmelon, Bottle guard etc.

Pome: This fruit develops from multicarpellary, syncarpous, inferior ovary and thalamus such as Pear, Lokat, Apple etc.

Hesperidium: A many seeded, fleshy fruit develop from multicarpellary, syncarpous, superior, ovary with axile placentation. Mesocarp fused with epicarp together forming distinct chambers. Juicy placental glandular hairs present as in members of Rutaceae.

Balausta: Develop from multicarpellary, syncarpous, inferior ovary with edible succulent testa such as Pomegranate.

Amphisaraca: This fruit develop from multicarpellary, syncarpous, superior many seeded ovary. Endocarp, mesocarp and placenta is edible such as *Aegle marmelos* (Bael).

Sorosis: Fruit develop from a spike or spadix inflorescence. Flower fused together by succulent sepals and the axis become fleshy as in Jack fruit, Mulberry, Pine apple etc.

Syconus: Fruits develop from a hypanthodium inflorescence as in members of genus *Ficus*.

6. Detailed study of families

This chapter deals with detailed study of the families- diagnostic features, floral variations, distribution and economic importance of the families of angiosperms as per new ICAR syllabus.

6.1 Magnoliaceae

Distribution: There are 12 genera and about 230 species family Magnoliaceae out of these 08 Genera and 27 species found in India. The family have its place in the temperate regions of northern hemisphere, with centres of distribution in eastern Asia, Malaysia, North-east and south east Asia.

Salient feature: Usually trees and shrubs; two tiered stipulate leaves, stipules enfold young buds; flowers hermaphrodite, actinomorphic, large; perianth commonly trimerous, whorled or spiral; stamens and carpels numerous; apocarpous, fruit an etario of follicles or samara.

Description: Trees or shrubs occasionally climbing, aerial, woody, branched.

Leaves: Simple, dissected (*Liriodendron*), petiolate, alternate, spiral, entire, commonly evergreen or deciduous, coriaceous, pinnately veined or palmately veined stipules large, covering young leaves, caducous.

Inflorescence: Solitary terminal or axillary.

Flower: Bracteate, large, complete, regular, actinomorphic, usually bisexual, unisexual (*Drimys*), hypogynous, aromatic. Floral axis is long convex.

Perianth: 6-18 tepals, free, all identical and petaloid or the three outer ones green (*Liriodendron*), organized in whorls of three, imbricate and cyclic (*Magnolia* and *Michelia*) or acyclic arranged on an elongated convex torus, free and inferior.

Androecium: Stamens numerous, free, frequently spirally organized in a good-looking series, filaments short or absent, anther lobes linear, with an elongated connective.

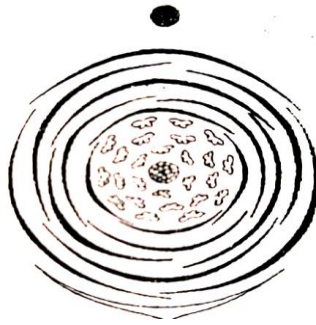
Gynoecium: Carpels many, free, superior, organized spirally on a cone-shaped extended thalamus (gynophore), rarely carpels are united, e.g., Zygogynum, placentation marginal.

Fruit: An aggregate of berries or follicles, sometimes, a samara.

Seed: Large, with abundant oily endosperm, and bright or orange testa, marks them extremely pretty.

Floral formula: $\oplus \overset{\sigma}{\text{P}}_3 - \infty \text{ or } \text{K}_3 \text{C}_{6-\infty} \text{A}_{\infty} \underline{\text{G}}_{\infty}$

Floral diagram:



Michelia champaca

Economic Importance:

- The Champ tree is a tall evergreen with tapering crown makes it very handsome and suitable for planting as an avenue tree along the roads.
- *Michelia excelsa*: wood of is an outstanding profitable timber recognized as “white wood”.
- The wood of *Michelia champaca* is very suitable for indoor constructional work, packing cases, pencils and furniture.
- Flowers of *M. champaca* caused to produce Champa oil, which is used in perfumery other than oil the flowers are also used to produce dye, which is used for colouring the textiles.
- *M. nilagirica* is a moderate sized tree grow in the *sholas* of Peninsular India.
- *M. hookeri*, *M. acuminata*, *M. doltsopa*, *M. baillonii* and *Pachylarnax pleiocarpa* produce valuable timber used for furniture, millwork, musical instruments, toys etc.

6.2. Rubiaceae

Distribution: About 500 genera and 6500 species chiefly distributed in tropical, sub tropical and temperate zone even a few species of *Gallium* occur in arctic region. About 75 genera and 275 species have been reported from India.

Salient feature: usually trees, shrubs, herbs, and climbers. Root is tap root and branched. Stipulate, bracteates, gamosepalous, gamopetalous, stamens two celled, placentation is axile. Seeds are endospermic.

Description: Mostly trees *Cinchona officinalis*, *Adina*, *Morinda*, *Coffea*. Shrubs- *Mussaenda luteola*, *Hamelia patens*, *Gardenia*, *Ixora*. Herbaceous species likewise *Borreria*, *Gallium*, *Oldenlandia*, *Rubia*. Climbers- *Paederia*, *Uncaria*. Tap root and branched. Erect, herbaceous or woody, climbing by hooks (*Uncaria*) or twiners (*Manettia*) or scramblers (*Gallium*).

- In *Cephalis ipecachuanha* roots are the source of a recognised drug Ipecachuanha, an exceptional remedy for the cure of amoebic dysentery.
- Fruit pulp of *Randia spinosa* is emetic and athelmintic. The fruit extracts possesses insecticidal and insect repellent properties.
- Roots of *Rubia tinctoria* contain a dye, Alizarin. It was widely cultivated before the introduction of aniline dyes.
- Some species such as *Adina cordifolia*, *Anthocephalus cadamba* syn. *Anthocephalus chinensis*, *Mitragyna parviflora* and *Randia spinosa* provide useful timber which is used for making packing cases, plywood, flooring and wall panelling etc.

6.3. Annonaceae

Distribution: There are 128 genera and about 2300 species of family Magnoliaceae out of these 26 Genera and 200 species found in India. The members of this family mostly confined to the peninsular India.

Salient feature: Usually aromatic trees or shrubs, or sometimes-woody climbers such as species of *Oxymitra* and *Melodorum*, often scandent or lianas. Oil passages are found in the stem and leaves. Resin canals with septate pith are present in the stem. Numerous stamens are present, one to many carpels are found.

Description: aromatic trees, shrubs sometimes climbing, scandent, or lianas. Oil passage present in stem and leaves.

Leaves: Simple, entire, exstipulate and alternate. Oil passages are present in leaves.

Inflorescence: Often Solitary terminal or axillary, sometimes fascicled. *Polyalthia fragrans* is cauliflorous.

Flower: Ebracteate, pedicellate, fragrant, complete, trimerous, actinomorphic, bisexual, hypogynous opens mostly opens before all parts are completely developed. Unisexual flowers are found in *Stelechocarpus*.

Calyx: Consists of 3 sepals, free or connate at the base and valvate.

Corolla: Comprises of 6 petals in two whorls. Petals are free or basally connate and show imbricate or valvate aestivation. In *Unona*, inner whorl is absent.

Androecium: Numerous free stamens, spirally organized on a large convex receptacle. Anthers are adnate, ditheous and extrose. Filaments are short. Connective is usually truncate and prominent. In *Xylophia*, anthers are transversely septate.

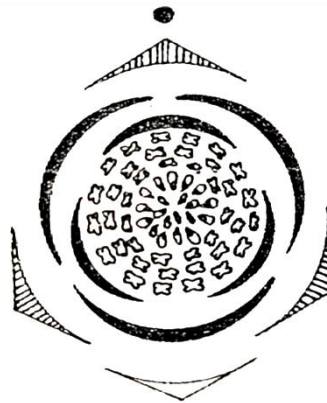
Gynoecium: It has one to many Carpels, spirally arranged on the receptacle above the stamens. Carpels are 1-3 in *Cyathocalyx*, few to many in *Artabotrys* and indefinite in *Polyalthia*. In *Annona*, carpels are subconnate with distinct stigmas.

Fruit: An aggregate of berries. Berries in *Annona* become confluent with each other and with the receptacle to form a globose or ovoid; many seeded fleshy fruit (etaerio of berries). *Anaxogorea* has follicular fruits.

Seed: Seeds are large with a small embryo and dense ruminant endosperm, often arillate.

Floral formula: $\text{Ebr } \oplus \text{ } \ominus \text{ } \text{K}_3 \text{ C}_{3+3} \text{A}_\infty \underline{\text{G}}_\infty$

Floral diagram:



Polyalthia longifolia

Economic Importance:

- Many species yield edible fruits, e.g., *Annona squamosa* (custard apple), *A. reticulata* (common custard apple) and *Cananga odorata* (Ylang-ylang).
- *Artabotrys hexapetalus* is a strong climbing or scrambling shrub with greenish or yellowish and very fragrant flowers. It is planted in gardens as an ornamental shrub that climbs with the help of hooks developed on the pedicels.
- *Cananga odorata* is a medium sized tree with long acuminate leaves and very fragrant greenish to yellowish flowers.
- *Polyalthia longifolia* and *P. pendula* are lofty trees with drooping branches and beautiful green foliage. They form one of the most beautiful avenue trees.
- Flowers of *Cananga odorata* and *Artabotrys odoratissimus* yield an essential oil which is used in high class perfumery and toilet preparations.
- The fruits of *Miliusa tomentosa* are consumed by the tribal communities during the famine.

6.4. Sapotaceae

Distribution: The family includes 40 genera and 590 species extensively dispersed throughout the tropics. 10 genera and about 52 species are found in the plains of India.

Salient feature: Plants are shrubs or trees with lactiferous ducts (milky). Flowers are pollinated by insect and fruits are dispersed by birds, animals or water currents.

Description: Younger portions are often rusty and tomentose. Leaves are alternate or infrequently sub-opposite (*Sarcosperma*), simple, entire, coraceous or leathery. Stipules are usually absent except in *Sarcosperma* which has caduceous stipules.

Inflorescence: Solitary or in cymose clusters or in simple or compound panicles in *Sarcosperma*. Sometimes, cauliflory is founded in *Madhuca* and *Dichopsis*.

Flowers: Flowers are bisexual, actinomorphic, hypogynous and bracteate. These are trimerous in *Palaquium* and *Manilkara* and pentamerous in *Sideroxylon*.

Calyx: Calyx comprises of 4-8 sepals, sometimes in two whorls, free or slightly united. Calyx lobes are imbricate but in biseriate condition, outer series is valvate and persistent. In *Sarcosperma* and *Pouteria*, there are five sepals in one whorl.

Corolla: It has petals as many as of 2-4 times as many as sepals and somewhat united (gamopetalous) to form a rotate or urceolate or funnel shaped and often with dorsal appendage. Petals are caducous in *Madhuca* and *Mimusops*, in *Mimusops*, petals have a pair of appendages and corolla appears to be biseriate with 18-24 lobes. aestivation is imbricate.

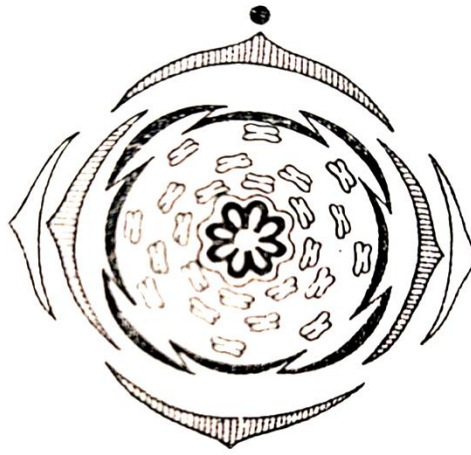
Androecium: Comprises stamens in 2-3 whorls of 4-5 each, epipetalous and lie opposite to corolla lobes. In *Madhuca*, stamens are 2-3 times as many as corolla lobes set in 2-3 whorls. Outer stamens are sometimes reduced to staminodes as in *Mimusops*. Anthers are oblong – lanceolate, ditheous, commonly introrse dehiscent longitudinally. Filaments are short.

Gynoecium: Consist of 4-5 carpels, syncarpous, forming a superior 4-5 celled (loculed) ovary. Locules number corresponds to the number of carpels. Each locule has a single, unitegmic and anatropous ovule ascending with a micropyle. Placentation is axile. Style is one and apically lobed.

Fruit: 1-8 seeded berries with lactiferous sacs in the inner pulp, rarely one sided and drupe like. Seeds are exalbuminous, embryo with a small radical and broad foliaceous cotyledon.

Floral formula: $\text{Br } \oplus \text{ } \text{♀} \text{ } K_{(4-8)} \text{ } C_{(4-8)} \text{ } A_{8-16} \text{ } \overline{G}_{(2-8)}$

Floral diagram:



Madhuca longifolia

Economic Importance

- *Calocarpum sapota* (marmalade plum), *Manilkara hexandra* Syn. *Mimusops hexandra* etc yield delicious edible fruits.
- Seeds of *Madhuca butyracea*, produces vegetable butter used as a cold cream and luminant.
- Flowers of *M. longifolia* are used for distilling alcohol and seeds yield mohwa butter (oil) used for cooking, laminating, for adultering ghee and to cure skin diseases and rheumatism.
- *Achras sapota* (Chikoo) is cultivated for edible fruits. The resinous latex derived from the bark is used in chewing gum (chikle gum).
-
- *Mimusops elengi* (maulsri) is an evergreen tree with dense foliage and fragrant flowers. It produces a very strong wood called bullet wood. The fruits are edible. Its bark yields tannin used for dyeing sails and fishing tackles.

6.5 Myrtaceae

Distribution: 114 genera and about 3000 species comprise this family widely distributed in tropical regions of the world. 14 genera and about 165 species are found in India. Most common examples are *Callistemon*, *Eugenia*, *Eucalyptus*, *Psidium*, *Syzygium* etc.

Salient feature: Plants are mostly trees or shrubs with aromatic fragrance.

Leaves: Leaves are simple, entire, exstipulate, shortly petiolate, mostly opposite (*Psidium*), rarely alternate (*Eucaplyptus*) and with oil glands.

Description: Flowers are insect pollinated. The insects are attracted by nectar – secreting disc around the ovary. Seeds are dispersed by winds, birds or animals. In *Callistemon*, flowers are pollinated by birds.

Inflorescence: May be raceme (*Barringtonia*), spike (*Callistemon*), cymose, panicle or rarely flowers may be solitary (*Myrtus* and *Psidium*).

Flowers: Bracteate, complete, hermaphrodite, actinomorphic and usually epigynous (*Myrtus* and *Psidium*), rarely perigynous.

Calyx: Comprises of 4 or 5 sepals, connate at the base and united with receptacle cup to form hypanthium, lobes free and quincuncial, rarely valvate

Corolla: Comprises of 4-5 petals, usually free, imbricate often quincuncial or connate to form operculum (*Eucalyptus*).

Androecium: Consists of indefinite number of stamens, all free or slightly connate at the base, arranged in several whorls, sometimes in bundle opposite the petals. Anthers are usually versatile or dorsally fixed, ditheous, introrse and dehiscent by longitudinal slits or sometimes apically. In *Callistemon*, the filaments are scarlet red and form a brush like structure. Stamens in *Melaleuca* are polyadelphous and in one whorl and bundles are equal to the number of petals.

Gynoecium: Consists of 2-5 or several carpels, combined to form an inferior or semi inferior, 2-5 locular ovary (number equal to the number of carpels) with 2 to many obliquely pendulous, campylo- or anatropous ovules in each chamber in axile, rarely parietal placentation. Style is one and stigma is simple.

Fruit: Loculicidal or septicidal dehiscent capsule but may be drupe, nut or berry (*Psidium*). Seeds are angular, cylindric, or compressed and non – endospermic or with scanty endosperm.

Floral formula: $Br \oplus \text{♀} K_{(4-5)} C_{4-5} A_{\infty} \overline{G}_{(2-5)or\infty}$

Floral diagram:



Callistemon lanceolatus

Economic Importance

- The family includes many economically important plants. Many species produce edible fruits e.g. *Psidium guajava* L. (guava), *P. cattleianum* Sabine (strawberry guava), *Eugenia uniflora* (Surinam cherry), *Syzygium cumini*, *S. jambos* (rose apple), *S. aromaticum* (the clove used as spice) etc.
- Valuable timber is obtained from many species of *Eucalyptus* (*E. cerebra*, *E. paniculata*, *E. punctata*, *E. leucoxylon*) and *Syzygium cumini*.
- Some plants are medicinally important, e.g. *Syzygium cumini* (seeds useful in diarrhea, dysentery and diabetes), *Melaleuca leucadendron* (cajaput tree) (yield cajaput oil used in laryngitis and bronchitis), *Eucalyptus leucoxylon*, *E. elaeophora*, *E. globules* (medicinally important eucalyptus oil extracted from leaves) etc.

6.6 Combretaceae

Distribution: The family consist of about 20 genera and 600 species spread in tropical and sub tropical regions of the world. In India, 8 genera with about 44 species.

Salient feature: Plants are trees (*Terminalia*) or shrubs, often lianous (*Quisqualis*), armed or bare. Leaves are simple, alternate or opposite, entire and exstipulate. In *Illigera*, leaves are trifoliate.

Description: Flowers are insect pollinated. Fruits are dispersed by water (*Terminalia arjuna*), wind or by animals.

Inflorescence: May be spicate, racemose or paniculate.

Flowers: Bracteates, bisexual or rarely unisexual or polygamo – dioecious (*Combretum*), actinomorphic or zygomorphic, usually pentamerous (sometimes 3-8 merous) and epigynous. The tubular receptacle together with the adnate tubular base of calyx forms hypanthium.

Calyx: Consists of 4-5 or more persistent lobes with valvate and imbricate aestivation.

Corolla: Consists of 5, free lobes (petals) or lobes equal to the number sepals, small, imbricate or valvate. Petals are often absent (*Terminalia* and *Anogeissus*).

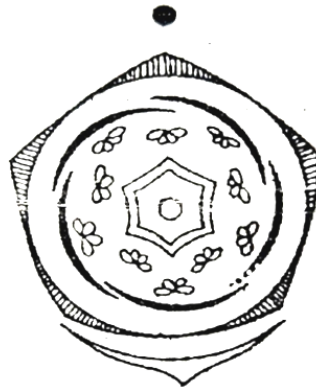
Androecium: Comprises 4-5 stamens in one whorl or double the number in two whorls. Outer whorl antisepalous and inserted on the calyx tube, and inner whorl, sometimes, reduced to staminodes. Filaments are inflexed in the bud and anthers are ditheous and versatile, dehiscing by longitudinal slits (*Terminalia*) or by recurved lateral valves (*Illigera*).

Gynoecium: 4 or 5, or often less capels and united (syncarpous). Ovary is inferior, unilocular, angular or ribbed –ribs equal to the number of calyx lobes and with 2-6 anatropous ovules

pendulous from the top of the locule. Style is slender with a capitate or pointed stigma. A nectariferous epigynous disc is present.

Fruits: Fruit is single seeded drupe with angled or winged pericarp. Seeds are ex-albuminous and embryo has convolute (*Terminalia*) or folded rarely flat cotyledons.

Floral formula: Br \oplus \ominus K₍₄₋₅₎ C₄₋₅ A₄₋₅ or 8 or 10 G₍₄₋₅₎ ⁻



Quisqualis indica

Economic Importance

- Useful timber is obtained from *Anogeissus latifolia* wall, *A. acuminata* wall, *Terminalia tomentosa*, *T. paniculata*, *T. bialata* attend, *T. catappa* L., *T. myriocarpa*, *T. ivorensis* (indigo timber), *T. chebula*, *T. citrine* (harira), *T. manii* (black chuglam), *T. myriocarpa* (hollock), *T. procera* etc. wood is largely used in construction works.
- The bark of *Terminalia arjuna* and *T. bialata* is highly valued as cardiac tonic.
- Fruits of *Terminalia chebula*, *T. bellerica* and *T. Arjuna* are laxative and are used for stomachic and alternative properties.
- Leaves of *Calycopteris floribunda* are used in colic, dysentery and malarial fever, and of *Combretum pilosum* as anthelmintic.

6.7 Meliaceae

Distribution: The family comprises of 50 genera and 400 species distributed solely in tropical parts of the world and some 19 genera and 72 species are found in India. Common examples are *Melia*, *Azadirachta*, *Cedrela*, *Toona*, *Swietenia*, *Chloroxylon* etc. *Melia* and *Toona* are deciduous trees.

Salient feature: Plants are mostly trees, sometimes shrubs emitting a very characteristic smell. Flowers are usually insect pollinated. Winged seeds are dispersed by wind but in other cases, these are dispersed by birds, bats or other animals.

Description: Trees, flower is complete, hypogynous; leaves are alternate, pinnate; calyx gamosepalous; corolla free; hypogynous disc is present; placentation is axile.

Leaves: Leaves are alternate, exstipulate, compound, pinnate (twice or thrice pinnate in *Melia*) and oblique at the base. In *Turraea*, leaves are simple.

Inflorescence: Inflorescence is usually axillary, cymose panicle.

Flowers: Flowers are actinomorphic, bisexual or rarely unisexual and hypogynous. In *Amoora* and *Aphanamixis*, these are polygamo – dioecious.

Calyx: Calyx comprises of 3-6 sepals which are united (gamosepalous) or rarely free or usually imbricate, rarely valvate.

Corolla: Corolla comprises 4 or 5 petals, free or rarely connate at the base. Occasionally, petals are adnate to the lower half of the staminal tube. These show imbricate, rarely valvate aestivation.

Androecium: 4-12 stamens inserted outside the base of a hypogynous disc, the filaments cohere to form a columnar tube (monoadelphous) at the mouth of which anthers are inserted. Stamens are free in *Cedrela*, *Toona*, and *Chloroxylon*. Anthers dithecos, introrse and dehiscent longitudinally.

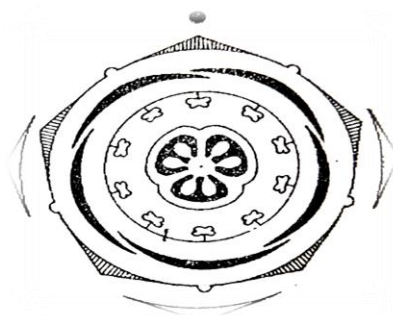
Gynoecium: consist of 2- 5 united carpels (syncarpous). Ovary is superior, 2-5 locular with 1 or 2 ovules in each locule in axile placentation. In *Soymida*, *Swietenia* and *Toona*, each locule has 2 or many ovules. Style is short or absent and the stigma is discoid or capitate.

Fruits: Fruit is berry or drupe or a capsule (drupaceous in *Melia*).

Seeds: Seeds are with and without endosperms and are winged in *Toona*, *Swietenia*, *Soymida*, *Khaya* etc. and wingless in *Azadirachta*, *Melia*, *Carapa* etc. In *Aphanamixis*, seeds are arillate.

Floral formula: $Br \oplus \ominus \text{♀} K_5 C_5 A_{(10)} \underline{G}_{(5)}$

Floral diagram:



Azadirachta indica

Economic Importance:

- The family comprises an excellent timber trees, e.g *Azadirachta indica*, *Melia azedarch*, *Swietenia mahogany*, *Khaya senegalensis*, *Toona ciliata*, *Cedrela toona*, *Chloroxylon swietenia*, *Dysoxylum malabaricum*, *Chickrassia tabularis*, *Cedrela odorata*, *Soymida febrifuga*, *Amoora wallichii*.

•

- *Azadirachta indica* is an important plant of which almost every part has medicinal value. Leaves are used as insect repellent; twigs are widely used as toothbrush (to prevent pyrrhoea).
- Seeds yield 'margosa oil' of commerce used in skin diseases and as anthelmintic and bark in the treatment of malarial fever.
- A drying oil obtained from the seeds of *Melia azedarch* L., is used in making soaps, hair oil and in the treatment of rheumatism.
- The important ornamental plants are *Algaia odorata* (white scented flowers), *Melia composita*, *M. azedarch*, *Azadirachta indica*, *Swietenia mahagoni* etc.

6.8 Rutaceae

Distribution: The family contains of 162 genera and 1650 species broadly spread in the tropical and sub tropical areas of the world. In India, 23 genera with 70 species are found with common examples as *Citrus*, *Aegle*, *Murraya*, *Feronia*, *Atlantia* etc.

Salient feature: The presence of pellucid glands filled with essential oils is a characteristic feature of the plants. Flowers are protandrous and insect pollinated. Seeds are dispersed by human agency and animals.

Description: Plants may be herbs, shrubs (*Murraya*) or trees (*Aegle*, *Citrus*, *Feronia*) and are often armed; leaves exstipulate, winged petiole present; flower complete; stamens twice the number of petals, gynophores is present; placentation is axile.

Leaves: Leaves are opposite and alternate, exstipulate and simple (*Clerodendron*, *Diosnia*) or compound, trifoliolate (*Aegle* and *Triphasia*) or pinnately compound (*Murraya*).

Inflorescence: Racemose (*Atlantia*) or cymose or the flower may be axillary or terminal solitary (*Triphasia*).

Flowers: Bracteates, hermaphrodite, actinomorphic, pentamerous (trimerous in *Triphasia* and tetramerous in *Achronychia*) and hypogynous. Flowers are *unisexual in Zanthoxylum and Toddalia and zygomorphic in Dictamnus, Galipea and Alnicida*.

Calyx: Consist of 4 or 5 sepals, free or variously connate. Aestivation is imbricate, rarely valvate.

Corolla: 4 or 5 free or rarely connate petals with aestivation valvate or imbricate.

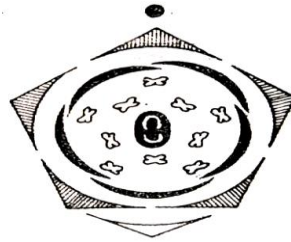
Androecium: Consists of 5, 8 or 10 stamens (double the number of petals) or indefinite. When stamens are 10, these show obdiplostemonous condition and when 5, these are antisepalous. In *Citrus*, stamens are numerous and polyadelphous, i.e. Arranged in several bundles. An annular disc or gynophore is present above the androecium.

Gynoecium: Consists of 2, 4, 5 or indefinite number of carpels. Ovary is more or less deeply grooved, superior, syncarpous, multilocular, each locule with 1 or 2 ovules with ventral raphe and set in axile placentation. Sometimes, carpels are free at the base and united above the style.

Fruits: Fruit is capsule (*Ruta*) or berry called hesperidium. In *Spathalia*, fruit is winged drupe. In *Feronia* and *Aegle*, the fruit is amphisarca with woody rind. Seeds may or may not have endosperm.

Floral formula: $\text{Br } \oplus \text{ } \overline{\text{K}}_{(5)} \text{ C}_5 \text{ A}_{5+5} \underline{\text{G}}_{(2)}$

Floral diagram:



Murraya sp.

Economic Importance

- The family is important for its vitamin C rich fruits of Citrus and a few others like *Citrus aurantifolia* (lime, nimbu), *C. aurantifolia* (sweet lime), *C. auranticum* (bitter orange), *C. decumana* L. (shaddock, chakotra), *C. limon* (L), *C. medica* L., *C. paradise* (grape fruit), *C. reticulata* (mandarin, santara), *C. sinensis* (L.), *C. aurantium*L. (sweet orange, musambi), *Aegle marmelos* (bael), *Feronia elephantum* (wood apple) etc.
- Most of the fruits are eaten raw or after making their preparation in confectionaries, pickles etc.
- Aromatic fruit pulp of *Aegle marmelos* is a good remedy for dysentery and other stomach disorders. Its root and bark are given in the intermittent fever.
- The fruit pulp of *Feronia limonia* is used as a substitute of bael in treating diarrhea and dysentery.

6.9 Sapindaceae

Distribution: 92 genera and 900 species composing this family are widely distributed in tropical regions of the world. it is fairly represented by 24 genera and 72 species in India.

Salient feature: Plants are trees or herbs rarely woody vines (*Cardiospermum*) climbs by tendrils or modified in inflorescence axes; stem has resin passages with plenty of gum.

Description: Stem shows of extra stelar vascular bundles (anamalous condition); leaves are pinnately compound, exstipulate; flower complete and hypogynous; calyx and corolla are free; extra stamina disc is found in form of a gland; placentation is axile.

Leaves: Leaves are rarely opposite or alternate (*Acer*) generally pinnately compound, rarely ternate and palmately lobed (*Acer*) or very simple (*Cardiospermum*), or digitate (*Aesculus*). Exstipulate or stipules are small and deciduous in climbing species. Latex or resin cells are present in leaves.

Inflorescence: Usually a cymose, panicle or a thyrus, rarely racemose.

Flowers: Small regular or obliquely zygomorphic bisexual or unisexual or polygamous pentamerous or hardly tetramerous and hypogynous.

Calyx: Comprises usually 5 free sepals or in regular flowers with sepals 4 due to Union of 3rd and 5th sepals and imbricate in bud.

Corolla: Made up of 5 free Petals but four Petals in actinomorphic flowers as a result of suppression. Petals are imbricate with Hairy scale like appendages. Petals are absent in *Schleichera* and *Dodonaea*

Androecium: In *Sapindus* and litchi, flowers are actinomorphic but in *Erioglossum* and *Cardiospermum* zygomorphic flowers with eccentric androecium are found. In many cases, flowers although apparently bisexual are functionally unisexual do not germinate.

Gynoecium: Usually tricarpeal or syncarpous. Ovary is trilobular and superior lobed or not with one or two ovules in each locule inserted on the central axis (axile presentation).

Fruit: Dry or fleshy dry fruit maybe a capsular nut or fleshy fruit a drupe or berry. It is double Samara in *Acer* and nut like in *Litchi*.

Seeds: Usually arillate (*Nephallium*, *Litchi*) with curved embryo and without endosperm. Fruits may show anemochory.

Floral formula: $\% \text{ or } \oplus \text{ } \text{♀} \text{ } K_5 C_{5 \text{ or } 0} A_{8-10} \underline{G}_{(3)}$

Floral diagram:



Cardiospermum halicacabum

Economic Importance

- Edible fruits are produced by several species e.g. *Litchi sinensis*, *Nephelium lappaceum*, *Melicocca bijuga*, *Blighia sapinda*, *Dimocarpus longan*, *Schleichera oleosa*, *Acer saccharinum* (sugar maple), *Aesculus indica*, *Schleichera oleosa*, *Dodonaea viscosa* etc.
- *Sapindus muskorossi* (Soap nut tree/Ritha) produces saponin rich fruits, largely used as substitutes for soap.

6.10 Anacardiaceae

Distribution: The family has 77 genera and about 600 species (22 genera and 110 species in India) found in tropical and subtropical areas of the world. The common plant of the family are *Mangifera*, *Anacardium*, *Rhus*, *Buchnanania* etc.

Salient feature: plants are trees or a shrub, rarely woody vines containing resin passages with abundantly of gum and acrid juice. Flowers are entomophilous. Seeds are dispersed by animals or human agencies.

Description: Usually trees; flower is bracteate and complete, with a cup shaped disc; calyx and corolla are free, staminodes present; placentation is parietal type.

Leaves: Leaves are simple or pinnate, alternate or rarely opposite (*Bouea*) and exstipulate.

Inflorescence: Axillary or terminal cymose panicle.

Flowers: Bracteate, small and numerous, actinomorphic bisexual or polygamous and hypogynous or rarely perigynous. With a glandular or cup shaped disc.

Calyx: Consists of 3 to 5 sepals free or more or less connate and imbricate. Calyx maybe deciduous or persistent.

Corolla: Made up of 3 to 5 Petals, free or rarely connate and imbricate, rarely absent. Petals are persistent and enlarged in fruit of *Melanorrhoea*.

Androecium: Shows variation, in number, sterile, and fertile stamens. In *Mangifera*, 4 staminodes and one fertile stamen, in *Anacardium*, 8-10 stamens in two whorls of which some are fertile and some are sterile.

Gynoecium: Consists of 1 to 5 carpels. One carpel and one locule in *Mangifera* and *Anacardium*. Ovary is superior and syncarpous one to many locules each with a single pendulous or ascending ovule arising from the side of wall. Rarely carpels are free in *Buchanania*.

Fruit: In most of the genera fruit is one seeded drupe but in spondious 4-5 seeds are found .the fruit is nut in *Anacardium* situated on pyriform fleshy structure, derived from the accrescent disc on top of thalamus. In *Mangifera*, mesocarp is fleshy and edible. **Seeds:** Non-endospermic with a straight or curved embryo.

Floral formula: $\text{Br } \oplus \text{ } \text{♀} \text{ } K_{5 \text{ or } (5)} C_5 A_{5-10} \underline{G}_{(1-5)}$

Floral diagram:



Mangifera indica

Economic Importance

- *Mangifera indica* produces delicious Mango fruits for which it is cultivated throughout India and tropical countries.
- *Anacardium occidentale* the cashewnut tree is a native of Brazil and now cultivated in India and several other tropical countries.
- The kernels are eaten raw or roasted and also used in preparation of wine locally called feni.
- *Pistacia* in Afghanistan is cultivated for the seeds which are *Pistaceo* nuts. The nuts are edible and used in sweets, meat, ice creams and confectionary.
- The fruit of *Spondias pinnata* are edible and used in preparation of pickles.
- Seeds of *Buchanania lanzan* are used as substitute of *Pistacio* nuts.

6.11 Tiliaceae

Distribution: The family includes 41 genera and 400 species distributed in tropical and temperate parts of the world with common examples like *Grewia*, *Tilia*, *Muntingera* and *Berria* grown in tropical parts of India.

Salient feature: Flowers are insect pollinated (entomophilous) and are usually protandrous. Fruits and seeds are dispersed by animals (zoochory).

Description: Plants are mostly trees or shrubs rarely herbs (*Corchorus* species); leaves are stipulate; flower is complete, hypogynous; calyx represented by 5 sepals; corolla is sepaloid; polyadelphous condition is seen with gynandrophore occurrence; placentation is axile.

Leaves: Leaves are usually alternate, rarely opposite, simple, entire or toothed, stipulate or exstipulate. Stipules are free and often caducous.

Inflorescence: Often arranged in axillary or terminal cyme.

Flowers: Flowers are complete bisexual rarely unisexual, actinomorphic (regular) and hypogynous.

Calyx: Consists of 5 sepals (rarely 3 or 4) free or connate with valvate aestivation and caducous.

Corolla: Comprises of 5 petals or equal the number of sepals, free with imbricate, contorted or valvate aestivation. Petals are sepaloid in elaeocarpus and absent in chartacalyx.

Androecium: Comprises 10 to numerous stamens inserted on a disc, free or polyadelphous (slightly connate at the base forming 5-10 bundles). Anthers are ditheous, introrse and opening by a longitudinal (lateral) slit or apical pore.

Gynoecium: Made up of 2 -10 carpels with superior ovary and axile placentation. Number of locules corresponds to the number of carpels.

Fruit: Capsule or drupe.

Seeds: Albuminous (copious endosperm) with a curved embryo having leafy cotyledons.

Floral formula: Br. Br1 \oplus \ominus K₅ C₅ A₁₀ $\underline{G}_{(2-10)}$

Floral Diagram:



Tilia cordata

Economic Importance

- Several forms are known as ornamental plants. The common examples are: *Tilia europaea* (Linden tree of Europe), *Grewia tiliaefolia*, *G. eriocarpa* etc. Most of them are grown for their spreading habits with large foliage and white flowers.
- *Grewia tiliaefolia*: Fruits are edible, antioxidant and a good source of micronutrients as well as vitamin C. Bark is used in dysentery and its wood as antidote to opium poisoning. Coarse fibers are obtained from the inner bark which are used for making ropes and cordage.
- Roots of *G. Villosa* are used in diarrhoea and *G. sclerophylla* in cough.

6.12 Malvaceae

Distribution: The family comprises 197 genera and about 2865 species spread over tropical and subtropical regions of the world. Some 22 general and 110 species are found in India.

Salient feature: Protandrous flowers; leaves with alternate arrangement; flowers are hypogynous with epicalyx; androecium shows monadelphous condition; placentation is axile.

Description: Vegetative characters of the family shows that plants are mainly herbs rarely shrubs (*Hibiscus*) or woody trees (*Kydia* and *Thespesia*). Stem is erect, branched, solid, jointed, cylindrical and hairy.

Leaves: Leaves are alternate, stipulate simple with multicostate reticulate venation. Stipules are free and often caducous.

Inflorescence: Flowers may be solitary axillary (*Hibiscus*) or terminal or in some cases set in racemose or cymose inflorescence.

Flowers: Bracteate, bracteolate, pedicellate, complete, hermaphrodite, actinomorphic hypogynous and pentamerous. Epicalyx may be present 3-8 in number or absent (*Sida*).

Calyx: Comprises of 5, free or connate sepals with valvate aestivation.

Corolla: Corolla comprises of 5 petals, often large and showy, free or basically with staminal column and with twisted or imbricate aestivation.

Androecium: Consists of numerous stamens, monoadelphous, all of them being united below into a tube and the upper parts of the filaments remaining distinct

Gynoecium: Consists of 5 to many fused carpels (syncarpous). Ovary is superior, multilocular, with axile presentation. Style is connate below or throughout its length and passes through the staminal tube but branches terminally. Stigmas are free and their number resembles to the number of carpels often velvety.

Fruit: fruits show variation, e.g. Loculicidal capsule in *Hibiscus* and *Gossypium*, schizocarpic in *Malva* or fleshy berry in *Malvaviscus*.

Seeds: Seeds are usually with endosperm and folded cotyledons and reniform or ovovoid.

Floral formula: $Br \oplus \text{♀} \text{Epi}_{3-8} \overbrace{K_{(5)} C_5 A_{(\infty)} \underline{G}_{(5)}}$

Floral diagram:



Hibiscus rosa-sinensis

Economic Importance

- *Abelmoschus esculentus* (lady's finger) is cultivated in India for its fruits used as vegetables.
- A Cotton fibre of Commerce is obtained from the epidermal hairs of seeds of *Gossypium* species. *G. herbaceum* and *G. arboreum* these two are generally named as old world cotton (diploid plants) while *Gossypium hirsutum* and *G. barbadense* are new world cotton (tetraploid plants).

- The family yields most important and valuable fibres for textile industries.
- *Hibiscus cannabinus* (patsan) is grown as a fibre crop in India to procure bast fibre used for ropes, cordages, ropes sacking etc.

6.13 Sterculiaceae

Distribution: The family is represented by 50 genera and 750 species distributed mainly in tropical parts of the world. Some 18 genera and over 90 species are found in tropical parts and Himalayas in India.

Salient feature: Pollination and dispersal Flowers show entomophily and seeds show anemochory (winged seeds) or Zoochory.

Description: Vegetative characters such as, plants are usually softwood trees or shrubs rarely herbs (*Pentapetes*) or climbers (*Buettneria* species). Young parts are often stellate - tomentose. Flowers unisexual or bisexual; calyx colored in *Sterculia*; staminodes present; placentation is axile.

Leaves: Leaves are alternate, simple, entire or palmately lobed or Digitate (e.g *Sterculia*). Stipules are present and caducous.

Inflorescence: Flowers are found arranged in axillary complex cymes. Sometimes cauliflowery is met, as in *Theobroma*.

Flowers: Flowers are bracteate, hermaphrodite, actinomorphic and zygomorphic pentamerous and hypogynous. Flowers are unisexual in *Sterculia*.

Calyx: Consist of five sepals, somewhat basally connate with valvate aestivation. Sepals are often colored in *Sterculia*.

Corolla: Comprises five petals, often minute and deciduous, occasionally absent as in *Sterculia*. Petals are free or adnate to the base of staminal tube. In *Dombeya*, petals are persistent.

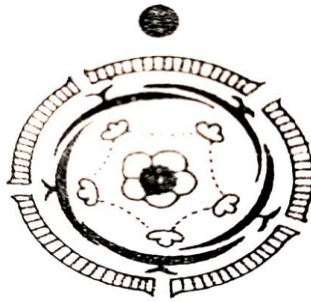
Androecium: Consists of few to many stamens, free or often connate into a tube and antisepalous. In *Melochia*, 5 stamens is it the petals and connate below, are found and in *Pentapetes* and *Pterospermum*, there are 20 stamens 15 fertile in five groups of three each alternating with 5 antipetalous staminodes. Staminodes are often present alternating with the fertile stamens and are antipetalous.

Gynoecium: Consists of 2-5 carpels. Ovary is syncarpous and superior. Number of locules corresponds to the carpels number rarely 10 to 12 locules are found. Ovary is sessile, sometimes androgynophore may be found. Placentation is axile with few to many anatropous ovules.

Fruit: Fruit is indehiscent or dehiscent capsule, sometimes separating into cocci. Capsule is woody in *Pterospermum*.

Seeds: Endospermic or non endospermic. Sometimes, seeds are winged (as in *Pterospermum*) or arillate (*Sterculia*).

Floral formula: Br Br1 ⊕ ♀ K₅ C₅ A_∞ G₍₂₋₅₎



Guazuma tomentosa

Economic Importance

- Quite a few species are grown as in ornamentals e.g. *Dombeya spectabilis*, *Pentapetes phoenicea* (Dopharia), *Guazuma ulmifolia*, *Pterospermum acerifolium* (The Muchkundo Champa), and many species of *Sterculia*.
- Fruit extracts of *Helicteres isora* (Marorphali) are used in diabetes and seed decoction *H. littoralis* is given for the treatment of diarrhoea and dysentery.
- Roasted seeds of *Guazuma ulmifolia* are stringent and are used in stomach disorders. Fruits of *Sterculia balanghas* are laxative.
- Several species of *Pterospermum*, *Sterculia*, *Pterygota* and *Heritiera* yield useful timber for furniture, cabinet and construction work.

6.14 Dipterocarpaceae

Distribution: Approx. 18 genera and 450 species in this family distributed majorly in tropical Asia and Indo Malaysia, with a lesser representation in tropical Africa and South America. The largest genera are *Shorea* (150 species) and *Dipterocarpus* (75 species).

Salient feature: The word Dipterocarpus derivative from Greek word *Di* means two, *Pteron* means wings and *karpos* means fruit referring to the two winged fruit. Trees, small to large with buttressed bases and smooth unbranched trunks up to the crown.

Description: Flowers are complete, fragrant; leaves are alternately arranged; calyx is wing shaped at maturity; placentation is axile.

Leaves: Leaves alternate, simple, generally evergreen, entire, stipules present frequently with special depressions known as domatia, which sometimes housing small insects or mites.

Inflorescence: In axillary or terminal racemes or panicles.

Flowers: Flowers fragrant, regular, perfect, perigynous or epigynous.

Calyx: Sepals 5, distinct or connate, occasionally enlarged and wing like at fruiting time.

Corolla: Petals 5, distinct or connate at the base, twisted and often leathery.

Androecium: Stamens 5 - many, filaments free or connate at the base, anthers distinctive with sterile tips.

Gynoecium: Pistil compound of 3 united carpels, locules 3, ovules 2 per locule, but only one ovule develops and placentation is axile. Ovary is superior or inferior.

Fruit: Fruit a single seeded nut but with persistent calyx in fruit forming wing like appendages that help in wind dispersal.

Seeds: Seed with endosperm lacking.

Floral formula: $\oplus \text{ } \overset{\sigma}{\text{K}}_5 \text{ C}_5 \text{ A}_{5-\infty} \underline{\text{G}}_{(3)}$



Floral Diagram:

Shorea robusta

Economic Importance

- This family consists of gigantic trees mostly evergreen and the world's main source of tropical hardwood Timber.
- The species *Shorea robusta* and *Dipterocarpus turbinatus* form almost pure forest stands.
- The *S. robusta* yields dammar commonly known as *ral* or *sal dhup* used in yaghya and Havana.
- The *S. stenoptera* of Sunda Islands yield fat which is used in manufacturing of chocolates
- The tree *Hopea parviflora* and *H. odorata* exudes resin that is known as rock dammar.

6.15 Guttiferae

(Clusiaceae)

Distribution: The family Clusiaceae is comprised of 40 to 50 genera and 1000 to 1200 species distributed widely but most common in the moist tropics. The largest genera are *Hypericum*, St. John's wort (350 species); *Garcinia*, *Mangosteen* (220 species); and *Clusia*, the autograph tree (200 species).

Salient feature: Exstipulate, secretory cavities are present with dotted resinous cavities in leaves.

Description: Herbs, shrubs and trees (rarely lianas); leaves are arranged in different fashion, often provided with resinous cavities.

Leaves: Leaves are usually opposite or whorled, simple, entire, lacking stipules, often found dotted with resin cavities, secretory cavities or Canals, scattered throughout the tissues and filled with white or yellow fluid.

Inflorescence: solitary flowers or flowers in terminal cymes.

Flowers: Flowers regular, perfect or unisexual, hypogynous.

Calyx: sepals 4-5, distinct, often with bracts just below.

Corolla: Petals 3-6 (rarely 4-14), free or connate at the base, often yellow.

Androecium: Stamens many, grouped in bundles, opposite the petals.

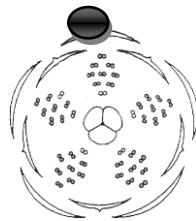
Gynoecium: Pistil compound and comprised of 3-5 (rarely more or less) United carpels, locules 1 or 3-5, ovules few to many and placentation is either parietal or axile, ovary is superior, styles are same as the same number of the carpels.

Fruit: Fruit a capsule but occasionally a berry or drupe.

Seeds: Seeds frequently with wings or an aril, embryo straight endosperm lacking.

Floral formula: $\text{Br}_1 \oplus \text{♀} \text{K}_{(2) \text{ or } (4) \text{ or } (6)} \text{C}_{3 \text{ or } 4 \text{ or } 6} \text{A}_{9 - \infty} \underline{\text{G}}_{(1-\infty)}$

Floral Diagram:



Floral Representaion of Clusiaceae

Economic Importance

- *Garcinia mangostana*, the mangosteen, is a well known tropical edible fruit.
- *Mammea Americana* (mammey apple) and *Platonia insignis* (Bakuri) cultivated in American tropics for edible fruits and wood.
- Bark and seeds of *Platonia insignis* (Bakuri) are used to cure eczema and diarrhoea.
- Drugs and cosmetics are obtained from *Harungana madagascariensis*, *Hyperic* spp., and *Mesua ferrea*.

- Bark sap and gums of *Harungana madagascariensis* medicinally valued as expectorant, purgative and emetic.
- Bark of *Pentadesma butyracea* used as a fish poison and seeds for extraction of edible fatty oil.

6.16 Rhizophoraceae

Distribution: The family consists of 14-16 genera and 100-120 species pantropical in distribution. The largest genus is *Cassipourea* (about 70 species). The mangroves include the genera *Avicennia* (14 species), *Bruguiera* (6 species), *Ceriops* (2 species), and *Rhizophora* (6-9 species). *Ceriops*, in Indian mangroves, *Bruguiera* viz., *B. parviflora* *B. gymnorrhiza*, *B. cylindrica*, and *B. sexangula* are described from India.

Salient feature: Hypanthium is seen.

Description: Shrubs, trees or lianas.

Leaves: Leaves generally opposite, simple, entire; stipules large but easily falling from plant.

Inflorescence: Solitary flower or flowers born in axillary cymes or racemes.

Flowers: Flowers regular, perfect (rarely unisexual), hypogynous to epigynous, hypanthium present or absent.

Calyx: Sepals 3- 16 often fleshy or leathery, distinct.

Corolla: Petals 3-16 often fleshy, commonly, shorter than sepals.

Androecium: Stamens 8 - 10 (rarely many), filaments distinct or connate, usually attached nectary disc and anthers are opening by a longitudinal valve.

Gynoecium: Pistil compound of 2-12 united carpels, locules 2-12 (rarely one), and ovules usually 2 in each locule and borne on apical axile placentas, so the placentation appears to be axile.

Fruit: Drupe or Berry or rarely a capsule.

Seeds: Seeds one per locule sometimes with an aril, often germinating on plant, embryo, straight, endosperm present or absent.

Floral formula: $\oplus \text{ } \overset{\sigma}{\text{K}}_{3 \text{ or } 4 \text{ or } 5 \text{ or } 16} \text{ } \overset{\sigma}{\text{C}}_{3 \text{ or } 4 \text{ or } 5 \text{ or } 16} \text{ } \overset{\sigma}{\text{A}}_{8 - 40} \text{ } \underline{\text{G}}_{(2 - 20)}$

Floral diagram:



Rhizophora mucronata

Economic Importance

- In reference to the timber production, the wood of *Ceriops tagel* is the most durable of all mangrove wood.
- The bark of the mangroves is highly recommended and used in tanning industry.
- *Rhizophora mucronata* is used for production and fulfilment of timber and pulp. The bark is a rich source of tannin that is used for tanning of leather.
- *R. apiculata* : wood is used for making furniture, poles for piling and construction of houses. Bark is used in tannin of the leather and as a medicine to cure dysentery.
- Various species are used locally by tribes as medicine, firewood, condiments and food.

6.17 Fabaceae

Distribution: 736 genera and 15800 species are distributed in tropical-subtropical of the world largely in warm temperate zone except arctic region. 143 genera and 960 species are reported from India. The larger genera are *Astragalus* (2000), *Acacia* (750), *Indigofera* (700), *Crotalaria* (600), *Cassia* (500-600), *Mimosa* (450), *Desmodium* (450), *Bauhinia*, *Dalbergia*, *Trifolium* (300), *Senna*, (250), *Phaseolus* (240), *Lupinus* (200), *Vicia* (150).

Salient feature: Family shows great range of variation in habit as twinners, lianas etc. represent its adaptation to various habitat and climatic conditions. In phyllotaxy leaf shows swollen base, stipulate; stamens are usually grouped into bundles of two, staminodes are present; placentation is marginal.

Description: Herbs like *Neptuniaoleracea*, *Cassiatora*, Shrubs *Crotalaria juncea*, Twinners *Clitorea*, *Dolichos*, *Phaseolus*, *Caesalpinia* or Liana with leaf tendril (*Entada*) and medium or large sized trees.

Leaves: Alternate with pulvinus or swollen leaf base, simple (*Bauhinia*, *Indigofera cordifolia*, *I. linifolia*, *Desmodium gangeticum*) or compound, pinnately compound, unipinnate (*Cassia*, *Zornia*), bipinnate (*Acacia*, *Mimosa*) or trifoliate (*Medicago*, *Trifolium*, *Trigonella*), paripinnate or imparipinnate.

Inflorescence: Flowers are grouped into composite clusters, Raceme (*Prosopis*), cymose Heads (*Acacia nilotica*) or racemose Heads or capitulum (*Trifolium*), Solitary (*Lathyrus*), or in spike (*Uraria*), panicle (*Dalbergia*).

Flowers: Bracteate or bracteolate (*Astragalus & Sesbania*), bisexual and rarely unisexual (*Gladitsia*), actinomorphic (Mimosoideae) zygomorphic (Caesalpinioideae & Faboideae) hypogynous or rarely perigynous, pentamerous or 3-4-6 merous, complete.

Calyx: 5-sepals (4 in *Mimosa*), more or less basally fused and persistent, valvate or imbricate or diagonal in *Mimosa*, odd sepal anterior, 2-posterior sepals fuse (*Tamarindus indica*), sepals petaloid in *Saraca indica*.

Corolla: 5 petals (4 in *Mimosa*), polypetalous or fused (*Acacia, Albizzia*), equal (Mimosoideae) or unequal (Caesalpinioideae & Faboideae), reduced (*Dialium*) or absent (*Ceratonia*), Valvate, or ascending imbricate (posterior petal innermost) or descending imbricate (posterior petal outermost-Papilionaceous or vexillary).

Androecium: Stamens many in *Prosopis* (free in *Acacia* & monadelphous in *Albizzia* or united below), 5+5 free in *Sophora*, or (9+1)diadelphous) often posterior stamen is sterile or absent and 9-monadelphous in *Arachis hypogaea*, *D. sissoo*, or diplostemonous, fluffy soft, few stamens reduced to staminodes (perfect stamens 3 in *Tamarindus*, 3-5 in *Bauhinia*, 5-7 in *Cassia*), filaments often unequal, dehisce by apical pore (*Cassia*).

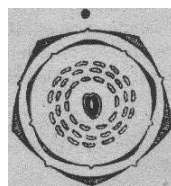
Gynoecium: Superior or semi-inferior ovary, monocarpellary, unilocular, many ovules in 1 row (Mimosoideae & Faboideae) or two alternating rows (Caesalpinioideae), marginal placentation, style and stigma simple.

Fruit: Legume or lomentum.

Seeds: Testa shining, leathery, endosperm very scanty or absent.

Floral formula: Br Brl % ♀ $K_{(5)} C_{1+(2)+(2)} A_{(9)} \underline{G}_1$

Floral diagram:



Vachellia nilotica

Economic importance:

- *Glycyrrhiza glabra* (mulathi): roots are used as flavouring agents and medicine. It is used to treat heartburn, hot flashes, cough, bacterial and viral infections.

- *Butea monosperma* (Palas): Natural dye is obtained from the flowers, leaves are used as fodder, making bowls and plates and rearing for lac, stem yields gum that is known as *Kamarkas* and taken orally by the tribal or rural women after delivery.
- *Dalbergia sissoo* (Shisham): Shisham is an important cultivated tree which is planted on bunds of agriculture fields, roadside and along the banks of canal. Timber is used to construction of floor in houses, furniture, boats and musical instruments.
- *Pterocarpus marsupium* (Bijasal): Wood of bijasal is tough and sturdy and used for building of furniture, musical instruments, boat and railway carriages.

6.18 Euphorbiaceae

Distribution: There are 300 genera and about 7,500 species of family Euphorbiaceae out of these 60 Genera and 350 species found in India. This family is cosmopolitan in distribution, majorly in tropical America and Asia. Some of the largest genera are *Euphorbia* (with 2,000 spp.), *Croton* (750 spp.), *Acalypha* (450 spp.) and *Phyllanthus* (600 spp.).

Salient feature: The laticiferous cells contain milky latex in almost all the plants, thorns are present, leaves are simple, lobed or palmately compound.

Description: Trees, herbs or shrubs sometimes climbing (*Tragia involucrate*), some of the species of *Euphorbia* showing xerophytic habit resembling cacti, (*E. nerifolia*).

Leaves: Cauline and ramal, usually alternate, sometimes opposite (*E. hirta*) or whorled, stipulate, petiolate, simple, dissected (*Liriodendron*), petiolate, often caduceous and drops easily, hairs are stellate, petiole with glands.

Inflorescence: May be a spike (*A. indica*), solitary terminal or axillary (*Phyllanthus fraternus*), raceme (*Antidesma*), panicle in *Jatropha*, *Croton bonplandianum* has scorpioid cymes with unisexual flowers, a special type of cyathium inflorescence is found in family Euphorbiaceae.

Flower: Bracteates, small, unisexual, either monoecious or dioecious (*Bridellia*), complete, regular, actinomorphic, trimerous or pentamerous.

Perianth: Outer sepaloid and inner petaloid whorl each having five units. In female flowers only one seriate sepaloid perianth are found often provided with white, yellow or orange colored glands on the inner face of the perianth.

Androecium: Stamens single (*Euphorbia*) three monadelphous (*Phyllanthus fraternus*), five (*Wielandia*) or ten or more (*Chrozophora*). Stamens of inner whorl are fused whereas outerwhorl stamens remain free. Usually ditheous, extrose, dehiscence by longitudinal or transverse slit.

Gynoecium: Carpels three (tricarpeal), sometimes two (*Bridellia*), syncarpous, superior, trilocular to pentalocular, 1 or 2 ovules in each locule, axile placentation, style three, often bifid to simple.

Fruit: A schizocarpic regma, drupe or berry (*Bischofia*).

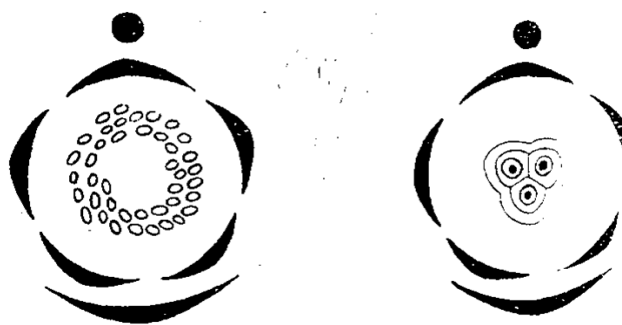
Seed: Seeds are endospermic with straight embryo with caruncle.

Floral formula:

Male Flower: $\text{Br, } \oplus \text{P}_{3+3} \text{ or } (3-5) \text{ or } 0, \text{A}_{1-\infty} \text{ or } (3-\infty), \text{G}_0$

Female Flower: $\text{Br } \oplus \text{P}_{3\text{Q}} \text{ or } (3-5) \text{A}_0 \text{G}_{(3)}$

Floral diagram:



Ricinus communis: Male flower

Female flower

Economic Importance

- *Bridelia retusa* (Kasai) Bark is used for tanning, leaves as fodder, wood is used for construction, cart shafts, agriculture implements, fuel wood and fruits are edible. Bark and roots are also used in ayurveda as medicine.
- *Bischofia javanica* (Paniala) wood is moderately hard, water resistant and used for general construction work, decking, mining props and veneer and ply wood. Bark is used in medicine and yield red colour dye. This is also used as shade tree in coffee and cardamom plantations.
- *Hevea brasiliensis* (Rubber) yields rubber.
- More than 500 species of *Croton* are being cultivated as indoor ornamental plants.

6.19 Bignoniaceae

Distribution: There are 120 genera and about 650 species of family Bignoniaceae out of these 15 Genera and 40 species found in India. Distributed in the tropical regions of the world, mainly in South America and Brazil.

Salient feature: The wood is often divided into wedge shaped cuttings due to failure of cambium so that, it fails to produce xylem in the intervening areas. Usually a nectariferous disc present below the ovary.

Description: Mostly trees or shrubs (*Jacaranda mimosaeifolia*, *Spathodea campanulata*, *Kigelia pinnata* and *Tecoma stans*), very rare herbs, climbers of tendril (*Bignonia unguis-cati*) or root (*Campis radicans*), sometimes twinnings (*Pandorea*).

Leaves: Cauline and ramal, usually opposite, pinnately compound, simple, sometimes whorled. Exstipulate, petiolate, terminal leaflet modified into tendril, may be simple to branch with hooks or terminal adhesive disc.

Inflorescence: A dichasial cyme.

Flower: Bracteates, bracteolate, large, complete, bisexual, regular, zygomorphic and pentamerous.

Calyx: Sepals are five in number, gamosepalous, 5-toothed, campanulate and aestivation is valvate.

Corolla: Five in number, often bilipped (2/3), gamopetalous, colors may vary, aestivation is valvate or imbricate.

Androecium: Stamens four, didynamous, epipetalous and alternate with the corolla lobes, posterior stamens may appear as staminodes, introse, dehiscence by longitudinal slit.

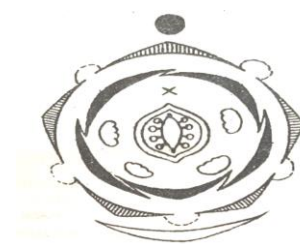
Gynoecium: Carpels two (bicarpellary), syncarpous, superior, bilocular, 1-may ovules in every single locule, placentation is axile, style is simple, stigma bifid and terminal in position.

Fruit: A capsule or a berry.

Seed: Seeds are non-endospermic with straight embryo and winged.

Floral formula: $Br\ Br1\ \% \ \overset{\circlearrowleft}{\text{♀}}\ K_{(5)}\ \overset{\text{---}}{\text{C}_{(5)}}\ A_{4+1}\ \text{staminode}\ \underline{\text{G}}_{(2)}$

Floral diagram:



Floral diagram: Bignoniaceae

Economic Importance:

- *Kigelia pinnata* (Balam kheera) Moderate sized used for roadside avenue plantation, Fruits are guard like drooping used in various ayurvedic medicine. Fruits are used as additives for fermentation of beer. It is also a potential tree for apiculture.
- *Stereospermum sauveolens* (Padal) flowers and tender fruits are used as vegetable. Wood is generally used for construction of furniture, tea boxes, conoes and as an excellent fuel wood.
- *Mellingtonia hortensis* (Akash neem) is a very beautiful tall tree used for avenue plantation. The wood is brittle used for light construction work and bark is the substitute of cork.

- *Wrightia tinctoria* (Sweet Indrajau/ Dyers Oleander, Dudhi) Moderate sized tree grows in forest; seeds are used in worships or in *Havan*. Wood is fine textured, light very suitable for making toys. Chitrakoot wooden toy industry is depend on this tree for wood.
- *Alastonia scholaris* (Saptaparni): Large, evergreen tree planted along the roadside as avenue tree and bark is used as febrifuge.
- *Carrisa carandus* (Karonda): Unripe fruits are used in vegetable, pickle and riped fruits are edible.
- *Rauwolfia serpentina* (Sarpghandha): The roots are used as sedative, lowering blood pressure and mental disorders.

6.21 Lamiaceae

Distribution: About 200 genera and 3500 species of worldwide distribution. In India 65 genera and 400 species have been reported. This family is cosmopolitan in distribution, with major distribution in Mediterranean region, Asia, Africa and Europe.

Salient feature: The plants of family Lamiaceae carry aromatic nature, quadrangular stem, opposite decussate leaves, and verticillaster inflorescence with gynobasic style.

Description: Mostly perennial herbs, shrubs, rarely trees (*Hyptis*). Plants are usually glandular hairy, with aromatic oils, Tap and branched, quadrangular in herbaceous plants.

Leaves: Simple, opposite, decussate, exstipulate, entire, whorled in a few species, venation unicostate, petiolate and reticulate. They are aromatic due to volatile oils.

Inflorescence: Verticillaster, condensed cymose head, formed by the union of the inflorescence in the axis of the two opposite leaves.

Flower: Bracteate, bracteolate, unisexual (*Nepeta*), complete, bisexual, zygomorphic, hypogynous.

Calyx: 5- sepals free or united with a funnel shaped or campanulate, bilabiate, persistent, valvate or imbricate.

Corolla: 5- petals, gamopetalous, bilabiate (4/1 in *Ocimum*, 2/3 in *Salvia*, *Leucas*) into tube and limb.

Androecium: 4- stamens, posterior one suppressed, polyandrous, epipetalous (2+2) didynamous, (*Ocimum*) or 2 stamens (*Salvia*) and stamenodes, intorse, with long connective while posterior or lower lobe is sterile thus it becomes monothealous, longitudinal dehiscence.

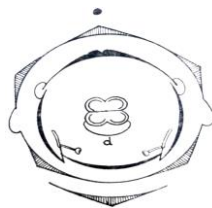
Gynoecium: Bicarpellary syncarpous, ovary superior, bilocular, become tetralocular due to false septum, placentation axile, and each locule with 1-2 ovules. Style is single, gynobasic, stigma two lobed. A hairy disc present below the ovary.

Fruit: A schizocarpic carcerulus, nutlet, drupe or berry.

Seed: Seeds are non-endospermic with straight embryo.

Floral formula: $\text{Br Br1 } \% \text{ } \overset{\text{♀}}{\text{K}} \text{ } 5 \text{ or } (1/4) \text{ or } (3/2) \text{C}_{(4/1) \text{ or } (2/3)} \text{A}_{2+2} \text{ staminode } \underline{\text{G}}_{(2)}$

Floral diagram:



Salvia sp.

Economic Importance:

- *Tectona grandis* (Teak): Tall tree cultivated for its best quality timber. The wood is firm and secure which is used for construction of bridge, houses, furniture, beams, musical instruments etc.
- *Leucosceptrum canum* (Toti) is a tall nectar tree common in Darjeeling important for rearing of honeybees and used in traditional medicines
- *Lycopus europaeus* (Gypsywort): Fruits yield red dye
- *Mentha pieprita*, *Lavandula officinalis*, *Pogostemon* sp. yield essential oil which is used in perfumery and soap industry.
- *Leucas cephalotes* (Gumma): used as a traditional medicine in snakebite.

6.22 Lauraceae

Distribution: This family distributed in tropical regions of Southeast Asia and Central and South America with 54 genera and 2500 species. There are 14 genera and 46 species found in India.

Description: All woody trees and shrubs. Flowers in most of species are unisexual or bisexual, small, yellow, aromatic and possess a perianth. An exception is the leafless parasitic vine of *Cassytha* genus.

Leaves: Alternate, rarely opposite, whorled, glands are dotted aromatic, simple, exstipulate, entire, deciduous or persistent.

Inflorescence: Solitary or cymose or racemose, Axillary often umbelliform with or without involucre bracts.

Flower: Regular, smaller, aromatic, actinomorphic, trimerous, hypogynous, bisexual or unisexual, incomplete.

Perianth: sometimes may be different calyx and corolla or undifferentiated 6 or 4 whorled, united valvate, sapaloid or petaloid green, white cream or yellow, fleshy persistent or deciduous.

Androecium: 3 or many polyandrous, attached to hypanthium, in 1-4 whorls. Mostly all fertile or may be innermost whorl as staminodes. Anthers ditheous, basifixed, introrse.

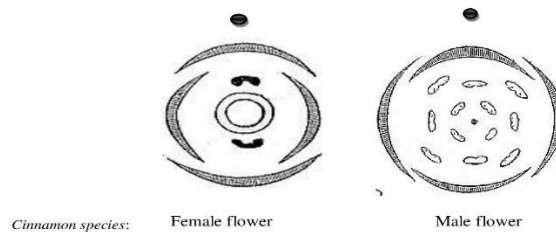
Gynocium: 1-3 carpels, unilocular, superior inferior in Hypodaphnis. Ovule pendulous.

Fruit: Fleshy drupaceous. It is enclosed in fleshy receptacle or hypanthium.

Seed: Non-endospermic, cotyledons massive, sometime ruminant.

Floral formula: Male Flower- $\text{Br } \oplus \text{ } \ominus \text{ } P_{(4-6)} A_{6-12} G_{(1-3)}$

Floral diagram:



Cinnamon flower, fruit and floral diagram

Economic Importance:

- *Ariba rosaeodora* (Brazilian rosewood): Bark and essential oil used in pharma industry. Wood is an important timber used in construction, furniture etc.
- *Machilus bombycina* (Som): Primary food plant of mugasilk (*Antheraea assama*), leaf poultice is applied to relieve from rheumatism and pimples. Essential oil obtained from the flowers and leaves have a medicinal efficacy.
- *Machilus odoratissima* (Kawala): Secondary food plant of mugasilk, bark yields red dye and leaves are generally used as a feedstuff for domestic animals.
- *Litsea monopetala* (Soalu): Wood is used for furniture, planks and handles of tools. Leaves and bark used in traditional medicine to cure arthritis, bruises and pains. Primary food plant of mugasilk

6.23 Bombaceae

Distribution: The family is mainly represented by 20 genera and 180 species distributed in tropical Africa and Asia.

Description: Large trees, stem thick with resin ducts, leaves simple or palmately compound, flowers bisexual, staminodes not present, pollen grains smooth, hypogynous ovary, carpels 2-5 syncarpus, seeds smooth and with mucilage cells.

Leaves: simple or digitately compound, alternate with deciduous stipules.

Inflorescence: Solitary or in cluster

Flower: regular, bracteates, bisexual, hypogynous

Sepals: 5 free or slightly jointed at base, valvate, often with epicalyx.

Petals: 5 free, ebracteate, twisted, or imbricate.

Stamens: 5 or many, free or mono or poly adelphous. Anthers two or more celled, stamenodes often present.

Gynocium: 2-5 carpellary, syncarpous, axile placentation, superior ovary, with 2 or more ovules in every single locule, style 1 with 1-5 stigma.

Fruit: loculicidal capsule or pod,

Seeds: smooth or hairy occasionally arillate.

Floral Formula: $\text{Br } \oplus \text{ } \text{♀} \text{ K}_{5 \text{ or } (5)} \text{ C}_5 \text{ A}_{5-\infty} \text{ } \underline{\text{G}}_{(2-5)}$

Floral diagram:



Bombex ceiba

Note: Recently family Bombaceae is no more it is merged with Malvaceae

Economic Importance:

- *Adansonia digitata* (Kalpvriksha or baobab)- fruit pulp medicinally used in dysentery and floss is used in filling in pillow.
- The bark of baobab is used as substitute of quinine and leaves fruit pulp as febrifuge.
- *Bombex ceiba*: (Semal or silk cotton) immature calyx of flower buds are cooked as vegetable, silk is used for filling pillow and wood is used in place of soft wood.
- *Ceiba pentendra* (Kapok): Wood is used for making tea and match boxes and also a good source of fiber. The cotton of kapok use to filling of pllows that is useful in relieving headache.

6.24 Casuarinaceae

Distribution: The family of Casuarinaceae consists of only one genus *Casuarina* with about 40 species occurring in Australia and S. E. Asia in dry or physically dry situations, therefore developing a xerophytic habit.

Description: Monoecious or dioecious evergreen trees or shrubs with green, jointed whorled stem and branches. The leaves are scale like arranged in whol at each node. The bract and bracteole enclose the ovary and become woody like cone.

Leaves: Scale like, whorled, 4-16 on each node, basally connate. The pallisade cells are arranged in the ridges of these branchlets below the sclerenchymatous hypodermis; the stomata are sunken and situated in the furrows.

Inflorescence: Catkin-like inflorescences.

Flowers: Unisexual, very small and inconspicuous, in catkin-like inflorescences at the end of the branchlets; Male flower in catkin like inflorescence while female in spherical heads on male and female branches, the internodes are short; every single flower in the axil of a bract.

Perianth: Two small tepals are present in male flowers whereas it is lacking in female flowers.

The Male flower: flower develops at each nodes of the inflorescence axis which protected by combination of bracts and two bracteole and two small tepals or perianth lobe around the central stamen, exerted, ditheous, basifixed, dehiscence by vertical slit.

Androecium: Only stamen; filament slender and anther bilobed; lobes dehiscing longitudinally.

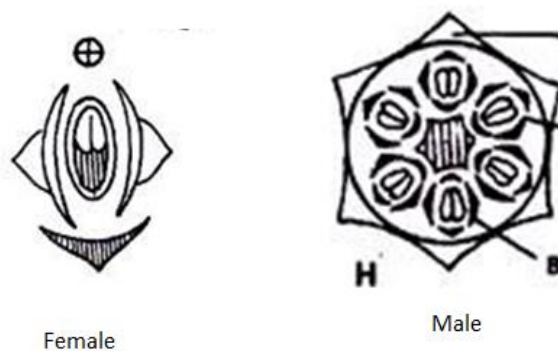
Female flower: Without a perianth; several female flower are crowded in spherical heads at the ends of the branches, a centrally located gynoecium is surrounded by a bract, a pair of bracteole.

Gynoecium: Naked with bicarpellary, syncarpous and superior ovary, placentation parietal, stigma-2, perianth absent.

Fruit: Carpel forms a winged nut; nuts are aggregated into a dry cone-like structure and form a multiple fruit. Seed without endosperm; cotyledons large; form a multiple fruit.

Pollination: Flowers wind-pollinated; the pollen grains are in tetrads.

Floral Diagram:



Economic Importance:

- *Casuarina equisetifolia* (Beefwood, saru, whistling pine) Wood is hard, heavy and resistant to termites.
- Bark of beefwood is used medicinally in treatment of pimples, dysenter and asthma.

- Root extract of beefwood is used to cure dysentery, diarrhoea and stomach pain.
- *Casuarina junghuhniiana* (She oak, red tipped ru) Tree is grown for giving shelter, protection of soil and as an ornamental. Wood is suitable for making hardboard, raw material for kraft pulp, firewood and charcoal.

6.25 Santalaceae

Distribution: widely spread in subtropical and temperate region of the world, often in drier areas and grasslands. This family harbours 36 genera and 500 species all over the world out of these In India 13 genera and 36 species have been reported.

Salient feature: Plants mostly semiparasite, leaves alternate or occasionally opposite bluish green and leathery, flowers tetramerous or pentamerous, ovary unilocular, single basal ovule, seed without seed coat.

Description: herbs, shrubs and medium size trees. Leaves well developed to much reduced, leathery, fleshy and membranous, lamina dorsiventral. Plants with root, parasitic, hausterial parasitic, xerophytic or mesophytic. Stem bifurcating, thorns some time present.

Leaves: Simple, petiolate, exstipulate, opposite or some time alternate, entire and leathery

Inflorescence: Spike, racem, head, dichsial sometimes flowers, axillary solitary

Flower: Small, bisexual or unisexual, staminate or pistillate, dioecious with unisexual flowers bracteates, regular.

Perianth: 3 tepals, pentamerous perianth, either sapaloid or petaloid, valvate aestivation.

Androecium: Stamens as many as perianth, opposite, epiphyllous, filaments short, bithecous, basifixed, vertically dehiscence.

Gynoecium: 3-5 carpellarly, syncarpous, ovary sinferior or semi-inferior, unilocular, ovules 1-5, usually 3, basal placentation, ovules without integument.

Fruit: 1-seeded achene or drupe.

Seed: Seeds without testa, with fleshy endosperm, embryo straight.

Pollination: entomophilous

Floral formula: $Br^{\oplus} \overset{\sigma}{\text{P}}_{4-5} \overset{\text{A}}{\text{A}}_{4-5} \overset{\text{G}}{\text{G}}_{(3-5)}$

Floral diagram:



Thesium sp.

Economic importance:

- *Santalum album* (Chandan): An essential oil distilled from heartwood and roots is used in perfumery. It is also used as medicine to cure various diseases. The wood is also used in construction of fancy articles, boxes, comb, costlr furniture etc.
- *Scleropyrum pentandrum* (Hard pear tree/thorny castor): Small spiny parasitic tree. Paste of leaves and stem bark is applied to cure skin disease. Its roots are boiled and decoction is taken orally as traditional medicine for its contraceptive activity.
- *Pyrularia edulis* (Karbi): small thorny deciduous tree found in forest of Assam and Arunachal. The wood of karbi is used in making kitechen tools. The fruits are somewhat like guava in flavour cooked and eaten raw.

6.26 Orchidaceae

Distribution: About 1000 genera and 20000 species of cosmopolitan distribution in tropical areas. The family is represented by more than 130 genera and 880 species mainly in eastern Himalayas, Western Ghats and khasia hills in India.

Salient feature: Terrestrial orchids are common in temperate region while epiphytic in tropical region. Fibrous, tuberous or rhizomatous, aerial roots with velamen, mycorrhiza often present.

Description: Perennial and terrestrial herbs, epiphytic (*Cymbidium*, *Cattleya*, *Cypripedium* or ladysliper), and climbers (*Bulbophyllum* and *Vanilla*). Epiphytic orchids contain fleshy pseudobulbs with one or more thickened internodes as storage reservoir of food.

Leaves: Simple, alternate, exstipulate, often distichous, rarely whorled or opposite or reduced to achlorophyllous scales (saprophytic species), usually fleshy and linear to ovate, often encircling the stem with a sheathing base.

Inflorescence: Racemose, paniculate (*Oncidium*), spicate or solitary (*Cypripedium*).

Flower: Bracteate, bisexual rarely unisexual, zygomorphic, epigynous, showy, coloured, mostly resupinate (twisted 180° or upside down).

Perinth: Six tepals, 3+3, outer whorl green or coloured (calyx), imbricate or subvalvate in bud, inner whorl petaloid (corrola) of which posterior highly modified as bulbous, spurred, tubular

or strap shaped, projected basally into a spur and called labellum or lip. Labellum works as landing place for pollinating insect.

Androecium: Two fused lateral or one terminal stamen. Anthers dithecous, introrse, pollen grains granular or bound together by viscin threads into masses called pollinea (2-8 pollinea per anther), free or united.

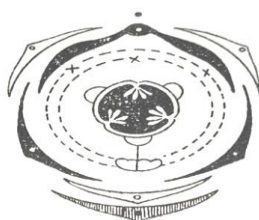
Gynoecium: Tricarpellary, syncarpous, inferior, unilocular, numerous ovules, placentation axile or parietal in trilobular ovary (*Apostasia*), style-1 (part of the column), stigma-3 of which two laterals are often fertile and third one is sterile forming a beak called rostellum.

Fruit: Capsule, berry or nut with many seeds.

Seed: Seeds are ex-albuminous with curved embryo and arillate.

Floral formula: $Br \% P_{3+3} A_{1-2} \overline{G}_{(3)}$

Floral diagram:



Vanda roxburghii

Economic Importance:

- Majorly this family is valued for sweet scented ornamental flowering plants like butterfly orchid (*Oncidium sphacelatum*), green fly orchid (*Epidendrum*), lady's sleeper orchid (*Cypripedium*), lady orchid (*Odontoglossum*) etc
- *Anoectochilus* leaves are used as vegetables in Malaysia and Indonesia.
- *Jumellea fragrans* (Madagascar tea) popular beverage known as "Faham" or Madagascar tea on islands of Madagascar and Mauritius prepared from this orchid.
- Rhizomes of *Platanthera*, *Spiranthes*, *Pholidota*, *Habenaria*, *Dipodium* and *Glossodia* are used as food in Asia.

6.27 Poaceae

Distribution: Largest monocot family represented by 620 genera and over 10000 species in every type of habitat in all regions of the world. 240 genera and 1200 species have been recorded from India.

Salient feature: Ligule membranous, reduced to ring of hairs or absent, project outside (*Hordeum*, *Triticum*) or embrace the culm and known as auricle. Blade is long, narrow and

parallel veined (in *Pharus*), motor cells in the upper epidermis below the furrow and curl on water stress condition.

Description: Annual, biennial or perennial grasses (*Dicanthium*, *Cynodon*, *Echinochloa*, *Imperata*), shrubs *Arundo donex*, *Arundinaria* or arborescent and attain a large size. Erect, ascending, hollow (first remain solid but later pith ruptures) and solid at swollen nodes (except in *Zea mays*, *Saccharum*).

Leaves: Simple, alternate, in two rows and distichous, often crowded at the base with sheath, ligule and blade. Sheath surrounds the culm, open (Two edges generally overlap on the opposite side of the culm) or closed (united forming a closed tube in *Poa*, *Bromus*).

Inflorescence: Spike of spikelet (*Triticum*), spike of compound spikelet (*Hordeum*), raceme (*Paspalum*), panicle of spikelet (*Avena sativa*), spikes or racemes are solitary, digitate or scattered along main axis (rachis).

Flower: Small, bisexual, rarely unisexual, zygomorphic, hypogynous and bracteate.

Perianth or Lodicule: Much reduced, membranous, usually 2 but 3 in *Bambusa*, 1 in *Melica*, fleshy or hyaline scales. Some botanist regarded the second whorl of bracteoles and thus grasses are naked.

Androecium: 3 stamens, or 1-∞ stamens, 1 in *Uniola*, *Festuca*, 2 in *Calianthus*, *Anthoxanthium*, 4 in *Microlaena*, *Tetrarrhena*, 6 in *Oryza* (3+3), 10-40 in *Pariana*, 6-30 in *Ochlandra*, mono or polyadelphous. Pollen grain generally smooth walled. Filaments free, anthers dithecous, basifixed or versatile, introse, longitudinally dehiscence.

Gynoecium: Mono, bi-tricarpellary, syncarpous, ovary superior, unilocular, basal placentation, style two, stigma two in number, hairy.

Fruit: Caryopsis, rarely a nut, utricle or berry (*Bambusa*).

Seed: Seeds are endospermic with abundant and starchy endosperm.

Floral formula: $Br \% \text{♀} P_{0 \text{ or Lodicules}} A_{3-6} \underline{G}_{(2-3)}$

Floral diagram:



Oryza sativa L.

Economic Importance:

Saccharum officinarum (Sugarcane): Perennial crop cultivated for the production of sugar and for fodder.

Bambusa vulgaris (Tiger bamboo): chiefly planted as a ornamental in homesteads and gardens. Leaves and stem is used in treatment of rheumatism, malaria and abscesses. Young shoots are edible and leaves are boiled as a hot tea.

Bambusa bambos (Syn.: *B. arundinacea*): known by many common names such as Indian thorny bamboo, spring bamboo, spiny bamboo etc. It is a soft and thick walled bamboo with wiry and thorny lower branches. Young sprouts harvested from soil are used to relieve from nausea, indigestion and strengthen the cartilage in osteoarthritis and osteoporosis.

Bambusa nutans (Nodding bamboo) cultivated as an agroforestry species for shelter in tea plantation. It is used as a major source of paper and pulp industry; and as poles, hut construction locally in India.

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