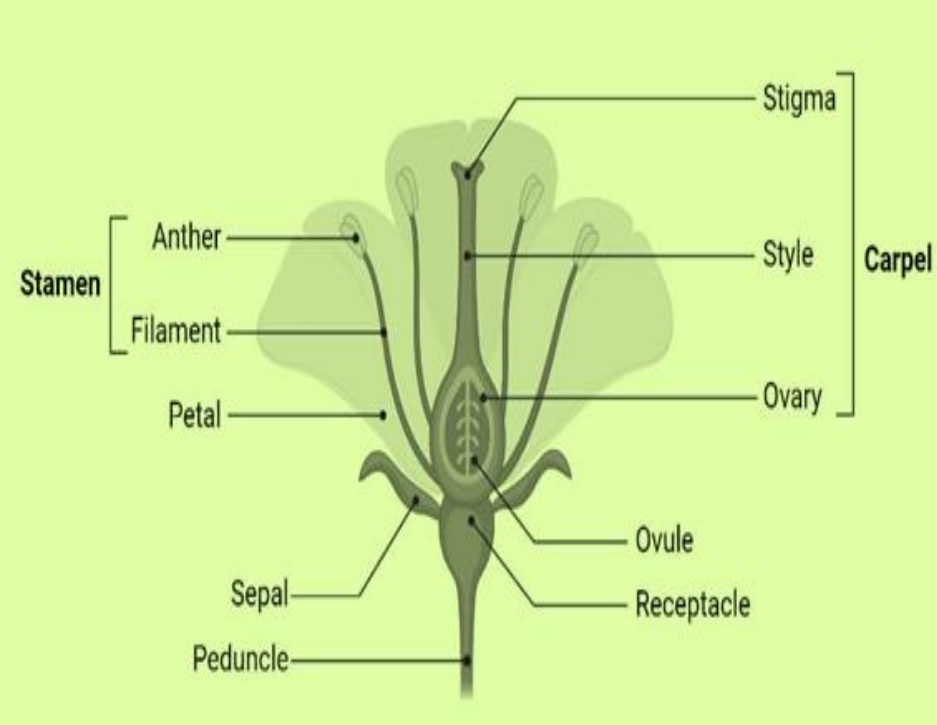
BOT(N)-201 & BOT(N)-201L

B.Sc. III Semester

TAXONOMY OF ANGIOSPERMS



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SCHOOL OF SCIENCES
UTTARAKHAND OPEN UNIVERSITY, HALDWANI

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UNIT-1 HISTORICAL BACKGROUND AND EVOLUTION OF CLASSIFICATION OF ANGIOSPERMS

Contents

1.1 OBJECTIVES

The main goal of this chapter is to broaden your understanding about the following issues:-

- Definition of classification
- History of classification
- Aims of Taxonomy
- Bentham and Hooker's system
- Hutchinson's system of classification

1.2 INTRODUCTION

Plant taxonomy is one of the earliest disciplines of Botany. It was started as "Folk Taxonomy" in early 15^{th} century but it has grown and gone very long way in the last 500 years. The concept and scope of Taxonomy has changed a lot. Though the flora of the earth was invented in the last three centuries yet the modern taxonomists are facing challenges. The tropical countries with rich flora are under threat. So far 4,000,000 plant species are identified of which 2, 86,000 are of angiosperms. Among the identified plants about seventy percent belong to tropical regions.

In the modern times people are running for the applied sciences as cytology, genetics, experimental biology, ecology, molecular biology etc. but a few people are thinking of the basic or fundamental branches of botany like Taxonomy and Morphology. It has become an old fashion. No applied branch can be approached without the proper identification of the plant material on which he/she is working and for this taxonomists are very much needed.

With the increased need for conservation of biological resources, the need for biodiversity assessment during the last few years has increased. The trend has, however, reversed and taxonomic studies are being encouraged throughout the world.

Simpson (1961) suggested that systematics included identification, taxonomy, classification and nomenclature and used as the scientific study of the kinds and diversity of organism and of any and all relationship between them. de Candolle (1813) first coined the term taxonomy.

Classification denotes the arrangement of a single plant or group of plants in distinct category following a system of nomenclature and in accordance with a particular and well established plan. The basic unit of classification is species which are grouped into genus and further grouped into family suborder, order, subclass, classes and divisions.

The beginning of the classification of organism took place at remote times by the non civilized people for their usage and in their own language, with the development of language the distinction between carnivores, herbivores, poisonous plants, edible plants etc. became clear. They feel the necessity of different plants and animals for their use. They selected certain plants and animals for festivals. In this way, the classification in crude sense got the foothold in the

society. Folk systematics is gaining popularity among the pre civilized men. They recognized groups of plants on the basis of gross morphology. This is the beginning of the artificial system of classification. Their ways of classification are rooted in their practical considerations. The history of classification starts from the time of the earliest Indian Philosophers like Charak, Sushruta, early Greek philosophers like Aristotle, Plato, Pliny and others also tried to classify plants from their own viewpoint which invariably were more philosophical in nature than scientific. The various classifications of plants proposed so far, belong to either of the three categories:

(a) Artificial: System classifies plants with the help of one or few characters, primarily with a intention of easy identification of the organism e.g. Banhin, Tournefort, John Ray, Carl Linnaeus.

(b) Natural: System is mainly based on from relationship realizing all informations available at that time. e.g., de Candolle, Robert Brown, de Lamarck, Bentham and Hooker's classification.

(c) Phylogenetic: System tries to classify plants based on their genetic relationships and according to their evolutionary sequences. e.g., Eichler, Hutchinsm, Bessey.

C. Jeffrey (1982) presented that the system of classification can be divided into four main types:

(a) Artificial: Habit based classification made upto 1830.

(b) Pre evolutionary Natural Systems: Overall similarly between plants were much more natural e.g., Bentham & Hooker, A. P. de Candolle, de Jussieu.

(c) Phylogenetic Systems: Natural grouping as a result of decent or common character are related to each other through a common ancestry, e.g., Eichler, Engler.

(d) Phenetic System: Maximal generalizations of the totality of the features of all phenotypes e.g. Hutchinson.

1.3 HISTORY

History of taxonomy begins with the categorization of useful plants of folk taxonomy. People differentiated them as economic plants. This paved the way for herbal taxonomy. The history can be studied in different phases as follows:

I. Initial Stage

- Theophrastus (370-285 BC) a Greek Naturalist also known as Father of Botany published "Enquiry into Plants". He proposed *Crataegus, Daucus* (daukan), *Asparagus* (aspargos) and *Narcissus* etc. in his work. He classified plants on habit base as herbs, undershrubs, shrubs, trees. He gives the name and description to 500 plants in *Historia Plantarum* oldest botanical work in existence. He pointed out the differences between dicots and monocots.
- Pliny (23-29) AD wrote multivoluminous *Natural History* of which 37 volumes are present.

- Pedanion Dioscorides (62 - 128 AD), a physician of Asia minor described 600 medicinal plants. His book was named *Materia Medica* in Greek.
- Andrea Caesalpino (1519 - 1603 AD) a Italian physician wrote *De Plantis* (1583), 1500 plants were described, Woody / herbaceous.
- Gaspard Bauhin (1560 - 1624 AD) Collected the plants from Italy, France, Switzerland, Books are *Prodromus Theati Botanici* (1620), *Penax Theati Botanici* (1623). He first attempted to use binomial system of nomenclature.
- John Ray (1628 - 1705 AD). British Botanist published 3 volumes *Historia Plantarum* (1686 - 1704). He is the first who divided the herbs / trees and divided monocotyledons and dicotyledous on the basis of one and two cotyledons.
- J. P. de Tournefort (1656 - 1708) described trees and herbs and considered corolla.
- The first herbarium was established in 1553 in Padua (ITALY)
- In the middle of 17th century, herbaria were established in different parts of the world.
- Carolus Linnaeus (1707 - 1778), a Swedish Naturalist also known as father of modern botany / taxonomy. He published *Genera Plantarum* (1737), *Classes Plantarum* (1738), *Philosophia Botanica* (1751), *Species Plantarum* (1753). 7300 species were described and arranged on sexual system. It was an artificial system based on few characters. He introduced Binomial system eg., *Rhododendron arboreum*. 24 classes of Linnaeus are (1) Monandria (one Stamen) (2) Diandria (2 stamen) ..... (24) Cryptogamia (No flower).
- In initial stage taxonomy was merely started for exploration and naming of species.

II. Natural System Stage

- Antoine L de Jussieu (1686 - 1758) published *Genera Plantarum* and classified plants into 15 classes.
- Augustin Pyrame de Candolle (1778 - 1841), a French botanist published *Theorie elementaire de la botanique* in 1813 and developed morphological approach to classification. He classified plants as Vasculares and Cellulares, Monumental works - *Prodromus Systematis Naturalis Regni Vegetabilis*. A. P. de Candolle could not complete his work and later his son Alphonse de Candolle completed the work.
- Charles Darwin (1859) published *Origin of Species*, where he suggested the principle of natural selection and evolutions of species.
- Bentham and Hooker (1800 - 1884) published *Genera Plantarum* (1862 - 1883) gave practical use of classification “ever since been as inspiration to generations of the Kew Botanists”.

III. Phylogenetic Stage

- Phylogenetic classification was based on the ideas of evolution. It started with Endlichler (1804-1849) and Eichler (1837-1887).
- Engler and Prantl. (1887-1915) suggested semi-phylogenetic system of classification.
- *Die Natiirlichen Pflanzen Familien* (1887 - 1899) and S*yllabus der Pflanzen Familien* (1964). He placed monocots before dicots and orchids were considered more evolved than grasses.
- Class 1 : Monocotyledons - 11 orders
- Class 2 : Dicotyledons
- Sub class - 1. Archichlamydeae - 29 orders.
- Sub class 2. Metachlamydeae (Sympetalae) - 9 orders
- A. B. Rendle (1865 - 1938) Classification of flowering plants. He treated monocots as primitive to dicots and amentiferae and apetalous as primitive dicots.
- The first purely phylogenetic system based on *Dictas of Phylogeny* was given by Charles Edwin Bessey (1845-1915) which was improved by Hans Hallier (1868-1938)
- John Hutchinson (1884 - 1972)) Britishers, put forth his 24 principles of phylogeny and based on that suggested phylogenetic classification of value, in *Families of Flowering Plants* (1959). His classification was based as Bentham and Hooker and Bessey. First volume deals with Dicots (1928), second with Monocots (1934) and published *British Flowering Plants* (1940).

IV. Recent Stage

- The system was improved by contemporary Botanists like Takhtajan in *Flowering Plants: Origin and Dispersal* (1969); Cronquist in *"Evolution and Classification of Flowering Plants"* (1981) Stebbins in *Flowering Plant Evolution above the Species Level* (1974) and Robert Thorne in "*A Phylogenetic Classification of Angiospermae"* (1976) etc.
- The Classifications were based on distribution, Ecology, Anatomy, Palynology Cytology and Biochemistry apart from Morphology.
- Techniques of herbarium preparation and presentation were developed and established.

V. Biosystematic Phase

- The last fifty years have seen a qualitative improvement in the area of taxonomic concept and application by advancement of Biosystematics.
- The "New systematics" is aimed at achieving the goal of "holotaxonomy".
- Huxley (1940) proposed the term "New systematics."

- Camp and Gilly (1943) proposed the term "Biosystematics" to new systematics.
- The number, size and shape of chromosomes were considered by cytotaxonomists as very reliable parameters for cytotaxonomic classification.
- The development of techniques like two-dimensional paper chromatography, identification of chemical substances in plants as secondary metabolites led to the development of "Chemotaxonomy".
- The new techniques can give details as amino acid sequencing and determining nucleotide sequences in DNA and RNA.

VI. Holotaxonomic Phase

Information is gathered, analysed, and a meaningful inference is drawn for understanding phylogeny.

- Collection of data, analysis and synthesis are the jobs of an independent descipline of taxonomy, *i.e.,* Numerical Taxonomy.
- Numerical Taxonomy or quantitative taxonomy is based on numerical evaluation of the similarity between groups of organisms and the ordering of these groups into higher ranking taxa on the basis of these similarities.
- Exploratory and Consolidation phase are considered as Alpha taxonomy while Biosystematic and Encyclopaedic phase are considered as Omega Taxonomy.

1.4 FUNDAMENTAL COMPONENTS OF TAXONOMY

Taxonomy is a fundamental science with the increase in knowledge of various components developed.

(i) **Alpha Taxonomy** (Descriptive taxonomy): The aspect of taxonomy is concerned with the description and designation of species. Typically on the basis of morphological characters, it developed in 19th century. It started with work of Tournefort, de Jussieu and Linnaeus**.**

(ii) **Beta Taxonomy** (Macrotaxonomy): The arrangement of species into hierarchical system of higher categories or taxa. It developed in 20^{th} century.

(iii) **Gamma Taxonomy:** Aspects of taxonomy concerned with intraspecific population and with phylogenetic trends are included in gamma taxonomy. An attempt is made to account for the origin and development of species. To determine the origin of a species, a taxonomist has to depend on paleobotany which includes all taxa of extinct plant groups.

(iv) **Omega taxonomy:** It is an ultimate perfect system, based upon all available characters.

The best is the concept of Alpha-Omega Taxonomy. As alphataxonomy forms the basis of biology while the final accumulation of all data is ultimately incorporated into Omega taxonomy.

1.5 AIMS OF TAXONOMY

There are three main aims of taxonomy, *i.e.*, Identification, nomenclature and classification. There are two main approaches:

(a) **Empirical approach:** It is based on practical aspects, observation of characters etc.

(b) **Interpretive approach:** The classification is based on interpretation and evolution of a taxon, e.g., phylogenetic system. Modern taxonomy combines both approaches with the following aims:

1. To provide a convenient method of identification and communication.
2. To provide classification which is based on natural affinities of organisms as far as possible.
3. To provide an inventory of plant taxa by means of flora.
4. To detect evolution at work, discovering its process of interpreting into results.
5. To provide an integrating and unifying role in the training of biology students regarding the relationships between many biological fields and data gathering science.

Deme Terminology

Gilmour and Gregor (1939) proposed the new system of terminology providing an infinitely flexible series of categories used to define any group of individuals. The system is known as Deme terminology. It is non-hierarchical and does not consider genus, species etc. Deme implies to a group of related individuals of a particular taxon. The precise meanings of the term are provided by various prefixes.

Topodeme: A deme occuring within a specified geographical area.

Ecodeme: A deme occuring within a specified kind of habitat.

Gamodeme: A deme composed of individuals which interbreed in nature.

Phenodeme: A deme differing from others phenotypically.

Plastodeme: A deme differing from others phenotypically but not genotypically.

Genodeme: A deme differing from others genotypically.

Autodeme: A deme composed of predominantly self fertilizing or autogamous individuals.

Endodeme: A deme composed of predominantly closely in-breeding (endogamous) but dioecious individuals.

Agamodeme: A deme composed of predominantly apomictic (non-sexually reproducing) individuals.

Clinodeme: A deme which together with other such deme forms a gradual variational trend over a given area.

Cytodeme: A deme composed of individuals all with the same karyotype (chromosome morphology).

Genoecodeme: An ecodeme differing from others genotypically (Ecotype)

Plastoecodeme: An ecodeme differing from others phenotypically and not genotypically (Ecophene).

1.6 BENTHAM AND HOOKER'S SYSTEM

The well known English systematists who brought out jointly '*Genera Plantarum*' (1862 - 1883) and their classification is used throughout the British empire. In our country the Central National Herbarium at Sibpur (Howrah) W. Bengal is maintained according to this system.

The system of classification is based on that of de Candolle, but greater stress is being given on the contrast between free and fused petals. The dicots are divided into Polypetalae, Gamopetalae and Monochlamydeae. The position of Gymnosperms between dicots and monocots is only for convenience rather than an indication of affinities.

An outline classification of Bentham and Hooker's system (1862 - 1883) is given below.

Class : Dicotyledons

Sub class 1 Polypetalae comprises three series

Series A: Thalamiflorae - 6 orders and 34 families

Order 1. Ranales - 8 families

Families: Ranunculaceae, Dilleniaceae, Calycanthaceae, Magnoliaceae, Annonaceae, Menispesmaceae, Berberideae, Nymphaeaceae.

Order 2. Parietales: 9 families

Families: Sarraceniaceae, Papaveraceae, Cruciferae, Capparideae, Resedaceae, Cistineae, Violaceae, Canellaceae, Bixineae.

Order 3. Polygalineae: 4 families

Families: Pittosporeae, Tremendreae, Polygaleae, Vochysiaceae.

Order 4. Caryophyllinae: 4 families

Families: Frankeniaceae, Caryophylleae, Portulacaceae, Tamariscineae.

Order 5. Guttiferales: 6 families

Families: Elatrineae, Hypericineae, Guttiferae, Ternstroemiaceae, Dipterocarpeae, Chlaenaceae.

Order 6. Malvales: 3 families

Families: Malvaceae, Sterculiaceae, Tiliaceae.

Series B: Disciflorae - 4 orders and 23 families

Order 7. Geraniales: 11 families

Families: Lineae, Humiriaceae, Malphighiaceae, Zygophyllaceae, Geraniaceae, Rutaceae, Simarubeae, Ochnaceae, Burseraceae, Meliaceae, Chaillentiaceae.

Order 8. Olacales: 3 families

Families: Olacineae, Ilicineae, Cyrilleae.

Order 9. Celastrales: 4 families

Families: Celastrineae, Stockhousieae, Rhamneae, Amplelideae.

Order 10. Sapindales: 5 families

Families: Sapindaceae, Sabiaceae, Anacardiaceae, Anomalous families Coriarieae and Moringeae.

Series C: Calyciflorae - 5 orders and 25 families

Order 11. Rosales: 9 families

Families: Connaraceae, Leguminosae, Rosaceae, Saxifrageae, Crassulaceae, Droseraceae, Hamomelideae, Bruniaceae, Halorageae.

Order 12. Myrtales: 6 families

Families: Rhizophoraceae, Combretaceae, Myrtaceae, Melastomaceae, Lythrarieae, Onagrarieae.

Order 13. Passiflorales: 7 families

Families: Samydaceae, Loaceae, Turneraceae, Passifloreae, Cucurbitaceae, Begoniaceae, Datisceae.

Order 14. Ficoidales: 2 families

Families: Cacteae, Ficoideae

Order 15. Umbellales: 3 families

Families: Umbelliferae, Araliaceae, Cornaceae

Sub class III Gamopetalae - Comprises three series.

Series A: Inferae - 3 order and 7 families.

Order 1. Rubiales: 2 families

Families: Caprifoliaceae, Rubiaceae.

Order 2. Asterales: 4 families

Families: Valerianeae, Dipaceae, Calyceerae, Compositae.

Order 3. Campanulales: 3 families.

Families: Stylideae, Goodeniaceae, Campanulaceae.

Series B: Heteromerae - 3 orders and 12 families

Order 4. Ericales: 6 families

Families: Ericaceae, Vaccinieae, Monotropeae, Epacrideae, Diapensiaceae, Lennoaceae.

Order 5. Primulales: 3 families

Families: Plumbaginaceae, Primulaceae, Myrsineae.

Order 6. Ebenales: 3 families

Families: Sapotaceae, Ebenaceae, Styraceae.

Series C: Bicarpellatae - 4 orders and 23 families

Order 7. Gentianales: 5 families

Families: Oleaceae, Salvadoraceae, Apocynaceae, Asclepiadaceae, Loganiaceae, Gentianaceae.

Order 8. Polemoniales: 5 families

Families: Polemoniaceae, Hydrophyllaceae, Boraginaceae, Convolvulaceae, Solanaceae.

Order 9. Personales

Families: Scrophalariaceae, Orobanchaceae, Lentiburaceae, Columelliaceae, Gesneraceae, Bignoniaceae, Pedalineae, Acanthaceae.

Order 10. Lamiales: 5 families

Families: Myoporineae, Selagineae, Verbenaceae, Labiatae, Anomalous family Plantagineae.

Sub class III. Monochlamydeae or Incomplete comprises A-H or 8 series.

Series A. Curvembyae: 7 families.

Families: Nyctagineae, Illecebraceae, Amarantaceae, Chenopodiaceae, Phytolaccaceae, Batideae, Polygonaceae.

Series B. Multiovalatae Aquaticae: 1 family

Family: Podostemaceae.

Series C: Multiovulatae Terrestris: 3 families.

Families: Nepenthaceae, Cytinaceae, Aristolochieae.

Series D: Microembryae: 4 families.

Families: Piperaceae, Chloranthaceae, Myristicaceae, Monimiaceae.

Series E: Daphnales: 5 families

Families: Laurineae, Proteaceae, Thymeleaceae, Penaeaceae, Elaeagnaceae.

Series F: Achlamydosporeae: 3 families

Families: Loranthaceae, Santalaceae, Balanophoreae.

Series G: Unisexuales: 9 families

Families: Euphorbiaceae, Balanopseae, Urticaceae, Platanaceae, Leitneriaceae, Juglandeae, Myricaceae, Casurinaceae, Cupuliferae.

Series H: Ordines Anomali (Anomalous families: 4)

Families: Salicaceae, Lacistermaceae, Empetraceae, Ceratophylleae.

Class 2: Gymnospermae: 3 families.

Families: Gnetaceae, Coniferae, Cycadaceae.

Class 3: Monocotyledons (A - G) : 7 series.

Series A: Microspermae: 3 families

Families: Hydrocharideae, Burmanniaceae, Orchideae.

Series B: Epigynae: 7 families.

Families: Scitamineae, Bromeliaceae, Haemodoraceae, Irideae, Amaryllideae, Taccaceae, Dioscoreaceae.

Series C: Coronarieae: 8 families

Families: Roxburghiaceae, Liliaceae, Pontederiaceae, Philydraceae, Xyrideae, Mayaceae, Commelinaceae, Rapateaceae.

Series D: Calycinae: 3 families

Families: Flagellarieae, Juncaceae, Palmae.

Series E: Nudiflorae: 5 families

Families: Pandanaceae, Cyclanthaceae, Typhaceae, Aroideae, Lemnaceae.

Series F: Apocarpeae: 3 families

Families: Triurideae, Alismaceae, Naidaceae.

Series G: Glumaceae: 5 families

Families: Eriocauleae, Centrolepideae, Restiaceae, Cyperaceae, Gramineae.

Characteristics of Bentham & Hooker

Emryo with two cotyledons: stem with open vascular bundles; leaves netted (reticulate) venation; flowers usually pentamerous, *Class*: *Dicotyledons*

Embryo with a single cotyledon: stem with vascular closed bundles; leaves with parallel venation; flowers usually trimerous *Class*: *Monocotyledons*

Class Dicotyledons

Sub-class I Flowers usually with two whorls of perianth i.e. (calyx and corolla). Petals free.....*Polypetalae*

Sub-class II Flowers usually with two whorls of perianth i.e. (calyx and corolla). Petals united.....*Gamopetalae*

Sub-class III Flowers usually with one whorl of perianth. commonly sepaloid or absent..... *Monochlamydeae*

Sub-Class I — Polypetalae

Series (i): Petals and stamens hypogynous. disc absent!..... *Thalamiflorae*

(1) Androecium rarely definite gynoecium free or immersed in toms, rarely united: embryo minute albuminous ..... *Ranales*

(2) Gynoecium syncarpous, parietal placentation.....*Parietales*

(3) Gynoecium syncarpous. free central placentation: Herbs. sepals 5 or 4. petals 5 or 4 stamens twice petals. Obdiplostemonous .....*Caryophyllineae*

(4) Flowers rarely irregular; sepals 5, 2 or 4. free or united: petals as many or (0); stamens indefinite monadelphous; gynoecium 3 to indefinite numbers of carpels. carpels united .....*Malvales*

Series (*ii*) Stamens hypogynous. disc present, ovary superior .....*Disciflorae*

(1) Ovary superior or inferior, syncarpous; stamens twice the number of sepals, in two or one whorl: .....*Geraniales*

Series (*iii*) Flower perigynous or epigynous: ovary sometimes inferior: ovary enclosed by developments of floral axis. .....*Calyciflorae*

(1) Gynoecium one or more carpellary, apocarpous: flower actinomorphic or zygomorphic. Perigynous. .....*Rosales*

(2) Flower regular, usually bisexual: Ovary syncarpous. inferior: styles undivided or very rarely styles are free….....*Myrtales*

(3) Flowers bisexual or unisexual. parietal placentation. styles free or connate ... ……*Passiflorales*

(9) Flowers bisexual, locules in Ovary one to indefinite number. inflorescence umbel….....*Umbellales*

Sub-Class III - Gamopetalae

Series (i): Ovary inferior. stamens usually as many as petals.....*Inferae*

(1) Flowers regular or irregular, stamens epipetalous, ovary with 2 - indefinite number of locules. ……..*Rubiales*

(2) Flowers regular or irregular, stamens epipetalous, ovary with one locule and one ovule; stamens, syngenesious .....*Asterales*

Series (ii) Ovary superior; stamens as many as petals or numerous, petals opposite or alternate to petals.....*Heteromerae*

(1) Flowers regular, petals 4-5, stamens as many as the petals or numerous, inserted on receptacle……..…….*Ericales*

(2) Flowers regular, petals 5, stamens 5 or numerous, ovary superior, herbaceous, prostrate or climbing plants ……*Primulales*

(3) Flowers regular, petals 4-5, stamens as many as the petals, inserted on the corolla, ovary superior……..……*Ebenales*

Series (iii) Ovary usually superior; stamens as many as or fewer than corolla lobes. alternipetalous: gynoecium 2 rarely to 1-3-carpellary.. ...*Bicarpellatae*

(3) Flower regular, hypogynous; stamens epipetalous: leaves generally opposite. ……..*Gentianales*

(4) Flower regular, hypogynous; leaves alternate; stamens epipetalous; ovary 1-5 loculed.....*Polemonianles*

(5) Flowers usually irregular, corolla often bilipped; stamens generally fewer than corolla lobes. usually 4, didynamous or 2; ovary 1-4 locular, ovules usually indefinite..... *Personales*

Indefinite number of ovules per loculus; sepals 5, fused; petals 3 + 2, gamopetalous; stamens 4 or 5, gynoecium bicarpellary. syncarpous.. ……*Acanthaceae.*

(6) Corolla usually bilpped; flower hypogynous, rarely regular;

Ovary 2 - 4 loculed. ovules solitary in loculus or rarely more than one; first a drupe or nutlets..... *Lamiales*

Sub-class - Monochlamydeae

Flowers usually with one whorl of perianth commonly sepaloid or perianth absent.

Series A. Terrestrial plants with usually bisexual flowers; stamens generally equal in number to perianth lobes; ovules usually solitary; embryo curved or coiled in endosperm..... *Curvembryae*

Series B. Plants are many seeded submerged aquatica ….*Multiovulatae Aquaticae*

Series C. Plants are many seeded terrestrial ……*Multiovulatae Terrestres*.

Series D. Seeds are endospermous and with aminute embryo ….*Microembryeae*.

Series E. Ovary is monocarpellary and one ovuled ……..*Daphnales*.

Series F. Ovary is one locular, inferior, no of ovules is 1 to 3.. *Achlamydosporeae*.

Series G. Flowers are unisexual, ovary is monocarpellary or syncarpous ……..*Unisexuales*

Series H. Unisexual families of doubteful or unknown affinities ……*Ordines Anomali*.

Class 2 : Gymnospermae

Class 3 : Monocotyledons

Series A. Ovary is inferior, seeds are minute ……..*Microspermae*

Series B. Ovary is inferior, seeds are large and with a copiuns endosperms ……. *Epigynae*

Series C. Perianth atleast the inner one is petatoid, the ovay is superior ……*Coronarieae*.

Series D. Perianth is sepaloid ovay is superior ……*Calycinae*.

Series E. Perianth is usually absent or reduced to minute scales, seeds are albuminous ……..*Nudifloreae*.

Series F. The perinath is about or uni-biseriate, ovary is superior with one or more than one tree coupels. Seeds albumiuoue ……*Apocarpeae*.

Series G. Perianth is scaly or glumaceous or about the ovary is usually one ovuled, seeds are alluminous..... *Glumaceae*.

Advantages and Disadvantages of Bentham & Hooker's Classification

Advantage is it provides easy means and ways of identifying plant.

Disadvantage are:

- Retention of Monochamydeae in which biseriate perianth as a rule in order.
- Family salicineae and cupuliferae are similar to now extinct.
- Simple flower to Paronychieae as elaborate primitive, thus Chenopodiaceae are apetalous allies of Caryophyllaceae.
- Position of Monochlamydeae and delimitation due to their affinities (Rendle)
- In Monocots greater emphasis on relative position of ovary, so Iridaceae, Amayllidaceae shows greater affinity to Liliaceae then Scitamineae and Bromelliaceae as common epigyuous character.

Key to the identification of the Families

(*a*) Flowers mostly penta or tetramerous

(*b*) Calyx and corolla mostly distinct.

(*a*) Flowers mostly trimerous

(*b*) Calyx and corolla mostly not distinguished as separate whorls; perianth present, Monocotyledons.

……*Dicotyledons*

I. DICOTYLEDONS

(i) Corolla consisting of mostly free petals ……*Polypetalae*

(ii) Corolla consisting of mostly fused petals…… *Sympetatae* (Gamopetalae)

(i) Polypelatae

(A) Ovary Superior

1. Flowers unisexual……..*Euphorbiaceae*
2. Gynoecium apocarpous, fruit never drupe. calyx and corolla sometimes not distinguished. ……*Ranunculaceae*
3. Gynoecium either apocarpous or monocarpellary, fruit may be a drupe. epicalyx often present. ……*Rosaceae*

4. Gynoecium monocarpellary

(a) Fruit drupe. …… *Rosaceae*

(b) Fruit legume or lomentum

(i) Flowers actinomorphic, stamens mostly indefinite ……*Mimosoideae*

(ii) Flowers zygomorphic, aestivation of the corolla ascending imbricate; stamens 10 but never diadelphous……..*Caesalpinoideae*

(iii) Flowers zygomorphic, aestivation of the corolla descending imbricate, stamens ten, diadelphous,.....*Papilionatae*

5. Gynoecium syncarpous

(a) Placentation free-central ……..…*Caryophyllaceae*

(b) Placentation parietal

(i) Gynoeceum tricarpellary ……..*Violaceae*

(ii) $K_{2 \text{ or } 3}\, C_{2+2 \text{ or } 3+3}\, A_{\square}\, G_{(2-\square)}$ ……*Papaveraceae*

(iv) $K_{2+2}\, C_4\, A_{2+4}$ (tetradynamous). $G_{\underline{(2)}}$ ……*Cruciferae*

(c) Placentation axile .

(i) Epicalyx present, stamens monadelphous …….*Malvaceae*

(ii) Prominent disc present below gynoecium, stamens obdiplostemonous or polyadelphous. …….*Rutaceae*

(d) *Ovary inferior:*

(i) Leaves exstipulate, inflorescence umbel ……..*Umbelliferae*

(ii) Leaves exstipulate, inflorescence mostly cymose or a spike, petals often nearly circular, stamens indefinite ....*Myrtaceae*

(iii) Leaves mostly stipulate, the latter often adnate to the petals, never circular: epicalyx often present ……..*Rosaceae*

(ii) Sympetalae (Gamopetalae)

(A) Ovary superior:

(a) Corolla actinomorphic

(i) Stamens often included in the corolla tube, anthers mostly sagittate and convinient round the stigmatic head, stigma dumble-shaped. ……..*Apocynacease*

(ii) Gynostegium present, gynoecium free below and fused above ……....*Asclepiadaceae*

(iii) Ovary bilocular with typically two ovules in each loculus. ……..*Convolvulaceae*

(iv) Carpels obliquely placed in the flower, ovary bilocular, placenta swollen, ovules shining and indefinite. ……*Solanaceae*

(b) Corolla zygomorphic

(i) Corolla mostly bilabiate, style gynobasic. ……*Labiatae*

(ii) Corolla often bilabiate, ovary elongated, style long and terminal. ……*Acanthaceae*

(B) Ovary inferior

(i) Mostly climbing plants with well developed tendrils, flowers unisexual, androecium complex, anthers twisted. ……*Cucurbitaceae*

(ii) Inflorescence capitulum, calyx in the form of pappus, anthers cohering by their edges (syngenesious), placentation basal. ……*Compositae*

(iii) Stipules prominent, either inter or intrapetiolar, placentation axile. ……*Rubiaceae*

II. MONOCOTYLEDONS:

(i) Gynoecium monocarpellary with two feathery stigmas, perianth absent, ovary superior …….*Gramineae*

(ii) Flowers unisexual, minute and produced in very large numbers, ovary superior. ……*Palmaee*

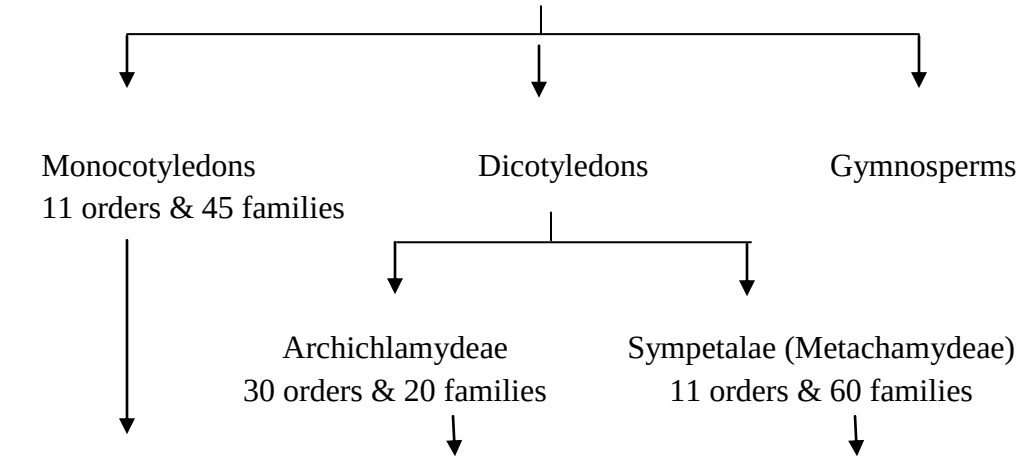
(iii) Flowers bisexual, six stamens in two whorls, ovary superior..*Liliaceae*

(iv) Flowers mostly bisexual, stamens five in two whorls, ovary inferior ……..M*usaceae*

1.7 ENGLER AND PRANTL'S SYSTEM

Adolf Engler (1844-1930) Professor of Botany at Berlin University adopted the main features of Eichler's classification and with Karl Prantl (1849-1893) published *Die Naturlichen Pflanzenfamilien* in 1909. The significant feature of this system is that monocotyledons take precedence over the dicotyledons, the polypetalae, monochlamydeae are united and form the single group Archichlamydeae. Amentiferae were regarded as primitive. Evolution is traced from hypogynous to epigynous. This system is also not perfect because the group Amentiferae is not artificial assemblage of families but probably reduced rather than primitive group as indicated. The placing of monocots before dicots is also not in present line. The general outline of the system proposed by Engler and Prantl is given below:

Phanerograms
(Seed plants)



7. Spathiflorae
8. Farinose
9. Lilliflorae
10. Scitamineae
11. Microspermae

7. Balanopsidales
8. Leitnerales
9. Juglandales
10. Batidales
11. Julianales (Archichlamydeae)
12. Fagales
13. Urticales
14. Podostemonales
15. Proteales
16. Santalales
17. Aristolochiales
18. Balanophorales
19. Polygonales
20. Centrospermae
21. Ranales
22. Rhoedales
23. Sarraceniales
24. Rosales
25. Pandales
26. Geraniales
27. Sapindales
28. Rhamnales
29. Malvales
30. Parietales
31. Opuntiales
32. Myrtiflorae
33. Umbelliflorae

7. Tubiflorae
8. Plantaginales
9. Rubiales
10. Cucurbitales
11. Campanulatae

1.8 HUTCHINSON'S CLASSIFICATION

The classification based on principles of phylogeny was suggested by John Hutchinson in his *"The Families of Flowering Plants"*. He was a British Botanist from England (1884-1972). He proposed 24 principles of Phylogeny parallel to Bessey's Dicta of phylogeny. In 1969, he published "*Evolution and Phylogeny of Flowering plants*." His other work is *Genera of Flowering plants* (1964-67). His classification was revised from time to time (1955, 1969) and finally appeared in 1973.

The classification suggests that origin of Angiosperms is Monophyletic; originating from hypothetical proangiosperms. Initially Angiosperms were regarded to have evolved along two evolutionary lines.

(*a*) **Herbaceae** (Herbaceous families starting from Ranales to Lamiales, 28 orders)

(*b*) **Lignosae** (Arborescent or woody plants starting from Magnoliales to Verbenales, 54 orders)

However, he considered monocots to be derived from Ranales. Monocots were divided into three groups based on nature of Perianth into Calciferae, Corolliferae and Glumiflorae within all 29 orders and 69 families.

In the new revised classification published in 1973 small alterations were made as: Lytherales were transferred to Myrtales, in Lignosae from Herbaceae. Now Dicots include 82 orders and 342 families while Monocots include 29 orders and 69 families.The important points are:

1. The system is based on Bessey's system.
2. It is based on the assumption that flowering plants with sepals and petals, associated with other floral and anatomical characters are phylogenetically primitive, than the plants without sepals and petals.
3. This system is based on considerable knowledge of phylogeny.
4. The Monocotyledons are placed after the Dicotyledons from which they were considered to have been derived at an early stage.
5. The Magnoliales and Ranales are considered most primitive orders of the Dicotyledons, where flowers are bisexual with numerous free stamens and carpels are spirally arranged.
6. Emphasizing resemblances rather than differences, the Gamopetalae and Monochlamydeae are distributed amongst the Polypetalae according to their relationships.
7. The flowering plants are divided into smaller groups on the basis of a combination of characters and closely allied families are placed together.
8. The Gymnosperms are considered as a distinct group.
9. The families of Monocotyledons are arranged in 29 orders and he proposed new conceptions for several families resulting in more natural groupings.
10. The Butomales and the Alismatales are placed at the beginning of the Monocotyledons. They share with the Ranales androecium of numerous stamens, apocarpous gynoecium and folicular and achenial fruits.
11. The Gramineae are considered as the most advanced family of the Monocotyledons which is inconsistent with the present understanding of the group.
12. He recognized 411 families of Angiosperms.

Principles of Classification

Hutchinson laid great stress on the phylogenetic arrangement of plants and predicated their classification on 24 principles which are briefly enlisted below:

1. Evolution is both upwards and downwards, the latter involving degradation and degeneration.
2. Evolution does not necessarily involve all organs of the plant at the same time, and one organ or set of organs may be advancing while another set is stationary or retrograding.
3. Evolution has generally been consistent and when a particular progression or retrogression has set in it is persisted into the end of the phylum.
4. In certain groups, trees and shrubs are probably more primature than herbs.
5. Tree and shrubs are older than climbers.
6. Perennials are older than biennials and from them annuals have been derived.
7. Aquatic flowering plants are as a rule more recent than terrestrial and same may be said for epiphytes, saprophytes and parasites.
8. Plants with collateral vascular bundles arranged in a cylinder (dicotyledons) are more primitive in origin than those with scattered bundles (monocotyledons), though it does not necessary follow that the latter have been directly derived from the former.
9. The spiral arrangement of leaves on the stem and of the floral leaves (sepals and petals) preceded that of the opposite and whorled types.
10. As a rule simple leaves precede compound leaves.
11. Bisexual precedes unisexual flowers, and the dioecious is probably more recent than the monoecious condition.
12. The solitary flower is more primitive than the inflorescence, the highest forms of the latter being the umbel and capitulum.
13. Spirally imbricate floral parts are more premature than whorled and valvate.
14. Many parted flowers (polymerous) precedes, and the type with few parts (oligomerous) follows from it, being accompanied by a progressive sterilization of reproductive parts.
15. Petaliferous flowers precede apetalous one, the later being the result of reduction.
16. Polypetaly is more primitive than sympetaly.
17. Actinomorphic flowers are more primitive than zygomorphic flowers.
18. Hypogyny is the primitive condition, and from it perigyny and epigyny derived later.
19. Apocarpy is more primitive and from it syncarpy has resulted.
20. Many carpels precede few carpels.
21. The endospermic seed with small embryo is primitive and the non-endospermic seed is more recent.

22. In primitive flowers there were many stamens and is more advanced flower, few stamens.
23. Separate stamens precede connate stamens.
24. Aggregate fruits are more recent than single fruits, and as a rule the capsule precedes the drupe or berry.

Detailed Classification (1959)

Phylum Angiospermae
Sub. Phylum Dicotyledones

Division 1 Lignosae

	Order	Family
1.	**Magnoliales**	1. Magnoliaceae, 2. Illicidaceae, 3. Winteraceae, 4 Canellaceae, 5. Schisandraceae, 6. Himantandraceae, 7. Lactoridraceae, 8. Trocoendraceae, 9. Cercidiphyllaceae.
2.	**Annonales**	10. Annonaceae, 11. Eupomatiaceae.
3.	**Laurales**	12. Monimiaceae, 13. Austrobaileyaceae, 14. Lauraceae, 15 . Trimeniaceae, 16. Hernandiaceae, 17. Gomortegaceae, 18. Myristicaceae.
4.	**Dilleniales**	19. Dilleniaceae, 20. Connaraceae, 21. Crossosomataceae, 22. Brunelliaceae.
5.	**Coriariales.**	23. Coriariaceae.
6.	**Rosales**	24. Rosaceae, 25. Dichapetalaceae, 26. Calycanthaceae.
7.	**Leguminales**	27. Caesalpiniaceae, 28. Mimosaceae, 29. Fabaceae.
8.	**Cunoniales**	30. Pterostemonaceae, 31. Cunoniaceae, 32. Philadelphaceae, 33. Hydrangeaceae, 34. Crossulariaceae, 35. Oliniaceae, 36. Greyiaceae, 37. Escalloniaceae, 38. Baueraceae, 39. Crypteroniaceae.
9.	**Styracales**	40. Lissocarpaceae, 41. Styracaceae, 42. Symplocaceae.
10.	**Araliales**	43. Cornaceae, 44. Alangiaceae, 45. Garryaceae, 46. Nyssaceae, 47. Araliaceae, 48. Caprifoliaceae
11.	**Hamamelidales**	49. Tetracentraceae, 50. Hamamelidaceae, 51. Myrothamnaceae, 52. Platanaceae, 53. Stachyuraceae, 54. Buxaceae, 55. Daphniphyllaceae,

	56. Bruniaceae.
12. Salicales	57. Salicaceae.
13. Leitneriales	58. Leitneriaceae.
14. Myricales	59. Myricaceae.
15. Balanopsidales	60. Balanophoraceae.
16. Fagales	61. Betulaceae, 62. Fagaceae, 63. Corylaceae.
17. Juglandales	64. Rhoipteleaceae, 65. Juglandaceae, 66. Picrodendraceae.
18. Casuarinales	67. Casuarinaceae.
19. Urticales	68. Ulmaceae, 69. Cannabinaceae, 70. Moraceae, 71. Urticaceae, 72. Barbeyaceae, 73. Eucommiaceae.
20. Bixales	74. Bixaceae, 75. Cistaceae, 76. Flacourtiaceae, 77. Cochlospermaceae, 78. Hoplestigmataceae, 79. Achatocarpaceae, 80. Lacistemaceae.
21. Thymeleales	81. Gonystylaceae, 82. Aquilariaceae, 83. Geissolomataceae, 84. Penaeaceae, 85. Thymeleaceae, 86. Nyctignaceae.
22. Proteales	87. Proteaceae.
23. Pittosporales	88. Pittosporaceae, 89. Byblidaceae, 90. Stegnospermaceae, 91. Vivianiaceae, 92. Tremandeaceae.
24. Capparidales	93. Capparaceae, 94. Moringaceae, 95. Tovariaceae
25. Tamaricales	96. Frankeniaceae, 97. Tamaricaceae, 98. Fouquieriaceae.
26. Violales	99. Violaceae
27. Poligalales	100. Polygalaceae, 101. Krameriaceae, 102. Trigoniaceae, 103. Vochysiaceae.
28. Loasales	104. Turneraceae, 105. Loasaceae,
29. Passiflorales	106. Malesherbiaceae, 107. Passifloraceae, 108. Archariaceae.
30. Cucurbitales	109. Cucurbitaceae ,110. Begoniaceae, 111. Datiscaceae, 112. Caricaceae.
31. Cactales	113. Cactaceae.

32. Tiliales	114. Dirachmaceae, 115. Scytopetalaceae, 116. Tiliaceae 117. Sterculiaceae, 118. Peridiscaceae, 119. Bombacaceae.
33. Malvales	120. Malvaceae.
34. Malpighiales	121. Ixonomthaceae, 122. Malpighiaceae. 123. Humiriaceae, 124. Linaceae, 125. Irvingiaceae, 126. Huaceae, 127. Ledocarpaceae, 128. Erythroxylaceae, 129. Ctenolophonaceae, 130. Lepidobotryaceae, 131. Blanitaceae, 132. Zygophyllaceae.
35. Euphorbiales	133. Euphorbiaceae.
36. Theales	134. Bonnetiaceae,135. Theaceae, 136. Sauraniaceae, 137. Actinidiaceae, 138. Pellicieraceae, 139. Pentaphyllaceae, 140. Tetrameristaceae, 141. Marcgraviaceae, 142. Caryocaraceae, 143. Medusagynaceae.
37. Ochnales	144. Straburgeriaceae, 145. Ochnaceae, 146. Rhodolaenceae, 147. Sphaerosepalaceae, 148. Dipterocarpaceae, 149. Ancistrocladaceae.
38. Ericales	150. Clethraceae, 151. Pyrolaceae, 152. Ericaceae, 153. Epacridaceae, 154. Diapensiaceae, 155. Monotropaceae, 156. Lennoaceae, 157. Vacciniaceae.
39. Guttiferales	158. Hypericaceae, 159. Clusiaceae, 160. Eucryphiaceae, 161. Quiinaceae.
40. Myrtales	162. Myrtaceae, 163. Lecythidaceae, 164. Rhizophoraceae, 165. Sonneratiaceae, 166. Punicaceae, 167. Combretaceae, 168. Melastomataceae.
41. Celastrales	169. Pandanaceae, 170. Aquifoliaceae, 171. Salvadoraceae, 172. Koeberliniaceae, 173. Cneoraceae, 174. Cardiopteridaceae, 175. Cyrillaceae, 176. Icacinaceae,

	177. Empetraceae, 178. Aextoxicaceae, 179. Pentadiplandraceae, 180. Celastraceae, 181. Corynocarpaceae, 182. Stackhousiaceae, 183. Goupiaceae, 184. Hippocaseaceae, 185. Erythropalaceae, 186. Capusiaceae, 187. Scyphostegiaceae.
42. Olacales	188. Olacaceae, 189. Opiliaceae, 190. Octoknemaceae, 191. Aptandraceae, 192. Dipentodontaceae, 193. Medusandraceae.
43. Santalales	194. Loranthaceae, 195, Grubiaceae, 196. Santalaceae, 197. Myzodendraceae, 198. Balanophoraceae.
44. Rhamnales	199. Heteropyxidaceae, 200. Elaeagnaceae, 201. Rhamnaceae, 202. Vitaceae.
45. Myrsinales	203. Myrsinaceae, 204. Theophrastaceae, 205. Aegicerataceae.
46. Ebenales	206. Ebaenaceae, 207. Sapotaceae, 208. Sarcospermataceae.
47. Rutales	209. Rutaceae, 210. Simaroubaceae, 211. Burseraceae, 212. Averrhoaceae.
48. Meliales	213. Meliaceae.
49. Sapindales	214. Melianthaceae, 215. Sapindaceae, 216. Podoaceae, 217. Sabiaceae, 218. Anacardiaceae, 219. Aceraceae, 220. Hippocastanaceae, 221. Staphyleaceae, 222. Akaniaceae, 223. Julianiaceae, 224. Didiereaceae.
50. Loganiales	225. Potaliaceae, 226. Loganiaceae, 227. Buddlejaceae, 228. Antoniaceae, 229. Spigeliaceae, 230. Strychnaceae, 231. Oleaceae.
51. Apocynales	232. Plocospermataceae, 233. Apocynaceae, 234. Periplocaceae, 235. Asclepiadaceae,
52. Rubiales	236. Dialypetalanthaceae, 237. Rubiaceae,
53. Bignoniales	238. Cobaeaceae, 239. Bignoniaceae, 240. Pedaliaceae, 241. Martyniaceae.
54. Verbenales	242. Ehretiaceae, 243. Verbenaceae, 244. Stilbaceae, 245. Chloanthaceae, 246. Phrymataceae.
Division II	**Herbaceae**
55. Ranales	247. Paeoniaceae, 248. Helleboraceae, 249.

	Ranunculaceae, 250. Nymphaeaceae, 251. Podophyllaceae, 252. Ceratophyllaceae, 253. Cabombaceae.
56. Berberidales	254. Sargentodoxaceae, 255. Lardizabaiaceae, 256. Menispermaceae, 257. Nandinaceae, 258. Cicaeasteraceae, 259. Berberidaceae
57. Aristolochiales	260. Aristolochiaceae, 261. Hydnoraceae, 262. Rafflesiaceae, 263. Nepenthaceae.
58. Piperales	264. Piperaceae, 265. Saururaceae, 266. Choranthaceae
59. Rhoeadales	267. Papaveraceae, 268. Fumariaceae.
60. Brassicales	269. Brassicaceae.
61. Resedales	270. Resedaceae
62. Caryophyllales	271. Elatinaceae, 272. Molluginaceae, 273. Caryophyllaceae, 274. Ficcidaceae, 275. Portulacaceae
63. Polygonales	276. Polygonaceae, 277. Illecebraceae
64. Chenopodiales	278. Barbeniaceae, 279. Phytolaccaceae, 280. Gyrostemonaceae, 281. Agdestidaceae, 282. Petiveriaceae, 283. Chenopodiaceae, 284. Amaranthaceae, 285. Theligonaceae, 286. Batidaceae, 287. Basellaceae.
65. Lythrales	288. Lythraceae, 289. Onagraceae, 290. Trapaceae, (Onagrales) 291. Halorrhagidaceae, 292. Callitrichaceae.
66. Gentianales	293. Gentianaceae, 294. Menyanthaceae.
67. Primulales	295. Primulaceae, 296. Plumbaginaceae.
68. Plantaginales	297. Plantaginaceae
69. Saxifragales	298. Crassulaceae, 299. Cephalotaceae, 300. Saxifragaceae, 301. Eremosynaceae, 302. Vahliaceae, 303. Francoaceae, 304. Donatiaceae, 305. Parnassiaceae, 306. Adoxaceae.
70. Sarraceniales	307. Droseraceae, 308. Sarraceniaceae
71. Podostemales	309. Podostemaceae, 310. Hydrostachyaceae
72. Umbellales	311. Apiaceae (Umbelliferae)
73. Valerianales	312. Valerianaceae, 313. Dipsacaceae, 314. Calyceraceae.

74.	**Campanulales**	315. Campanulaceae, 316. Lobeliaceae
75.	**Goodeniales**	317.Goodeniaceae, 318. Brunoniaceae, 319. Stylidiaceae.
76.	**Asterales**	320. Asteraceae (Compositae)
77.	**Solanales**	321. Solanaceae, 322. Convolvulaceae, 323. Nolanaceae.
78.	**Personales**	324. Scrophulariaceae, 325. Acanthaceae. 326. Gesneriaceae, 327. Orobanchaceae, 328. Lentibulariaceae, 329. Columelliaceae.
79.	**Geraniales**	330. Geraniaceae, 331. Limnenthaceae, 332. Oxalidaceae, 333. Tropaeolaceae, 334. Balsaminaceae.
80.	**Polemoniales**	335. Polemoniaceae, 336. Hydrophyllaceae, 337. Cuscutaceae.
81.	**Boraginales**	338. Boraginaceae.
82.	**Lamiales**	339. Myoporaceae, 340. Selaginaceae, 341. Globulariaceae, 342. Lamiaceae (Labiatae).
	Sub-phylum:	**Monocotyledones**
	Division 1:	**Calyciferae**
83.	**Butomales**	343. Butomaceae, 344. Hydrocharitaceae,
84.	**Alismatales**	345. Alismataceae, 346. Scheuchzeriaceae, 347. Petroniaceae.
85.	**Triuridales**	348. Triuridaceae
86.	**Jucaginales**	349. Jucaginaceae, 350. Liliaceae, 351. Posidoniaceae.
87.	**Aponogetonales**	352. Aponogetonaceae, 353. Zosteraceae.
88.	**Potamogetonales**	354. Potamogetonaceae, 355. Ruppiaceae.
89.	**Najadales**	356. Zannichelliaceae, 357. Najadaceae.
90.	**Commelinales**	358. Commelinaceae, 359. Cartonemataceae, 360. Flagellariaceae, 361. Mayacaceae.
91.	**Xyridales**	362. Xyridaceae, 363. Rapateaceae.
92.	**Eriocaulales**	364. Eriocaulaceae.
93.	**Bromeliales**	365. Bromeliaceae.
94.	**Zingiberales**	366. Musaceae, 367. Strelitziaceae, 368. Lowiaceae, 369. Zingiberaceae, 370. Cannaceae, 371. Marantaceae.

Division-2-	**Corolliferae**
95. Liliales	372. Liliaceae, 373. Tecophilaeaceae, 374. Trilliaceae, 375. Potenderiaceae, 376. Smilacaceae, 377. Ruscaceae.
96. Alstroemeriales	378. Alstroemeriaceae, 379. Petermanniaceae, 380. Phileriaceae.
97. Arales	381. Araceae, 382. Lemnaceae.
98. Typhales	383. Sparganiaceae, 384. Typhaceae.
99. Amaryllidales	385. Amaryllidaceae.
100. Tridales	386. lridaceae.
101. Dioscoreales	387. Stenomeridaceae, 388. Trichopodaceae, 389. Roxburghiaceae, 390. Dioscoreaceae.
102. Agavales	391.Xanthorrhoeaceae,392.Agavaceae.
103. Palmales	393. Palmae (Arecaceae)
104. Pandanales	394. Pandanaceae.
105. Cyclanthales	395. Cyclanthaceae.
106. Haemodorales	396. Haemodoraceae, 397. Hypoxidaceae, 398. Velloziaceae, 399. Apostasiaceae, 400. Taccaceae, 401. Philydraceae.
107. Burmanniales	402. Burmanniaceae, 403. Thismiaceae, 404. Corsiaceae.
108. Orchidales	405.Orchidaceae
Divison 3:	**Glumiflorae**
109. Juncales	406. Juncaceae, 407. Thurniaceae, 408. Centrolepidaceae, 409. Retionaceae.
110. Cyperales	410. Cyperaceae.
111. Graminales	411. Gramineae (Poaceae)

Merits of Hutchinson's System

1. It is a phylogenetic system purely based on principles of phylogeny.
2. This system provided a base for the phylogenetic system of Oswald Tippo, Cronquist, Takhtajan and Dahlgren etc.

3. The system considers Ranales as primitive Herbaceous dicots while Magnoliales as primitive Lignoceous dicots.
4. Families and orders are very small and comprises of only very much related taxa.
5. The arrangement of families in Monocots is widely accepted.
6. Monocots are considered to be more advanced than Dicots.

Demerits of Hutchinson's System

1. Dicots were divided on the basis of habit into two major groups, *i.e.,* Lignosae and Herbaceae. Lignosae includes woody plants. This was not accepted by many as otherwise closely related plants were kept far apart and the two evolutionary lines cannot be considered distinct.
2. The two related families on the basis of floral structure were separated, *e.g.,* closely related families of Ranales as Ranunculaceae and Magnoliaceae were kept far away.
3. Several herbaceous families which are closely related or even derived from woody families, e.g., Apiaceae (Herbaceous) is considered to be derived from Cornaceae and Araliaceae (woody) or Brassicaceae (Herbaceous) is derived from woody Capparidaceae via Cleomaceae.
4. This system is not very practical for plant classification.

Phylum Angiosperms

Subphylum Dicotyledones

Div I Lignosae (54 orders)

Magnoliales (9)
Annonales (2)
Laurales (7)
Dilleniales (4)
Coriariales (1)
Rosales (3)
Leguminales (3)
Cunoniales (10)
Syracales (3)
Araliales (6)
Hamamelidales (8)
Salicales (1)
Leitneriales (1)
Myricales (1)
Balanopsidales (1)
Fagales (3)
Juglandales (3)
Casuarinales (1)
Urticales (6)
Bixales (7)
Thymeleales (6)
Proteales (1)
Pittosporales (5)
Capparales (3)
Tamaricales (3)
Violales (1)
Polygalales (4)
Loasales (2)
Passiflorales (3)
Cucurbitales (4)
Cactales (1)
Tiliales (6)
Malvales (1)
Malpighiales (12)
Euphorbiales (1)
Theales (10)
Ochnales (6)
Ericales (8)
Guttiferales (4)
Myrtales (7)
Celastrales (10)
Olacales (6)
Santalales (5)
Rhamnales (4)
Myrsinales (3)
Ebenales (3)
Rutales (4)
Meliales (1)
Sapindales (11)
Loganiales (7)
Apocynales (4)
Rubiales (2)
Bignoniales (2)
Verbenales (5)

Div II Herbaceac (28 orders)

Ranales (7)
Berberidales (6)
Arstolochiales (4)
Piperales (3)
Rhoeadales (2)
Brassicales (1)
Resedales (1)
Caryophyllales (5)
Polygonales (2)
Chenopodiales (10
Onagrales (5)
Gentianales (2)
Primulales (2)
Plantaginales (1)
Saxifragales (9)
Sarraceniales (2)
Podostemales (2)
Umbellales (1)
Valerianales (3)
Campanales (2)
Goodeniales (3)
Asterales (1)
Solanales (3)
Personales (6)
Geraniales (5)
Polemoniales (3)
Boraginales (1)
Lamiales (4)

Total orders 110
Total families 411

Subphylum Monocotyledones

Div I Calyciferae (12 orders)

Butomales (2)
Alismatales (3)
Triuridales (1)
Juncaginales (3)
Aponogetonales (2)
Potamogetonales (2)
Najadales (2)
Commelinales (4)
Xyridales (2)
Eriocaulales (1)
Bromeliales (1)
Zingiberales (6)

Div II Corolliferae (14 Orders)

Liliales (6)
Alstroemeriales (3)
Arales (2)
Typhales (2)
Amaryllidales (1)
Iridales (1)
Dioscoreales (4)
Agavales (2)
Palmales (1)
Pandanales (1)
Cyclanthales (1)
Haemodorales (6)
Burmanniales (3)

Div III Glumiflorae (3 orders)

Juncales (4)
Cyperales (1)
Graminales (1)

1.9 SUMMARY

In this unit plant classifications were discussed. Plant taxonomy is one of the earliest disciplines of Botany. Simpson (1961) suggested that systematics includes identification, taxonomy, classification and nomenclature. Classification denotes the arrangement of single plant or group of plants in distinct category following a system of nomenclature and in accordance with a particular and well established plan. The basic unit of classification is species. The various classifications of plants proposed so far, belong to either artificial, natural and phylogenetic systems. Initially classification of plants was based on own principles. In this unit fundamental components of taxonomy, aims of taxonomy and deme terminology are also discussed. Natural system proposed by Bentham and Hooker in *Genera Plantarums* (1862-1883) which is based on free and fused petals was discussed in details. Advantages and disadvantages of Bentham & Hooker's classification have also been provided. Engler and Prantl published their plant classification in *Dienaturlichen Pflanzen Familien* in 1909. In this classification monocots precede dicots. Hutchinson proposed plant classification based in phylogeny in *Families of Flowering Plants* plants. 24 basic principles were also discussed proposed by Hutchinson with 411 families.

1.10 GLOSSARY

Classification: arrangement of a single plant or group of plants in distinct category following a system of nomenclature with a particular and in accordance and well established plan.
Taxonomy: includes identification, taxonomy, classification and nomenclature.
Artificial: system with the help of few characters with a intention of easy identification.
Nature: system based on form relationships.
Phylogenetic: System based on genetic relationship and evolution.
Alpha taxonomy: taxonomy of description and designation of species.
Beta taxonomy: arrangement of species in hierarchical manner.
Gamma taxonomy: taxonomy with intraspecific population and with phylogenetic trends.
Omega taxonomy: perfect system based on available characters.
Aims of taxonomy: Identification, nomenclature and classification
Polypetalae: free petals
Gamopetalae: fused petals

1.11 SELF ASSESSMENT QUESTIONS

1.11.1 Fill in the blanks:

(i) Natural system of classification was proposed by.....

(ii) Phylogenetic classification was proposed by.....

(iii) "*Genera Plantarum*" was written by.....

(iv) The term taxonomy was coined by.....

(v) Who is known as father of botany.....

(vi) The first herbarium was established in 1553 at ……..

(vii) The aspect of taxonomy is concerned with the disciplined designation of species is called ……..

(viii) "*Die Naturlichen Pflanzen Familien*" was written by ……

(ix) Hutchison recognized …… families.

(x) Hutchinson published his classification in ……..

1.11.1 Answers Key:

(i) Bentham & Hooker, (ii) Hutchinson, (iii) Bentham & Hooker, (iv) de Candolle, (v) Theophrastus, (vi) Panua (Italy), (vii) Alpha taxonomy, (viii) Engler and Prantl, (ix) 411, (x) The families of flowering plants.

1.12 REFERENCES

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1.13 SUGGESTED READINGS

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- Angisoperms by B. P. Pande, S. Chand & Co., Delhi.
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1.14 TERMINAL QUESTIONS

1.14.1 - Long answer questions:

1- Describe classification proposed by Bentham and Hooker.

2-Describe classification proposed by Engler and Prantl.

3-Discuss the history of classification.

4- Describe Hutchison's classification with its principles.

5- Describe different types of classification.

UNIT-2 BASIC PRINCIPLES, PLANT NOMENCLATURE AND ICBN

Contents

2.1 OBJECTIVES

After reading this unit students will be able to understand-

- Definition of names
- ICBN (Different Codes)
- Principles of ICBN
- Phylocode
- Rules

2.2 INTRODUCTION

Name is the means of reference to all living and non-living things. Any object known to human being is given a name to describe and communicate ideas about it. The name may be different in different languages and at different places. The art of naming the object is known as nomenclature and when it comes to naming of plants it is called botanical nomenclature.

The process of naming plants based on international rules proposed by botanists to ensure a stable and universal uniform system is called botanical nomenclature.

Common Names

Common name is the name of the plant in a particular area or locality given by the people of that particular area. Such names vary from place to place and language to language. In India the name changes with the dialect.

Scientific Name

Scientists suggested name in such a way that it is accepted in the world and is used internationally. But again, the problem remains the same, *i.e.,* the language which is not universal. So the botanists agreed to lay down certain rules and conditions. The main suggestion was that the language of the name should be in Latin. Botanical Latin is an international language used by botanists the world over for naming and describing plants. It originates from the Latin of the Roman plant writers, notably Pliny the Elder (A.D. 23-79). The Swedish botanist Carolus Linnaeus (1707-79) formally established the tradition that all plants should be given Latin names (or names of Latin form) and that works relating to them should also be in Latin. It is because:

1. Latin is a dead language, so the meanings of words do not change in the same way as those for living languages.
2. Botanical, Latin is very descriptive, with many terms for shape, texture and colour.

3. Latin does not inspire the political jealousies that might emerge if botanists were to convert to, say, English or Spanish.

During 1600 to 1850 AD Europe, particularly Greece, had dominated the world of science. The language was Latin but the script was Roman.

2.3 BINOMIAL NOMENCLATURE

Linnaeus for the first time proposed that every living being has a binomial name, *i.e.*, a name with two epithets. One is generic and the other is specific epithet. If an organism has a variety also, then the name becomes trinomial. Linnaeus proposed some rules for generic names of plants in Fundamental Botanica (1736) and Critica Botanica (1737). A.P.de Candolle for the first time proposed rules for nomenclature of plants which were passed by International Botanical Congress at Paris (1867). Swedish Naturalist Carolus Linnaeus who started naming plants in 1753 as Binomial names. It was published in his book "Species Plantarum".

The generic name is always a noun showing colour, name or adjective, *e.g., Sarracenia* named after a scientist Michel Sarracin. Species is always an adjective, *e.g.,* for white flower, it is alba., for edible one it is sativa, black colour-nigrum etc.These names are not used always. Species may be a Pronoun, *e.g., americana, indica, benghalensis,* etc. It may be shape of a leaf (character of plant), *e.g., sagittifolia,* name of other scientist to whom the plant is dedicated, *e.g., Sahnii* etc.

2.4 INTERNATIONAL CODE FOR NOMENCLATURE OF ALGAE, FUNGI AND PLANTS (ICN)

At the middle of 18^{th} century, plant names were generally polynomial consisting of several words in a series. Linnaeus proposed the elementary rules in Philosophia Botanica in 1751. In 1813 A.P.de Candolle proposed details of the rules regarding plant nomenclature in *Theorie elementaire de la botanique*. Alphonse de Candolle son of A.P.de Candolle convened an assembly of botanists of the world to present a new set of rules. Candolle convened the first International Botanical Congress at Paris in 1867. The *International Code for Nomenclature of Algae, Fungi and Plants (ICN)* passed by Melbourne Congress was earlier known as *International code Botanical Nomenclature (ICBN).*

(1) *Paris Code (1867)*

The first International Botanical Congress was held at Paris in August 1861. About 150 American and European Botanists were invited to make laws for Botanical Nomenclature (*Lois de la nomenclature botanique*). The laws were called Paris code, as they were adopted at French capital. According to this code, the starting-point, for all nomenclature was fixed with Linnaeus. The rule of Priority was considered as basic for valid publication, author citation was very

important. Paris code has many inherent defects. After some years the American and British Botanists deviated from the rules and started following a new rule called Kew Rule.

(2) *Rochester Code (1892)*

N.L. Britton headed the Botanical Congress at Rochester, New York, USA in 1892. The Paris code was modified and with new recommendations, it was called as Rochester Code. Some important recommendations were

(i) Strict adherence to Principles of Priority.

(ii) Name and date of publication for interpretation of priority.

(iii) Acceptance of alternate bionomials resulting from employment of the principles of priority even in case of tautonyms.

(iv) Establishment of the type concept to ascertain the correct application of names.

(3) *Vienna Code (1905)*

The third International Botanical Congress was held at Vienna in June 1905. In this congress, it was established that Linnaeus *Species Plantarum* (1753) is the starting point for naming vascular plants. *Nomina generica conservenda* by which generic names having a wide use would be conserved over earlier but less well known names. Tautonyms are banned and the names of new taxa to be accompanied by Latin diagnosis.

(4) *American Code (1907)*

The botanists who proposed Rochester Code were dissatisfied with Vienna Code and refused to accept it in 1907. They modified the Rochester code to American Code. American code does not subscribe to the principle of *Nomina generica conservenda* or the requirement of Latin diagnosis. It accepts type concept. In American Code, a binomial cannot be used again for a plant in any way either has been employed previously for another plant.

(5) *Brussels Code (1912)*

Fourth International Botanical Congress was held at Brussels in 1910. This code accepts different starting points for priority of names of non-vascular plants. It recognizes the type concept and classification of the Vienna rules.

(6) *Cambridge Code (1935)*

The difference between Vienna code and American code was removed at the fifth Botanical Congress held at Cambridge (1930). The provisions suggested in this code are as follows:

(i) Type concept should be pursued.

(ii) A list of Nomina generica conservanda should be provided.

(iii) Tautonyms should be discarded.

(iv) Latin diagnosis of plants is necessary after January 1, 1932.

(7) *Amsterdam Code (1947)*

Sixth International Botanical Congress was held at Amsterdam in 1935. In this a major change in the rules was made, *i.e.*, from January 1, 1935 names of new groups of recent plants, (except Bacteria) are to be considered as validly published only when they have a Latin diagnosis.

(8) *Stockholm Code (1952)*

The 7th International Botanical Congress was held at Stockholm in 1952. For the first time the word 'Taxon' was introduced to designate any taxonomic group or entity.

(9) *Paris Code (1956)*

8th International Botanical Congress was again held in Paris in July 1954. Here, the rule of compulsion of Latin diagnosis was scraped out and it was decided that it should be published in English, French and German languages. Preamble and Principles of the code were separated from the Rules and Recommendations. *Nomina Generica Conservenda* et *rejecienda* was amended and supplemented.

(10) *Montreal Code (1961)*

9th International Botanical Congress held at Montreal in August 1959, where a committee was appointed to study the question of conservation of family names. *Nomina familiarum conservanda* for Angiospermae was introduced. The code also assersted that the naming of fossil plants should also follow the same lines as those of recent ones.

(11) *Edinburgh Code (1966)*

In the 10th Botanical Congress held at Edinburgh in August 1964, the report of committee was presented. According to it, for family names the starting point should be A.L.de Jussieu's *Genera Plantarum* (1789). Some of the spellings of a few families were changed, (e.g., Capparaceae for Capparidaceae and Cannabaceae for Cannabinaceae) in the list of *Nomina familiarum Conservenda.* A new committee was formed to work upon the preparation of Glossary of technical terms which was called An Annotated Glossary of Botanical Nomenclature.

(12) *Seattle Code (1972)*

11th International Botanical Congress met at Seattle in August 1969. The code was published in 1972 by F.A. Stafleu. Seattle Code includes the tautonymous designations of taxa between genus and species and below it. Code introduced a new word Autonym, *i.e.*, automatically established names.

(13) *Leningrad Code (1978)*

12th International Botanical Congress was held at Leningrad in July 1975. The out-comes were published in 1978. It included minor changes, *e.g.*, concept of organ genera was eliminated for fossil plants. The code does not apply for bacteria. Principle of automatic typification was extended to the names of taxa above family rank, etc.

(14) *Sydney Code (1983)*

13th Botanical Congress was held at Sydney in August 1981 and the outcomes were published in 1983.

(15) *Berlin Code (1988)*

14th International Botanical Congress was held at Berlin in 1986 and the outcomes were published in 1988. *Nomina Specifica Conservenda* was introduced in the congress. Articles 66 and 67 were removed. In this two species names *Triticum aestivum* Linn, and *Lycopersicon esculentum* P .Miller were conserved against the rules of priority as these names were used widely and it was thought that if the names were changed confusion might arise.

(16) *Tokyo Code (1994)*

15th International Botanical Congress held at Yokohama in Japan in 1993. The code was translated into Chinese, French, German, Italian, Japanese, Russian and Slovak.

(17) *St. Louis Code (1999)*

16th International Botanical Congress was held at St Louis, Missouri in 1999. This code is also available in many languages. The code is divided into Rules, Articles and Recommendations. Rules are set up to put the nomenclature of the past into order and to provide space for the future.

(18) *Vienna Code (2005)*

17th International Botanical Congress was held in Vienna, Austria, July 2005. The *Vienna Code* does not differ substantially in overall presentation and arrangement from the *St Louis Code*, and the numbering of Articles remains the same, although there have been a few additions to, and modifications of, paragraphs, Recommendations, and Examples, often involving changes in their numbering.

(19) *Melbourne Code (2011)*

The XVIII International Botanical Congress held in Melbourne, Australia in July 2011 made a number of very significant changes in the rules governing what has long been termed botanical nomenclature, although always covering algae and fungi as well as green plants. This edition of

the *Code* embodies these decisions; the first of which that must be noted is the change in its title. This edition of the code changed the title of the code as ***International code for Nomenclature for algae, fungi and plants***

Recommendations deals with subsidiary points. According to it in future the names not following the recommended ones are rejected. Rules and Recommendations apply for all living and fossil organisms and fungi but do not include Bacteria. For Bacteria International Code of Nomenclature of Bacteria (ICNB) was proposed separately.

Presently, the rules and recommendations of Vienna code which were proposed by J. McNeill et al in 2005 are in practice.

The present International Code of Botanical Nomenclature (Lanjouw, 1956) is the result of many years of trial and error. 1956 edition of the code gives detailed instructions on the steps to be taken when any change appears necessary. It is interesting to note that during the last three or four International Botanical Congresses there have been, but few changes, except perhaps in the rearrangement of the code and in some less important points of nomenclature. The ICBN is based on Linne's own 'Philosophia Botanica', when he lays down the main points of nomenclature in the form of aphorisms (principles). The code is divided into three clear parts, principles, rules and recommendations. In addition there are a few interesting appendices. The principles are basic points on which the code is based. They do not give detailed rules about nomenclature, but show the main ideas that have guided the compilers of the code, and should be kept in view by any botanist attempting to publish a new taxon.

2.5 PRINCIPLES

There are six principles-

I. Botanical nomenclature is independent of zoological nomenclature. The code applies equally to names of taxonomic groups treated as plants whether or not these groups were originally so treated (Plants do not include Bacteria).

II. Application of names of taxonomic groups is determined by means of nomenclature types.

III. The nomenclature of a taxonomic group is based upon priority of publication.

IV. Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the rules, except in specific cases.

V. Scientific names of taxonomic groups are treated as Latin regardless of their derivation.

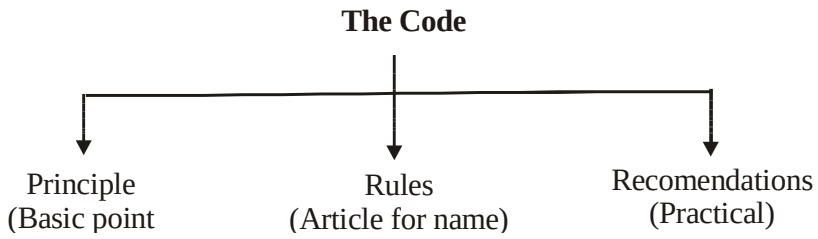
VI. The rules of nomenclature are retroactive unless expressly limited.

According to the code, every taxon or group of plants can bear only one correct name and vice versa a name can be applied to one group of plants. The rules or articles give detailed

prescriptions on all the points connected with the naming of the plants. The recommendations are practical application of the rules.

2.6 FOCAL POINTS OF ICN (2011)

1. Plants require a precise and simple system of nomenclature used by Botanists in all countries, dealing, on the one hand, with the terms which denote the ranks of taxonomic groups or units, and on the other hand with the scientific names which are applied to the individual taxonomic groups of plants. The purpose of giving a name to a taxonomic group is not to indicate its character or history, but to supply a means of referring it and to indicate its taxonomic rank. The code aims at the provision of a stable method of naming taxonomic groups, avoiding and rejecting the use of names which may cause error or ambiguity or throw science into confusion. It avoids the useless creation of names.
2. The Principles form the basis of the system of Botanical Nomenclature.
3. The detailed provisions are divided into Rules and Recommendations. Examples are added to the rules and the recommendations to illustrate them.
4. The object of the Rules is to put the nomenclature of the past into order and to provide for the future; names contrary to a rule cannot be maintained.
5. The Recommendations deal with subsidiary points, their object being to bring about greater uniformity and clearness, especially in future nomenclature, names contrary to a recommendation cannot, on that account, be rejected, but they are not examples to be followed.
6. The provisions regulate the modification of this code from its last decisions.
7. The Rules and Recommendations apply to all organisms treated as plants (except Bacteria), whether fossil or non-fossil. Special provisions are needed for certain groups of plants. The International Code of Nomenclature of cultivated plants (1980) was adopted by the International Commission for the Nomenclature of Cultivated Plants.
8. The only proper reasons for changing a name are either a more profound knowledge of the facts resulting from adequate taxonomic study or the necessity of giving up nomenclature that is contrary to the rules.
9. In the absence of a relevant rule or where the consequences of rules are doubtful, established custom is followed.
10. This edition of the code supersedes all previous editions.



Some Important Rules and Recommendations

1. All those plants which belong to one genus must be designated by the source generic name (Rule 213)
2. All those plants which belong to different genera must be designated by different generic names (Rule 214)
3. He who establishes a new genus should give it a name (Rule 218)
4. Those generic names are best which show essential characters of plants or its appearance (Rule 240)
5. Generic names one and a half foot long or difficult to pronounce or unpleasant are to be avoided (Rule 249)
6. The specific name must distinguish a plant from all its relatives (Rule 257)
7. Size does not distinguish species (Rule 260)
8. The original place of plant does not give specific difference (Rule 264)
9. A generic name must be applied to each species (Rule 284)
10. The specific name should always follow the generic name (Rule 285)

2.7 PHYLOCODE

The Linnaean system of binomial nomenclature is now becoming unsuitable to govern the naming of clades and species. Clade is a group in which every member shares a common ancestor (a unique common ancestor). A clade is a group for which all the descendants of the last common ancestor of the members of the group are included in the group.

In the pre-existing code the name of a species changes whenever a species is referred to a different genus as a result of phylogenetic or phenetic consideration. In this the supraspecific names are associated with clade as they are operationally defined in terms of ranks and types.

The phylocode (Phylogenetic code) of botanical nomenclature is proposed to promote clear communication and efficient storage and retrieval of biological information. The code was cited on 1st January 2000. Presently phylocode governs only clade names.

Phylogenetic nomenclature was established after meeting of the American Institute of Biological Sciences in San Diego, California, USA (1995). This was organized by Richard G. Olmstead and was entitled as "Translating Phylogenetic Analysis into Classification", Second Symposium was organized by J. Mark Porter (1996) at Ranchosanta Ana Botanic Garden in Claremont, California USA entitled as "The Linnean Hierarchy: Past, Present and Future". Third symposium was organized at XVI International Botanical Congress in 1999 at St. Louis, Missouri USA. It was entitled as "Overview and Practical."

Implications of phylogenetic Nomenclature

The initial draft of Article 21 was written by F. Pleijel, A. Minelli and K. Kron which was modified by M. Donoghue and P. Cartino. The initial drafts of Recommendations 10 D and 11.8 B were written largely by I. Eriksson and the Latin terms in Article 9.3 were provided by W. M. Owens.

Properties of Phylocode

The following are the properties of Phylogenetic system:

1. The system is rankless as assignment of rank is not a part of naming process.
2. Rules are framed for naming of clades.
3. The categories 'species' and 'clade' are not ranks. A species is a segment of a population lineage, and clade is a monophyletic group of species.
4. In Phylocode a supraspecific name is given a phylogenetic definition and is applied to the clade which fits that definition, irrespective of its hypothesized composition. Species specimens and synapomorphies cited within these definitions are called specifiers as they specify the clade to which the name applies and function somewhat like types.
5. Application of names is restricted with respect to clade composition.
6. Basic difference is there in the rules governing the super specific names. According to phylocode and earlier traditional systems there is the operational difference in the determination of synonymy and homonymy.

Pre-existing system suggests that synonyms are names of the same rank based on types within the group of concern, regardless of prior association with particular clades. According to phycogenetic system, synonyms are names whose phylogenetic definitions specify the same clade; regardless of prior association with particular ranks.

Advantages of Phylogenetic Nomenclature (Phylocode)

1. Phylocode allows naming the intermediate ranks such as super family etc.
2. It improves nomenclatural stability. The phylogenetic position can easily be indicated by associating the species name with the names of one or more clades to which it belongs.

3. The abandonment of ranks in Phylocode also eliminates the error caused by many taxonomists who treat taxa at the same rank.

Hierarchy of Classification

Kingdom - Division - Class - Subclass - Order - Suborder - Family - Subfamily - Genus - Subgenus - Section - Species - Categories - Subspecies (ssp) - Varieties (var.) - Sub varieties (sub var.) - Forma (f.) - Clone (cl.)

2.8 THE RULES

2.8.1 Rank of Taxa

Every individual plant when placed in classification, the species is the basic unit of classification. Each species belongs to a series of taxa of consecutively higher rank. In Article 3 "the principal ranks of taxa in ascending sequence are species, genus, family, order, class, division and kingdom. This code defines the categories only by listing their sequence. This may not be true for small order, family, or genus but the sequence must not be changed

Categories such as family (ending with- aceae, Polygonaceae) suborder (ending with ineae, Chenopodineae), order (ending with- ales, Malvales) and so on may be used. In other words, the code provides standardized grammatical endings for the categories from division down to subtribe. The name of taxonomic group which do not follow these ending should be changed. Following this procedure the name of family ending with- aceae, the alternative names of the families which do not confirm the endings are changed as.

Graminae into Poaceae

Palmae- Arecaceae

Cruciferae- Brassicaceae

Leguminosae- Fabaceae

Umbelliferae- Apiaceae

Labiatae- Lamiaceae

Compositae- Asteraceae

The ending with- aceae are used basing on its generic names e.g. Poa, Poaceae, Aster, Asteraceae etc.

oideae- subfamily, -eae tribe and -inae subtribe.

A unique exception to article 52 of the code is the name Leguminosae is sanctioned only as long as it includes all three subfamilies Papilionoideae, Caesalpinoideae and Mimosoideae. If the subfamilies are upgraded to family status the Papilionaceae shall be called Fabaceae.

Types of Taxon

Names of different taxonomic groups are based on the type method. The principles and articles of the ICBN provide that all taxonomic groups will be based on nomenclatural types, meaning thereby that all names are permanently attached with some taxon or specimen designated as type. For species (and intraspecific taxa) the type is a specimen or in some circumstances only an illustration. The name of the first author should be attached. Names of the taxa above the level of species, *i.e,* Section, Subgenus, genus, tribe, and family etc., are based on the name of immediately next lower taxon on which the group was originally based, *e.g.,* Lamiaceae was based on genus *Lamium.* Orchidaceae was based on genus *Orchis* etc. When a new species is described, the author of new species has one or more specimen having characters which are distinctive enough to be segregated into new species.

A type is that constituent element of a taxon to which the name of the taxon is permanently attached. According to Principle II "the application of name of taxonomic groups is determined by means of nomenclatural types". This means that when a species is described as new the author must indicate type of specimen on which the new species is based. In the case of species or infra-specific names, the type is an individual specimen, which is the type specimen on which the new species is based. Small herbaceous plants all mounted on one herbarium sheet, the whole sheet may be marked as the type. When a specimen cannot be preserved, an illustration or figure or a description may be a type. The type of a genus is a species that of a family is a genus.

(a) **Holotype:** Single specimen, may be whole plant or a part of it with which the name of taxon is permanently attached, is known as holotype.

(b) **Isotype or Cotype:** An isotype is a biological specimen duplicate of the holotype collected in the same place and at the same time (in the type locality).

(c) **Paratype:** A paratype is any of one or more biological specimen other than the holotype listed as representative and used for the development of the original description of a species or subspecies.

(d) **Syntype:** The specimen which is the basis of new taxon when no holotype is designated by author is known as syntype. If author studies collection from different localities and by different collectors and decides to establish a new species, labels all of them as types, all these specimen become syntypes.

(e) **Lectotype:** It is type chosen to serve as Holotype, when either an earlier designated holotype was lost or destroyed or holotype was never designated and from the isotype, paratype or syntype a specimen is chosen by a specialist to serve as the type.

(f) **Neotype:** If holotpe, isotype, paratype or syntype are lost or not available a Neotype is selected from other specimens, to serve as Type. Some taxonomists call it Standard Specimen.

(g) **Topotype:** When no original type material is available and a specimen is collected from type locality is chosen to serve as type it is called Topytype.

It is also felt that a species might be undergoing some natural adaptation and variations in course of time and also in space. Type has served in valuable purpose in correct identification of specimens. It is also agreed that a preserved specimen is always a better representation of any taxonomic group than a description or illustration.

2.8.2 Principle of Priority

Principle of Priority is concerned with the selection of a single correct name of taxonomic group. Only legitimate names should be retained while the illegitimate names should be rejected. According to article 11-12 rules for priority are:

(i) Each family or taxon of lower rank with a particular circumscription, position and rank can bear only one correct name (Art 11).

(ii) For any taxon from family to genus, the correct name is the earliest legitimate one, validly published with the same rank (Art -11).

(iii) A name of a taxon has no status under this code unless it is validly published (Art-12).

(iv) The application of both conserved and rejected names is determined by nomenclatural type (Art-14).

(v) "When a name proposed for conservation has been provisionally approved by the general committee, botanists are authorized to retain it pending the decision of a later international Botanical Congress".

Valid Publication of names is usually considered beginning in May 1753, the date of publication of *Species **P**lantarum* vol. I by Linnaeus.

With many names of a taxon, the valid will be the earliest name which is regarded as correct name. Rule of Priority provides stability to this name.

The principle that seniority is fixed by the date of valid publication is known as Principle of Priority.

Example 1.

Nymphea nouchali Burro f. 1768; *N. pubescence Willd* 1799 and *N. torus* Hook. f. et. T., 1872 are names of the same species but if rule of Priority is applied the first name is the correct name and other two are synonyms.

Example 2.

Loureiro described a plant and named it *Physkium nataus* in 1790. A.L.de Jussieu transfered it in genus *Vallisneria* in 1828. He instead of *natans* gave the specific name as *V.physkium.* It is superfluous name. Graebner (1912)-described the same plant as *V.gigantee* and Miki (1934) named it as *V.asiatica.* Harg while studying Asiatic species confirned that all these names are synonymous. There is no legitimate combination based on *Physikium natans* (Leru) existed. He made *V. natans* Hara in 1974. The correct name of the specimen is now the recent name, but it is based on earliast basionym, others will be synonyms. *V. gigantea* and *V. asiatica* will be known as nomenclatural synonyms or homotypic synonyms. *V. gigantea* and *V. asiatica* are the names based on separate types. Such synonyms are known as taxonomic synonyms or heterotypic synonyms.

With a few exceptions, where alternative names are permitted, each taxon of plants can bear only one correct name, "the correct name is the earliest legitimate one validly published except in cases of limitation of priority by conservation.

There are however many exceptions, as in the case of Musci, Fungi and Algae. For Algae the dates of publication only begin rather late in time e.g. for the Oedogoniaceae the date is 1900 when Hirm published his monographs *Iconographic der Oedogoniaceen*". All groups of fossil plants start from December 31, 1820.

When the specific name repeats unaltered the generic name this is called tautonym e.g. *Malus malus*. This method is accepted in zoological nomenclature when we find such names *Corvus corvus*.

Each taxon with a given circumscription, taxonomic position and rank can bear only one valid name, the earliest that in accordance with the rule of nomenclature. Whoever publishes the name validly and effectively first will be given the credit and all subsequently published names will be rejected.

Suppose a name was published by Linnaeus in 1753 and later two or more authors published the same plant name differently not knowing that it was already published say in 1780 or 1790, according to the rule of priority the name published by Linnaeus in 1753 will be taken as valid and all subsequently published names will be rejected.

2.8.3 Limitations of the Principle of Priority

1. **Starting dates:** Principle of Priority starts with the *Species Plantarum* of Linnaeus published on 1-5-1753.
2. **Limited only up to family ranks:** This principle does not apply over family rank.
3. The correct name should not be outside the rank. Only when a correct name in the taxon is not available, a combination with other rank is allowed.
4. The application of Principle of Priority resulted in numerous name changes. To avoid it a list of conserved generic and family names has been prepared and published in the code with some changes. Such Nomina conservanda *(nom. Cons.)* are to be used as correct

name replacing earlier legitimate names, e.g., *Sesbania scop,* 1777 is the conserved genus as against *Sesban adam* 1763 and *Agati adam* 1763.

2.8.4 Effective and Valid Publication

From the discussion of the principles of priority, it seems that publication is the most important step in nomenclatural procedures. The name is effectively published when the published name should appear in printed from and distributed to the botanical institutions. The name is valid when the name is published in accordance with the provisions of the code.

In section 6 of the code the heading is "conditions and dates of valid publication of names". Here the effective publication means, the names must be published accompanied by a valid and effective publication.

A validly published name is one which has been (1) effectively published (2) accompanied by description of the taxon or by client or by direct or indirect reference to a previously and effectively published description of it. Effectively publication of a name deals with the mechanisms of its distribution, valid publication deals with both distribution of the name and with the preparation of the textual matter prior to distribution e.g. *Phalaris arundinacea* L. sp. Pl. 55, 1755 there is a literature citation, following the italicised name, the binomial name was published by Linnaeus in his "*Species Plantarum*" page 55 in 1753. The name was accompanied by Latin diagnosis. Hence the publication was effective and valid e.g. *Digitaria sanguinalis* (L.) Scop. Fl. Carn. Ed. 21:52, 1772, basionym (synonym) *Panicum sanguinalis* L. Sp. Pl. 47, 1753.

The name *Digitaria sanguinalis* was made by Scopoli which was effectively and validly published by him in his second edition of the *Flora Carniciola* page 52 Vol. 1 in 1772. Description of a taxon which is available to the public with direct or indirect reference to a previously and effectively published description. This means that if anybody wants to check back to the original publication of a name, it will be relatively easy to find the publication in which it appeared. The ICBN does not approve names which have not been published effectively.

A valid publication deals with both distribution of name and with preparation of the textual matter prior to publication. The name of the plant must be accompanied by the description of the plant. A plant though effectively published without description of the plant, is not validly published. Similarly names of plants which have not been validly published have not recognized by ICBN and the names must be ignored.

Art 29 states that publication of hand written description or descriptions printed in a nursery catalogue or seed exchange lists is not considered to be effective publication. Since 1935, all diagnosis of new taxa must be written in Latin nor will it be treated as valid.

Scopoli changed the name from *Panicum sanguinale* to *Digitaria sanguinale* retaining the species name *Sanguinale* originally published by Linnaeus. So as a rule of priority the name

Linnaeus was included in brakets (L.) and new name as proposed by Scopoli is valid as *Digitoria sanguinale* (L.) Scop. Fl. Carn. Ed 2. 1:52, 1772. Scopoli did not accompany his name with diagnosis of the plant but referred to Linnaeus's earlier validly and effectively published description of it. The listing of the name of the plant on which the new name is based is called basionym.

Names of families and lower taxa except in certain hybrids published on or after January 1, 1958 are valid only if the nomenclature types are indicated. The legal botanical nomenclature must meet the above requirement when published.

2.8.5 Publication of Names

The name of a Taxon should fulfill certain requirements before its effective publication as:

(*i*) **Formulation:** It should indicate

(*a*) *sp. nov.* (species novum) for a new species

(*b*) *Comb. nov.* (combination novum) for change in the epithet of basionym. The name of the original author should be kept in Parantheses.

(*c*) *nom. nov.* (Nomen novum) when the original name is completely replaced.

(*ii*) **English or Latin diagnosis: -** As per ICN **(**The Melbourne Code) the requirement of Latin diagnosis for Names of New Taxa has been changed. As per this code the description of new names should be in English or Latin.

(*iii*) **Typification: -** Holotype should be designated. The name of new Taxon is valid only when the type of the name is mentioned after January 1, 1990. The name of the taxon whose type is a specimen or unpublished illustration; the herbarium or institution in which the type is conserved must be specified.

(*iv*) After January 1, 1996 the name of new taxon of fossil should be accompanied by a Latin or English description of character.

Article 32,1-2 of Tokyo Code (ICBN) is amended as new names of plants and fungi will have to be registered in order to be validly published after January 1, 2000.

2.8.6 Citation of Author's Name

A name cannot be complete without an author's name. The author's name is abbreviated, *e.g*, Linneaus is Abbreviated as Linn or L, Bentham as Benth; Hooker as Hook, Roxburgh as Roxb, Lamarck as Lamk etc.

According to Article 46 the indication of name of a taxon are to be accurate and complete. It is necessary to cite the name of the author who first validly published the name. If the author's name is too long it should be abbreviated. *e.g., Hibiscus L.,lndigofera grandulosa* var. *Syskessi* Baker, *Solanum nigrum* Linn etc. According to Article 49 when a genus or taxon of a lower rank is altered in upper rank but retains its name or epithet, the author who first published

this as a legitimate name or epithet must be cited in parentheses; followed by the name of the author who effected the alteration *e.g., Citrus aurantium* var. *grandis L;* when raised to rank of species it becomes *Citrus grandis* (L) Osbeck. Here L is the first author and Osbeck altered it. Similarly, when a subdivision of a genus or a species is transferred to another genus or placed under another generic name (Articles 54 and 55), it will be written as

(i) *Saponaria* section *vaccaria* DC when transferred to *Gypsophila*, it becomes *Gypsophila* sec. *vacca ria* (DC) Godr.

(ii) *Limonia aurantifolia* Christm, when transferred to *Citrus* it becomes *Citrus aurantifolia* (Christm) Swingle.

In case of infraspecific changes it is, *Alysicarpus nummularifolius* DC when reduced to variety it becomes *Alysicarpus viginalis* var. *nummularifolius (DC) Baker.*

The names of two authors are linkded by ex. when the first author proposed a name but was validly published only by second author, the first author failing to satisfy all requirements of the code, *e.g.*

Cerasus cornuta Wall ex. Royle. When two or more authors publish a new species their names are linked by et, *e.g., Delphinium viscosum* Hook.f. et Thomson. When the first author publishes a new species or a name in a publication of another author, in is used, *e.g., Carex kashmirensis* Clarke in Hook.f, it means Clarke published the new species in Hooker's Flora of British India.

The names of two authors are linked using emend (emendavit) or person making amendment or correction in the diagnosis or circumscription of a taxon without altering the type, *e.g, Phyllanthus* Linn. emend. Mull.

When a name was already suggested but it is before 1753, *i.e.,* the starting of binomial system, the name of the author will be put in brackets [D, *e.g., Lupinus* [Tourne] Linn. here Tournefort suggested the name in 1719, i.e., before 1753 (Species Plantarum).

In the citation of infra specific taxon both authorities are called as *Acasia nilotica* (Linn) Del. ssp *indica* (Benth). In case of autonym, the infraspecific epithet does not bear author's name since it is based on same type as the species, *e.g., Acacia nilotica* (Linn.) Del. ssp *nilotica.*

The complete scientific name consists of a generic name, a specific epithet and the name of the author who originally described that taxon. The name of the author is cited in abbreviated from e.g. *Mangifera indica* Linn. This enables one to trace the original description and to ascertain its type and date of publication. If the name of the plant is published by two authors or more jointly, their names are linked by means of an ampersand and *et* instance respectively e.g. *Opuntia pollardii* Britt. et Rose. If an author takes upon unpublished name for a new species and valildly publishes it with his own description *ex* is usually inserted. Other examples are:

The complete name generic name/species epithet and author's name.

Mangifera indica Linn.

- Enable to trace original description, type and date of publication.
- When two authors jointly publish *Opuntia pollardii* Britt et Rose.
- If an author-unpublished and published/effected by another author/equal important to both eg., *Senecio nudicaulie* Buch. Ham ex D. Don.

Capparis lasiantha R. Br. ex DC

- When species described in one genus and later transferred to another.
- *Anthirrhinum spurium* L.

  Linaria spurium by Miller

  Linaria spurium (L.) Mill.- double citation with parenthesis

Abbreviations are:

Linnaeus – abbreviated L.

Adanson – Adan.

Scopoli – Scop.

Robert Brown – R. Br.

De Candolle – DC.

Sir J. D. Hooker.- Hook.f.

When a species has been described in one genus and later transferred to another, the name of the original author is cited in brackets followed by the name of the second author who transferred it (e.g. *Antirrhinum spurium* L. is treated as *Linaria spurium* by Miller. The citation will be *L. spurium* (L.) Mill. this is also referred as double citation and by this citation the description of the original specimen can be traced.

2.8.8 Retention, Choice and Rejection of Names

When a genus is divided into two or more genera or a species is split into two or more species, the original generic or specific name must be retained for the new taxon containing the type, this applies also to infra-specific taxa.

When a section of a genus or species is transferred to another genus or species without alternation in rank, the original name must be retained whenever possible.

When the rank of a genus or infra generic taxon is changed, the correct name of epithet is the earliest legitimate one available in the new rank.

When taxa of the same rank are united into the same rank or are united into one, the oldest legitimate name must be used for the new combined taxon, if the names are of same date, the author who first unites them has a right to choose one of the names and his choice must be followed by subsequent botanists.

A name or epithet must not be rejected merely because it is badly chosen or disagreable. The name must be rejected when it is illegitimate and superfluous when published or homonym or tautonym.

The authors have full liberty to coin their names but in Latin or Latinized form of other words; names of genera and higher taxa are written with a capital initial letter. Specific names should start with a small letter.

Example: Retention of names of epithets of taxa which are remodelled or divided:

When Genus is divided into 2 or more genera, the generic name must be retained for one of them.

When species is divided into two or more species the specific epithet must be retained for one of them.

Sugar Maple *Acer saccharum* Marsh. Later Michaux considered as composed of two taxa, each he treated as species.

Michaux – retained *Acer saccharum* Marsh. other – *Acer nigrum* Michx.

Retention of name or epithets of taxa below the rank of genus on transfer to another genus or species.

Species transferred to another genus without change of rank the specific epithet must be retained.

In 1753 Linnaeus named *Pinus Canadensis* Carrier later *Tsuga, Tsuga canadnsis* (L.) Carr. e.g. *Pinus laricina* du Roi corrected by Koch as *Larix laricina* (du Roi) Koch.

Choice of name when two taxa of same rank are united.

When two or more taxa of the same rank are united the oldest legitimate epithet is retained. If the names or epithet are of the same date, the author who united the taxa has right of choosing one of them.

Choice of names when the rank of taxon is changed.

When tribe becomes family

Subgenus – genus

Subdivision – species.

e.g. three varieties of the genus *Areria*

1. *A. canescens* (Hort.) Ebel (1827).

2. *A. majellensis* Briss. (1848).

3. *A. majellensis* var. *brachyphylla* Bris. (1879).

Later last two names (2 and 3) are treated as a single variant of *A. canescens.* By applying rule *A. majellensis becomes* a variety in the new category must be employed. Now named as *A. canesceus* var. *brachyphylla* Bris.

2.8.9 Rejection of Names

a) A name is rejected if name is illegitimate:
   i) Nomenclature superfluous
   ii) If published in contravention of specific rules (duplicate/invalidly published)
   iii) If it is rejected generic name.
   iv) If tautonym.

b) If owing to its use with different meaning source of confusion.

   e.g. *Quercus rubra* L. American oak.

   Quercus falcata Michx. Spanish oak.

   Quercus borealis Michx. f. Red oak.

   Reder proposed that *Quercus rubra* L. as nomen ambiqua and rejected *Quercus falcata* and *Quercus borealis* as valid name.

c). name of taxon must be rejected if the characters derived from 2 or more entirely discordant element, unless it is possible to select one of these element as site factory type of the name.

   e.g. *Actinotinus* established by Oliver 1888 a specimen derived from *Viburnum* and *Aesculus* rejected.

   The rules for rejection of names are

(i) ***Nomen nudunm (nom. nud):*** Name without description, without typification and Latin diagnosis etc is rejected.

(ii) **Tautonym:** Botanical nomenclature does not allow tautonym (repetition of generic name), *e.g., Malus malus.* Repetition of specific epithet in infra specific epithet does not constitute tautonym.

(iii) **Later homonym:** If a name which already exists is given to other taxa once again then the later homonym is rejected.

(iv) **Nomen *ambiguum* (nom. ambig):** The name is rejected in different sense by different authors.

(v) ***Nomen confusum (nom. confus):*** The name should not be confusing.

(vi) ***Nomen dubium (non. dub):*** Dubious name, *i.e.,* with uncertain application is also rejected.

2.8.10 Names of Cultivated Plants

The name of the cultivar is not analogous to the botanical variety and according to ICNCP the names are written with a capital letter preceded by abbreviation CV or placed in a single inverted comma. The name may be used after generic, specific or common names e.g. *Citrullus lanatus* CV Sugar baby. *Camelia japonica* CV. Purple Dawn etc.

It is recommended that cultivar names be registered with a recognised registration authority which undertakes to keep a list of cultivars for plants concerned. Registration is a precaution against duplication, misuse or fraudulent usage of cultivar names.

2.8.11 Names of Hybrids in Cultivation

The names of hybrids may follow the pattern of monohybrid crosses of Mendal between the species may be connected by multiplication sign (X). Again the name of the plant may be used in Latin for *Salix aurita* X *Salix caprea, Agrotis* X *Polypogon* X *Andropogon* etc.

2.9 SUMMARY

In this unit nomenclature process of plants was discussed. The process of naming plants on international rule proposed by botanists to ensure a stable and universal uniform is called botanical nomenclature. In this unit common name, scientific names, binomial nomenclature, different codes of ICBN (e.g. Paris code 1067 to Vienna code 2005) were also discussed. The principles (6), focal points of ICBN 1983, phylocode, The rules, rank of taxa, principle of priority, effective and valid publication, publications of names, citation of authors names, retention, choice and rejection of names, rejection of name, name of cultivated plants and names of hybrids in cultivation were discussed in detail.

2.10 GLOSSARY

Scientific name:	name of plan accepted to the world and used internationally.
Binomial:	A name with two epithels (one generic and another specific)
ICBN:	International Code of Botanical Nomenclature.
Phylocode:	proposed to promote clear communication and efficient storage and retrieval of biological information.
Species:	a unit of classification.
Type:	Name of the taxon is based on type.
Sp. Nov	(species novum) for a new species
ICNCP:	International Code for Nomenclature of Cultivated Plants

2.11 SELF ASSESSMENT QUESTIONS

2.11.1 Fill in the blanks:

(i) Three parts of ICBN are ……...
(ii) Valid publication initial date is ……..
(iii) Basic unit of classification is ……...
(iv) Suffix used for denoting order ……
(v) Suffix used for denoting family ……
(vi) Binomial name consists of two epithets ……
(vii) The name of a taxon is permanently attached with ……
(viii) Paris Code was formulated in the year …….

2.11.1 Answers Key:

(i) Principles, rules and recommendation, (ii) 1 May 1753, (iii) Species, (iv) ales, (v) aceae, (vi) Generic & specific, (vii) Holotype, (viii) 1956.

2.9 REFERENCES

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2.10 SUGGESTED READING

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2.11 TERMINAL QUESTIONS

2.11.1 Long Answer Type Questions

1- Describe ICBN in detail.
2- What is type? Describe various kinds of type.
3- Describe various Codes of plant nomenclature.
4- What is effective and valid publication?

UNIT-3 TOOLS AND TECHNIQUES IN COLLECTION AND PRESERVATION OF SPECIMENS

Contents

3.1 OBJECTIVES

After reading this unit students will be able to understand-

- Definition of Herbarium and Museum
- Different kinds of plant collection
- Preservation of plant specimen
- Tools of Herbarium

3.2 HERBARIUM

Herbarium is a collection of pressed and dried plant specimens mounted on appropriate sheets, arranged according to some known system of classification and kept in pigeon holes of steel or wooden cupboards usually specially prepared for this purpose. There are thousands of plants in the universe and it is not possible to identify them without assigning them in a definite system. This was the beginning of the systematic botany and arrangement of plants in definite system is one of the steps of the process. Before arranging them it is necessary to collect plants according to certain system. The collected plant is the plant specimen and the specimens are the prime sources for floristic studies. Plant materials must be carefully selected, collected and preserved in such a way that they provide a clue for identification and later arranged accurately for classification. The preserved specimen becomes a permanent record for investigation. This is herbarium specimen.

The science of creation of herbarium started way back in the 16^{th} century when Luca Ghini (1490-1556) developed the first Herbarium. Ever since then, there has been remarkable progress both in the areas of collection of plant specimens and the techniques that have been adopted through research over the years for enhancing the storage life of herbarium specimens. The concept of preserving plant specimens in dried form is 450 years old. The oldest preserved herbarium specimen is kept in Rome, collected by the naturalist Gherardo Cibo a pupil of Luca Ghini (1532). Luca Ghini made many plant collecting journeys in Italy. The plants were presented in this way by him and the first herbarium of the world was established in 1545 in University of Padua, Italy. The first Botanic Garden was also established in the same year. The word 'Herbarium' was originally applied not to collection of plants but to a book dealing with medicinal herbs. Tourneforte around 1700 used two terms as an equivalent to *Hartussiccus*, which was later on adopted by Linnaeus. In the middle of 16th century three students of Ghini namely Aldrovondi, Cesalpino (from Italy) and Turner (from England) also made their herbaria. Cesalpino's herbarium in Firenze is very important and is compared with his book "De Plantis libri XVI" introducing a scientific approach to the study and classification of plants. John Falconer prepared Herbarium in 1553.Dioscorides's "Materia Medica" includes an account of the medicinal use of about 100 plants. As the Renaissance developed in Italy, the Italians began

teaching Botany and developed the first ever botanical garden. They prepared 'Book' of mounted dried specimens (plants) and called them "Dry gardens" or *"'Harti Sicci"*.

3.3 TOOLS FOR HERBARIUM

The tools used in making herbarium are given below:

- Pocket knife
- Pruning sheets
- Newspaper
- Plastic bags or vasculum (metal box)
- Plant press (Plywood / Iron)
- Digging Tool
- Field note book
- Lead pencil
- Lox hand lens
- String tags
- Collecting vials & jars
- Fixing solution
- Field note book

Field Equipments

- **Field Equipment & Tools**
  * All-Pro Trowel
  * Clippers
  * Field Bags
  * Forceps
  * Hori-Hori
  * Manual Cover
  * Light-Duty Bags
- **Pressing**
  * Presses
  * Blotting
  * Ventilators
  * Straps

* Newsprint
* Polyurethane Foam

- **Mounting**
  * Mounting Papers
  * Adhesives
  * Levels
  * Bryophyte Packets
  * Fragment folders
  * Seed Envelopes
  * Bond Paper
  * Display Envelopes
- **Storage & Filing**
  * Genus Covers
  * Species Folders
  * Binding Tape
  * Cabinets
  * Bin Boxes
  * Shelf Markers
  * Insect Traps
  * Humidity Indicators
  * Zip-lock Style Bags
  * Cartons
- **Optics**
  * Hand Lenses
  * Microscopes
- **Books**
  * Presses
  * Blotting

3.4 TECHNIQUES IN COLLECTION

Making of herbarium involves collection, drying, poisoning, mounting, stitching, labeling and deposition etc.

3.4.1 Collection

Angiospermic material must be chosen that should have leaves, complete inflorescence, flower and fruit etc. If necessary one has to make many visits to the spot. Size of the material depends upon the requirement and availability. Herbaceous small plant may be collected in 2-2, *i.e.*, with roots also, but in woody plants 4-6 twigs are sufficient. One should not collect diseased, infected or inappropriate plant material. The collection should be given a field number. The species should have at least 4-6 specimens with same field number. The habit, habitat, flower colour, locality interesting features etc. should be noted down in the field note book. Some tools are rather important while collecting up plants for herbarium: A small knife, scissors, thorn-proof gloves and a small handy spade could be of great help. The collected specimens should be put into a strong bag made of cloth or polythene, the function of these containers being to protect plants from damage during your collection visit. If your excursion takes place in summer time or lasts for two or more days, it is better to bring a folder of approximately 45x30 cm or more. The folder must be made of cardboard or some other strong stuff, e.g. aluminum, and it must contain some old newspapers (the more plants you collect the more newspapers you need). The folder can be covered with cloth and it should be closed with straps or belts, and a handle or shoulder-belt should be added for easy carrying.

3.4.2 Field Note

After specimen collection, a field record is noted in small pocket sized notebook. Date of collection, location (name of place or distance from definite point)), collection number, if possible, name of the specimen, and description of the floral parts that may change after drying are noted down. The good quality specimens also become worst if it does not have good field record. The range, latitude and longitude as well as ecology of the plant need to be noted down by GPS (Global Positioning System) and eyesight vision. Likewise specimen's microhabitat; means associated species should be mentioned, at least five species. Finally the distribution status of plant also needs to be mentioned, either the collected species is rare, frequent, common, locally common or occasional. Duplicate specimens of one species that are collected on the same date and same locality should be given the same collection number.

3.4.3 Taking Pictures

Taking color pictures of each plant in its natural environment is also something which could substantially enrich the quality of herbarium. In that way the dried specimen can be placed together with one or more photographs, which are very helpful for bulky plants like trees or bushes, which obviously cannot be entirely included in a herbarium. Also the habitat of a plant can be well described with a photograph, taking care not to be too distant from the nearby bushes or trees.

The suggested equipment is a 35 mm. single lens reflex camera, with a standard lens and a macro-lens, the latter very useful for close-ups of flowers and other specific features. Also a

tripod can be very important if many close-ups have to be made, allowing the camera to remain steady. A tripod can also alleviate the need for a flash, which may be used when taking pictures in low light, but has the disadvantage of giving quite unnatural looking images. The speed of print films can range from 64 - 100 ISO to 200 or 400 if pictures in the woods are planned.

Each photograph you take should be recorded in a note-book to provide further data for the classification and to include in the herbarium. Be careful that your camera and films are not damaged by rough handling and do not become wet.

3.4.4 Pressing

The specimens are kept gently within newspaper. Parts of flower are much carefully spread without overlapping in original shape. If the specimens are long, then it needs to be folded in V and N or Z shape.

Unnecessary overlapping of leaves and other parts must be avoided. Large leaf, if palmately compound, split in half lengthwise and one half is discarded. If pinnately compound, a branch is only kept. A few leaves may be turned over to show lower and upper view. If there is bulgy rhizome, needs to cut or dissect longitudinally by knife, so that moisture evaporates through there. Specimens should be of good quality with good field note. Collection numbers have also to be written in the flimsies (newspaper or blank newspaper). The standard size of the press is 30 x 45 cm.

If the specimen is gymnosperms, the specimens needs to dip in the glycerine before pressing. In case of flowers with gamopetalous corolla a few flowers should be pressed separately and some of these should be split open and spread. If flower is large, cotton padding is often helpful to dry quickly. The specimens thus kept inside flimsies, are covered on either side by blotters and then it is put in herbarium press. After press is filled or all the specimens are put in the press, the plant press is closed and pressure is applied by means of tightening the straps. Hard and dried fruits and cones need not to be preserved or pressed, but have to be kept in special boxes.

Fig. 3.1 Pressing of specimen in press board

Fig. 3.2 Steps of pressing

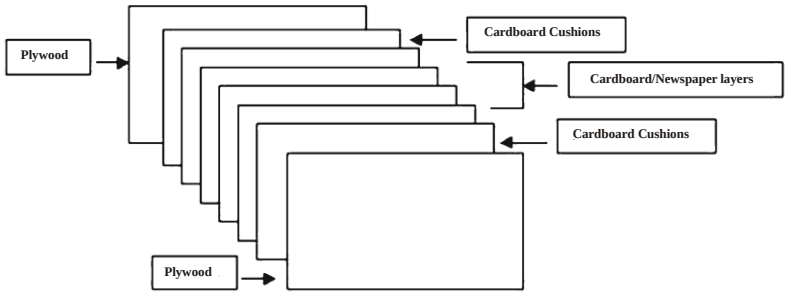

Fig. 3.3 Basic Structure of press

3.4.5 Drying

Drying techniques are of two types; those accomplished without heat, and those with the aid of artificial heat. Drying with the aid of artificial heat is the prevalent method. It is accomplished by means of heated dry air passing up and through the canal of the corrugate. Corrugates, often referred to as ventilators are used in presses when plants are dried by means of artificial heat. It is as sheet of pasteboard or thin aluminum metal, with fluted ducts. It provides air passages through the press for movement of dry heated air. The most common method of drying is without applying heat. Plants are placed in pressing papers between the blotters of the plant press. No corrugates are used. The press is locked up for about 24 hours. This is known as the sweating period. It is then opened, and as blotters are removed each pressing sheet is turned back, the specimens are examined, and parts rearranged as the situation demands.

After rearrangement the folder sheet is lifted on to a fresh dry blotter and covered by another dry blotter. The new pile of blotters and specimens is then locked up in the press and allowed to stand for another 24 to 36 hours, when the process of replacing wet blotters with dry ones is repeated. A third change of blotters follows usually after 2 to 3 days. Blotters must be changed 3-4 times; every wet blotter removed must be dried, usually by placing in the sun and reused. About a week is required for completion of drying. Dried specimens are packed with much care. Fungi as well as insects damage if proper care is not given till the permanent storage.

3.4.6 Poisoning

Precaution should be taken to protect herbarium specimens from damage by insect pests. The most destructive insects are herbarium beetle, cigarette beetle, booklice and silverfish. Insect repellants such as naphthalene ball or Para dichlorobenzene are sometimes placed in small quantities in herbarium cabinet. Although dangerous and hazardous to health, mercuric chloride is believed to be valuable because it provides long –term protection against insect attack. Besides the insect pest, the moulds and mildew are constant threat to material stored in damp condition or in areas of high humidity. Naphthalene and LPCP are believed to have fungicidal properties. However, thymol is quite effective as a fungicide.

3.4.7 Mounting

Mounting is the process by which a specimen is attached to a herbarium sheet and a label affixed at the lower right corner. Specimens are mounted on sheets of standard size herbarium paper (29 x 43 cm).

Most herbaria use a glue or paste to fasten specimens to the sheets. The specimen may be attached by various methods. A common method involves smearing a glass plate with a water-soluble paste, placing the specimen on the paste, and ten transferring the glued plant to the mounting sheet. Small paper envelopes called fragment packets are attached to the sheet to hold seeds, extra flowers, or any part of the specimen.

Fig. 3.4 Mounting of specimen

3.4.8 Label

Herbarium label is an important and essential part of permanent plant specimens. The size and shape of label may vary slightly but will usually be a rectangular and range between 10 x 15 cm (4 x 6 in.). The best position for the main label is generally thought to be the bottom right; this makes the label easier to read when kept in genus covers which open on the right hand side. Ideally a space should be left above the label to allow for the future attachment of determination slips. Generally herbarium label should contain the following information-

1. Heading- name of the institution in which the specimens originated /deposited.
2. Scientific name- Genus, specific epithet, author, or authors
3. Family-
4. Locality-
5. Range, latitude and longitude-
6. Habitat-
7. Date of collection-
8. Name of collector(s)-
9. Determined by-
10. Remarks-

3.4.9 Preservation of Specimens

Heating repellant and fumigants are used to check the attack of such destructive agents. The specimens may be treated by heating in a specially constructed cabinet at 60^0C for 6 hours, which kills larvae, eggs etc. A common process is-Ethylene dichloride mixed with one part of CCl_4 (carbon tetrachloride) used for fumigation in closed chamber, which is effective process. DDT (Dichloro Diphenyl Trichloroethane) is an important insecticide and it is dusted.

3.4.10 Problems in Management

In the current era of biotechnology and molecular biology the classical subjects like Taxonomy and Herbarium witnessed a great debacle. Herbaria contribute to the development of all biological disciplines. Today herbaria are ignored by so called modern biologists who have least knowledge of the significance of a herbarium.

Some herbaria developed over several decades of efforts of taxonomists are today at the verge of collapse due to wrong impression among the ruling biologists that herbaria are merely a storehouse of collections of dead plants which cannot contribute to the national development nor can generate funds for research forgetting that herbaria are simply a facility of a database on plants from which all biologists draw their basic information directly or indirectly about the plant species on which they carry out all advanced researches.

A national herbarium like the Central National Herbarium (CAL), Herbarium of the Forest Research Institute Dehradun, and the Herbarium of the National Botanical Research Institute, Lucknow are critically endangered due to lack of sufficient trained manpower facility.

Herbarium requires large building, curators, collection, tables for researchers and funds for continuous exploration. Funds are not provided for this subject now- a- days so it becomes very difficult to maintain. Policy makers must realize this and efforts should be made to maintain the important herbaria and Taxonomists should come up for exploration and maintenance of herbarium.

3.4.11 Index Herbariorum (IH)

For the past three centuries, scientists have documented the earth's plant and fungal diversity through dried reference specimens maintained in collections known as herbaria. There are approximately 3,990 herbaria in the world today, with approximately 10,000 associated curators and biodiversity specialists. Collectively the world's herbaria contain an estimated 350,000,000 specimens that document the earth's vegetation for the past 400 years. *Index Herbariorum* is a guide to this crucial resource for biodiversity science and conservation.

The Index Herbariorum (IH) entry for a herbarium includes its physical location, Web address, contents (e.g., number and type of specimens), history, and names, contact information and areas of expertise of associated staff. Only those collections that are permanent scientific repositories are included in IH. New registrants must demonstrate that their collection is large (usually 5,000 specimens minimum), accessible to scientists, and actively managed. Each institution is assigned a permanent unique identifier in the form of a four to eight letter code, a practice that dates from the founding of IH in 1935.

The first six editions of Index Herbariorum were published by the International Association for Plant Taxonomy in the Netherlands (1952-1974). Dr. Patricia Holmgren, then Director of the New York Botanical Garden (NYBG), served as co-editor of edition 6, and subsequently became the senior editor of IH. She oversaw the compilation of hard copy volumes 7 and 8, and Dr. Noel Holmgren, a scientist on the NYBG staff, oversaw the development of the IH database, which became available on-line in 1997.

3.4.12 Important Herbaria of India

S.NO	Name of Herbarium Places	No. of plants	Year of Specimens founding	Abbreviation
1	Central National Herbarium, Calcutta	2,500,00	1793	CAL
2	Forest Research Institute, Dehradun	3,000,00	1816	DD
3	Herbarium of the National Botanic Garden, Lucknow	1,00,000	1984	NBG
4	4. Botanical Survey of India, Dehradun Northern circle	60,000	1956	BSD

Important World's Herbaria

2	New York Botanical Garden	7,200,000	USA
4	Royal Botanic Gardens Kew	7,000,000	UK; Kew, England
6	Missouri Botanical Garden	5,870,000	USA; St. Louis, Missouri
7	British Museum of Natural History	5,200,000	UK; London, England

3.4.13 Steps For Herbarium Preparation

– Preparation of specimen
– Drying of specimen
– Preservation of specimen
– Mounting of the specimen
– Labeling of the specimen
– Filing of the specimen

Collection - Drying - Preservation - Mounting - Labeling – Filing

3.4.14 Functions of Herbarium

A modern Herbarium serves valuable functions or utility. The following are few important functions of a herbarium are:

1. It provides necessary information for verifying and identifying newly collected plants.
2. It is an invaluable conservatory of plant material and data.
3. It is storehouse of collections including the valuable type specimens. The herbaria greatly aid in all kinds of taxonomic researches.
4. Serves as a fundamental resource for identification of all plants of the world.
5. It serves as a source for collection of biodiversity. Most estimates on global biodiversity today are based on herbarium collection only.
6. It aids in biodiversity monitoring by carrying out security of herbarium collection to obtain quantitative baseline data on the distribution and abundance of keystone species is essential for all monitoring programmes.
7. It serves as a repository of voucher specimens on which various botanical researches are carried out.
8. Aids in assessment of conservation status of a taxon.
9. Vast collection of a particular species in a herbarium aids in assessing the diversity or variations exhibited by a species in its distributional range helping in population biology studies.
10. It serves as a source for search of new genetic material for improvement of cultivated stock.
11. It helps in development of computer database on plants and maintains active links to international networks of systematic resources and electronic database.
12. It provides research facilities to the students of taxonomic research.
13. It provides complete idea of vegetation and place of origin of plants.
14. The ecological, economical and ethnobotanical data may be obtained, and
15. It provides key for the preparation of modern system of classification.

The herbaria are classified as:

(a) Major or National Herbaria which cover the flora of the world and serve the purpose of research as well as identification.

(b) Minor Herbaria which include smaller herbaria such as Regional herbaria, local herbaria and College / University herbaria

3.5 BOTANICAL MUSEUMS

Institutions that collect, classify, preserve, and display botanical collections and also do scientific and educational work in botany. In 1969, there were more than 200 museums that disseminated botanical knowledge. In Great Britain, Indonesia, Norway, USA, France and other nations, botanical museums are usually divisions of botanical gardens, natural history museums, museums of local lore, and other museums. Thus, in the Museum of Natural History in Chicago, the botanical division consists of displays of plant life and plant raw materials and their uses. Plant groups are presented in biological groups that serve as a background for zoological exhibits. The collections of the Botanical Museum of the London Botanical Garden at Kew are kept in four buildings. Dicotyledons and various products from them are in the first building. Specimens of monocotyledons are in the second building. Collections of the varieties of trees in Great Britain and an exhibit of the methods of their industrial use are in the third building. A collection of drawings of plants from all continents of the world is in the fourth building, called the Miss North Gallery. In Vienna Natural History Museum Botany is represented in the so-called phytopaleontological division.

In the USSR there are botanical museums in Leningrad, Kiev, Baku, Dushanbe, and other cities. The largest specialized botanical museum is the museum of the V.L. Komarov Botanical Institute of the Academy of Sciences of the USSR (AN SSSR) in Leningrad. It was founded in 1823 as part of the Imperial Botanical Garden, on the basis of collections of specimens of dead plants, as well as everyday articles made from plants and products of plant origin collected by many generations of Russian botanists and travelers.

The possessions of the Botanical Museum — up to 70,000 specimens – are grouped in four sections. The collections of the economic botany section consists of objects of economic significance or those used for technical, pharmaceutical, and other purposes (fatty and volatile oils, resins, gums, samples of certain food products, fruits, seeds, types of tea, cocoa, coffee, various spices, medicines, and samples of fiber, narcotic, and sugar-containing plants.)

3.5.1 Definitions of Museum

It is necessary to begin with an understanding of what a museum is. This is vitally important, because most people think that a museum, in short, is a building which exhibits some old objects. There is some truth in the notion. However it sounds too scientific and dull. Similarly the Oxford Advance Learner's dictionary suggests that a museum is "a building in which

objects of artistic, cultural, historical or scientific importance and interest are displayed" (Hornby, 1990). Needless to say, a dictionary describes the meaning of a word concisely, so the description is not always relevant to helping readers understand the whole meaning. The problem with these definitions is, firstly, a museum is not always in a building; secondly, it aims at educationally affecting the general public; and thirdly it also offers recreational opportunities to the public. In addition it is important to research.

There have been many definitions of a museum over time and throughout the world. For instance, George Brown Goode mentioned the definition at a general meeting of British museums in 1895.

"A museum is an institution for the preservation of those objects which best illustrate the phenomena of nature and the works of man, and the utilization of these for the increase in knowledge and for the culture and enlightenment of the people" (Burcaw, 1990).

This idea emphasizes the enlightenment of the people, and also does not insist that the institution is a building.

Nearly one century later Goode had defined a museum in 1989, as:

"a non-profit making, permanent institution in the service of society and of its development, and open to the public which acquires, conserves, researches, communicates and exhibits, for purposes of study, education and enjoyment, material evidence of people and their environment" (ICOM International Council of Museums – Statutes, 1990).

Also, the term "institution" is defined by ICOM as follows:

1. Natural, archaeological, ethnographic, historical monuments and sites.
2. Botanical and zoological gardens, aquaria and vivaria.
3. Science centres and planetaria.
4. Conservation institutes and exhibition galleries permanently maintained by libraries and archive centres.
5. Nature reserves.

This definition improves on that a George Brown Goode. It clearly describes the function of museums to:

a) exhibit to the public for their enjoyment.

b) include many types of institutes such as botanical, zoological gardens and aquaria.

The word "museum" comes from a *mouseion* in classical Greece (in Greek myth) which was a place of contemplation, a philosophical institution or a temple of the Muses (Lewis G. 1992) who are the nine goddesses, daughters of Zeus or Jupiter, who protected and encouraged poetry, music, dancing, history and other branches of art and literature (Hornby, 1990). That is to say, originally museums meant that the places for not only philosophical discussion but also for enjoyment such as dancing or singing. After the fifteenth century, the term began to be used

to describe a collection in Renaissance Florence and then it carried with it connotations of comprehensiveness and encyclopedic knowledge (Lewis, 1992).

The ICOM definition seems to have accepted the original idea of a museum and developed it for public education and enjoyment.

The definition of a museum in each country differs slightly. According to the American Association of Museums in 1962:

"A museum is a non-profit permanent establishment, not existing primarily for the purpose of conducting temporary exhibitions, exempt from federal and state income taxes, open to the public and administered in the public interest, for the purpose of conserving and preserving, studying interpreting, assembling, and exhibiting to the public for its instruction and enjoyment objects and specimens of educational and cultural values, including artistic, scientific (whether animate or inanimate), historical, and technological material. Museums thus defined shall include botanical gardens, zoological parks, aquaria, planetaria, historical societies, and historic houses and sites which meet the requirements set forth in the preceding sentence" (Burcaw, 1990).

The Canadian Museums Association officially adapted this definition with minor changes. These definitions are quite similar to that of the ICOM. It particularly emphasizes.

1. Public benefit
2. The inclusion of a wide range of institutes

The Japanese definition is shorter than the above. However it states all the basic functions of a museum in one paragraph as follows:

A museum is an institution which collects and preserves material concerned with history, art, anthropology, industry, natural history, and so on, and exhibits them to the general public from a educational point of view, and carries out projects needed to contribute to the public education, study and recreation, and also it researches on the materials (Museum Law – translated by this author).

This definition does not mention the range of institutions exactly in the main paragraph. However if some institution follows this definition, it should be called a museum. It means that the range of museums is very wide. Also public benefit is regarded as the top priority.

Finally the English definition (adopted by MA-Museum Association) is as follows:

A museum is an institution which collects, documents, preserves, exhibits and interprets material evidence and associated information for the public benefit (Barbour 1992). This is particularly brief and concise, but in the same publication, each element (eg. Institution) is fully explored. This definition, too, complies with the significance of that from the ICOM. Especially this author feels that an important additional element of this definition is that "*Museums are the servants of society".*

3.5.2 Museum Mission Statements

Two major UK museums have the following mission statement:

1. *The Natural History Museum (NHM)*

The mission of the NHM is to promote the understanding and enjoyment of the variety of our natural world through high quality exhibitions, education and science (The Natural History Museum, 1992).

2. *The National Museum of Science and Industry (The Science Museum)*

The mission of this museum is to be the nation's leading centre for the public understanding of science by carrying for, presenting and interpreting the national collections of science, technology and medicine (quoted by Mazda X. 1993).

From above definitions and the nature of mission statements, author wants to summarize and reform it slightly to help develop new museology which is as follows:

A museum is a non-profit making, permanent institution which collects, preserves and researches material evidence of people and / or their environment, and exhibits them to the general public from an educational, point of view, and carries out projects needed to contribute to public education, study and recreation. It includes art galleries, botanical and zoological parks, aquaria, planetaria, historic houses and sites, and others which have the above characteristics. This ultimate objective is to facilitate the peaceful coexistence between human beings and the natural world.

Indian Museum is the largest and oldest museum in India and has rare collections of antiques, armour and ornaments, fossils, skeletons, mummies, and Mughal paintings. It was founded by the Asiatic Society of Bengal in Kolkata (Calcutta), India, in 1814. The founder curator was Dr. Nathaniel Wallich, a Danish botanist.

It has six sections comprising thirty five galleries of cultural and scientific artifacts namely Art, Archaeology, Anthropology, Geology, Zoology and Economic Botany. At present, it includes six cultural and scientific sections, viz. Art, Archaeology, Anthropology, geology, zoology and economic botany, with a number of galleries under each section. Many rare and unique specimens, both Indian and trans-Indian, relating to humanities and natural sciences, are preserved and displayed in the galleries of these sections. The administrative control of the Cultural sections, viz. Art, Archaeology and Anthropology rests with the Board of Trustees under its Directorate, and that of the three other science sections is with the Geological Survey of India, the Zoological Survey of India and the Botanical Survey of India. The Museum Directorate has eight co-coordinating service units: Education, preservation, publication, presentation, photography, medical, modeling and library. This multipurpose Institution with multidisciplinary activities is being included as an Institute of national importance in the seventh schedule of the Constitution of India. It is one of oldest museums in the world. This is an autonomous organization under Ministry of Culture, Government of India. The present

Director of the Indian Museum is Dr. B. Venugopal. The museum was closed to visitors due to massive restoration and upgrades from 1 September 2013 to 3 February 2014. This great museum is relentlessly exploring the sea of knowledge seeking a new configuration of the vast meeting ground of the people coming from various cultural and social backgrounds.

The India Museum Ministry of Culture, Govt. of India

Botany Gallery:

The Botanical Gallery has a permanent exhibit display in 8 bays and various sections such as Indian timbers, Food products, Medicinal produces, Vegetable fibers, Oil and oilseeds, Dyes and Tans and finally Gum and Resins. The gallery provides the first hand information on both wild and cultivated economical plants commonly used in India as well as its commercial perspectives.

The gallery has smaller display units on various economic products, such as 'Story of paddy', 'Story of Sugarcane', 'Story of Arrowroot', 'Tea story', 'Varieties of Paddy and Wheat', 'Common vegetables', 'Fruits of tropical region', under Food produces section.

'Crude drug', 'Crude drug products', 'Cinchona and its products', 'paper and paper materials', 'Shola products', 'Silk industry products', under Vegetative fiber section; sort of museum which situates on the border of the museum definition (this idea comes from Professor Tsuruta, a committee member of ICOM, on his lecture at Hosei University in Tokyo, 1988).

Finally, the ultimate objective of museums is "to facilitate the peaceful coexistence between human beings and the natural world'. This is his original idea, but basically this idea may have been a dormant element of museum philosophy, therefore he wants to bring it to light, and carry it out. Needless to say, this author believes that education is the most important task, as museums, as a subject will be highlighted and the evidence of the subject will be evaluated from various angles.

3.6 SUMMARY

In this unit Herbarium, Museum and Herbarium techniques were discussed. Herbarium is a collection of pressed and dried plant specimen mounted on appropriates sheets arranged to some known system of classification and kept in pigeon holes. The science of herbarium has been started by Luca Ghini. The function of Herbarium, classification of herbarium, tools for herbarium, techniques of collection, index herbarium, important herbarium of India were discussed. Institution that collect, preserve and display botanical collections and also do scientific and educational work in botany is known as museum. Definitions of Museum were also discussed in this unit.

3.7 GLOSSARY

Herbarium: dried plant material (specimen) on appropriate sheets

Major herbaria: cover the flora of world
Minor herbaria: smaller herbaria
Mounting: specimen attached to herbarium sheet
CNH: Central National Herbarium
FRI: Forest Research Institute
Museum: an institution for the preservation of those objects which best illustrate the phenomena of nature

3.8 SELF ASSESSMENT QUESTIONS

3.8.1 Fill in the blanks:

(i) Plant press is made up of ……..

(ii) A collection of plant material (after being dried) is called ……

(iii) Full form of CNH is …….

(iv) Creation of Herbarium was started by …….

(v) NHM (Natural History Museum) is situated at ……

(vi) Major herbarium covers the flora of …….

(vii) Standard size of herbarium sheet is ……..

(viii) DDT full form ……..

3.8.1 Answer Key:

(i) Wood / Iron, (ii) Herbarium, (iii) Central National Herbarium, (iv) Luca Gini, (v) London, (vi) World, (vii) 29 x 43 cm, (viii) Dichloro Diphenyl Trichloroethane.

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3.10 SUGGESTED READINGS

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3.11 TERMINAL QUESTIONS

3.11.1 Long answer type questions

1- Describe Herbarium.

2- How museums are useful for plant preservation?

3- Describe plant collection in details.

4- Describe the steps for herbarium preparation.

UNIT-4 BOTANICAL GARDENS, HERBARIA & BSI

Contents

4.1 OBJECTIVES

The main goals of this chapter are to broaden your understanding about the following issues:

- Definition of Herbarium and Botanical Garden
- to know about herbarium
- to know about Botanical Garden.
- to get the information regarding Botanical Survey of India

4.2 INTRODUCTION

Herbarium is a collection of pressed and dried plant specimens mounted on appropriate sheets, arranged according to some known system of classification and kept in pigeon holes of steel or wooden cupboards usually specially prepared for this purpose. There are thousands of plants in the universe and it is not possible to identify them without assigning them in a definite system. This was the beginning of the systematic botany and arrangement of plants in definite system is one of the steps of the process. Before arranging them it is necessary to collect plants according to certain system. The collected plant is the plant specimen and the specimens are the prime sources for floristic studies. Plant materials must be carefully selected, collected and preserved in such a way that they provide a clue for identification and later arranged accurately for classification. The preserved specimen becomes a permanent record for investigation. This is herbarium specimen.

The science of creation of herbarium started way back in the 16^{th} century when Luca Ghini (1490-1556) developed the first Herbarium. Ever since then, there has been remarkable progress both in the areas of collection of plant specimens and the techniques that have been adopted through research over the years for enhancing the storage life of herbarium specimens. The concept of preserving plant specimens in dried form is 450 years old. The oldest preserved herbarium specimen is kept in Rome, collected by the naturalist Gherardo Cibo a pupil of Luca Ghini (1532). Luca Ghini made many plant collecting journeys in Italy. The plants were presented in this way by him and the first herbarium of the world was established in 1545 in University of Padua, Italy. The first Botanic Garden was also established in the same year. The word 'Herbarium' was originally applied not to collection of plants but to a book dealing with medicinal herbs. Tourneforte in around 1700 used two terms as an equivalent to *Hartussiccus*, which was later on adopted by Linnaeus. In the middle of 16th century 3 students of Ghini namely Aldrovondi, Cesalpino (from Italy) and Turner (from England) also made their herbarium. Cesalpino's herbarium in Firenze is very important and is compared with his book "De plantislibri XVI" introducing a scientific approach to the study and classification of plants. John Falcener prepared Herbarium in 1553.Dioscorides's "Materiamedica" includes an account of the medicinal use of about 100 plants. As the Renaissance developed in Italy, the Italians

began teaching Botany and developed the first ever botanical garden. They prepared 'Book' of mounted dried specimens (plants) and called them "Dry gardens" or *"'HartiSicci"*.

The herbaria are classified as:

(a) Major or National Herbaria which cover the flora of the world and serve the purpose of research as well as identification.

(b) Minor Herbaria: which include smaller herbaria such as: Regional herbaria, local herbaria and College / University herbaria.

Fig. 4.1: Pressing of specimen in press board

4.2.1 Important Herbaria of India

	Name of Herbarium	Places	No. of plants specimens	Year of founding	Abbreviation
1.	Central National Herbarium	Calcutta	2,500,00	1793	CAL
2.	Forest Research Institute	Dehradun	3,000,00	1816	DD
3.	Botanical Survey of India Northern circle	Dehradun	60,000	1956	BSD
4.	Herbarium of the National Botanic Gardens, Lucknow	Lucknow	1,00,000	1984	NBG
5.	Botanical Survey of India Central Circle	Allahabad	40,000	1955	BSA
6.	Madras Herbarium	Coimbatore	1,50,000	1874	NH

Important World's herbaria

S.N.	Name	No. Specimens	Location
1	Muséum National d'Histoire Naturelle	9,500,000	France; Paris
2	New York Botanical Garden	7,200,000	USA
3	Komarov Botanical Institute	7,160,000	Russia; St. Petersburg
4	Royal Botanic Gardens Kew	7,000,000	UK; Kew, England
5	Conservatoire et Jardinbotaniques		

	de la Ville de Genève	6,000,000	Switzerland; Geneva
6	Missouri Botanical Garden	5,870,000	USA; St. Louis, Missouri
7	British Museum of Natural History	5,200,000	UK; London, England
8	Harvard University Herbaria	5,005,000	USA; Cambridge
9	Swedish Museum of Natural History	4,400,000	Sweden; Stockholm
10	United States National Herbarium, Smithsonian Institution	4,340,000	USA
11	National Herbarium of the Netherlands	4,000,000	Netherlands; Leiden
12	National Botanic Garden of Belgium	3,500,000	Belgium, Meise
13	Zentraleinrichtung der Freien Universität Berlin	3,000,000	Germany, Berlin
14	Botanische Staatssammlung München	3,000,000	Germany, Munich
15	Chinese National Herbarium	2,470,000	China
16	Royal Botanic Garden, Edinburgh	2,000,000	UK; Edinburgh, Scotland
17	Herbarium Bogoriense	2,000,000	Indonesia
18	Royal Botanic Gardens, National Herbarium of Victoria	1,200,000	Australia
19	National Herbarium of New South Wales	1,000,000	Australia
20	National Herbarium Nederland, Utrecht University branch	800,000	Netherlands; Utrecht
21	Institute Botànic de Barcelona	700,000	Spain; Barcelona
22	National Botanic Gardens, Ireland	600,000	Ireland; Dublin
23	Zimbabwe National Herbarium	513,700	Zimbabwe; Harare
24	Bolus Herbarium	373,000	South Africa

4.3 TAXONOMIC LITERATURES

There are vast literatures on taxonomic botany is available and the literatures are in various forms:

General Taxonomic indexes

World floras and manuals

Monographs and revisions

Bibliographic, catalogues and review series

Periodicals

References

Maps and Catalogues

Biographic reference

Data of Publication

Location of type specimen

Directories, addresses and Colour Charts

Outstanding botanical libraries

Flora: The word "flora" refers to the plants occurring within a given region as well as to the publication of scientific descriptions of those plants. A Flora may contain anything from a simple list of the plants occurring in an area to a very detailed account of those plants. Floras are different from popular manuals in that they attempt to cover all of the plants, rather than only the most common or conspicuous ones. A Flora almost always contains scientific names, and it may also include common names, literature references, descriptions, habitats, geographical distribution, illustrations, flowering times, and notes. Sometimes the plants are listed alphabetically, and sometimes they are represented within a classification system that indicates which plants are most similar or are thought to be related. Floras often also include devices called "keys" that enable the user to identify an unknown plant.

4.3.1 FLORA WRITING

1. Firstly the area is identified to study the flora.
2. Geography of the identified area is to be defined and the map is to be presented.
3. Provide a detailed account of ecology of the area, *(e.g.*, maximum and minimum temperature, rainfall, water bodies, major habitats, soil condition, physiographic regions etc.)
4. Identify floristic zones or ecological habitats within the area.
5. Extensive field survey for study of vegetation and collection of all plants time to time.
6. Field book is to be maintained for the plants collected including its field number and description, local name, frequency, phenology etc.
7. Plant specimens collected are to be identified with the help of other regional and local flora. The specimen is to be confirmed by matching it with authentic sheets in any regional herbarium of Botanical Survey of India.
8. Nomenclature of the species should be confirmed by ICBN.
9. Author citation is to be checked for a new species.
10. Provide botanical keys for identification of all families, genera and species.
11. Description of the species should be in accordance with the actual specimen collected from the area.
12. New species found, if any, should be described and published following the norms of ICBN.
13. Generally in a flora the families are arranged according to an accepted classification. It was Benthan and Hooker's system mostly but in recent times some of flora adopts Cronquist's system of classification.

A species must include

(a) Correct name
(b) Vernacular name
(c) Clear description with variation
(d) Distributional data
(e) Ecological condition
(f) Uses
(g) Conservation status
(h) Native or exotic origin
(i) Specimens examined from the area

Flora should contain

(a) Title
(b) Geography
(c) Environmental condition
(d) Taxonomic treatment
    (i) Nomenclature
    (ii) Vernacular name
    (iii) Description
    (iv) Cultivar, if any
    (v) Phenology
    (vi) Distribution
    (vii) Ecological data
    (viii) Use
    (ix) Conservation status
    (x) Origin
    (xi) List of voucher specimens
(e) Summary statistics
(f) Bibliography
(g) Illustration
(h) Index

Summary of the work should be given in 2-3 pages which should include total number of families, genera, species number of exotic and native species, Rare and endemic species etc., in a graphic or tabular form. Recent day computer is used to work it out.

Palmer et al. (1995) Provided Abundance Scale

	Density	Score	Description
(1)	Abundant	5	Dominant in one or more common habitats
(2)	Frequent	4	Easily found but not dominant in common habitats.
(3)	Occasional	3	Widely scattered but not very difficult to find.
(4)	Infrequent	2	Difficult to find with few individuals or colonies but found in several locations.
(5)	Rare	1	Very difficult to find only few specimens is found in the area.
(6)	Absent	0	Not found in the area presently But it might be present in the previous survey.

Utility of flora

Flora is a valuable document for research and university, college teachers, students of Botany and Agriculture. It is used to identify the plants. It is useful in Biodiversity assessment and management. Flora is useful in forest management, ecosystem and land management. It provides basic information of plants in the area. Flora is useful in Development of Botanical

Garden and Park. Flora may be made for particular use as medicinal or drug plants for pharmaceutical and Ayurvedic Company, seed companies etc. Flora helps in planning a city, village or town. It is also useful in Assessment of rare and endangered species and vegetation study etc. Flora helps in evaluation of phytogeography pattern.

4.3.2 MONOGRAPH

It is the study of a taxon (genus, or family) regardless of geographical occurrence. Monographic studies provide keys, description, correct nomenclature and even the evolution of the taxon. Monograph is written after very intensive investigation and survey of the area. It also includes studies of pollination behaviour, seed dispersal and physiological adaptation.

Difference between monograph and flora

	Monograph	Flora
1.	Comprehensive account of the taxonomic data	Taxonomically less critical and superficial.
2.	Provides total variation of a Taxon.	Does not cover any variation of taxon.
3.	Biosystematic information and infraspecific variation are studied in detail.	Not included in flora.
4.	It accounts for a systematic synthesis of all available data of Taxa.	It is a means for identification of data.

4.3.3 GENERAL LITERATURE

(1) ***Taxonomic Literature***

It covers full bibliographical details including precise data of publication as well as biological data of the authors. Taxonomic literature is a series of seven volumes and commonly known as TL 2, because it is expanded version of an earlier catalogue. The work was compiled by F. A. Stafleu and R. S. Cowan. The work is very useful for locating type specimens of a particular author. Five supplementary volumes of TL 28 were published during 1992-98 after the death of Stafleu and Cowan. They were edited by Norbet Kilian and Ralf Hand**.**

(2) ***Index Nominum Genericoruni (ING)***

It is a list of all generic names of plants of all groups (Fossils and Recent). It was published by E.R. Far, J. A. Leussinke and F. A. Stfleu in 1979 in 3 volumes. It includes all generic names from 1753 to 1975.

(3) ***Index Kewensis Plantarum Phanerogamarun***

Generally called Index Kewensis (IK). It is the most comprehensive list of scientific names of seed plants (Gymnosperms and Angiosperms). The first 2 volumes were compiled by J.D. Hooker and B.D. Jackson in 1893-1895 at Kew. It includes generic names in alphabetical order between 1753-1885. Now the Index kewensis is available in CD ROM also.

(4) ***Gray herbarium Card Index.***

It lists all names or new combinations including infraspecific names also of flowering plants and ferns of New World.

(5) ***A Dictionary of Flowering Plants and Ferns***

Lists of every family name published since 1789 and every genus since 1753. It was published by J.C. Willis in 1897. The revised enlarged edition was published by H.K. Airy Shaw in 1973.

(6) ***Index Filicum***

It includes names of all ferns. In 1961 the names of other Pteridophytes are also included in it.

(7) ***Index Nominum Algorum***

It is an ongoing project producing and maintaining an index of scientific names of Algae (living and fossil). It was initiated by P.C. Silva (1949).

(8) ***Index muscorum***

Consists of 6 volumes of *Regnum Vegetabile* indexing all species and infraspecific taxa of mosses upto 1973.

(9) ***The Kew Record of Taxonomic Literature***

It is an annual publication listing all periodical articles and books and new names of floweing plants, gymnosperms and ferns of the world.

(10) ***Index Lendinensis***

It is an alphabetical Index of illustration of flowering plants, ferns published between 1753-1935. compiled by O.Stapf in 6 volumes.

(11) ***Draft Index of author abbreviation committed at the Herbarium, Royal Botanic Garden, Kew***

It gives the full name of author, his life dates and standard abbreviation of his name to be used in nomenclatural citation.

(12) ***International code of Botanical Nomenclature (ICBN)***

It aims to provide internationally accepted code of practice on nomenclature. It lays down the criteria for naming a taxon. The recent edition of ICBN is known as Vienna Code (2005)**.**

(13) ***Index Herbarium***

It is a guide to the location and contents of the world's public herbaria (8th ed. 1980).

(14) ***The families of Flowing Plants***

Published by J. Hutchinson in 2 volumes. The first vol. includes Dicots and second volume includes all Monocotyledon Families.

(15) ***The Genera of Flowering Plants***

It was published by J. Hutchinson is 2 volumes in 1964 and 1967, dealing with dicotyledonous plants. It is based on Genera Plantarum of Bentham and Hooker.

(16) Evolution and classification of Flowering Plants published By A. Cronquist (1968**)** providing his system of classification.

(17) Outline of the classification of flowering plants written by A. L. Takhtajan in 198**0** providing his system of classification.

Classical Literature

(1) ***Species Plantarum***

It was published by Carolus Linneaus, in 2 volumes. First in May 1753 and second in August 1753. Binomial system of nomenclature was adopted in it for the first time. It accepted the rules of priority in the nomenclature of flowering plants and pteridophytes. It does not provide generic description.

(2) ***Hortus Indicus Malabarlcus (1678-1703)***

Published in 12 parts containing the account of 794 plants of Malabar region. It is Prelinnean publication and first authentic record of plants.

(3) ***Prodromus* Systematisnaturalis vegetables**

Published by AP de Candole, in 17 volumes (1824-1873) providing the account for all species of seed plants.

(4) ***Monographlae Phanerogamarum***

It was edited by Alphonse de Candolle. It provides monographic account of families.

(5) ***Genera Plantarum***

Bentham and Hooker published their classification of flowering plants in 3 volumes. Description of all genera are original and in latin. No key is used in the work.

(6) ***Die Naturlichen Pflanzenfamillen***

Published by A. Engler and K. Prantl in 23 volumes. It is written in German Plants are described using dichotomous key.

(7) ***Genere Siphonogamarum***

Edited by G.G. Dalla Torre and H. Harne. It follows Engler's system of classification.

(8) ***Wallichian catalogue***

It is a list of 9,148 plants collected during Naithaniel Wallichi's suprintendent of Royal Botanic Garden**,** Calcutta. Many new plant names proposed in this work are nomen-nudum, *i.e.*, species names without "description and contrary to rules of nomenclature.

(9) ***lcones (Illustration)***

BSI published the Roxburghleones (1829) in small fascicles in 1964: Wight's lcones contain 201 plates in 6 volumes.

Some Important Taxonomic Literature Published in India

1. *Hortus Inidicus Malabaricus* published in 1676 by Hendrik Van Rheede.
2. *Flora Zeylanica* (1747) published by Linnaeus including plants of Ceylon and Peninsular India.
3. *Flora Indica* (1768) by Nicolus Burmen.
4. *The plants of Coastal cormandel* (1798) by William Roxburgh.
5. *Flora Indica* (1824) by William Roxburgh.
6. *Wall Cat* (Catalogue of dried specimen) (1849) by Nathanial Waluchi.
7. *Icones Plantarum India Orientalis* (6 vol.) (1853) by Robert Weight.
8. *Flora of Kumaon* (1824) by J.F. Watson.
9. *Forest Flora of Kumaon* (1927) by A.E.Osmaston**.**
10. *Flora of Kashmir* (1835) by J.F. Royle.
11. *Flora of Bombay* (1939) by J. Groom.
12. *Flora of Calcutta* (1840) by W. Masters.
13. *Flora of Agra* (1844) by W. Munro.
14. *Flora of Bengal* (1857) by J. Long.
15. *Flora of Andhra* (1859) by W. Elliot.
16. *Flora of Lucknow* (1859) by I. Anderson.
17. *Flora of Punjab* (1869) by J.L. Stewart.
18. *Flora of British India* (upto 1897) by J.D. Hooker.
19. *Flora Simlensis* (1902) by H. Collett.
20. *Flora of Upper Gangetic Plains and Adjacent Siwaliks and Sub Himalayan tract* (upto 1922) by J.F. Duthie.
21. *The flora of Travencore* (1906) by T.F. Bourdillion.
22. *A Hand Book of South India Grasses* (1921) by R. Range Charier.
23. *Beautiful Indian Trees* (1929) by E. Blatter and W.S. Millard.
24. *Flora of Assam* (upto 1940) by U. Kanjilal.
25. *Common Grasses of United Provinces* (1940) by N.C. Bor.
26. *Poisonous Plants of India* (1949) by R.L. Bahadur and S. Ghosh**.**
27. *Flora of Delhi* (1963) by J.K. Maheshwari.

28. *Flowering Trees* (1965) by M.S. Randhawa.
29. *The Roses in India* (1966) by B.P. Pal.
30. *Flora Nainitalensis* (1968) by R. K. Gupta.
31. *Dictionary of Flowering Plants in India* (1973) by Santapau and Henry.
32. *Supplement to the Duthie's flora of Upper Gangetic Plains* (1975) by M.B.Raizada.
33. *Flora of Mussoorie* (1978) by M.B. Raizada and H.O. Saxena.
34. *Orchids of India* (1979) by V.N. Naik.
35. *Medicinal Plants* (1981) by S.K. Jain.
36. *Flora of Himachal Pradesh* (1984) by H. J. Chaudhary and B.M. Wadhwa.
37. *Weed Flora of Kashmir, valley* (1986) by M. K. Kaul.
38. *The Useful Plants of India* (1986) by CSIR Publication.
39. *The Orchid Flora of N.W. Himalayas* (1987) by Somdev and H.B. Naithani.
40. *Orchids of Kumaun Himalaya* (1991) by Y.P.S. Pangtey, S.S. Samant and G.S. Rawat
41. *Flora of Garhwal Himalaya* (1999) by R.D. Gaur.
42. *Medicinal Plants of Ranikhet* by L.M.Tewari et al.
43. *Biodiversity Potentials of the Himalaya* (2010) by Lalit M. Tewari, Y.P.S. Pangtey and Geeta Tewari.

4.4 BOTANICAL GARDEN

Botanical gardens or botanic gardens are generally well-tended parks displaying a wide range of plants labeled with their botanical names. They may contain specialist plant collections such as orchids, cacti and succulent plants. Botanic gardens and arboretums are primarily outdoor collections of labeled living plants, the entire structure being systematically and beautifully landscape and playing passive role in their communities. They are the basic source of plants and information about plants to people who have made gardening their hobby. They are the basic source of new information concerning a large number of plants. They exhibit the native vegetation of their region and sometimes also act as "outdoor laboratories" for students and researchers. They provide beauty to the institution to which they belong some botanic gardens are large enough for a pleasing drive through them all the blossom time and act as a serene site of relaxation, Some gardens have special exhibits such as hedge displays or are made up of smaller gardens to be chosen for our own kitchen gardens, From them we learn what plants and in what combinations we may have them in our little home gardens to give a good design, In several public or government gardens there are regular well-organized popular courses for public, and people can learn both theoretically and practically about gardens, especially house plants, home landscaping, flower arrangement Christmas decoration.

A modern botanical or botanic garden should display, the following:

(1) Collections of different varieties of cultivated plants especially ornamental ones such as roses, peonies dahlias, poppies, cannas, lilies, primulas, violas, crotons, coleus, ferns, palms, orchids etc,

(2) Medicinal plants, plants of economic value, and plants of special interest.

(3) Plants of certain geographic formations, such as desert plants alpine plants, marsh plants, aquatic plants etc.

(4) Weeds and methods of their control.

(5) Plants mentioned in classical and religious literature, state f1owers, national flowers and favourate flowers of the locality

4.4.1 HISTORY

From various reports the presence of various types of gardens was observed in and around the temples before the Christian era. The Romans, the Chinese the Persians have wonderful habit of cultivation of food and medicinal plants and plants of ornamental nature. This was the beginning of the establishment of gardens. After the Christian era, the use of medicinal plants increased many fold and cultivation of medicinal plants was taken up for curing diseases. The herbalists were honored as they were acquainted with numerous plants. Later, the importance of study of plants attracted numerous people and the necessity of establishing gardens for learning was felt and this led to the foundations of academic institutions and gardens. At 300 to 200 BC gardens have contributed to this science of Botany. Long before the dawn of history man grow plants in garden and in ancient India cultivation of food and Medicinal Plants stored 4000 to 2000 BC. In Mediterranean civilization gardens were prominent features of grounds of temples and religious places. The Hanging garden of Babylon is excellent example of this creation. The romans gathered plants from the conquered lands and grew them chiefly in Italy. Later on Chineses, Aztecs and Persian started gardening of ornamental and for perfume. During the middle age 600 - 1600 AD little attention paid to plants. In Seventeenth century the look *Garcia d'Orta's* on Medicinal plant in 1565 was translated to Latin. This attracted numerous visitors from Europe to India and cultivation of medicinal plants was taken up in various countries in 16^{th} century - numerous plants were grown in the garden. Botanic gardens then experienced a change in usage during the 16th and 17^{th} century. This was the age of exploration and the beginnings of international trade. Gardens such as the Royal Botanic Gardens, Kew and the Real Jardín Botánico de Madrid were set up to try and cultivate new species that were being brought back from expeditions to the tropics. Not only did these gardens promote and encourage botanical exploration in the tropics they also helped found new gardens in the tropical regions to help cultivate these newly discovered plant species. The British established Calcutta Botanic Gardens in 1787 while the French set up Pamplemousse Botanic Gardens in Mauritius in 1735 and the Real Jardín Botánico de Madrid established the botanic gardens of La Orotava on Tenerife. These tropical gardens were created almost solely to receive and cultivate

commercial crops such as cloves, tea, coffee, breadfruit, cinchona, palm oil as well as chocolate. It was during these times that Para rubber was introduced to Singapore, teak and tea to India and breadfruit, pepper and star fruit to the Caribbean. These tropical gardens could not strictly be called "Botanic Gardens" as there was no real scientific basis to their work and this almost led to their decline. Separate institutions and schools of agriculture were developed which meant that these 'cultivational' gardens were almost redundant. During the 19^{th} and 20^{th} century municipal and civic gardens were created throughout Europe and the British Commonwealth. Nearly all of these gardens were mainly pleasure gardens with very few of them having any scientific programmes. Missouri botanic garden is an exception to this and was the first botanic garden to be established in the United States of America in 1859. During this section of botanic garden history the only real scientific activities undertaken by gardens was the labeling of collections correctly and exchanging seeds on a worldwide basis. In the last 30 years botanic gardens have seen a revival as scientific institutions due to the emergence of the conservation movement. They are now seen as very important due to their existing collections and the scientific knowledge they posses in the propagation of plant species. Conservation is now seen in many gardens as their rasiond'etre. The beginning of this was seen in the 1970's when IUCN began encouraging ex situ conservation of threatened plants. There are now currently 1775 botanic gardens and arboreta in 148 countries around the world with many more under construction or being planned such as the first botanic garden in Oman which will be one of the largest gardens in the world once it is completed and will house the first large scale internal fog-forest in a huge glasshouse.

4.4.2 FUNCTIONS OF BOTANIC GARDEN

1. Provide basis for modern taxonomic studies, such as for comparison of morphological characters in the preserved and living specimens.
2. Provide adequate facilities for plant introduction and acclimatization work and thus are an important tool for promotion of economic plants.
3. Germplasm collections in botanical gardens act as basic material for hybridisation and improvement.
4. Botanical gardens, with their elaborate facilities of glass houses, green houses (and in some even phytotrons) provide shelter to many rare and endangered plant species of the world, which for various reasons are facing danger of extinction in their natural habitat. Thus gardens also help in conservation of the world flora.
5. Material for study and research for those plants which will not otherwise be available in that place or region.
6. Provides facilities for training in landscape, gardening, horticultural operations and other allied discipline.

7. Well established botanic gardens maintain exchange relations with other gardens of the world and thus distribute seeds, saplings and other propagules to far off places, some botanic gardens also bring out at regular intervals, lists of plants available for distribution and exchange. The term '*Index Seminum*' is often applied to such lists of seeds offered for exchange.
8. Botanic gardens remain important for their records of local flora and as basis for continued monographic work. According to Holttum (1970), it is essential basis for all other studies of plants. The gardens also provide facilities for collection of living plant material for bio systematic studies. Many of these gardens supply seeds and material for botanical investigation. Supply of seeds has been listed by Haywood (1964). The green houses, herbaria, library and research laboratory. The IABG (International Association of Botanic Gardens) was established in 1962. At present there are over 125 botanic gardens with such documented collections. This association has published the International Directory of Botanic Gardens (1963).
9. Botanic gardens are centers of recreation and aesthetic beauty.

4.4.3 SPECIAL KINDS OR SECTIONS OF GARDENS

a. Arboretum (Arboreta): Botanic gardens or parts of botanic gardens where the main collection are of woody species are called arboreta. Small areas in forests set aside for conserving arborescent species can serve the functions of Arboreta.

b. Pinetum (Pineta): Main collections are of conifers. One such pinetum is maintained of Indian botanical Garden, Calcutta.

c. Orchidarium (Orchidaria): Collections of orchids in a garden form an orchidarium. BSI established at Shillong and Coimbatore.

d. Bambusetum (Bambuseta): Main collections are of bamboos. A good Bambusetum maintained at Indian Botanic Garden, Calcutta.

A useful database cataloging of the world's botanic gardens can also be found at the Botanic Gardens Conservation International (BGCI) website. With over 800 participating botanical gardens, BGCI forms the world's largest network for plant conservation and environmental education.

4.4.4 IMPORTANT BOTANIC GARDENS OF THE WORLD

Australia	Botanic Gardens of the New South Wales, Sydney.
Argentina	Buenos Aires botanic garden.
Austria	Belvedere Schenbrunn. Vienna, Innsbruck.
Brazil	Rio-de-janeiro botanic garden.
Belgium	Meise botanic garden.
Canada	Montreal botanic garden.
England	Royal botanic gardens, Kew; Oxford, Cambridge.

France	Garden Das Plant, Les Cedres botanic gardens.
Germany	Munich, Berlin, Dahlem; Heidelberg, Hamburg.
Italy	Padua, Pisa, Palermo, Villatanto, botanic gardens
Ireland	Glasnevian botanic garden.
India	Indian botanic garden, Howrah; Lloyd botanic garden, Darjeeling; National botanic gardens, Lucknow.
Japan	Japan botanic garden.
Java	Bogor botanic garden, Buitenzong.
New Zealand	Christ Church botanic garden.
Netherlands	Leyden botanic garden.
Russia	Moscow, Kiev, Tashkent, Minsk, Yalta, botanic gardens.
South Africa	Kirstenbosch, Stellenbosch.
Singapore	Singapore botanic garden.
Sri Lanka	Paradeniya botanic garden
Scotland	Royal botanic garden, Edinburgh.
Scandinavia	Uppsala, Gateborz botanic gardens
United States	Arnold Arboratum of Harvard University, Brooklyn, Cambridge, Washington New York, Long Wood, Missouri, Strybing Arboratum, Huntington, Fairchild botanic gardens.
Uganda	Entebbe botanic garden.

Royal Botanic Gardens, Kew, England

In England, the famous Royal Botanic Gardens at Kew started as the private garden of Sir Henry Capel an enthusiastic horticulturist who died in 1696.

Arthur William Hill (Knighted in 1931), Sir Geoffrey Evans, Edward James Salisbury (Knighted in 1946) served the Kew Gardens as Directors. George Taylor is the present director of Kew. The present area of the Royal Botanic Gardens, Kew is about 300 acres and they are now under the Ministry of Agriculture, Fisheries and Food; although the Director has a wide degree of autonomy.

Among the more important publications of botanical research carried out at Kew are *Kew Bulletin, Index Kewensis.* Hooker's *lcones Plantarum* (with black and white drawings and detailed descriptions of the plants preserved at Kew), *Botanical Magazine* (consisting of coloured plants of living plants with descriptions) etc. in addition to papers in numerous scientific journals and to official publications. Complete books are also written and published on numerous botanical subjects.

Missouri Botanical Garden, St. Louis, Missouri, USA

The Missouri Botanical Garden is a botanical garden located in St. Louis, Missouri. It is also known informally as Shaw's Garden for founder Henry Shaw, a botanist and philanthropist.

Founded in 1859, the Missouri Botanical Garden is one of the oldest botanical institutions in the United States and a National Historic Landmark.

Botanical Garden of Curitiba Southern Brazil

The Jardim Botânico de Curitiba, in Portuguese, or the Botanical Garden of Curitiba, in English, is also known as the "Jardim Botânico Fanchette Rischbieter". This is a park located in the city of Curitiba, the capital of the state of Paraná, and the biggest city in southern Brazil. Opened in 1991.

Royal Botanic Gardens, Sydney

The Royal Botanic Gardens in Sydney, Australia, are the most central of the three major botanical gardens open to the public in Sydney. (The others are the Mount Annan Botanic Garden and the Mount Tomah Botanic Garden.) The Botanic Gardens were founded on this site by Governor Macquarie in 1816 as part of the Governor's Domain.

Royal Botanic Garden Edinburgh, Scotland

The Edinburgh botanic garden was founded in 1670 at St. Anne's Yard, near Holyrood Palace, by Dr. Robert Sibbald and Dr. Andrew Balfour. Nearly 36,000 plants are grown at the Botanics in Edinburgh or its three smaller satellite gardens located in other parts of Scotland.

Kirstenbosch National Botanical Garden, South Africa

Kirstenbosch is the name of a famous botanical garden nestled at the foot of Table Mountain in Cape Town. The garden is one of eight National Botanical Gardens covering five of South Africa's six different biomes.

Beijing Botanical Garden, China

The Beijing Botanical Garden is a botanical garden situated in the northwestern outskirts of Beijing, China between Xiangshan (Fragrant Hills) Park and Jade Spring Mountain in the Western Hills. The Beijing Botanical Garden was established in 1955.

Saint Petersburg Botanical Garden, Russia

The Saint Petersburg Botanical Garden, also known as the Botanic Gardens of the Komarov Botanical Institute or the Komarov Botanical Garden, is the oldest botanical garden in Russia.

Singapore Botanic Gardens

Singapore Botanic Gardens is a 63.7-hectare (157-acre) botanical garden in Singapore. It is half the size of the Royal Botanic Gardens in Kew or around one-fifth the size of Central Park in New York. It is the only botanic garden in the world that opens from 5 a.m. to 12 midnight every single day of the year.

4.4.5 BOTANICAL GARDENS IN INDIA

In India there are many Botanical Gardens that include many plants and trees. The Botanical Gardens preserve many indigenous plant species as well as many exotic examples of floral species. The Botanical gardens are places for research regarding plantation, cultivation and quality and quantity of fruits and flowers. It also organizes regular flower show.

Sl. No.	State/ Union territory	Name of the garden
1	Andaman & Nicobar	Andaman-Nicobar Experimental Garden (BSI)
2	Andhra Pradesh	Osmania University Botanic Garden
3	Arunchal Pradesh	Cheesa Botanic Garden, Itanager
4	Assam	Guwahati University Botanic Garden
5	Bihar	Bhagalpur University Botanical Garden, Post Graduate, Magadh University Botanical Garden, Jubilee Park Telco Garden and Nursery
6	Chandigarh	P. N. Mehra Botanical Gardens, Department of Botany, Panjab University
7	Delhi	National Bureau of Plant Genetic Resources Botanical Garden Delhi University Botanical Garden
8	Gujarat	The Retreat Botanical Garden of Sarabhai Foundation, Gujarat University, Ahemdabad; Gujarat Agricultural University Botanic Garden, Anand; Department of Agricultural Botany Botanical Garden, Junagadh Saurashtra University Experimental Garden, Rajkot South Gujarat University Botanical Garden, Surat Maharaja Sayajirao University Botanical Gardens, Vadodara Waghai-Dangs Botanical Gardens, Waghai-Dangs
9	Himachal Pradesh	Forestry Arboretum, Dhaulakuan Department of Forestry Arboretum, Manali Dhauladhar Botanical Gardens and Arboretum, Palampur Botanical Garden and Arboretum, Solan
10	Jammu & Kashmir	University of Jammu Botanic Garden.Regional Herbarium and Botanic Garden Kashmir University Botany Garden Shalimar Gardens Nishat Bagh Chashma-E-Shahi
11	Karnataka	Indian Institute of Horticultural Research, Bangalore Ethno -Medicinal Garden, near Bangalore The Botanical Garden, Gandhi Krishi Vignana Kendra, Bangalore Sri Chamarajendra Park (formerly Cubbon Park), Banglore Lalbagh Botanical Garden, Banglore Karnataka University Botany Garden, Dharward Pampavana Garden, Munirabad Brindavan Gardens, Mysore University of Mysore Botanic Garden Curzon Park, Mysore Nishat Baugh, Mysore Forest Research Centre Botanic Garden, Sirai Taluka Gandhi Park, Sirai Taluka
12	Kerala	Calicut University Botanical Garden, Calicut

		Narayana Gurukula Botanical Sanctuary, North Wayanad Nelliyampathi Hills Conservation Society, Padagiri AVREFA Herbal Garden, Palghat Kerala University Botanic Garden,Thiruvanantha-puram Tropical Botanic Garden and Research Institute, Thiruvananthapuram Government Botanic Gardens, Thiruvanantha-puram Botanic Garden, Kerala Forest Research Institute, Thrissur
13	Madhya Pradesh	Tropical Forest Research Institute, Jabalpur Ravi Sankar University Botanical Garden, Raipur Botanical Garden, Dr H.S. Gour Vishwavidyalaya, University of Sagar Vikram University Botanic Garden, Ujjain
14	Maharashtra	Marathwada University Botanic Garden, Aurangabad Veermata Jijabai Bhosle Udyan and Pranisangrahalaya Institute of Sciences Botanical Garden, Bhabha Atomic Research Centre, Mumbai Satpuda Botanic Garden, College of Agriculture, Nagpur BSI Experimental Botanical Gardens, Pune
15	Manipur	Manipur University Botanic Garden
16	Meghalaya	National Orchidarium and Botanic Garden Forestry Department Botanic Garden
17	Orissa	State Botanical Garden, Orissa, Baranga Utkal University Botanic Garden Regional Plant Resources Centre Bhubaneswar
18	Pondicherry	The Pondicherry Botanical Garden
19	Punjab	Botanical Garden Guru Nanak Dev University Ram Bagh Garden, Amritsar Punjabi University Botanic Gardens Chotti Baradari Gardens, Patiala
20	Rajasthan	University of Rajasthan Botanic Garden, Jaipur Desert Botanic Garden, Cazri, Jodhpur BSI Arid Zone Botanic Garden, Jodhpur Ganga Niwas Garden, Jodhpur Mandore Garden, Jodhpur Nehru Park and Umaid Garden, Jodhpur
21	Sikkim	Rhododendron Arboretum, Gangatok Jawaharlal Nehru Botanic Garden
22	Tamil Nadu	Agri-Horticultural Society, Chennai Entomology Research Institute, Chennai University of Madras Botanic Garden, Chennai Tamil Nadu Agricultural University Botanic Garden (BSI), Institute of Forest Genetics & Tree Breeding, Coimbatore Sim's Park Coonoor, Coonoor Pomological Station, Coonoor State Horticultural Farm, Coonoor State Horticultural Farm, Kallar The Bryant Park, Kodaikanal Auroville Botanic Garden, Kottakuppam Madurai Kamraj University Botanic Garden, Madurai Government Botanic Gardens, Udhagamandalam, Nilgiris

		St. Xavier's College Botanic Garden, Palayamkottai The Anglade Institute of Natural History, Shembaganur, Thirumala The Rapinat Herbarium, Tiruchirapalli Botanic Gardens, Center for Biodiversity and Biotechnology, Research Department of Botany, St. Xavier's College, Tirunelveli
23	Uttarakhand	Government Gardens G.BPIHED, Almora Forest Research Institute and College Botanical Garden, Dehradun Experimental Gardens Dehradun (BSI), Dehradun G..B.Pant Botanical Garden, G.B.P.U. A & T, Pantnagar BSI Experimental Garden Mughal Garden, Pauri Himalayan Botanic Garden, Nainital Prof. Y.P.S.Pangtey, Botanic Garden, DSB Campus, Kumaun University, Nainital Governor House Botanical Garden, Nainital
24	Uttar Pradesh	Agra College Botanical Garden, Agra Botanical Survey of India Experimental Garden, Allahabad Kulbhaskar Ashram Post Graduate College Botanic Garden, Allahabad Roxburgh Botanic Garden, Allahabad Motilal Nehru Park, Allahabad Aligarh Muslim University Botanic Garden, Aligarh BHEL Garden Complex, BHEL Dept. of Botany & Botanic Garden, Chitrakut National Botanical Research Institute, Lucknow Botanic Garden of the Central Drug Research Institute, Lucknow Meerut University Botanical Garden, Meerut Botanic Garden of Indian Republic, Noida Indira Gandhi Memorial Botanical Garden, Rae Bareli Horticultural Experiment and Training Centre, Saharanpur Banaras Hindu University Botanic Garden, Varanasi
25	West Bengal	Jawahar Kunj Garden, Barrackpore Botanic Garden, Ravindra Bharti University, Bolpur Burdwan University Botanic Garden, Burdwan Narendra Narayan Park and Botanic Garden Botanic Garden of Bidhan Chandra Krishi Viswavidyalaya, Cooch Behar Lloyd Botanic Garden, Darjeeling Botanic Garden Padmaja Naidu Himalayan Zoological Park, Darjeeling Indian Botanic Garden, Kolkata Eden Gardens, Kolkata The Agri-Horticultural Society of India, Kolkata University of Calcutta Experimental cum Botanic Garden, Kolkata The Assembly House, Kolkata Bidhan Sishu Udyan, Kolkata Deshbandhu Park, Kolkata Jatindra Mohan Park, Kolkata Jheel Meel Safari Park, Kolkata Raj Bhavan Garden, Kolkata Victoria Memorial Garden, Kolkata State Horticultural Research Station, Krishna Nagar Uttarayan Complex and Gardens, Santiniketan

National Botanic Gardens, Lucknow, India

The site of the National Botanic Gardens is popularly known to the public of Lucknow as Sikander Bagh. There is an old garden situated at the south-eastern corner of the present National Botanic Gardens. It was built by Nawab Saadat Ali Khan (1789-1814). The present National Botanic Gardens with K.N. Kaul as its director is spread over about 75 acres on the south bank of the river Gomti.

Indian Botanic Garden, Howrah

Indian Botanic Garden is established in 1787 by Lieutenant Colonel Robert Kyd, this garden is situated on the west bank of the river Hooghly (Ganga). The garden covers an area of 273 acres. Its unique landscape design initiated by Sir George King in 1872 is considered to be one of the best in the botanic gardens of the world with undulated land surfaces, artificial lakes and moats interconnected with underground pipes receiving water from the river Hooghly.

The garden was known as East India Company's Garden or the 'Company Bagan' or Calcutta Garden and later as the Royal Botanic Garden which after independence was renamed as the 'Indian Botanic Garden' in 1950. It came under the management of the Botanical Survey of India on January 1, 1963. Over 12,000 trees and shrubs belonging to 1400 species together with thousands of herbaceous plants are in cultivation in the open in 25 Divisions, Glass houses, Green Houses and conservatories. The garden maintains the germplasm collection of Bamboos, *Bougainvillea, Citrus, Jasmine, Pandanus, Water Lilies* and has the richest collection of Palms (about 109 species) in whole of South East Asia. In addition succulents, *Hibiscus, Ficus*, Aromatic plants, Gymnosperms (in two Pinetums), Creepers, Ferns and a number of floricultural and arboricultural plants are grown in its Flower Garden, National Orchidarium, Student Garden. Besides a large number of medicinal plants in its Medicinal Plant Garden named as 'Charak Udyan' enrich the garden. A few interesting plants of the garden worth to mention are Branched Palm, Bread Fruit Tree, Double Coconut, Giant Water Lilies, Krishnabot , Mad tree, Shivalinga tree, etc. In addition researches are also conducted on plant introduction, multiplication, horticultural aspects and conservation. The Great Banyan Tree (*Ficus bengalensis* L.) of the Indian Botanic Garden attracts millions of visitors every year. It looks like a miniature forest and is over 250 years old with 2800 prop roots covering an area of 1.5 hectares. The large palm house of this garden has several interesting plants including the Double Coconut *(Lodoiceamaldivica)* which produces the largest known seeds in the whole plant kingdom.

Lloyd's Botanical Garden

Lloyd's Botanical Garden is a 'one of its kinds' botanical garden in the Darjeeling city of West Bengal. In 1878 William Lloyd donated a piece of beautiful land with an area about 40 acres which was developed as a branch establishment of the Royal Botanic Garden Calcutta.

4.5 BOTANICAL SURVEY OF INDIA (BSI)

The Botanical Survey of India is a government organization, which function is to explore the plant resources of the country by systematic surveys. It secures accurate and detailed information regarding the occurrence, distribution ecology and economic utility of plants in the Indian Union for the benefits of science and people working in the universities and other academic institutions. It collects, identifies and distributes plant materials that may be of in service of education and research.

4.5.1 HISTORY

The Botanical Survey of India was established in 1890 and reorganised in 1954. India being such a vast country with great variations in its geographical features and exhibits a variety of flora and forest types within a confine area for which there is perhaps no similar example in another country of the world. From early historic times, the vegetable resources of India attracted people all over the world, the ancient Egypt first established a trade with India for the luxuries obtained from vegetable and other sources. The Arabs, the Turks, the Portuguese, the Dutch, the French and finally the English started trade with India. In order to have trade connections with India, the British East India Company was formed by British people and its charter was signed by Queen Elizabeth in the year 1599. Later on as the English Traders became the Rulers, they attached more importance on the utilization and scientific management of the forest wealth in India and established an institution for the survey of the enormous botanical resources in the country (India).

Towards the 18th century there was a wide-spread interest in the botanical collections in India and large number of people including missionaries, medical men, servant of Hon'ble East India Company and the Government of Madras, Bombay and Bengal were all actively engaged probing into different forest areas and making valuable collections. More important amongst them were Koenig, Roxburg, Heyne, Wight, Campbell, Klein, Rottler, Gibson etc. Arrangements were also made to transfer the collection of Linneaus, Sir Joseph Banks, Hooker and from time-to-time to the India House, Linnean Society and some more places. Along with such botanical enterprises, horticulture also assumed importance and new botanical gardens were set up in order to introduce and cultivate exotic plants at several important centres. In 1857, the Hon'ble East India Company set up a garden at Sibpur, Calcutta with 350 acres of land allotted to it. Simultaneously, other similar gardens were also set up at Bombay, Saharanpur, Madras and some other places. Each such garden had its own herbarium. Thus help in the study of vegetable, forest flora taxonomy with medicine in the practices of Horticulture and in Forest utilization and conservation. These efforts are based on single efforts. The real effort to create a central survey for a coordinated activity for a detailed study of the flora of the country came after the government of the country passed from the Hon'ble East India Company to the Crown in 1858.

4.5.2 ORGANISATION AND SET UP

Around the ultimate quarter of the 19th century, there has been a decline in efficiency and standard in respect of the botanical work done in the Gardens, set up by the local Governments of Bengal, Bombay, NW Provinces and Madras at Sibpur, Poona, Saharanpur, and Madras. It was thus decided by the Government of India that a central organisation for the Botanic work be set up. JF Duthie who was then the Superintendent of the Gardens at Saharanpur be disassociated from the Gardens, to North Western Provinces, to enable him to undertake the explorations in North Western Provinces with the co-ordination of the Botanical work of the country through a central organisation. This proved useful, and the scheme for the organisation of a survey having met with the approval of secretary of state for India in July 1887, the survey was formally constituted on 13th February 1890 under the designation 'Botanical Survey of India'. Its main functions were laid down as -

(1) To explore the vegetable resources of the Indian Empire.

(2) To co-ordinate the botanical work of other indifferent parts of India.

The country was divided for the purposes of the Survey into four Botanical regions viz. the East, North, West and South with Lt. Colonel Sir George King as Director of BSI. Thus survey started work without its own staff and with a co-ordination among four zones. This did not work satisfactorily and links was disconnected. In 1901 government of India appointed Dr. E. J. Butler as Cryptogamic Botanist and he was attached to BSI but disassociated himself in 1902. In 1911 with the amagamation of the Industrial Section the BSI was under the Superintendent of Royal Botanic Gardens.

Regional Floras Influence

Before the formation of the Botanical Survey of India in 1890 there has been a large number of contributions were made by various workers on the floras of many local areas. More important amongst them were:-

(1) Flora of Upper Assam by Griffth (1836)

(2) Naga Hill flora by Masters (1844)

(3) Banda District flora by Edgeworth (1852)

(4) Moulmein Flora by Parish (1859)

(5) Bihar and Lucknow flora by Anderson (1893)

(6) Burmese flora by Kurz (1863)

(7) Jhelum flora by Stewart (1881)

(8) Darjeeling flora by Gamble (1875-76)

(9) Jeypore flora by Beddome (1879)

(10) North Western and Central India flora by Stewart and Brandis (1874).

(11) Rajputana vegetation by King (1878) etc.

A direct and positive influence is to be seen in the compilation of the flora of Upper Gangetic Plains by Duthie and the Flora of Bombay by Cooke. There had been similar other projects under the survey e.g. the Flora of British India by J. D. Hooker was also made.

There were some other factors which had affected the progress of survey are the starting of Forest Research Institute and Indian Institute of Agriculture Research.

Botanical Survey of India (Between 1937 - 1952)

Mr. C. C. Calder was the last incumbent to the post of the Director, BSI. In 1936 the govt. of India sanctioned the post of Superintendent for four zone instead of Director BSI. The state of affairs of the survey from 1930 onwards was in process of deterioration and disintegration. After the Second World War and on the achievement of Independence by India there social and economic aspirations of the free India aroses which provided the opportunity for scientific advancement and economic developments. In 1952-53 when the Botanical Survey was to be reorganized, it consisted of the Industrial Section, Indian Museum and Systematic Division, Indian Botanic Gardens.

Reorganization of Botanical Survey of India

Dr. E. K. Janaki Ammal was appointed OSD on 14 Oct. 1952 of BSI. On 29 March 1954 the sanction permitted the formation of the following organizations -

1. A Head quarters establishment under a Chief botanist at Calcutta. This was meant for controlling and coordinating the activities of the various units of BSI and for implementing the policy laid down by the Govt. of India.
2. Four regional circles based on Phyto-geographical affinities namely - Eastern, Western, Northern and Southern Circles with their headquarters at Shillong, Poona, Dehradun and Coimbatore respectively under a Regional Botanist. Each Regional Botanist will be responsible for the survey of its area and utilise the facilities provided by the states and the universities.
3. A Central Botanical Laboratory under a Director at a suitable place in UP where the living plant shall be studied in relation to its botany and utility to the nation.
4. A National Herbarium which will house the type specimens and fully representative collection of the plants comprising the flora of the country.
5. Maintenance of a Botanical Museum on modern lines at Calcutta.

In the reorganized survey it was decided that the Botanical Survey will collaborate with the Universities and the Research Centres in the country and encourage research students in the universities and other research centres to take up problems relating to Indian flora.

Five Year Plans launched in respect of various projects in the country. Some progress has been made during the second and third Five Year Plan periods with the establishment of Regional circles and herbaria at Dehradun, Coimbatore, Allahabad, Poona and Shillong.

Father H. Santapau, S. J. was appointed as Chief botanist on 1st Dec. 1954. On 1955 Dr. J. C. Sen Gupta took over as Chief Botanist. Later on in 1961 H. Santapau took over again as Chief Botanist BSI. The designation of Chief Botanist was changed to Director BSI. On retirement of Father Santapau, Dr. K. Subramanium became the Director and after Subramanium, Dr. S. K. Mukerji, Dr. M. P. Nayar and now Dr. M. Sanjappa.

Setting up of Four Regional Circles

1. **Southern Circle:** This was the first to be setup on 10 Oct., 1955 at Coimbator with its jurisdiction as Madras, AP, Hyderabad, major part of M.P. and old Vindhya Pradesh, Andaman and Nicobar Islands.
2. **Eastern Circle:** It followed the Souther circle and was set up on 10 Dec., 1955 at Shillong with its jurisdiction as Orissa, Bihar, W.B., Assam, Bhutan, Sikkim, NEFA, Tripura and Manipur.
3. **Western Circle:** It followed the Eastern Circle and was set up on the 17 Dec., 1955 at Poona with its jurisdiction as states of Rajasthan, Cutch, Saurashta, Bombay, Mysore, Kerala, part of M.P., Madras.
4. **Northern Circle :** It start functioning at Calcutta on 21 March, 1956 and on 1st Aug., 1956 its Head quarters was shifted to Dehradun with its jurisdiction as Jammu & Kashmir, Punjab, Himachal Pradesh, UP and Delhi.

Principal Local Herbaria transferred to BSI

Since herbaria are most important for all the work connected with the survey of the flora, the important herbaria hitherto with the state Governments were transferred to BSI. The Herbarium of the Forest Department of Assam Govt., the herbarium of the Economic botanist to the Govt. of Bombay, the herbarium at Sibpur Botanical Gardens Govt. of West Bengal, the Madras herbarium at the Agriculture College and Research Institute Govt. of Madras was transferred to their respective zonal BSI circle.

There was, however, no transfer of any herbarium of the Northern Circle, since the necessary facilities of the herbarium existed at the Herbarium of the Forest Research Institute at Dehradun. Apart from the transfer of herbaria, books and publications were also transferred in some cases.

Reprinting of old standard Floras

Flora helps in teaching and systematic botany. A number of floras e.g. Flora of Madras Presidency by Gamble and Fisher, Flora of Bombay Presidency by Cooke, Flora of Upper

Gangetic Plains by Duthie, Botany of Bihar and Orissa by Haines and Bengal Plants by Prain has been reprinted.

4.5.3 SETUP OF BSI

For scientific and executive functions of the survey, a Central botanical Laboratory under a Director of the laboratory, a Botanical Museum under a Curator, a Central National Herbarium under a keeper and four regional circles each under a Regional Botanist have been established.

Further progress has been made to the establishment of the experimental Gardens for working out various aspects of botany and usefulness of plants at Shillong, Poona and Yercaud (Shevroy hills). The Central National Herbarium which has at present a collection of about 6.5 lakh specimens is now engaged in making monographic studies of the families included in the first volume of the Hooker's Flora of British India.

Apart from the normal activities of the Botanical Survey of India, the department also works in collaboration with the following schemes and organisations in carrying out various research projects and programmes.

1. CIMAP (Central Indian Medicinal Plants Organisation) CSIR setup this organisation as BSI co-ordinator of research.
2. Schemes sponsored by UNESCO on Ecological problems.
3. Monographs and Research Schemes.
4. Tea research under the Tea Board.
5. Indian Council of Ecological Research (ICER)
6. Setting up of National Orchidarium
7. Setting up of Cryptogamic and other collections and laboratories.
8. Studies on Economic and Medicinal plants.
9. A new circle for MP and on Arid Zone Research Centre in Rajasthan.
10. Special studies on Marine Plants.
11. Special studies on Fresh Water Plants.
12. Experimental Gardens in different climatic regions.

A Scientific Programme Implementation and Evaluation Committee (SPIEC) advises the Government on the research programmes of the Survey and periodically evaluates it's functioning. The main objectives or functions of the survey can be summarized as below:

1. Exploration of unexplored and underexplored regions for new plant resources.
2. Preparation of floras at the local, district, region and national levels.
3. Floristic and taxonomic researches.

4. Preservation of types and other authentic specimens by establishing herbaria (herbarium) and musea (museum) and exchange of plant specimens in India and abroad.
5. Maintaining germplasm of economic, rare and interesting plants for conservation and education.
6. Study of phytogeography and ecological changes in the flora and vegetation.
7. Investigation to floras and habitats for conservation of ecosystems.
8. Advising the Government on all matter relating to the utilization and conservation of natural plant research of the country.

The Head office of Botanical Survey of India is at Calcutta (P.O. Botanic Garden, Howrah-3) and for the purpose of extensive exploration and study, several regional circles have been established in different parts of the country. They are as follows :-

(a) Northern Circle (at Dehradun) - This circle was established in 1956 and now covers Kashmir, Punjab, Delhi and parts of Uttar Pradesh. It has an experimental garden at Pauri, about 130 kms. from Dehradun.

(b) Eastern Circle (at Shillong) - This circle was established in 1956 and now covers Assam, Meghalaya, Manipur, Tripura, Mizoram and Nagaland. It has a National Orchidarium and experimental garden at Barapani about 18 kms north of Shillong. The herbarium of the Forest Department of Assam was transferred to this office.

(c) Southern Circle (at Coimbatore) - This circle was established in 1956 and now covers Tamil Nadu, Kerala and parts of Karnataka. The National Orchidarium of Yercaud in Shevory hills is under this circle. The old Madras herbarium was transferred to this office.

(d) Western Circle (at Poona) - This circle was established in 1956 and now covers Maharashtra, parts of Karnataka and Andhra Pradesh. The old herbarium based on Corkels collections and Talbot's collections was transferred to this office.

(e) Central Circle (at Allahabad) - This circle was established in 1962 and covers Madhya Pradesh and Southern parts of Uttar Pradesh.

(f) Arid Zone Circle (at Jodhpur) - This circle was established in 1972 and covers Rajasthan, Gujrat and Haryana.

(g) Andman and Nicobar Circle (at Port Blair) - This circle was also established in 1972 for the survey of Andman and Nicobar Islands.

(h) Arunachal Pradesh Circle (at Itanagar) - This circle was established in 1977 to explore the flora of Arunachal Pradesh.

(i) Sikkim Himalaya Circle (at Gangtok) - This circle was established in 1979 to collect and study the flora of Sikkim.

(j) Deccan Circle (at Hyderabad) - This circle is established in 1984.

(k) High Altitude Circle (at Jalan) - This circle also established in 1984.

The states of Bihar, Orissa and Bengal are explored by the Central National Herbarium Calcutta.

The Headquarters of the Botanical Survey of India is located in the Indian botanic Garden. The Headquarters Organization consists of the following sections – such as :- Ecology, Cryptogamic botany, Plant chemistry, Pharmacognosy, Pathology and publications, in addition to the administrative section. The Central botanical Laboratory consists of the Economic Botany, Plant Physiology, Biochemistry and genetic sections. In addition to all these units in India, the survey maintains a liaison officer (Botanist) at Royal Botanic Garden, kew, London, whose duty is to supply information on taxonomical problems to workers all over India in the Botanical Survey as well as in other Institutions. The Survey also maintains liaison with other Research Institutions of the country is Council of Scientific and Industrial Research (CSIR), Indian Council of Agricultural Research (ICAR), Indian Council of Medical Research (ICMR) and universities.

4.5.4 ACTIVITIES OF THE BOTANICAL SURVEY OF INDIA

1. Presently the Survey's main programme is to bring out a flora of India. For this purpose, the accounts of different families are being prepared by various experts on the concerned groups. Accounts of families have also been allotted also to the universities and other research workers. Many family accounts have already been worked out and have been published.
2. Monographs and Revisions - Monographic work is also being undertaken on certain families and genera.
3. Apart from the surveys of higher plants, the Botanical Survey of India has also undertaken work on cryptogams.
4. Supplementary laboratories of researches on cytotaxonomy, anatomy, phytochemistry, palynology, biosystematics and ecology are also part of the present day work of the survey.
5. The Survey has a separate herbarium and museums for extensive study of economic and medicinal plants.
6. The Survey has also undertaken studies on ethnobotany and conservation of rare and endangered plants.
7. The Survey has instituted a number of scholarships for work on flora of India. The scholarships are available at various offices of the Survey as well as in some universities.
8. The Survey researches on almost all branches of Botany and information on every aspect of plant life is furnished to research workers and interested public. Seedlings and plant materials are also distributed to other institutions, municipalities and persons interested in gardening.

Publication of the botanical Survey of India - The documentation of library unit provide bibliographic support in research activities.

(a) Reprinting of floras - Soon after the recognisation of Botanical Survey of India, many institution/universities started showing keen interest in plant collections and systematic studies. Many of the regional/local floras were out of print and were not readily available. Therefore, the Botanical Survey of India reprinted the old floras like - *Flora of Presidency of Madras* (by Gamble); *Flora of Presidency of Bombay* (by Cooke); *Flora of Upper Gangetic Plain* (by Duthie); *Botany of Bihar and Orissa* (by Haines); *Bengal Plants* (by Prain).

(b) The Publication Section projects the work of Survey through a quarterly Bulletin - *Bulletin of Botanical Survey of India*; *Records of Botanical Survey of India* and fascicles of Roxburghe Icones besides Annual Reports and News Letters.

It also publishes occasionally books on floristic or taxonomy such as - *Aquatic Angiosperms* (Subramanyam 1962), *Illustrations of West Himalayan Flowering Plants* (Rau 1963); *Flora of Rajasthan* (Puri et al., 1964); *Phytologia Indica* (Srinivasan 1969); *Flora of Punjab Plains* (Nair 1978); *Medicinal Plants* (Jain 1981) and many others.

Botanical collections and publications of the Survey have been used not only by Scientists of India but also monograph writers all over the world cited these research findings. The BSI after independence and reorganisation has been doing very important and useful service in regard to the study and research on the Indian flora both from systematic and Economic points of view.

Conclusion

During the IVth Five Year Plan it is proposed to further strengthen the activities of this organisation and establish a circle in the Andamans and a Botanic Garden at Delhi and for the high altitude areas in the Himalayas. The work of the survey of the country has been expedited and a map has been prepared showing the lacuna in our knowledge regarding areas unexplored or under explored so that the exploration work can be taken on a priority basis in such areas to improve our knowledge on plant wealth of the country.

4.5.5 PRESENT ORGANIZATIONAL SET-UP OF BSI

Director : Dr. Paramjeet Singh

Headquarters organisation

The administrative wing acts as the controlling centre of the survey located at Calcutta while the research wing consisting of Flora Division, Ecology Division, Cryptogamic Division, Pharmacognosy Division, Plant Chemistry Division, Publication Division, Documentation and Technical Information service located at Indian Botanical Garden Complex.

Unit Offices and Circles

1. Central National Herbarium (CAL) was started by William Roxburgh in 1793 and specially built in 1883 acts as the Central custodian of herbarium specimens including types (ca 15,00,000) and historical collections, exchanged material collected from all over the world and south East Asia in particular. The herbarium also maintain hand-coloured drawings, photonegatives and microfilm obtained from Kew and other renowned herbaria of the world.
2. The Indian Botanic Garden, Howrah is used for study, introduction and conservation of flora.
3. The Central Botanical Laboratory at Howrah conducts research on cytology and economic botany
4. The Botanical Museum (Industrial Section, Indian Museum, Calcutta) for popularising the role of plants in our lives.

Regional Circles

The Botanical survey of India has the following nine regional circles situated at different regions of the country.

a. Southern Circle, Coimbatore: Tamil nadu, Pondicherry, Kerala, Andhra Pradesh and Lakshadweep.

b. Western Circle, Pune : Karnataka, Maharashtra, Goa and the major parts of Gujarat excepting arid and semi-arid regions adjacent to Rajasthan.

c. Arid Zone Circle, Jodhpur : Rajasthan and Arid and semi-arid regions of Gujarat.

d. Northern Circle, Dehradun : North-western U.P., Haryana, Himachal Pradesh, Punjab and Jammu & Kashmir, Chandigarh and Delhi.

e. Central Circle, Allahabad : U.P. excepting the northern parts and Madhya Pradesh, Meghalaya, Assam, Nagaland, Mizoram, Manipur and Tripura.

f. Sikkim Himalayan Circle, Gangtok : Sikkim and Darjeeling District of West Bengal.

g. Arunachal Pradesh Circle, : Arunachal Pradesh

h. Andaman & Nicobar Circle, Port Blair : All the islands of Andaman & Nicobar group.

Experimental Gardens, Arboreta, Orchidaria & Gymnosperm Sanctuary

There are two National Orchidaria, three Experimental Gardens and one gymnosperm Sanctury. These are:

(i) National Orchidarium, Yercaud, Tamil nadu.

(ii) National orchidarium, Shillong, Meghalaya.

(iii) Mundhwa Botanic Garden, Pune, Maharashtra.

(iv) Dhanikhari Arboretum, Port Blair, Andaman and Nicobar Islands.

(v) Sankai wilderness area, Itanagar, Arunachal Pradesh

(vi) Gymnosperm Sanctuary, Pauri, Uttar Pradesh.

4.6 SUMMARY

In this unit preservation of plant material as herbarium and living plant collection (botanical garden) and Botanical Survey of India (BSI) were discussed. The science of herbarium started way back in the 16 century when Luca Ghini (1490-1556) developed the first herbarium. Important herbarium of India, World, Taxonomic literature, flora writing, flora utility, monograph were discussed under herbarium. Botanical gardens history, function, special kinds, important gardens were mentioned. In Botanical Survey of India(BSI), History, organizational set up, regional flora influence, reorganization, four regional centre, activities and present organizational setup of BSI were included.

4.7 GLOSSARY

Herbarium: Collection of pressed and dried plant specimen mounted on appropriate sheets arranged according to some known system of classification.

Flora: Plant occurring in a given regions with systematic study.

Monograph: Study of a taxon regardless of geographical occurrence.

Botanical garden: Well tended parks displaying a mid range of plants labeled with their botanical names.

Arboretum: Botanic garden with a main collection of wood.

Pinelum: Botanic garden with a collection of pines.

Orchidarium: Collection of orchids as botanic garden.

Bambuselum: Botanic garden with a main collection of bamboos.

BSI: Botanical Survey of India.

4.8 SELF ASSESSMENT QUESTIONS

4.8.1-Fill in the blanks:

(i) The process of herbarium started in the century …….

(ii) Largest herbarium of India is …….

(iii) Germplasm bank is also known as ……

(iv) Collection of woody plants is called ……

(v) CNH is situated at ……..

(vi) BSI stands for …….

(vii) Head quarter of Northern circle, BSI is ……

(viii) NBRI is situated at ……

4.8.1 Answer Key:

(i) 16 century, (ii) CNC, (iii) Botanical garden, (iv) Arboretum, (v) Howrah, (vi) Botanical Survey of India, (vii) Dehradun, (viii) Lucknow.

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4.11 TERMINAL QUESTIONS

4.11.1 Long Answer Type Questions

1- What is herbarium?

2- Describe botanical gardens in details.

3- Describe present setup of BSI.

4- Describe History of BSI.

BLOCK -2 FAMILIES

UNIT-5 RANUNCULACEAE, CARYOPHYLLACEAE AND RUTACEAE

Contents

5.1 OBJECTIVES

In the present unit students will be able -

- to become familiar with the general distribution, systematics, General characters, Important genera and economic importance etc. of families Ranunculaceae, Caryophyllaceae and Rutaceae.
- to know the phylogenetic and evolutionary relations of the families. Some of the important genera of the concerning families are also mentioned here to let you familiar with them.

5.2 INTRODUCTION

Student must be knowing different types of classification for angiospermic plants in your previous units. The classification used in Indian subcontinent is that proposed by Bentham and Hooker. They discussed 163 families under dicotyledons in their *Genera Plantarum*. Economic importance of each family is also discussed in some detail.

The dicotyledons include all those angiosperms in which the embryo possess two cotyledons, leaves with reticulate venation and vascular bundles are open and arranged in one or more rings. These plants have secondary thickenings in the stems due to the presence of the cambium. These plants may be either woody or herbaceous, having pentamerous flowers. They posses persistent primary root that develop into tap root.

Families Ranunculaceae, Caryophyllaceae and Rutaceae belong to Polypetalae (Petals are free and flower with Calyx and Corolla) group. Of them Family Ranunculaceae and Caryophyllacee belong to SeriesThalamiflorae (Polysepalous, petals hypogynous) while family Rutaceae belongs to Disciflorae (Thalamus expanded into a disc, ovary superior).

The members of the subclass Polypetalae contain flowers with free petals and their perianth is usually in two whorls i.e. calyx and corolla. Polypetalae have been divided into 3 series viz, Thalamiflorae, Disciflorae and Calyciflorae.

Series Thalamiflorae is characterized by (i) Usually distinct sepals free from ovary (ii) presence of many stamens (iii) Hypogynous flowers (iv) superior ovary and (v) Absence of disc . Thalamiflorae includes 6 cohorts (= orders) and 34 orders (= families)

Series Disciflorae is characterized by (i) distinct or united sepals free or adnate to ovary (ii) stamens hypogynous, usually definite flowers (iv)superior ovary and (v) presence of disc. Disciflorae includes 4 cohorts (= orders) and 23 orders (= families)

Series Calyciflorae is charactrised by (i) Usually inferior ovary (ii) united or usually free sepals and flowers perigynous or epigynous. It includes 5 cohorts (= orders) and 27 orders (= families)

Table 5.1 Generalized Systematic position of families mentioned in your syllabi

	Dicotyledons					**Monocotyledons**
Subclass	**Polypetalae**			**Gamopetalae**		
Series	Thalamiflorae	Disciflorae	Calyciflorae	Inferae	Bicarpellatae	
Families	Ranunculaceae, Caryophyllaceae	Rutaceae	Rosaceae Fabaceae		Asclepediaceae Solanaceae Lamiaceae	Orcidaceae Liliaceae Poaceae

5.3 FAMILY: RANUNCULACEAE

Bentham & Hooker included family Ranunculaceae under Ranales, one of the 8 orders (families). It is commonly known as **Buttercup family**. According to Dr John David, (2010) the Ranuculaceae are combined with the Eupteleaceae, Lardizabalaceae, Menispermaceae, Berberidaceae, and Papaveraceae in the Ranunculales, the only order in the superorder Ranunculanae. This follows the work of the Angiosperm Phylogeny Group.

Takhtajan 1997 includes the Ranunculaceae as the only family in the Ranunculales which he placed in a subclass, the Ranunculidae, instead of a superorder. Previously, Thorn 1992 placed the Ranunculaceae in the Berberidales, an order within the Superorder Magnolianae. Earlier Cronquist in 1981 included the Ranunculaceae along with seven other families in the Rancunculales which was included in the Magnoliidae, which he regarded as a subclass.

Diagnostic characteristics - Herbaceous, leaves palmately divided, flowers with many stamens, gynoecium of many simple pistils, fruit an aggregate of achenes or follicles.

Distribution pattern

It is a large family and includes 50 genera and 1900 species. It is mostly distributed in the temperate regions of the Northern Hemisphere. In India this family is represented by 20 genera and 165 species, mostly confined to the Himalayan region of Pakistan and India.

5.3.1 Systematics

Bentham & Hooker	**Engler & Prantl**	**Hutchinson**
Dicotyledons	Dicotyledoneae	Dicotyledons
Polypetalae	Archichlamydeae	Herbaceae
Thalamiflorae	Ranales	Ranales

Ranales	Ranunculaceae	Ranunculaceae
Ranunculaceae		

5.3.2 General Characteristics

Habit: Annual or perennial herbs, rarely shrubs or vines (*Clematis*). Some species are aquatic herbs (*Rannunculas aquatilis*). The perennial species usually develop rhizome and tuberous root (*Aconitum* and *Ranunculus*)

Roots: Tap as well as adventitious root, Tuberous root (*Aconitum)*

Stem: Herbaceous (*Rannunculas*), woody (*Paeonia*) or climbing (*Clematis*) stem, develops rhizome

Leaves: Usually basal and cauline, Petiolate. Usually exstipulate but stipulate in *Ranunculus* Alternate rarely opposite (*Clematis*). Simple, pinnately compound (*Clematis*), decompound (*Thalictrum*) some aquatic species show heterotrophy, reticulate venation. The leaves are modified into tendrils in *Clematis aphylla* and photosynthesis is carried out by the stem.

Inflorescence: Inflorescence is variable. Dichasial Cyme (*Rannunculas sp.*), sometimes raceme (*Aconitum*), axillary (*Clematis*), solitary and terminal (*Nigella*)

Flower: Pedicillate, ebracteate rarely bractate, hermaphrodite, unisexual in *Thalictrum* actinomorphic (*Rannunculas sp.*) rarely zygomorphic (*Delphium*), hypogynous, complete, pentamerous, Regular.The floral parts are arranged spirally on the elongated receptacle. An involucres of leaves is present outside the calyx.

Calyx: Sepals 5-8 which are distinct and usually deciduous, free, In Delphinium and *Aconitum* the sepals are petaloid and the posterior sepal is spurred. Aestivation is imbricate

Corolla: 5 or more petals or sometimes petals may be absent, polypetalous, variously colored, Sometimes, petals are changed into nectaries, In *Delphinium* the posterior pair of petals forms spur which projects into the spur of the sepal, another pair of the petal if present is very much reduced (*Aconitum*). In *Clematis* petals are altogether absent and sepals become petaloid.

Androecium: Stamens are numerous, polyandrous. Spirally arranged on the thalamus, In some genera (*Nigella* ansd *Aquilegia*) the stamens are arranged in definite rings, anthers adnate, dithecous, extrose, dehiscing longitudinally.

Gynoecium: Numerous free carpels (Polycarpellary) arranged spirally on a distinct thalamus (one to three carpels in *Delphinium*), apocarpous rarely syncarpous (*Nigella*), ovary superior, one to several ovules in each ovary. Placentation basal or marginal.style and stigma one.

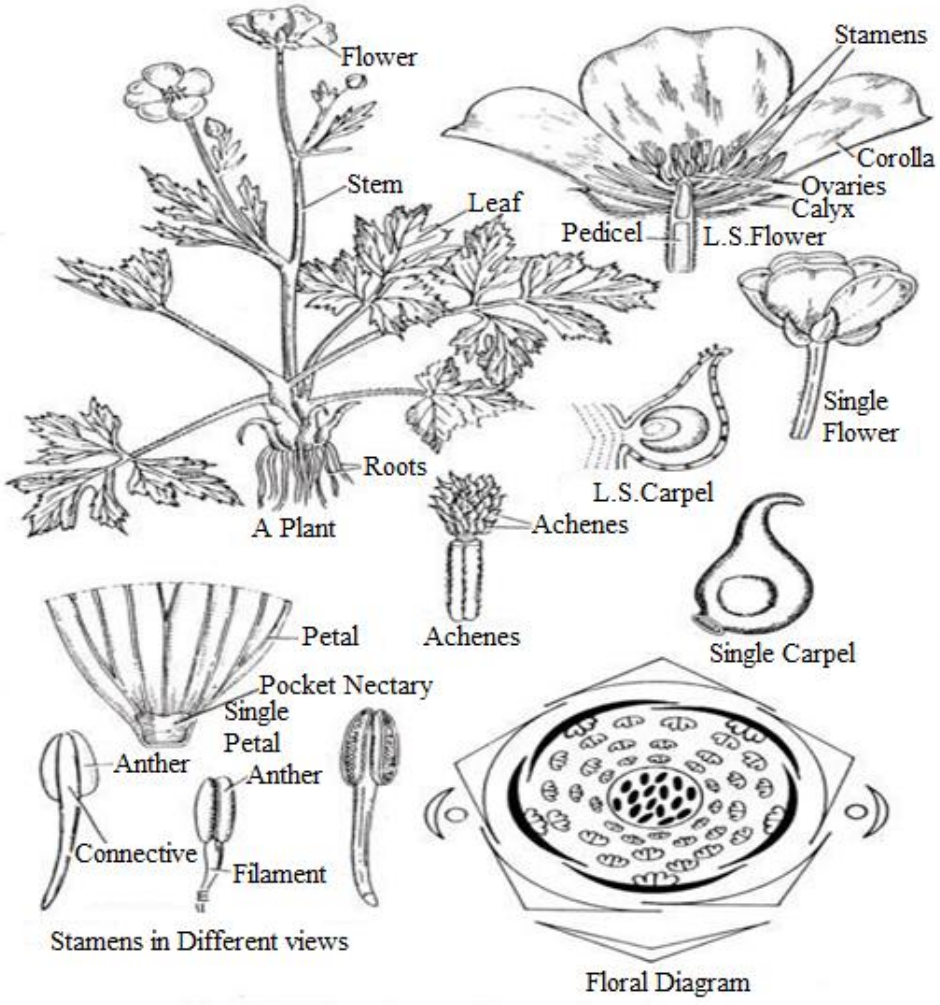

Fig. 5.1 ***Ranunculus sceleratus***

Fruits: An etaerio of achenes or follicles**,** sometimes berry or capsule.

Seed: Small**,** endospermic seed

Pollination: Generally entomophilous

Floral formula

Ranunculus	**Br**	Brl	⊕	♂♀	$K_5\ C_5\ A\alpha\ \underline{G}\alpha$
Delphinium	**Br**	Brl	⊕	♂♀	$K_5\ C_4\ A_{15}\ \underline{G}_1$

Nigella	**Ebr**		⊕	♂♀	$K_5\ C_0\ A\ \alpha\ \underline{G}_{(5\text{-}12)}$
Clematis	**Br**	Brl	⊕	♂♀	$K_5\ C_5\ A\alpha\ \underline{G}\alpha$

5.3.3. Important Genera

The familiar examples of the family are *Delphinium* (Larkspur) *Thalictrum* (Meadow-rue) *Ranunculus* (Butter-cup), *Nigella* (Kala-jeera), *Anemone* (Wind flower), *Aconitum* (Aconite)

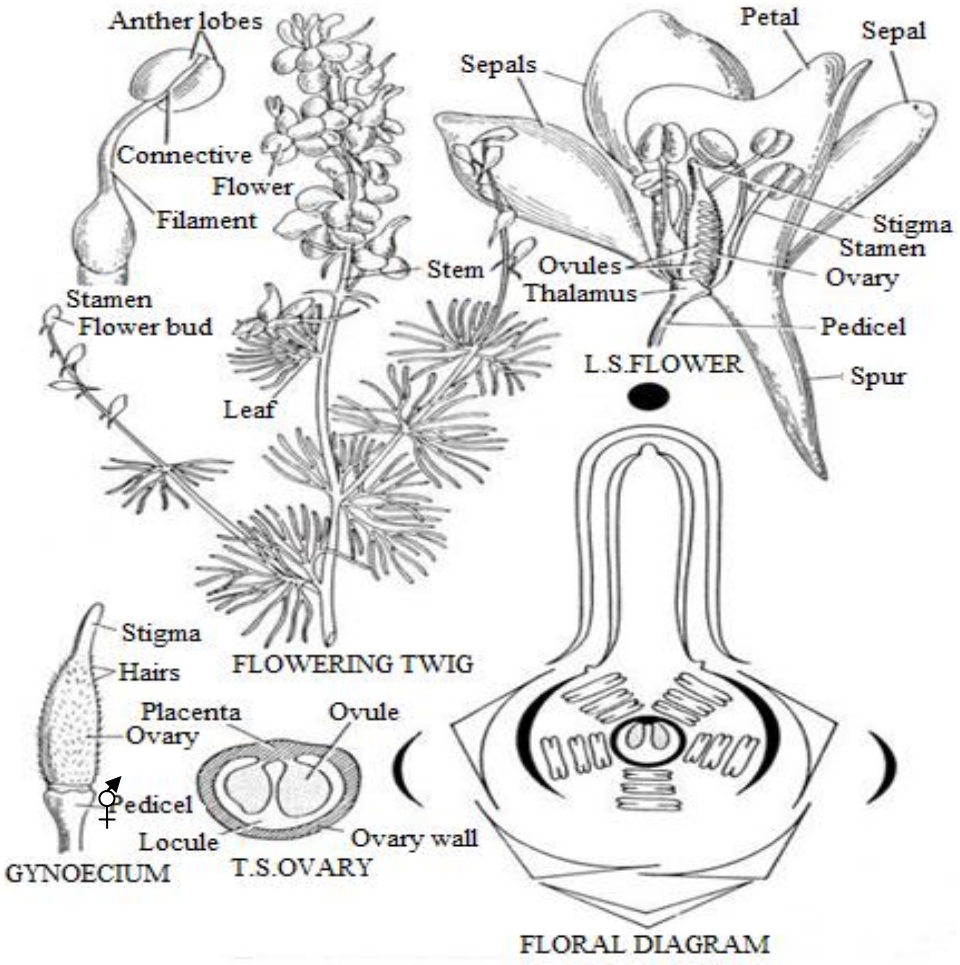

Fig. 5.2 ***Delphinium ajacis***

5.3.4 Economic importance

1-Ornamental plants: Most plants are cultivated for their beautiful flowers like *Ranunculus* (Buttercup), *Thalictrum, Clematis etc*.

2-Medicinal plants: Some members are used as medicinal plants. *Aconitum napellus* yields an alkaloid **aconite used for rheumatism and as nerve sedative.** *Thallicirom* yields **mamira.** It is used in the treatment of ophthalmia. Some species of *Clematis* are used as a remedy for leprosy and blood diseases. Juice of some sp, of ranunculus used for intermittent fever. Roots of *Hydrastis canadensis* are used as antidote of snake bite.

3-Condiments: Some members are used as condiments for flavoring. Seeds of *Nigella* (Black fennel, Kala jeera) are used as drug for bronchial asthma, fever and cough

4-Importance for honey: Most members of this family have nectaries. Flower nectaries have great importance for honey bees for honey production.

5-Poisonous species: Some members of this family produce acrid juice. It is highly poisonous.

5.4 FAMILY: CARYOPHYLLACEAE

Caryophyllaceae commonly known as the pink, or carnation family of flowering plants. According to Bentham and Hooker it belongs to order Caryophyllales. Currently Amaranthaceae and Caryophyllaceae are sister groups and considered closely related.

Formerly, Caryophyllaceae was considered the sister family to all of the remaining members of the suborder Caryophyllinae because they have anthocyanins, and not betalin pigments. However, cladistic analyses indicate Caryophyllaceae evolved from ancestors that contained betalin, reinforcing betalin as an accurate synapomorphy of the suborder. This family is traditionally divided in three subfamilies:

Alsinoidae: no stipules, petals not united
Silenoideae: no stipules, petals united
Paronychioideae: fleshy stipules, petals separate or united

Diagnostic characteristics: The members are diverse in appearance and habitat; most of them have swollen leaf and stem joints. They have five sepals and five petals, but it is thought that the latter are in origin modified stamens. There are usually 5 or 10 stamens, with an ovary borne above them. The ovules are borne in the centre of the ovary, and there are usually no walls dividing up the ovary cavity.

Distribution: Caryophyllaceae comprising some 86 genera and 2,200 species of herbaceous annuals and perennials, mainly of north temperate distribution. The members of this family are commonly found in the temperate regions of the Northern hemisphere. Certain genera are found in the Southern hemisphere and few are found in the mountains of tropical regions. In our country the plants of this family are either found in the hilly tracts or they grow in the plains during winter season, e.g., *Stellaria, Spergula, Dianthus*, etc.

5.4.1 Systematics

Bentham & Hooker	Engler& Prantl	Hutchinson
Dicotyledons	Dicotyledoneae	Dicotyledones
Polypetalae	Archichlamydeae	Herbaceae
Thalamiflorae	Centrospermae	Caryophyllales
Caryophyllinaeae	Caryophyllaceae	Caryophyllaceae
Caryophyllaceae		

5.4.2 General Characteristics

Habit: Most of them are annual, while some of them are perennial herbs. Certain small shrubs, e.g., some species of *Acanthophyllum* are also found in the warmer parts of the world. Some species of *Stellaria* (*S. aquatica*)

Stem: The stem is erect, branched, green, herbaceous, solid and mostly swollen at the nodes.

Leaves: The leaves are simple, opposite decussate (rarely alternate), entire and exstipulate. The leaves sometimes possess shortly connate perfoliate base, e.g., in *Dianthus*. linear to lanceolate in shape. At each node one leaf develops earlier than the other. The stipules are usually absent but scarious stipules are present in some genera (*Spergula*). This leaf bears in its axil a more vigorous bud than on the other side and frequently it is only this bud which develops later.

Inflorescence: The inflorescence is cymose. Usually it is a dichasium which later on becomes a dichasial cyme ending in a scorpoid monochasial cyme. This is known as cincinnus or caryophyllous type inflorescence which is characteristic of the family. In certain cases the flowers are arranged in racemes or solitary (*Arenaria*).

Flower: The flowers are pedicellate, actinomorphic, usually hermaphrodite and pentamerous (but rarely unisexual or tetramerous *Sagina*). They are regular, complete and hypogynous slightly perigynous in *Arenaria.*

Calyx: It is composed of five and very rarely of four sepals (*Sagina*). The sepals may be free or united together into a tube. They are usually persistent with membranous margins. The aestivation is imbricate (quincuncial).

Corolla: It is composed of five and rarely of four petals. They are always free and usually differentiated into lomb and claw. The petals are mostly notched (*Cerasrium*) sometimes deeply bifid, e.g *Stellaria media*.In Dianthus aligulate outgrowth is present on the adaxial side of the petal forming the corona. Occasionaly the petals are minute or absent (*Sagina*). Usually the aestivation is imbricate.

Androecium: Stamens are usually twice the number of petals (ten or eight) in two equal and alternate whorls. Sometimes the number of stamens reduces to eight, five, four, three or even one. They are polyandrous, obdiplostemonous, i.e., the stamens are arranged in two whorls of five each, the stamens of the outer whorl are seen to be opposite the petals and of inner whorl alternating the petals (*Stellaria*). In caryophyllaceae the obdiplostemony is not real but apparent as it has been brought about as a result of mechanical pushing of the stamens of inner whorl outwards. The filaments are distinct or slightly connate at the base. The anthers are dithecous, introrse and dehiscing longitudinally.

Gynoecium: It consists of two (*Dianthus*) or three to five (*Cerastium, Spergula and Stellaria*) carpels; syncarpous. The styles are free. The ovary is superior (slightly inferior in *Arenaria*) and unilocular; Occasionaly in *Vaccaria,* the ovary becomes chambered in the basal region due to the formation of the septa the ovules are many, campylotropous and arranged on a central column.

The placentation is free-central which is most characteristic of the family. The number of carpels corresponds to the number of styles and stigmas. In *Stellaria* the number of carpels is reduced to three. A disc is present at the base of the stamens which is annular or divided into glands.

Fruit: Generally the fruit is an unilocular capsule, e.g., *Stellaria, Arenaria, Spergula,* etc. In some cases the fruit, may be an achene or a nut, e.g., *Herniaria, Dysphania, Scleranthus*, etc.

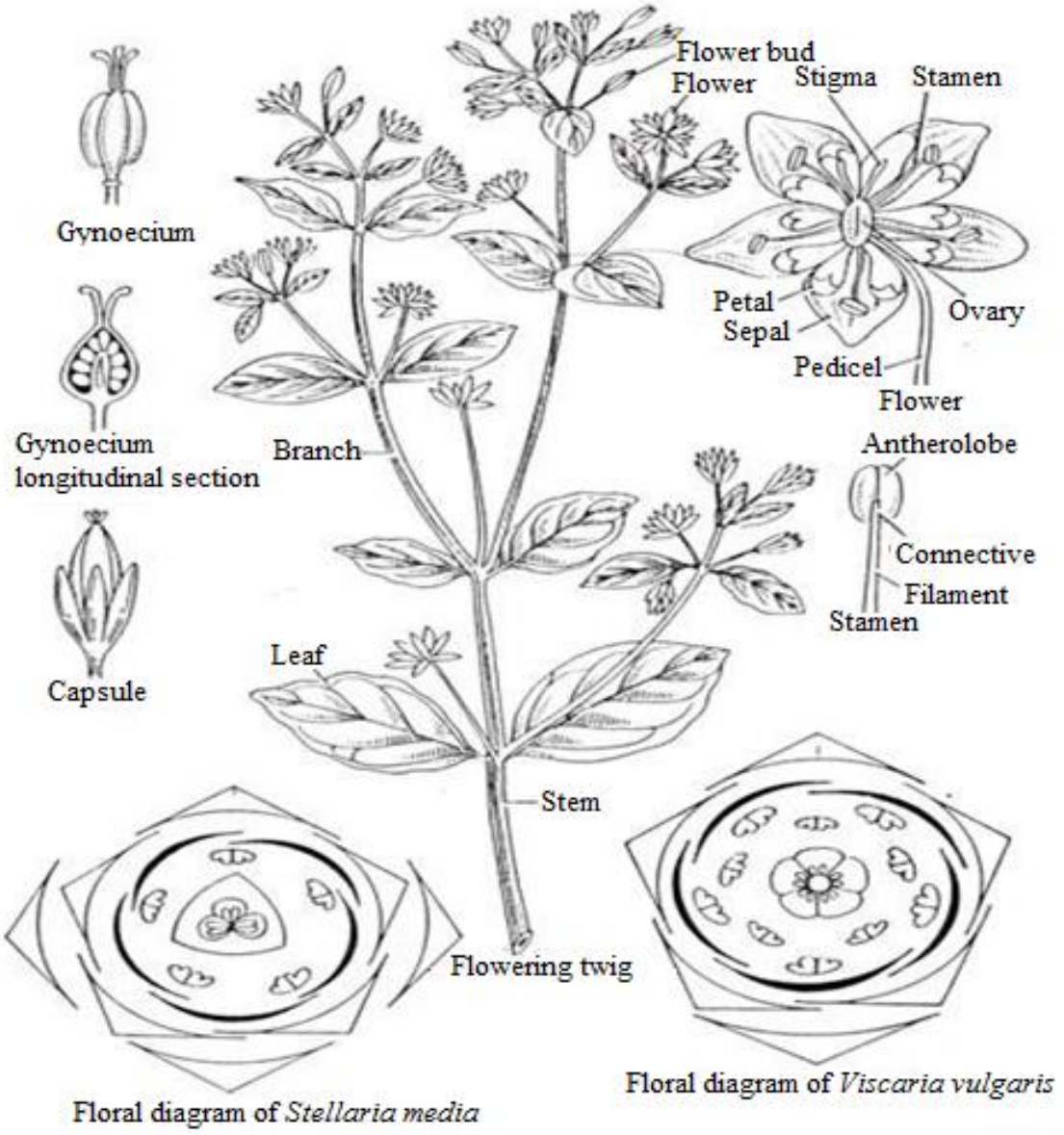

Fig.5.3 *Stellaria media*

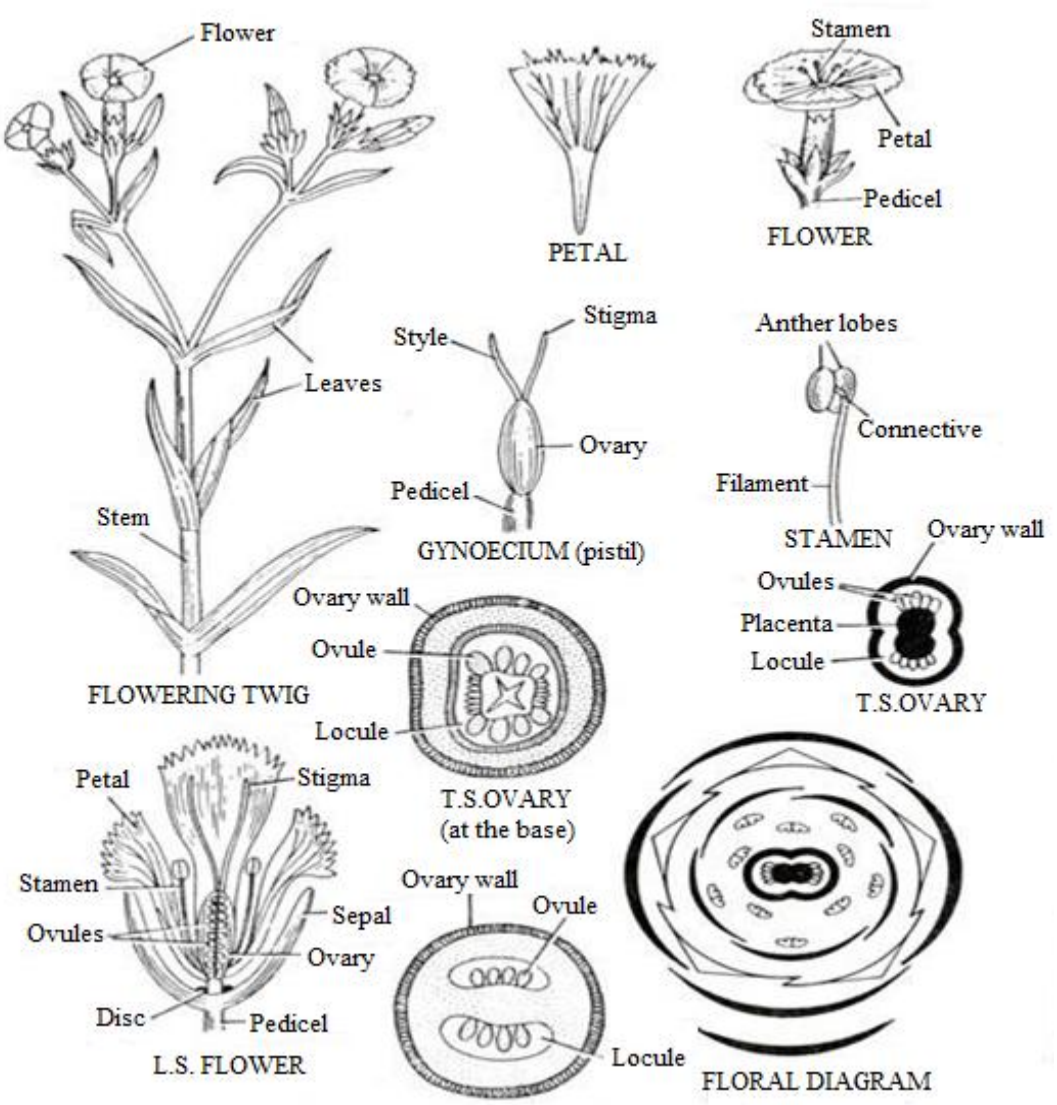

Fig 5.4 *Dianthus*

Seeds: The seeds are small and endospermic. The embryo is curved in the endosperm. Sometimes the funicle is conspicuous. They are dispersed by censor mechanism.

Pollination: It usually takes place by means of insects (i.e., entomophily).

Floral formula: Generalized for family ⊕ ♀♂ $K_5\ C_5\ A_{5+5}\ \underline{G}_{(2-5)}$

Stellaria media	**Br**	Brl	⊕	♀♂ $K_5\ C_5\ A_{5+5}\ \underline{G}_{(3)}$
Spergula arvensis	**Br**	Brl	⊕	♀♂ $K_5\ C_5\ A_5\ \underline{G}_{(3\text{ or }5)}$

Dianthus caryophyllatus	⊕	♂	Epi	K_{2+2}	$K_5\ C_0\ A\ \alpha\ \underline{G}_{(5-12)}$
Silene conoides	⊕	♂			$K_5\ C_5\ A_{5+5}\ \underline{G}_{(3)}$

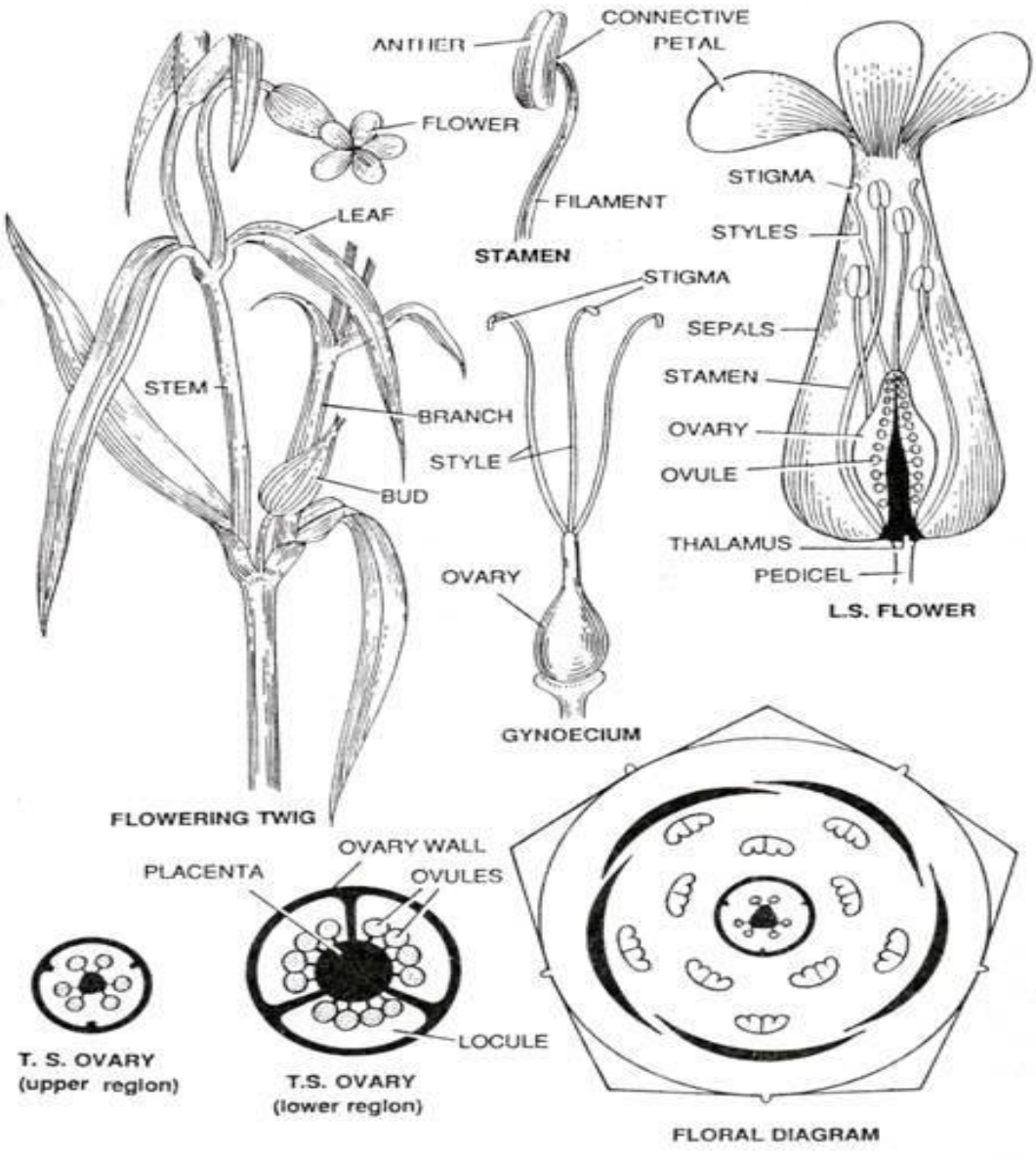

Fig 5.5 *Silene*

5.4.3. Important Genera

Among the important genera are *Stellaria, Cerastium, Arenaria, Silene, Lychnis, Gypsophila* and *Saponaria*. The most valued horticulturally is *Dianthus,* which includes the carnation, commonly cultivated by florists and also grown in Europe for use in perfumes.

5.4.4 Economic Importance of Family

The members of the family are important as ornamentals and as the source of medicines

(I) Ornamentals

Dianthus barbatus, Dianthus caryophyllatus, Dianthus chinensis,. Arenaria sp, Cerastium sp, Saponaria vaccaria, Silene armeria, Gypsophila sp. etc. are grown as an ornamental.

(II) Medicinal

- Alcoholic extract of the whole plant of *Stellaria semivestita* shows anti- cancer activity
- Decoction of *Stellaria vestita* relieves bone ache and rheumatic pain
- Seeds of *Spergula arvensis are* employed against pulmonary tuberculosis

(III) Other uses

- The plant juice of *Saponaria vaccaria*, *Lychnis* etc. is used as a substitute of soap.
- The shoots of *Stellaria aquatica* (Eng.-Chick weed; Verna.-Badeola) are eaten as vegetable.
- *Spergula arvensis* is used as fodder. It is diuretic.

5.5 FAMILY: RUTACEAE

Rutaceae commonly known as citrus family usually with strong scents. They range in form and size from herbs to shrubs and small trees.

Distribution: Consists of 160 genera and 1,700 species distributed throughout the world, especially in warm temperate and tropical regions. The largest numbers are found in Africa and Australia, often in semiarid woodlands. In India the family is represented by 23 genera and over 80 species occurring mostly in tropical and subtropical Himalayas and the western peninsular India.

5.5.1 Systematics

Bentham & Hooker	Engler & Prantl	Hutchinson
Dicotyledons	Dicotyledoneae	Dicotyledones
Polypetalae	Archichlamydeae	Lignosae
Disciflorae	Geraniales	Rutales
Geraniales	Rutaceae	Rutaceae

Rutaceae		

The family is closely related to Sapindaceae, Simaroubaceae and Meliaceae, and all are usually placed into the same order, although some systems separate that order into Rutales and Sapindales. The families Flindersiaceae and Plaeroxylaceae are sometimes kept separate, but nowadays generally placed in Rutaceae, as are the former Cneoraceae. The subfamilial organization has not been fully resolved, but the subfamily Aurantioideae (=Citroideae) is well supported; the placement of several genera remains unclear.

5.5.2. Generalized characters

Habit: Mostly perennial trees (*Citrus*), some shrubs (*Murrya paniculata*), a few are herbs (*Boenning hausenia),* frequently aromatic with glands on the leaves, sometimes with thorns

Roots: Fibrous tap root

Stem: Woody; spiny; Cylindrical

Leaves: Petiolate; Leave alternate or opposite simple (*Citrus*) or compound (pinnately compound in *Murraya* and digitate compound in *Aegle*, exstipulate; reticulate venation. Pellucid glands, a type of oil gland, are found in the leaves responsible for the aromatic smell of the family's members. In citrus leaves are unifoliate with a joint at the junction of the blade and winged petiole. The stipules are absent.

Inflorescence: Terminal or axillary cymes or panicle solitary or in cyme, rarely form raceme as in *Dictamnus.* In some species of *Citrus* the flowers are axillary solitary.

Flower: Flowers are Pedicilate; bracteate or ebracteate; usually hermaphrodite, unisexual and polygamous (*Zanthoxylum*), actinomorphic (rarely zygomorphic in *Dictamnus*), Regular, complete pentamerous (tetramerous in some species of *Ruta*), hypogynous. A fleshy nectariferous disc is present between the stamens and ovary.

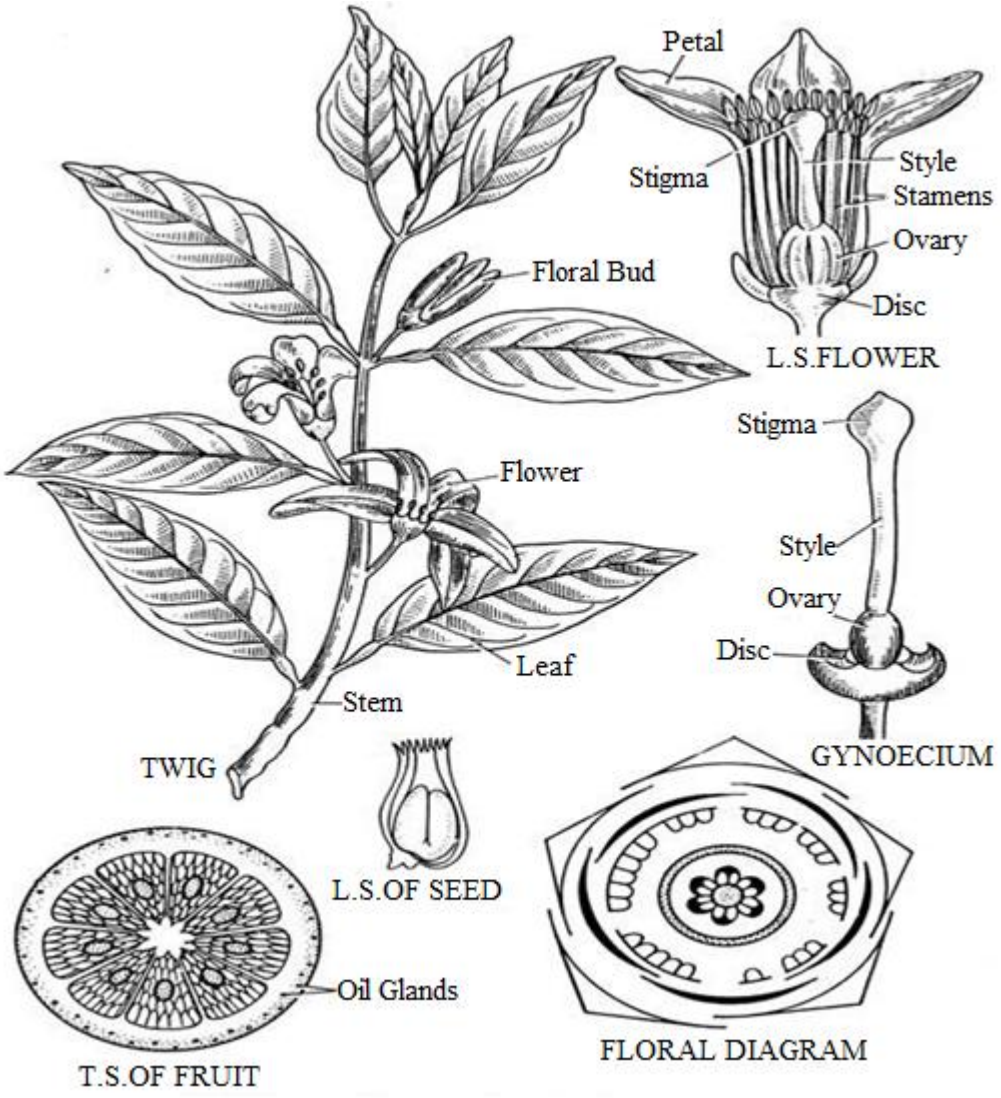

Fig. 5.6 *Citrus aurantium* Linn. Orange Verna, Narangi

Calyx: 4 or 5 sepals which are free or more often show various degrees of connation**. In citrus the** calyx is copular or urceolate imbricate aestivation in bud; green. Rarely sepals are absent (*Zanthoxylum*), In *Peganum* the sepals are foliaceous, pinnatifid and persistent.

Corolla: 4 or 5 petals, free, valvate or imbricate aestivation in bud. In *Dictamnus*, where the corolla is zygomorphic, the four petals are in pairs and are ascending, whereas the lower one is declinate.

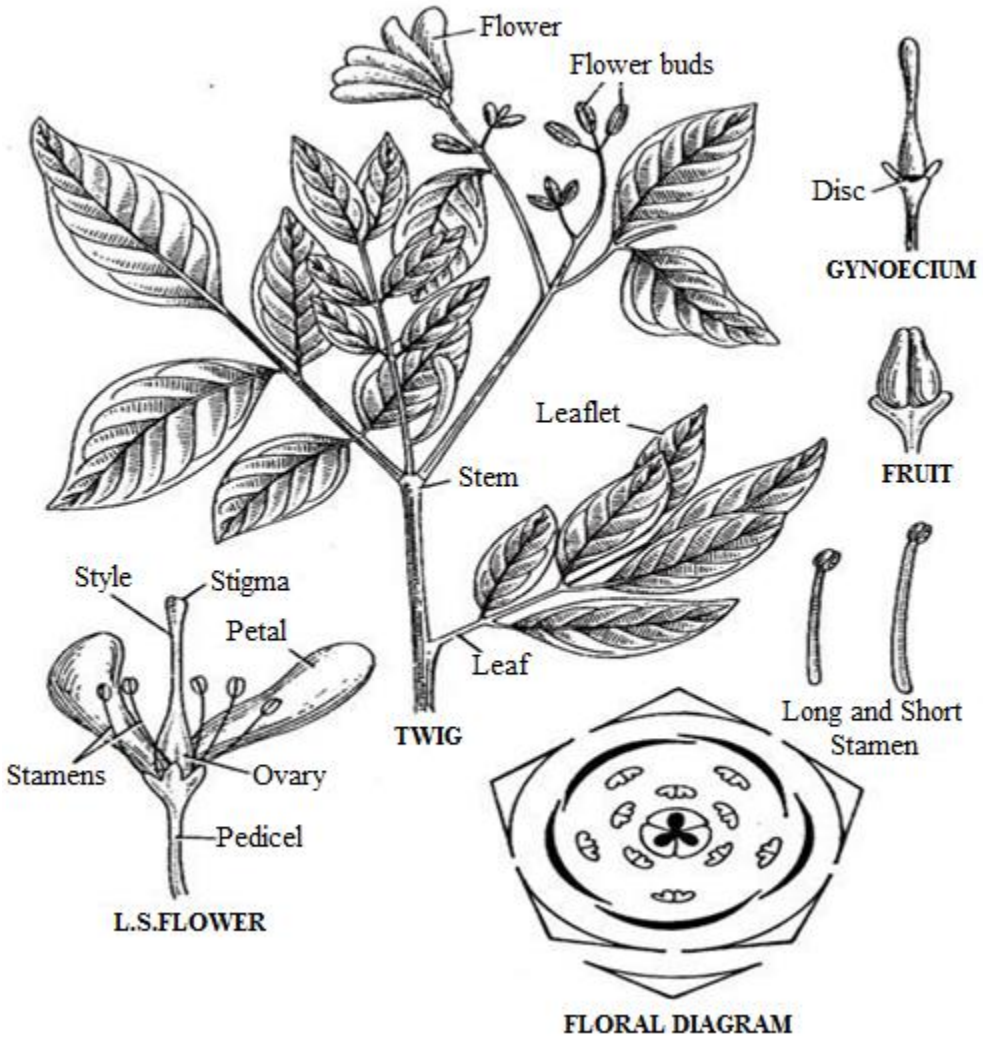

Fig.5.7 *Murraya exotica* Spreng.

Androecium: Stamens are as many as or twice the number of petals or sometimes numerous (*Citrus*) five in *Skimmia*. When the stamens are equal to the number of petals they are arranged in an antesepalous whorl (*Zanthoxylum*). More frequently the stamens are double the number of petals then they are obdiplostemonous. The filaments are usually free or but in *Citrus* they are united in several bundles (polyadelphous condition); the anthers are dithecous, introrse and dehiscing longitudinally basifixed.

Gynoecium: 2 to 5carpels, which are completely united or free towards the base and the ovary is deeply lobed as in *Peganum, Dictamus* and other related genera. The ovary has as many locules as the number of carpel with two to many sometimes one anatropus ovule in each

locule; superior ovary, axile placentation, . The styles are as many as the carpels, free or variously united. The stigmas are terminal and lobed

Fruits: The fruits of the family are various, Capsule (*Ruta*), follicles (*Zanthoxylum*), drupes (*Amyris*), berries (*Triphasia*), samaras (hop tree), and schizocarps (*Helietta*). Hesperidium of citrus fruit is actually a modified berry.

Pollination: mainly pollinated by insects

Seed: non-endospermic seed.

Floral formula ⊕ ♂♀ $K_{5or(5)}\ C_5\ A_{10}\ \underline{G}_{(3-5)}$

Citrus	**Br**	Brl	⊕	♂♀	$K_{(5)\ or\ (4)} C_{(5)\ or\ (4)}\ A_{\alpha\ (polyadel)}\ \underline{G}_{(\alpha)}$
Murraya	**Br**	Brl	⊕	♂♀	$K_{(5)}\ C_5\ A_{5+5}\ \underline{G}_{(2-3)}$
Aegle marmelos		**Br**	⊕	♂♀	$K_5\ C_5\ A_\alpha\ \underline{G}_{(\alpha)}$

5.5.3 Important Genera: The well known examples of the family are Lemon (*Citrus lemon*), Malta or sweet orange (*C. sinensis*), Bael fruit (*Aegle marmelos*), Kamini or orange jasmine *(Murraya paniculata*), Lime *(Citrus acida)* and Citron (*Citrus medica).*

5.5.4 Economic Importance

1. **Fruits**: This family is important for citrus fruits like orange (Santra; *Citrus reticulata*) lemons, Chakotra (*Citrus maxima syn. Citrus decumana*). This family is ranked third in food production. Besides these, fruits of Bael and *Feronia* are also edible. The aromatic pulp of large globose fruits of *Aegle marmelos* is eaten and very good remedy for dysentery and other stomach troubles. The root and stem bark is used in intermittent fever. The pulp of ripe fruit *of Feronia limoni (*wood apple) is eaten and also used in chutney and sharbat.

2. **Medicinal plants**: Most of the plants of this family have medicinal importance. Their fruits are rich in vitamins and minerals. Most of vitamin C is extracted from these fruits. *Aegle* gives tannic acid. Leaves of *Murraya paniculata* are used in flavouring. The twigs of *Zanthoxylum armatum* (Tejpat) is carminative, stomachic and anti-helminthic and are

used in soap making and dental cream preparations. The root bark of *Toddalia asiatica* is a potent antimalarial drug. It is also used in cough and influenza. Oil of lemon is used in the preparation of mosquito oil. The leaves of *Murraya koenigii* (Meetha-neem) are aromatic which are used for flavouring curries, especially in South India.

3. **Ornamental plants:** The following species are used as ornamentals:
   Murraya paniculata (Orange jasmine)
   Skimmia arborescens
   Ruta graveolens (Comman Rue)
   Glycosmis pentaphylla

4. **Uses in perfumes**: The large white fragrant flowers and fruits are used in perfumery.

5.6 SUMMARY

Now you can sum up the important criteria of the families student studied in this Unit.
Ranunculaceae show combination of primitive and advanced characters. The Ranunculaceae is considered primitive in the presence of predominantly herbaceous habit, bisexual and actinomorphic flower, numerous free and spirally arranged stamens and capels, follicular fruit. They are advanced in the presence of unisexualiuty, few and whorled appendages, zygomorphy, connation in the gynoecium and achenial fruit.

Family Caryophyllaceae is considered to have been derived form the order Ranunculales or from ranalian ancestors. It belongs to order Caryophyllinae where flowers are actionomorphic, stamens usually the twice as many as the petals, ovary unilocular with free central placentation. The diagnostic features of the this family are herbs with opposite and simple leaves, inflorescence dichasial cyme ending into monochasial cyme, flowers actionomorphic, pentamerous, hypogynous , sepals 4-5, Petals 4-5,stamens usually the petals and obdiplostemonous, ovary unilocular with free central placentation , capsule 2-6 valved.

Family Rutaceae belongs to order Geraniales of Series Disciflorae in which carpels are several, syncarpous, ovules 1 or 2 in each locule, ascending and pendulous, raphae ventral.
Salient features of Rutaceae are trees and shrubs with usually compound and exstipulate, pellucid punctuate leaves , flowers bi- or unisexual, sepals 4-5, imbricate, petals 4-5 imbricate or valvate, stamens usually definite, carpels 4-5, free or connate.ovules1-many in each locule, fruit usually berry.

5.7 GLOSSARY

Actinomorphic- A flower having radial symmetry

Adnate – Grown together or fused, used only to describe unlike parts. For comparison, connate.

Adventitious – Arising from an unusual or irregular position

Alternate – Arrangement of leaves or parts one at a node, as leaves on a stem. For comparison, opposite and whorled

Angiosperm – Having seeds borne within a pericarp. For comparison, gymnosperm.

Anther – Pollen-bearing part of a stamen, borne at the top of a filament.

Apex – The tip or terminal end.

Apocarpous-Carpels in flower free from each other *e.g. Ranunculus, Nigella, Clematis* etc.

Axillary – Borne or carried in the axil.

Basifixed- Fixed to the filament at the base

Berry – A fleshy, indehiscent, pulpy, multi-seeded fruit resulting from a single pistil, e.g. tomato.

Bipinnate – Twice pinnate, the primary leaflets being again divided into secondary leaflets.

Bract – A much-reduced leaf, often scale-like and usually associated with a flower or inflorescence

Bracteole- Secondary bract at the base of individual flower

Calyx – The outer whorl of perianth, composed of the sepals, usually green in color and smaller than the inner set.

Capsule – A dry dehiscent fruit produced from a compound pistil, e.g. fruit of a tobacco, *Catalpa, Dianthus*.

Complete. The flower with all the four whorls i.e. calyx, corolla, androecium and gynoecium

Compound leaf – A leaf of two or more leaflets.

Corolla – Inner whorl of the perianth, between the calyx and the stamens; a collective term for the petals of a flower.

Cotyledon – The primary leaves of the embryo, present in the seed. One of the first leaves to appear after germination (there may be more than 1).

Cyme – A more or less flat-topped determinate inflorescence whose outer flowers open last, e.g. *Sambucus*, elderberry.

Decompound – Leaf having more than one compound.

Dioecious – Having unisexual flowers, each sex confined to a separate plant, said of species.

Dithecous- Two - celled anther

Drupe – A fleshy, indehiscent fruit whose seed is enclosed in a stony endocarp, e.g. date, cherry.

Dissected - Leaf divided into very fine, somewhat indistinct segments

Dorsifixed -Filament attached to the dorsal side of the anther

Extrorse- Facing outward from the centre of flower referred for anthers

Hermaphrodite (bisexual)- The flower having both male and female reproductive organs

Hypogynous- situated below the gynoecium or ovary referring to stamens, petals and sepals

Imbricated – Overlapping, as shingles on a roof.

Inferior – Beneath, below; said of an ovary when situated below the apparent point of attachment of stamens and perianth.

Inflorescence – The arrangement of flowers on the axis.

Introrse- Facing inward from the centre of flower referred for anthers

Involucre – One or more whorls or series of small leaves or bracts that are close underneath a flower or inflorescence.

Lanceolate – Much longer than wide, broadest below the middle and tapering to the apex.

Linear – Long and very narrow, as in blades of grass.

Nectary- A nectar-secreting gland

Obdiplostemonous - the stamens are arranged in two whorls of five each, the stamens of the outer whorl are seen to be opposite the petals and of inner whorl alternating the petals

Oblique – Lop-sided, as one side of a leaf base larger, wider or more rounded than the other.

Opposite – Describing leaves that are situated in pairs at a node along an axis.

Orthotropus - An straight ovule with the micropyle opposite to chalaza

Palmately compound - like the fingers on your hand

Panicle – An indeterminate inflorescence whose primary axis bears branches of pedicelled flowers (at least basally so); a branching raceme.

Pedicel – Stalk of a single flower in an inflorescence.

Peduncle – Stalk of a flower or inflorescence. **Perfect** – Having both functional stamens and pistils (not imperfect); a unisexual flower.

Perianth – A collective term embracing both the **corolla** and the **calyx**.

Petaloid- Coloured resembling petals

Pollination-Transference of pollen grain from anthers to stigma

Polyandrous-Androecium that consists of free stamens

Polyadelphous- Stamens united in many bundles

Raceme – A simple indeterminate inflorescence, having a single long axis, with pedicelled flowers.

Sepal – A single segment of a divided calyx.
Sepaloid- Green resembling to sepal
Stamen – Male or pollen-bearing organ of a flower, composed of filaments and anthers.
Syncarpous- United carpels, compound ovary *e.g. Citrus*
Tendril - modified leaf or stem
Thorn – modified stem/branch; since a stem comes from a bud, thorns are located above leaves. Examples include apple, pyracantha and *Cotoneaster* **Unisexual** – Bearing either stamens or pistils but not both.
Valvate – (1) dehiscing by valves; (2) meeting at the edges without overlapping, as leaves or petals in the bud.
Venation- The arrangement of veins in a leaf
Whorl – Arrangement of three or more structures arising from a single node.
Zygomorphic-Asymmetrical, irregular

5.8 SELF ASSESSMENT QUESTIONS

5.8.1 Multiple Choice Questions

1. Which one of the following has deeply bifid petals?
(i) *Citrus* (ii) *Ranunculus*
(iii) *Stellaria* (iv) *Nigella*

2. Which one of the following is commonly known as Pink Family?
(i) Ranunculaceae (ii) Caryophyllaceae
(iii) Rutaceae (iv) Fabaceae

3. Which one of the following is more primitive than others?
(i) Ranunculaceae (ii) Caryophyllaceae
(iii) Rutaceae (iv) Fabaceae

4. Aconite**,** an alkaloid **is** present in
(i) *Thalictrum* (ii) *Aconitum napellus*
(iii) *Clematis* (iv) *Ranunculus*

5. Botanical name of *Kari-patta* (Meetha- Neem) is
(i) *Azadirachta indica* (ii) *Murraya koenigii*
(iii) *Clematis* (iv) *Ranunculus*

6. Members (plants) of family Rutaceae are generally good source of

(i) Vitamin –A (ii) Vitamin -B

(iii) Vitamin –C (iv) Vitamin –D

7. Obdiplostemonous condition of stamens is general criterion of which one of the following families

(i) Ranunculaceae (ii) Caryophyllaceae

(iii) Rutaceae (iv) Fabaceae

8. Which one of the following families belongs to series Disciflorae as proposed by Bentham & Hooker

(i) Ranunculaceae (ii) Caryophyllaceae

(iii) Rutaceae (iv) Malvaceae

9. Botanical name of the *Bael* fruit

(i) *Citrus lemon* (ii) *Murraya paniculata*

(iii) *Citrus medica* (iv) *Aegle marmelos*

10. Tejpat (*Zanthoxylum armatum*) belongs to family

(i) Ranunculaceae (ii) Caryophyllaceae

(iii) Rutaceae (iv) Fabaceae

5.8.1. Answer Keys:

1- iii	2- ii	3- i	4- ii	5- ii
6- iii	7- ii	8 -iii	9- iv	10- iii

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5.11 TERMINAL QUESTIONS

1. What is Cincinus or Caryophyllus type of inflorescence.
2. Give medicinal and condiment uses of family Ranunculaceae.
3. Give distribution pattern of family Rutaceae.
4. Draw obdiplostemonous condition of the stamen.
5. Give characteristic floral features of family Caryophyllaceae.
6. Write taxonomical characteristics of citrus family.
7. Write floral formulae of the following plants:
   (a) *Ranunculus*
   (b) *Nigella*
   (c) *Citrus*
   (d) *Stellaria media*
8. Give comparative account of taxomnomic characters of family Ranunculaceae and Rutaceae.

UNIT-6 ROSACEAE, FABACEAE AND ASCLEPIADACEAE

Contents

6.1 OBJECTIVES

In the present unit students will be able -

- to become familiar with Order: Rosales of Series: Calyciflorae of Division-Polypetalae including family Rosaceae and Fabaceae. While Family Asclepiadaceae will be studied under Order Gentianales of Series Bicarpellatae under Division- Gamopetalae (According to Bentham and Hooker).
- to know Detailed description of the general distribution, General characters, Important genera and Economic Importance *etc.* of families **Rosaceae,** Fabaceae and Asclepiadaceae. Moreover an outline of the phylogenetic and evolutionary relations of the families will be drawn. Figures of some of the important genera of the concerning families are also given here for correlating this text to your surrounding nature.

6.2 INTRODUCTION

Students have already studied characteristic features of division Polypetalae and its series Thalamiflorae (Family- Ranunculaceae and Caryophyllaceae) and Disciflorae (Family - Rutaceae) in Unit -5. This unit introduces you with series Calyciflorae (Order Rosales; Family Rosaceae and Fabaceae) of Division-Polypetalae and series Bicarpellatae (Order Gentianales Family Asclepiadaceae) under Division- Gamopetalae.

Series Calyciflorae is characterized by its perigynous or epigynous flower a disc rarely present at the base of ovary,sub- inferior or inferior ovary. It consists of seven orders namely- Rosales, Myrtales, Passiflorales, Ficoidales and Umbellales.

Order Rosales having bisexual flower, regular or zygomorphic flower, gynoecium with 1 or more carpels, styles usually distinct *e.g,* Family Rosaceae and Fabaceae

Division-Gamopetalae is having corolla of united petals. It is divided into three series

(i) Inferae (ovary inferior)- consists of three orders namely Rubiales, Asterales, Companulales

(ii) Heteromerae (ovary usually superior, stamens as many as or twice the corolla segments, carpels more than two) – contains three orders Ericales, Primulales and Ebenales

(iii) Bicarpellatae (ovary superior, stamens as many or fewer than the corolla, carpels usually two)- consists of four orders Gentianales, Polemoniales, Personales and Lamiales

Order Gentianales includes plants having Flower regular, stamens as many as the corolla lobes, leaves opposite (Family Apocynaceae and Asclepiadaceae)

6.3 FAMILY: ROSACEAE

The **Rosaceae** (rose family) family is a medium-sized family of flowering plants, including about 2,950 known species belonging to 100 genera.

The name is derived from the type genus *Rosa*. The Rosaceae family includes herbs, shrubs, and trees. Most species are deciduous, but some are evergreen. Among the most species-rich genera are *Alchemilla , Sorbus , Crataegus ,Cotoneaster , Rubus, Prunus* (plums, cherries, peaches, apricots, and almonds) with about 200 species. They have a worldwide range, but are most diverse in the Northern Hemisphere.

Several economically important products come from the Rosaceae, including many edible fruits (such as apples, pears, quinces, apricots, plums, cherries, peaches, raspberries, loquats, and strawberries), almonds, and ornamental trees and shrubs (such as roses, meadow sweets).

Diagnostic characteristics – Herbs, shrubs or trees with simple or compound stipulate leaves, Flowers regular and bisexual, sepals and petals 5 each, stamens many, distinct, gynoecium of 1 or more free or connate carpels, ovules 1-2 in each carpel, fruits various.

Distribution pattern

The Rosaceae have a cosmopolitan distribution (found nearly everywhere except for Antarctica), but are primarily concentrated in the Northern Hemisphere in regions that are not desert or tropical forestland hawthorns.In India they are represented by over 25 genera and 215 species mainly confined to Himalaya ascending upto to about 6000 meters . The familiar examples of the family are Rose (*Rosa spp*.), Apple (*Pyrus malus*), Peach (*Prunus persica*), Strawberry (*Fragaria vesca*), Brambles (*Rubus spp*.) and Cinquefoil (*Potentilla spp*.)

6.3.1 Systematics

Bentham & Hooker	**Engler & Prantl**	**Hutchinson**
Dicotyledones	Dicotyledoneae	Dicotyledons
Polypetalae	Archichlamydeae	Lignosae
Calyciflorae	Rosales	Rosales
Rosales	Rosaceae	Rosaceae
Rosaceae		

Subfamily Rosoideae: Traditionally composed of those genera bearing aggregate fruits that are made up of small achenes or drupelets, and often the fleshy part of the fruit (e.g. strawberry) is the receptacle or the stalk bearing the carpels. The circumscription is now narrowed (excluding,

for example, the Dryadoideae), but it still remains a diverse group containing five or six tribes and 20 or more genera, including rose, *Rubus* (blackberry, raspberry), *Fragaria* (strawberry), *Potentilla*, and *Geum*.

Subfamily Amygdaloideae: Within this group remains an identified clade with a pome fruit, traditionally known as subfamily Maloideae (or Pyroideae) which included genera such as apple, *Cotoneaster*, and *Crataegus* (hawthorn). To separate it at the subfamily level would leave the remaining genera as a paraphyletic group, so it has been expanded to include the former Spiraeoideae and Amygdaloideae. The subfamily has sometimes been referred to by the name "Spiraeoideae", but this is not permitted by the International Code of Nomenclature for algae, fungi, and plants.

Subfamily Dryadoideae: Fruits are achenes with hairy styles, and includes five genera (*Dryas, Cercocarpus, Chamaebatia, Cowania*, and *Purshia*), most species of which form root nodules which host the nitrogen-fixing bacteria *Frankia* spp.

6.3.2 General Characteristics

Habit and Vegetative Characters

Perennial herbs (*Fragaria* and *Potentilla*), shrubs (*Spiraea* and *Prinsepia*), and trees (*Pyrus, Prunus and Eriobotrya*). Several species of *Rubus* and *Rosa* scramble over the surrounding vegetation with prickles. Sometimes plants are armed with sharp spines, which are modified branches (*Crataegus* and *Prinsepia*).

Vegetative reproduction takes place in several ways for example by runners **(*Fragaria*),** by suckers (***Rubus***) and leafy buds are formed on the roots of some species *Pyrus* and *Prunus*

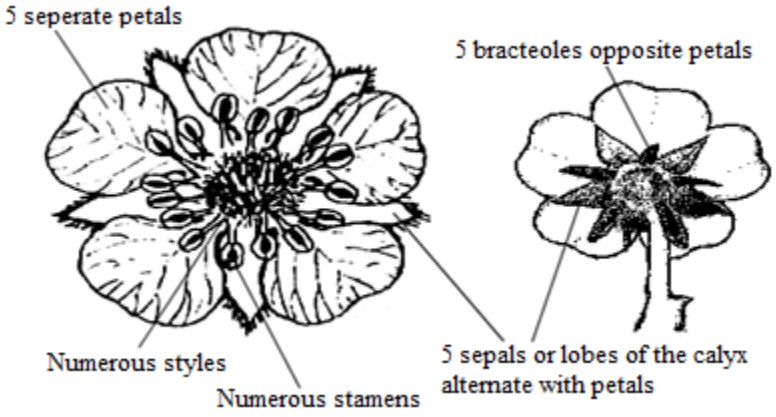

Fig 6.1 Structure of typical Rose Flower

Leaves: Petiolate; alternate, stipulate and simple (*e.g. Pyrus and Prunus*) or pinnately (*Rubus* and *Rosa*) or palmately compound (*Fragaria* and *Potentilla*): Stipules are small and caducousin *Pyrus, Prunus* and *Pygeum* but more commonly they are persistent and adnate to the petiole.

Inflorescence: commonly arranged in various types of definite or indefinite inflorescences Racemes (*Pygeum*), Corymbs (*Rubus*) or thyrsoid panicles (*Eriobotrya*). In *Prinsepia* short racemes are borne on the sides of spines rarely solitary (some species of *Rubus* and *Rosa*.

Flower: Pedicellate; bracteate, Regular; complete, actinomorphic (zygomorphic in *Parinarium*), hermaphrodite (unisexual in Pygeum) or sometimes polygamous, pentamerous, hypogynous (e.g.*Prunus*) or perigynous (*Rosa*). Sometimes epigynous (*Pyrus*).

Calyx: Five petals which are basally connate: the calyx tube is free or adnate to ovary, aestivation is imbricate or valvate. In some species (*Rosa*) sepals become foliaceous. In some (e.g. *Fragaria* and *Potentilla*) an epicalyx of small green leaves is present outside and alternating with the sepals.

Corolla: Five or multiple of five petals. In cultivated species of *Rosa* there are numerous petals usually imbricate in bud. Sometimes they are absent (*Alchemilla*) or very small (*Neurada*).

Stamens: number of stamens varies considerably. In some species of *Agrimonia* there is a single whorl of stamens alternating with the sepal lobes. One to four in *Alchemilla* (two unilateral stamen in *Parastemon*). Usually the stamens are two, three or four times as many as petals or indefinite. In *Pyrus* there is an outer whorl of ten stamens in five antesepalous pairs. They are followed by second whorl of five antepetalous stamens and a third whorl of five antesepalous stamens.

In *Prunus* outer whorl of ten stamens followed by second whorl of ten stamens alternating with those of the first whorl. A third whorl of stamens is sometimes also present alternating with those of the second. In several genera the stamens are usually many (*Fragaria*) to numerous (*Geum*). The stamens are usually bent in the bud. The anthers are dithecous and introrse. A cushion shaped or ring like nectar secreting disc is present between the stamens and carpel.

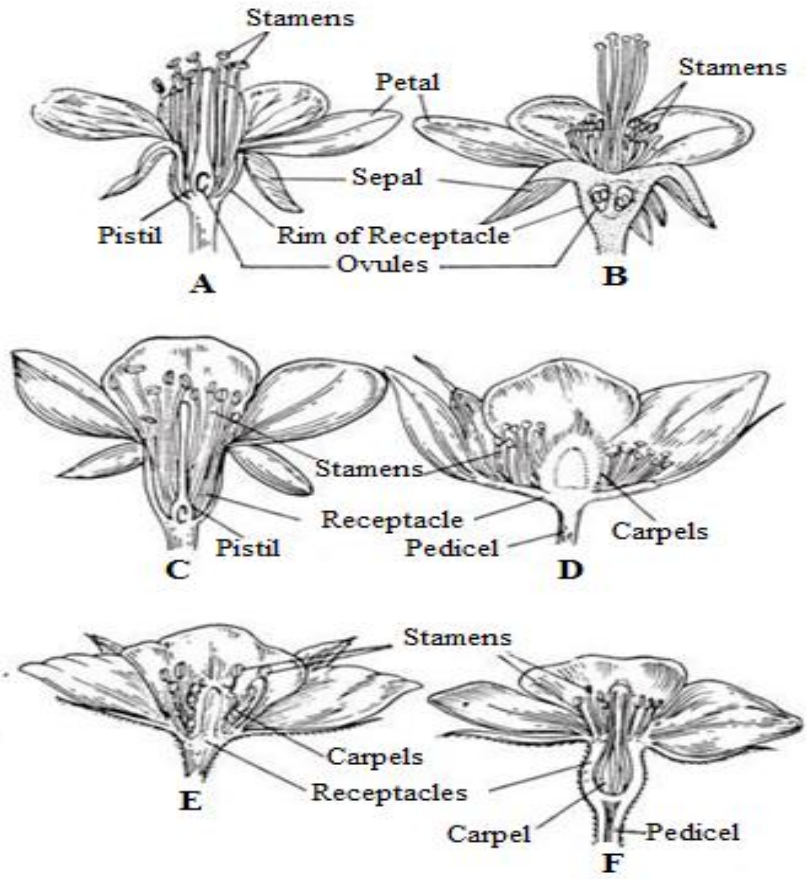

Fig.6.2 A-F Floral variations in Rosaceae. A- *Prunus sp*. B-*Malus sylvestris* C- *Prunus avium* D-*Rubus sp*. E- *Fragaria vesca* F- *Rosa* sp.

Gynoecium: It shows much variation. The number of carpels is one to many, the gynoecium consists of either one compound carpel (syncarpous) or many simple carpels (apocarpous). The carpels are usually situated within the hypanthium or the hypanthium remains adnate to the compound ovary arranged in cyclic or spiral manner the ovary is either superior or inferior or half superior half inferior (i.e., perigynous condition. Monocarpellary (*Alchemilla, Prunus*) or pentacarpellary and apocapous (*Spiraea*) or multicarpellary and apocarpous (*Fragaria, Rosa, Rubus*) or five carpels fused only in the basal region or capels united completely with each other as well as with the floral cup (*Pyrus*), if the receptacle is convex or dome shaped, the ovary is superior (*Fragaria, Potentilla. Rubus*), if the receptacle is cup shaped and the carpels are developing on the inner surface , the ovary is half inferior (*Prunus, Rosa, Spiraea*) and if carpels are fused with one another and also with the floral cup (Pyrus) the ovary is inferior, placentation is marginal or axile.

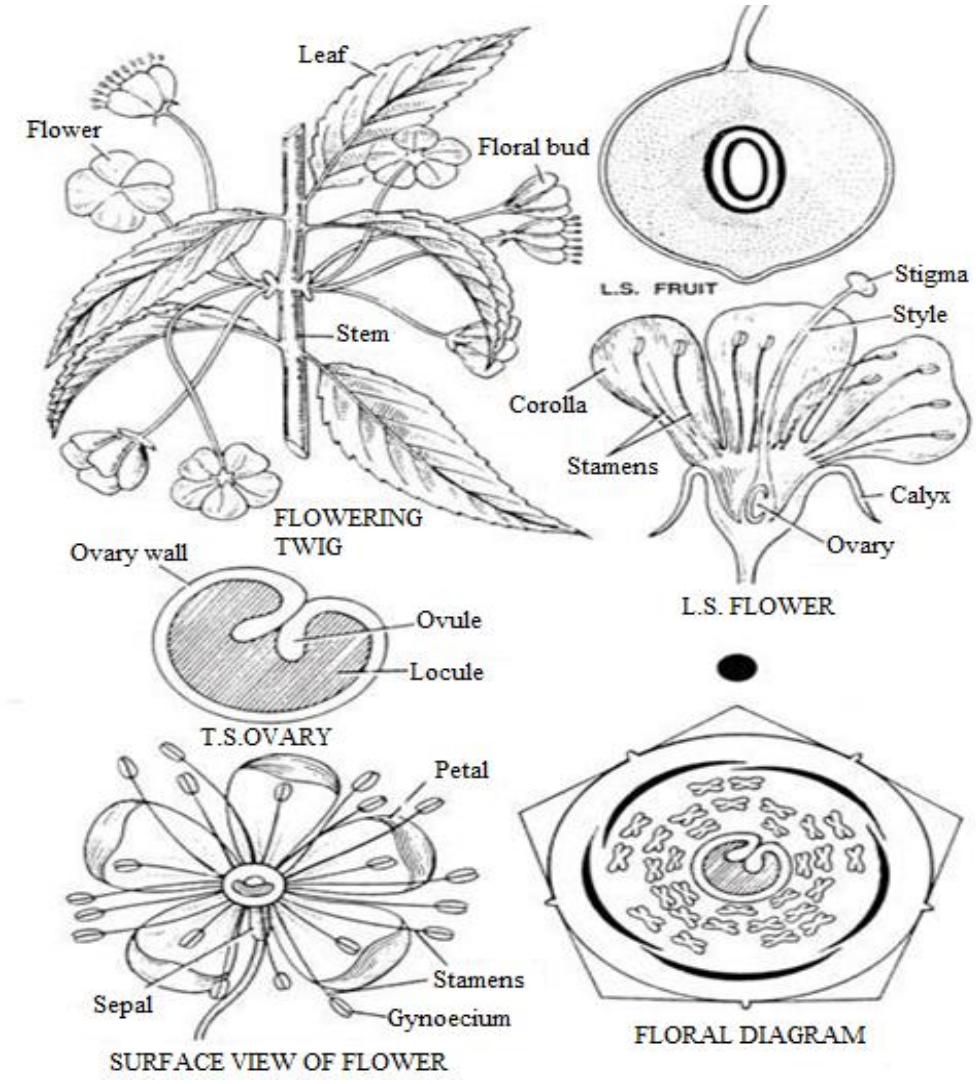

Fig.6.3 *Prunus persica* Verna. Aru

Styles and stigmas as many as carpel number. The style is free or connate; the stigma is simple, lobed or capitate. when syncarpous, 2-5 locules are found, placentation basal or axile, the placentation is axile, and the stigmatic lobes are as many as the number of carpels. The placentation is basal when one carpel is present (apocarpous); the ovules are one to many in each carpel.

Seed: non-endospermic seed

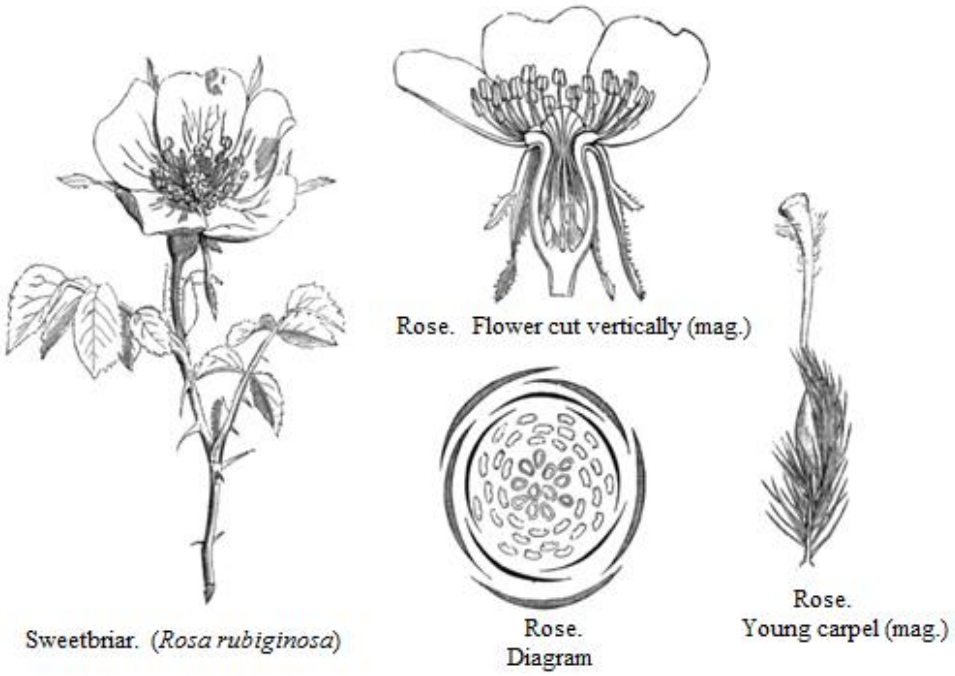

Fig. 6.4 Floral parts of *Rosa*

General Floral Formula

$$Br \quad \oplus \quad ♂♀ \quad K_{5 \text{ or } (5)}\ C_5\ A_{\alpha}\ \underline{G}_{1-\alpha} \text{ or } G_{1-\alpha}\ \overline{\text{or}}\ G_{(\alpha)}$$

Prunus	**Br**	$\oplus$	♂♀	$K_{(5)}\ C_{(5) \text{ or } (4)}\ A_{\alpha}\ \underline{G}_1$
Eriobotrya	**Br**	$\oplus$	♂♀	$K_{(5)}\ C_5\ A_{\alpha}\ \overline{G}_{(2-5)}$
Potentilla	**Ebr**	$\oplus$	♂♀	$K_{(5)}\ C_5\ A_{\alpha}\ \underline{G}_{(\alpha)}$

6.3.3 Important Genera: The well known examples of the family are *Rosa indica* (rose), *Pyrus malus* (apple), *Prunus persica* (peach) , *Fragaria vesca* (Strawberry) *Eriobotrya japonica* (loquat) , *Prunus persica* (Aru)

6.3.4. Economic Importance

This family has a great economic importance for mankind. It has great importance in temperate (cold) region. This family is ranked third in the flowering families for commercial importance in the temperate zone.

1- Fruits: Many fruits are obtained from the plants of this family. A list of some important plants is given here:

Prunus persica Eng.-Peach; Verna-Aru- The fruits are edible and rich in vitamins; the oil is obtained from the seeds which is used for cooking and other purposes.

Prunus domestica Syn. *Prunus communis var. insititia*; Eng.-Plum; Verna- Alucha, Alu-bokhara- The fruits are edible.

Prunus amygdalus Eng.-Almond; Verna. Badam-This is a tree yielding edible seeds. There are two varieties of almonds, i.e., sweet and bitter. The oil obtained from the seeds of both the varieties is used in perfumery and medicinal purposes.

Prunus armenica Eng. Apricot; Verna.-Khubani, Zardalu.. The fruits are edible and rich in vitamins.

Prunus cerasoides Eng. Wild Himalayan cherry ; Verna. Paddam- They are commonly found in the temperate Himalayas from Garhwal to Sikkim and also in Nilgiris. The wood is used for walking sticks.

Eriobotrya japonica Eng.-Loquat; Verna.-Lokat. This is a small tree. Fruits.are edible

Fragaria chiloensis Eng. Garden strawberry. Used as edible fruits

Pyrus communis; Eng.-Pear; Verna.-Nakh,-This is a small tree. It is native of Eurasia but now cultivated in Kashmir, Kulu, Kumaon and Himachal Pradesh. The fruits are edible.

Pyrus malus Eng.-Apple; Verna-Seb.- The fruits are edible, delicious, rich in iron and vitamins.

Pyrus pyrifolia var. culta; Eng.-Chinese pear; Verna.-Nashpati- Used as edible fruits.

Rubus ellipticus Eng. Himalayan yellow raspberry; Verna.-Lal anchu, Hisalu-This is a shrub found in the Western Himalayas, South India, the Western ghats and the Khasia hills. The fruits are edible.

2-Ornamental Plants: A large number of plants of this family are ornamental. They are grown in gardens for their beautiful and scented flowers. The genus *Rosa* is widely cultivated for decorative purpose. *Rosa damascene, Rosa centifolia, Rosa chinensis* and *Rosa alba* have been in cultivation since ancient times. Many other genera such as *Spiraea corymbosa* and *Spiraea cantoniensis* are also grown in gardens and parks for beautiful flowers.

3- Wood: The branches of *Crataegus* are used as walking sticks and wood. The wood of P*ints pactia* is used for making tobacco pipes. *Cotoneaster acuminata*; Verna-Riu-This is a shrub found in Himalayas.

4-Commercial and medicinal uses

The petals of some common roses are called **gulabs** in many Asian countries like Pakistan. These petals are used for making **gulkand**. Petals of rose are used tor extraction of **rose oil.** This oil is used in perfumes. The petals give **Ark-Gulab** on distillation with water. This Ark-Gulab is used tbr curing eye disease and for many other purposes. *Potentilla nepalensis*-this is medicinal plant; used as a remedy for burns. *Potentilla reptans*-The infusion of the herb is used as a remedy of diarrhoea.

6.4 FAMILY: FABACEAE

This is the third largest family of the flowering plants. It is represented by 600 genera and 12000 species, annual or perennial herbs, shrubs, vines, or trees, fibrous tap root often develops nodules in herbs. Nitrogen fixing bacteria live in these nodules, herbaceous or woody; cylindrical, tendril climbers, leaves petiolate; alternate: compound of pinnate type, stipulate, stipules may be modified into leaves or thrones, parallel venation. Inflorescence: Racemose or cymose, the flowers are clustered in heads. Flower: Pedecillate; bracteate: actinomorphic or zygomorphic; regular: complete; hermaphrodite; pentamerous; hypogynous but slightly perigynous, Calyx: 5 or sometime 4 sepals: free or fused green S. Corolla: 5 sometimes 4 petals; free or united, coloured. Androecium: 10 or numerous stamens; polyandrous, in some cases diadelphous, anther basifixed. Gynoecium: monocarpillary: ovary superior, placentation marginal. Fruits: Legume or sometimes lomentum, Seed: Non-endospermic seed.

6.4.1 Systematics

Bentham & Hooker	Engler & Prantl	Hutchinson
Dicotyledones	Dicotyledoneae	Dicotyledons
Polypetalae	Archichlamydeae	Lignosae
Calyciflorae	Rosales	Rosales
Rosales	Fabaceae	Fabaceae
Fabaceae		

Traditional approach is to treat all legumes as one large, somewhat heterogenous family, the Fabaceae (Leguminosae). Bentham and Hooker divided the family into three subfamilies: Papilionaceae, Caesalpinieae and Mimosaceae. Most of the recent taxonomist treats them as three distinct families, Papilionaceae, Caesalpiniaceae and Mimosaceae respectively. The three subfamilies of Bentham and Hooker, which differ in several characters, are described here separately

Description of the Sub–families

6.4.2. (A) General characteristics of Papilionaceae or Papilionoideae (Pea family)

This sub-family has about 500 genera and 10000 species. The members of this family occur all over the world except Arctic regions. Largely represented in temperate regions of Northern and Southern Hemisphere. Over 100 genera and 800 species have so far been reported from India

Habit: Mostly herbs, however shrubs (*Crotolaria*), trees (*Dalbergia, Pterocarpus*), In some climbers (*Clitoria*) twinning stem while in *Vicia* leaf tendrils are found.

Root: Lateral roots of most of the plants have nodules which contain nitrogen fixing bacteria (*Rhizobium*) which convert atmospheric nitrogen into nitrogenous material.

Stem: It may be herbaceous, woody or climber with tendrils. Tendrils are wiry, coiled and thread like structures.

Leaves: Alternate and stipulate leaves.They may pinnately (*Sesbania, Abrus, Dalbergia)* or digitately compound (*Trifolium*), rarely simple (*Crotalaria*), The stipules are mostly leafy. Sometimes, these leaves are partially or completely modified into tendrils. The leaf base is usually pulvinous. Leaves of several genera (*Desmodium*, etc) perform sleep movements.

Inflorescence: It is commonly an axillary, leaf opposed or terminal Raceme, sometimes panicle (*Dalbergia*), axillary head (*Trifolium*), solitary axillary (*Lathyrus*).

Flowers: Bracteate, sometimes bracteolate (*Sesbania*) , complete, bisexual. zygomorphic, pedicellate, perigynous, pentamerous and papilionaceous.

Calyx: They have usually 5 sepals. These petals are mostly united to form tube. These are hairy. Aestivation is valvate or imbricate. The odd sepal is usually anterior.

Corolla: Five petals, very unequal and papilionaceous corolla. These petals are not similar, clawed and show bilateral symmetry. The upper (posterior) one is largest and conspicuous called

Standard or Vexillum, two lateral free petals which are slightly curved **known** as **Wings** and two anterior most petals united to form a boat- shaped structure called the **Keel** or **Carina** which enclose the stamens and carpels. The petals show descending imbricate aestivation. In *Amorpha* wings and keel are absent and in *Lespedeza* flowers are apetalous.

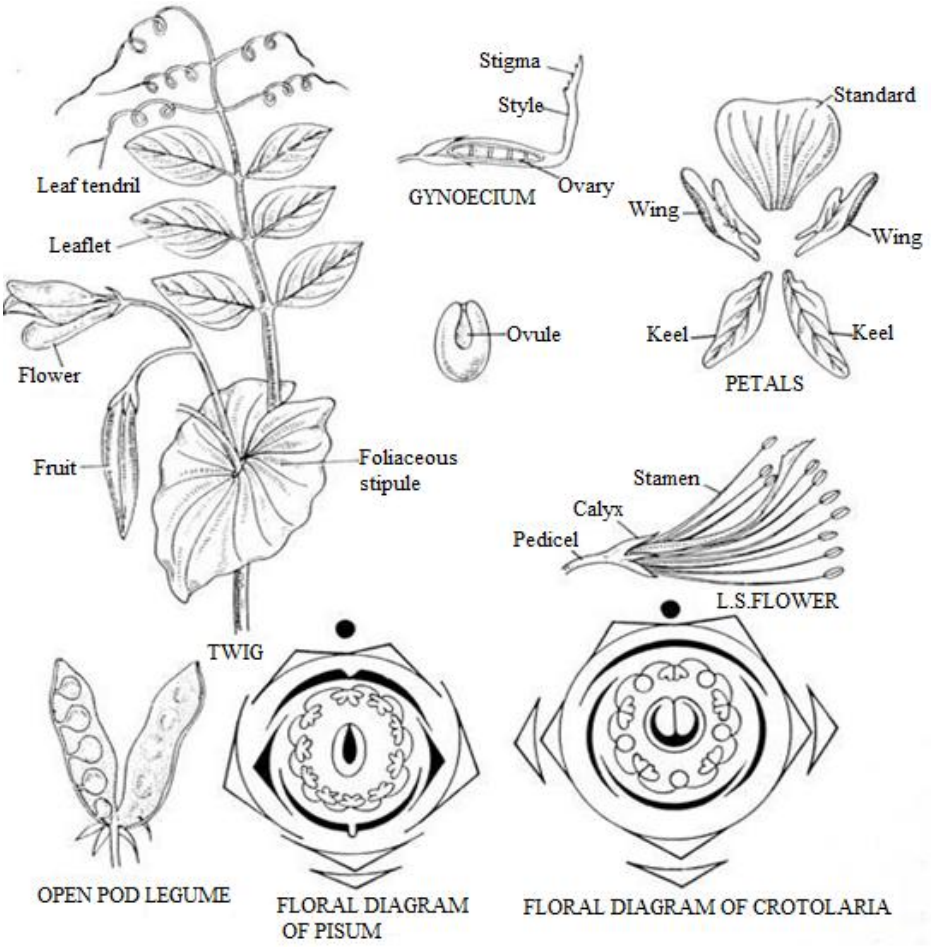

Fig. 6.5 Floral details of *Pisum sativum*

Androecium: 10 stamens, mostly diadelphous stamens, usually 9+1 or sometimes 5+5. In case of 9+1 arrangement, the 9 stamens fused to form a sheath around the pistil and the posterior stamen is free which is often sterile or absent (*Arachis hypogea, Dalbergia sissoo*). Anthers are dithecous, introrse and dehisce by longitudinal slits, rarely all the 10 stamens are free (*Sophora*).

Gynoecium: It has simple pistil. This pistil has single carpel (monocarpellary) with single locule, the ovary is superior. Ovules many to several on the ventral suture, marginal placentation, style is long bent at its base, stigma capitate and lobed.

Fruit: Fruit is usually a legume or pod dehiscing by one or both the sutures into two valves or it is indehiscent (*Dalbergia*). Fruits of *Arachis hypogea* (Groundnut) develop underground.

General Floral Formula

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

6.4.3. (A) Important Genera of Papilionaceae

Astragalus is the largest genus of this subfamily, *Lathyrus odoratus* (Sweet pea) *Arachis hypogea* (Peanut), *Cicer arietinum* (Chick pea) *Dalbergia sissoo* (Shisham), *Trifolium* (Clover), *Medicago sativa* (Alfalfa) *Indigofera, Crotolaria, Vigna* are common genera and speceis found in India.

6.4.4. (A) Economic Importance of Papilionaceae

This family is of great economic importance and provides food stuffs, fodder, fatty oils, fibers, timbers, dyes, gums and ornamentals.

Pulses: Most of the important pulses are belonged to this family. These pulses are used as food. Pulses are rich in proteins. The common species of pulses are *Pisum sativum* (Pea; Matar), *Cicer arietinum* (Gram; Chick pea), *Glycine max* (Soybean), *Cajanus cajan* (pigeon pea, Arhar), *Lens culinaris* (Lentil; Masur), *Vigna radiata* (Green gram; Moong) *Vigna mungo* (Black gram;Urd), etc.

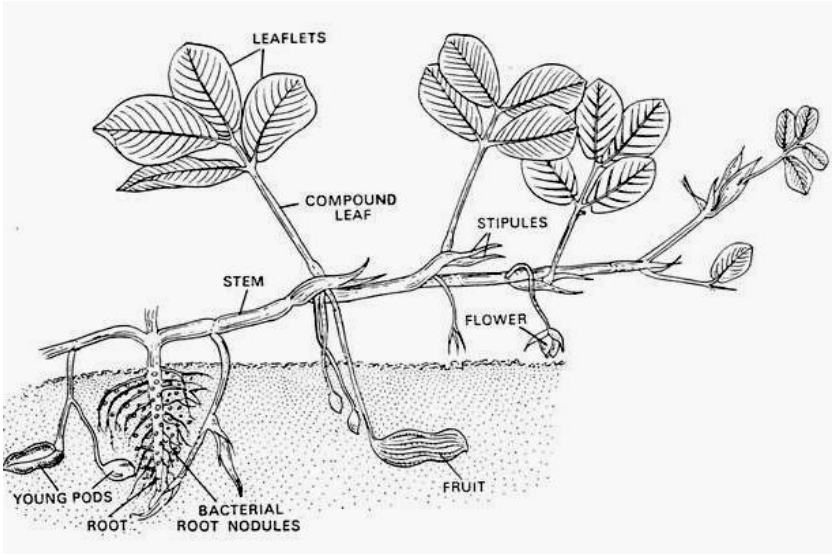

Fig. 6.6 Fruit formation in *Arachis hypogea*

Vegetables: *Vigna unguiculata* (Cow pea, Lobia), *Phaseolus vulgaris* (Kidney bean,French bean, etc.

Fodders*: Medicago sativa* (Alfalfa) is one of the best forage crops. Several species of clover (*Trifolium*) are also cultivated as main fodder crops.

Timber: Many trees of this family provide timber for building furniture and fuel. Main timber plants are *Dalbergia sisso* (Shisham), *Pterocarpus, Butea* etc.

Vegetable oil: The seeds of *Arachis hypogea* (peanut) are edible. They are also used for extraction of peanut oil. This peanut oil is hydrogenated and used as vegetable oil. Soyabean oil is obtained from *Glycine max.*

Dyes: *Indigofera tinctoria* (Indigo) and its other species are source of indigo dye. *Pterocarpus santalinus* (Red Sandalwood) give yellow and orange dyes.

Medicinal plants: Many plants of this family are used as medicines. *Glycorrhiza glabra* (Lquorice) is used for cough and cold. *Clitoria ternata* is used against snake bite. Decoction of leaves and roots of *Abrus precatorius* (Rati) is used for cough and cold.

Ornamental plants: Some important ornamental plants are *Lathyrus* (sweet pea), *Lupinus*, *Clitoria*, *Butea*, *Erythrina*, etc.

Subfamily: Caesalpiniaceae

6.4.2. (B) General characteristics of Caesalpiniaceae (Cassia family)

This family has **152** genera and **2800** species distributed both in subtropical and tropical regions of the world. It has 23 genera and **80** species in India.

Habit: They are mostly trees (*Tamarindus indica*) or shrubs (*Parkinsonia*) or rarely herbs (*Cassia tora*) occasionally woody climber (*Buahinia*)

Stem: It is erect, woody, herbaceous or climbing.

Leaves: The leaves are alternate, stipulate, compound (rarely simple e.g. *Bauhinia*), and unipinnate (*Cassia*) or bipinnate (*Tamarindus).*leaf base often swollen

Inflorescence: It may be axillary **or terminal raceme** or panicles, rarely cymose.

Flower: Flower is mostly large and showy, bractate, complete, bisexual, zygomorphic, pentamerous and hypogynous

Calyx: Sepals are 5. Basally connate or short or long tube. Odd sepal is usually anterior. They are often coloured (*Saraca*).

Corolla: usually 5 free petals, alternate with sepal, aestivation ascending imbricate

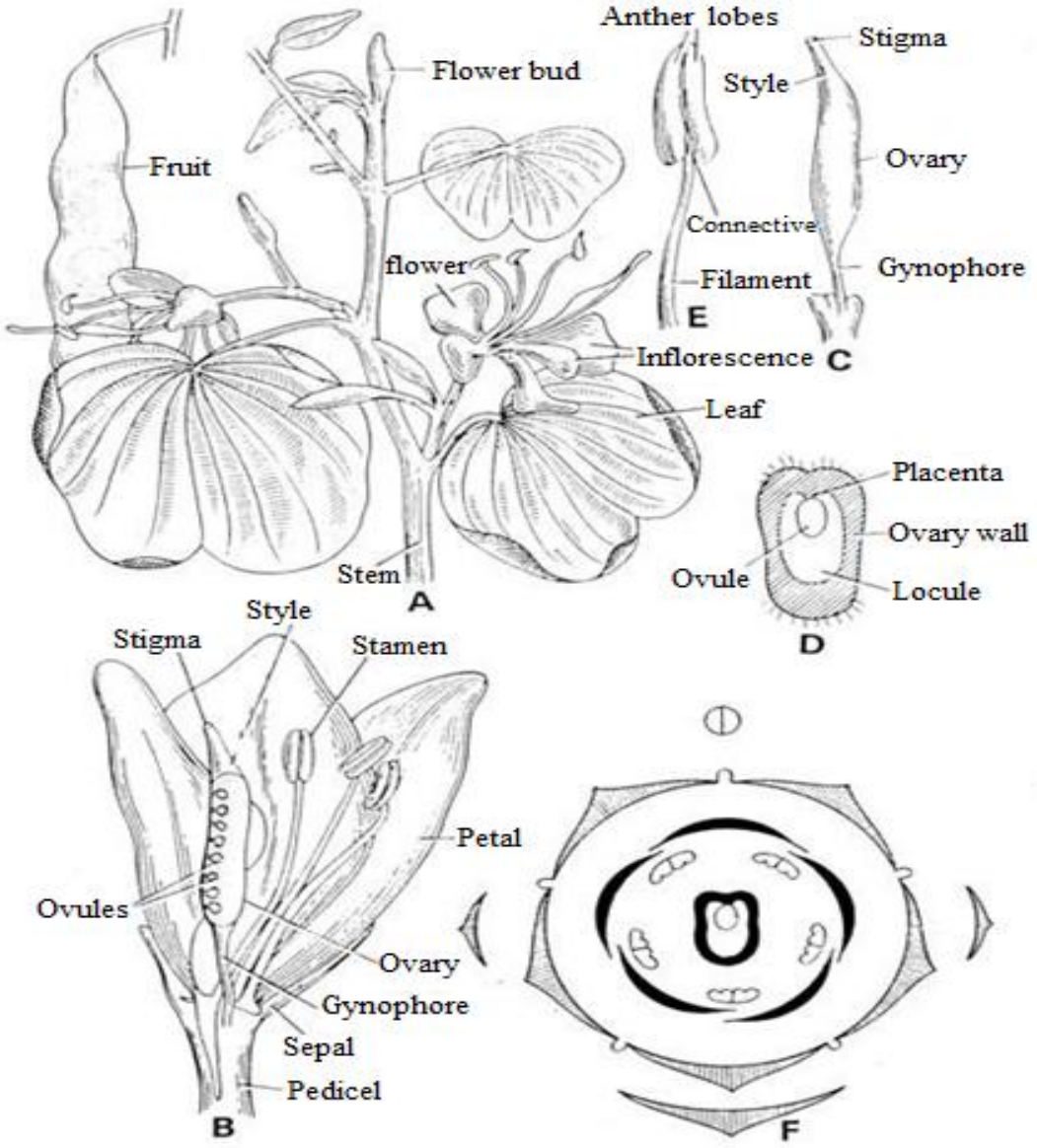

Fig. 6.7 Floral details of *Bauhinia varigata*

Androecium: Stamen are 10 or less (rarely numerous) but often some of the stamens reduced to staminodes or altogether absent (*e.g.* In *Cassia* five to seven, *Bauhinia* three to five are perfect rest are staminodes. Anthers are dithecous, introrse and dehisce by longitudinal slits

Gynoecium: The pistil has single carpel (monocarpellary) with single locule., ovary superior, two rows of ovules on the marginal placentation . The style is simple with capitate stigma.

Fruit: Fruit is usually a legume or pod, often becomes transversely septate (*Cassia*)

General Floral Formula

$$Br \quad \% \ ♂♀ \quad K_{(5)} \ C_5 \ A_{5+5} \ \underline{G}_1$$

6.4.3. (A) Important Genera of Caesalpiniaceae

Tamarindus indica (Imili), *Bauhinia* (Kachnar), *Cassia* (Senna), *Parkinsonia, Saraca* (Ashok tree), *Cassia fistula* (Amaltas), *Delonix regia* (Gulmohar) are some of the important genera and species found in India

6.4.4. (B) Economic Importance of Caesalpiniaceae

Medicinal importance: The leaves of *Cassia alata* are used to cure ringworm and skin diseases. The leaves of *Cassia senna* and *Cassia obovata* are used in making drug called Senna. This oil is applied externally for skin diseases.

Vegetables and fruits: The leaves and flower bud of *Bauhinia variegata* are used as vegetable. The acidic fruit of *Tamarindus indica* are edible. It is rich in tartaric acid.

Tanning and dyes: The bark of *Buahinia* and *Tamarindus* indica is used in tanning. Heart wood of *Haematoxylon campechianum* provide red-orange dye

Ornamental plants: *Bauhinia variegata* (kuchnar), *Cassia***,** *Delonix regia, Caesalpinia pulcherrima* are used as ornamentals.

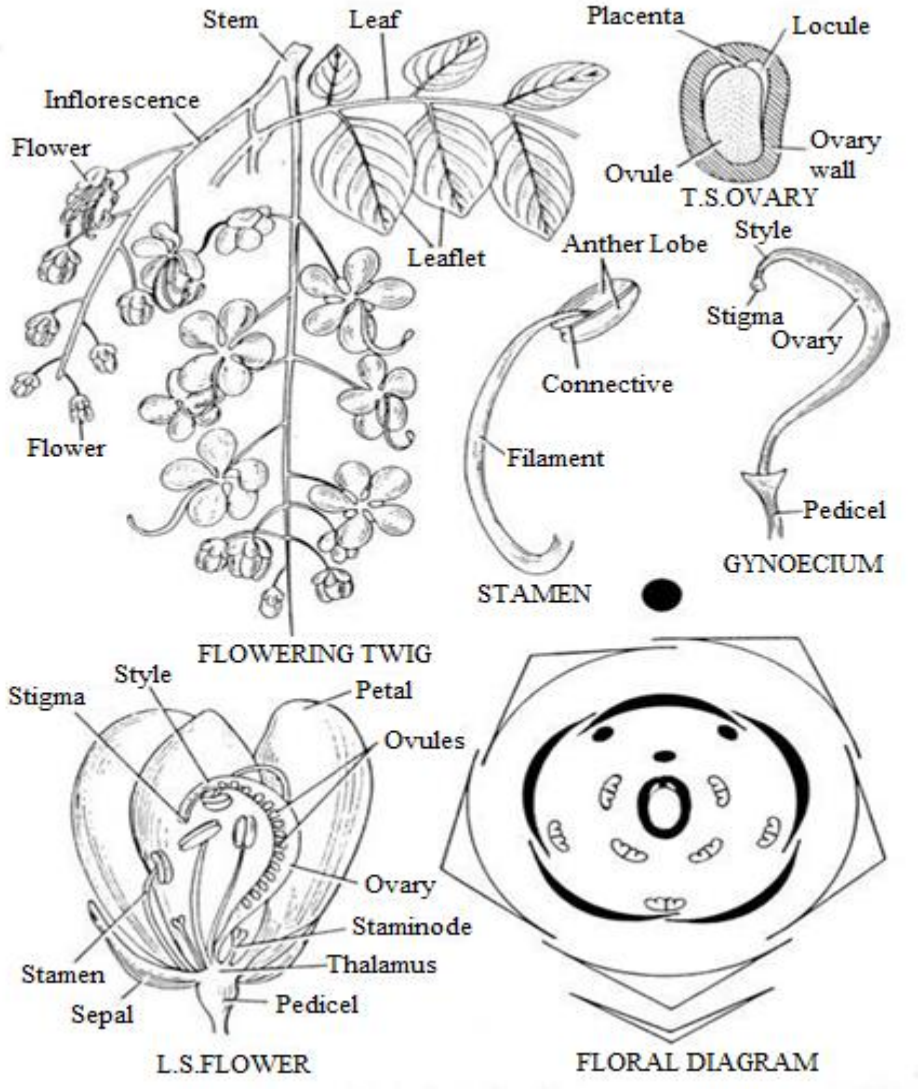

Fig. 6.8 Floral details of *Cassia fistula*

Subfamily-Mimosaceae

6.4.2. (C) General characteristics of Mimosaceae (Acacia family)

This famiy has 56 genera and about 2800 species, widely distributed in subtropical and tropical regions of the world. It has 15 genera and **72** species in India.

Habit: Mosly trees (*Acacia, Albizzia*) or shrubs. Rarely climbers or herbs (*Neptunia*) or woody climbers with most of them are xerophytes.

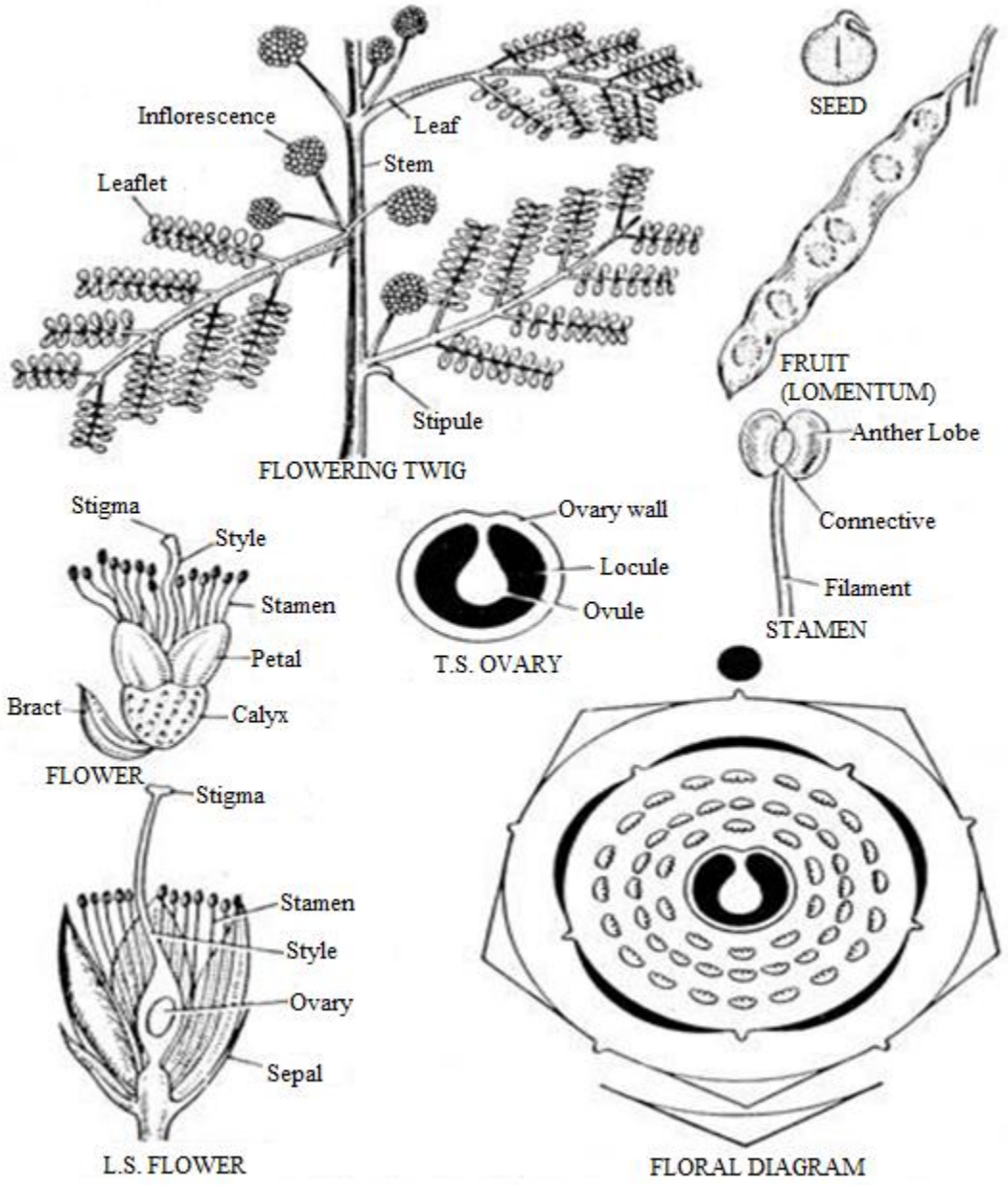

Fig. 6.9 Floral details of *Acacia nilotica*

Stem: Mostly woody, Tannin sac and gum passage are common in the pith and medullary rays

Leaves: Alternate and stipulate leaves, they are bipinnate (unipinnate in *Inga*) compound,. The stipules are modified into thrones (Acacia). Leaves of *Mimosa pudica* and *Neptunia* are sensitive to touch and assume sleep position.

Inflorescence: Minute flowers are condensed in spike-like or head or umbel. It is rarely racemose or globose umbel.

Flowers: The flower is bisexual, actinomorphic, hypogynous to slightly perigynous and bracteate.

Calyx: They have 4-5 sepals. These sepals are fused to tube, toothed or lobed. Aestivation is valvate to imbricate

Corolla: They have 4-5 petals. petals may be free or united tube. Aestivation is valvate

Androecium: The number and cohesion of stamens show much variation. In *Acacia* numerous stamens which are free, whereas in *Albizzia* indefinite stamens are monoadelphous at the base. In several genera (*Prosopis*) stamens are twice the number of petals, free, sometimes as many as the petals (*Mimosa*), the filaments are long, filiform and often exerted. Anthers are dithecous, introrse and dehiscing by longitudinal slits

Gynoecium: The pistil has single carpel (monocarpellary) with single locule., ovary superior and unilocular with several ovules along with ventral suture on the marginal placentation . The style and stigma one.

Fruit: Fruit is usually a legume or pod, indehiscent. In several species of *Acacia* it is lomentum.

General Floral Formula

$$Br \quad \oplus \quad \varsigma\!\!\!\!\male \; K_{(4) \text{ or } (5)} \; C_{4 \text{ or } 5} \; A_{\alpha} \; \underline{G}_{1}$$

6.4.3. (C) Important Genera of Mimoseae

Acacia nilotica (Babul), *Acacia catechu* (Khair), *Albizzia lebbek* (Siris), *Mimosa pudica* (sensitive plant), *Prosopis glandulosa, Prosopis cineraria*, *Leucaena leucophloea* (White popinae) are some of the important genera and species found in India.

6.4.4. (C) Economic Importance of Mimoseae

Wood: Many trees of this family provide commercially important wood, for example many species of Acacia (*A. nilotica*), *Albizzia* (*A. lebbek*, *A. procera*) and *Xylia*. Their wood is used for construction, for furniture and for fuel.

Gum: Gum is obtained from *Acacia nilotica* and *Acacia senegal* used in medicine and confectionary and as a sizing material in textile industry.

Dye: A dye catechu (Katha) is obtained from *Acacia catechu* used in industries and betel.

Medicinal plants: The tender leaves of *Acacia nilotica* are used as blood purifier.

Ornamental plants: Some common plants are grown for their beautiful flowers. Some of these are *Mimosa pudica* and *Acacia melanoxylon.*

Tannins: It is mostly obtained from the bark of *Acacia nilotica* (Babul), *Acacia catechu* (Khair) and *A. leucophloea.*

As Wind breakers: A few species of *Prosopis* are planted in the arid zone for breaking the wind pressure e.g. *Prosopis glandulosa, Prosopis cineraria.*

6.5 FAMILY: ASCLEPIADACEAE (MILKWEED FAMILY)

They form a group of perennial herbs, twining shrubs, lianas or rarely trees but notably also contain a significant number of leafless stem succulents. The name comes from the type genus *Asclepias* (milkweeds).

6.5.1 Systematics

Bentham & Hooker	Engler & Prantl	Hutchinson
Dicotyledones	Dicotyledoneae	Dicotyledons
Gamopetalae	Sympetalae	Lignosae
Bicarpellattae	Contortae	Apocynales
Gentianales	Asclepiadaceae	Asclepiadaceae
Asclepiadaceae		

According to APG II, the Asclepiadaceae is a former plant family now treated as a subfamily (subfamily Asclepiadoideae) in the Apocynaceae (Bruyns 2000).

The florally advanced tribe Stapeliae within this family contains the relatively familiar succulent stem genera such as *Huernia, Stapelia* and *Hoodia*. They are remarkable for the complex mechanisms they have developed for pollination, which independently parallel the unrelated Orchidaceae, especially in the grouping of their pollen into pollinia. The fragrance from the flowers, often called "carrion", attracts flies. The flies pollinate the flowers.

Distribution

There are 175 genera, with about 2,200 species. They are mainly located in the tropics to subtropics, especially in Africa and South America. Most common species is *Calotropis procera* and *Crptostegia grandiflora* is cultivated in gardens.

6.5.2 General Characteristics

Habit: The members are Herbs (*Asclepias*) or shrubs *Calotropis*, or rarely trees or woody climbers (lianas) *e.g.* laticiferous. 'Normal' plants, or switch-plants, or plants of very peculiar vegetative form; sometimes (e.g. *Stapelia*) 'cactoid', succulent, *Hoya has* fleshy photosynthetic stems, Mesophytic or xerophytic. Perennial, self supporting or climbing. When climbing, stem twiners or root climbers, or scrambling, the twiners twining anticlockwise (*Araujia*, *Ceropegia*, *Stephanotis*).

Root: They have tap root, fleshy and tuberous.

Leaves: Opposite decussate (rarely alternate), simple, entire or whorled 'herbaceous' or fleshy or membranous, or modified into spines (*Stapelia*). Leaves stipulate or exstipulate. A thick waxy covering is found in the leaves of *Calotropis*. Leaves of *Asclepias* are Petiolate semiamplexicaule in *Calotropis*, pulvinous in C*ryptostegia grandifolia.*

Inflorescence: It is usually dichasial cyme, arising from leaf axil or flowers aggregated, racemose or umbelliform (*Asclepias* and *Calotropis*).

Flower: Flowers are bractate, usually bracteolate, perfect pentamerous and bi-sexual, cyclic, They have succulent flowers. Their symmetry is mostly actinomorphic, zygomorphic is very rare. Hypogynous disc absent.

Calyx: 5 sepals, usually gamosepalous (at the base) to form calyx tube. Calyx lobes markedly longer than the tube. Calyx regular; imbricate or valvate, with the median member posterior.

Corolla: 5 gamopetalous (the tube short) usually rotate or 5-lobed but sometimes campanulate (*Gymnema*) or funnelform (C*ryptostegia*). Corolla lobes about the same length as the tube

Androecium: 5 stamens. Epipetalous and inserted at or near the base of the corolla tube Anthers are united and form a blunt cone. In the subfamily Periploceae, the filaments are free. The anthers are coherent and apprised to the expanded stylar head. The pollen is granular and united into tetrads, the pollen of the one half of the two adjacent anthers discharge on the spathulate translator arising from the style head and alternating with the anthers. Each translator ends below

in an adhesive disc. Usually a staminal corona of five free lobes arises from the base of the filaments.

In the subfamily Euasclepiadeae, the filaments are connate in a short fleshy column Androecial member adnate; united with the gynoecium forming a gynostegium with it coherent (via the filaments, forming a short sheath around the style (by contrast with *Periplocaceae*). The pollen grains are united in two waxy masses (pollinia) in each cell. The pollinia are united in pairs by caudicles (retinaculae) of various shapes to a gland (Corpusculum) which lies on the stigma. The short filaments are ornamented with necteriferos corona which varies in form in different genera.

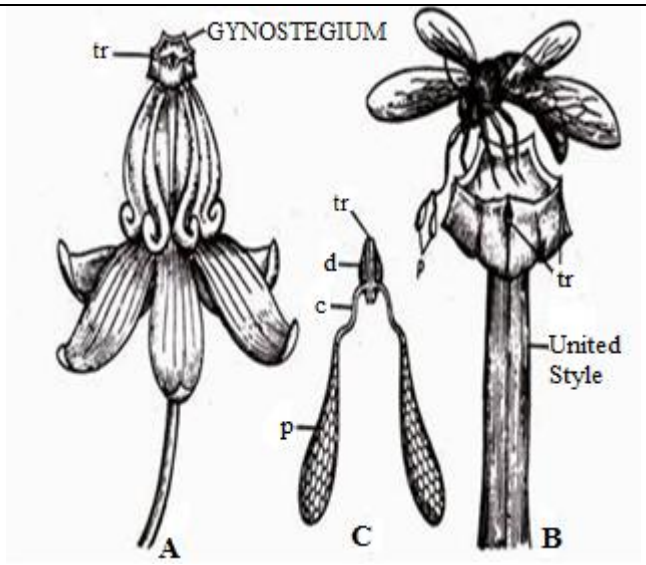

Fig 6.10 Pollination mechanism in *Calotropis gigantea*
A- A Flower , B- A bee removing a pair of pollinia from the gynostegium, C- A pair of pollinia
tr=translator locating paired pollinia d=disc, c=caudicle, p= pollinia

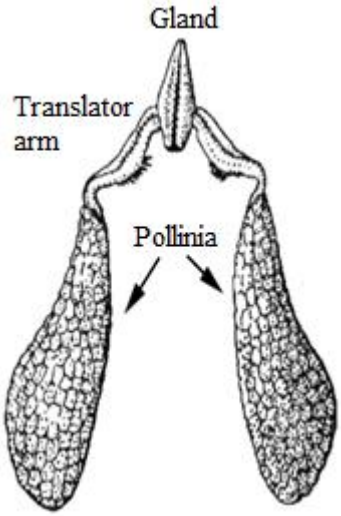

Fig.6.11 A pair of pollinia

Gynoecium: Bicarpellary. Ovary is mostly superior the ovaries of the two carpels are free and so their styles which are united by their apices and dilate in the form of peltate stigma with five lateral stigmatic surfaces. The ovary of each carpel is unilocular with a single (ventral) placenta bearing numeropus anatropous ovules, Styles short.

Fruit: non-fleshy, an aggregate (of two carpels dehiscent, comprising a pair of 'follicles' with thin papery placental flaps.

Seeds: endospermic, seeds conspicuously hairy (with a terminal coma of long, silky hairs), The purpose of long hairs is for dispersal. Winged (usually, all round), or wingless

General Floral Formula

Br ⊕ ♀ $K_{(5) \text{ or } 5}\ C_{(5)}\ \overset{\frown}{A}_{(5)}\ \underline{G}_{(2)}$

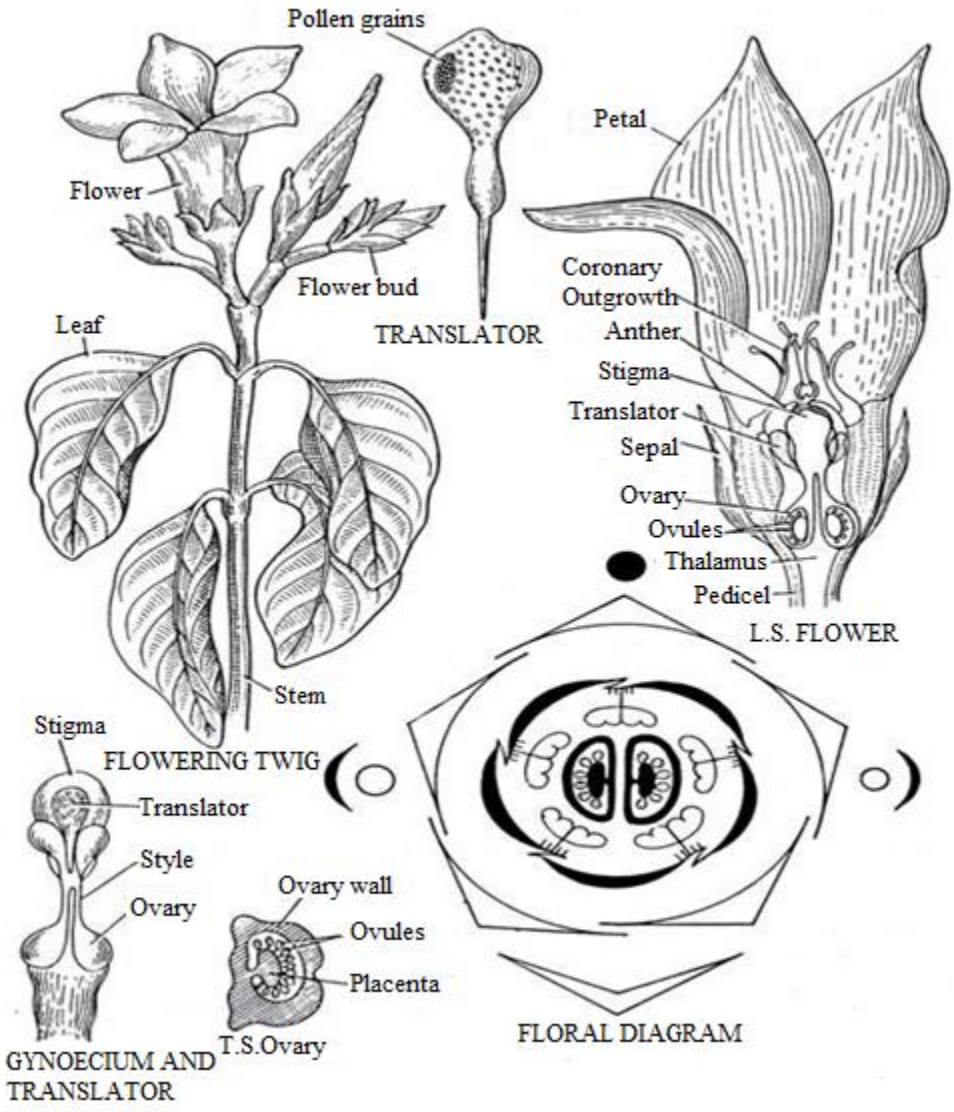

Fig. 6.12 ***Cryptostegia grandiflora***

6.5.3. Important Genera

Asclepias curassavica (Milkweed), *Oxystelma esculentum*, *Calotropis procera (*Madar), *C. gigantea, Stapelia variegata, Hoya longifolia, Daemia extensa, Cryptostegia grandiflora.*

6.5.4 Economic Importance

The family is important for ornamental and drug plants

Ornamentals: Species of *Asclepias curassavica* (Milkweed), *Stapelia variegata*, *Cryptostegia grandiflora* (Rubber vine) are grown for ornamental purpose.

Medicinal: Roots of *Tylophora indica* (Indian ipecacuanha) are used for the treatment of asthma, bronchitis and whooping cough. Dried root of *Hemidesmus indicus* (Indian sarasparilla) constitute Hemidesmus or Anantmul which is blood purifier. *Gymnema sylvestris* is stomachic, stimulant; laxative and diuretic and useful in cough and sore eyes.

Other uses: The latex of *Calotropis procera* (Madar) and *C. gigantea* is used in tanning industry for deodorizing hair and imparting yellow colour to hides. The latex of *Cryptostegia grandiflora* is commercial source of rubber.

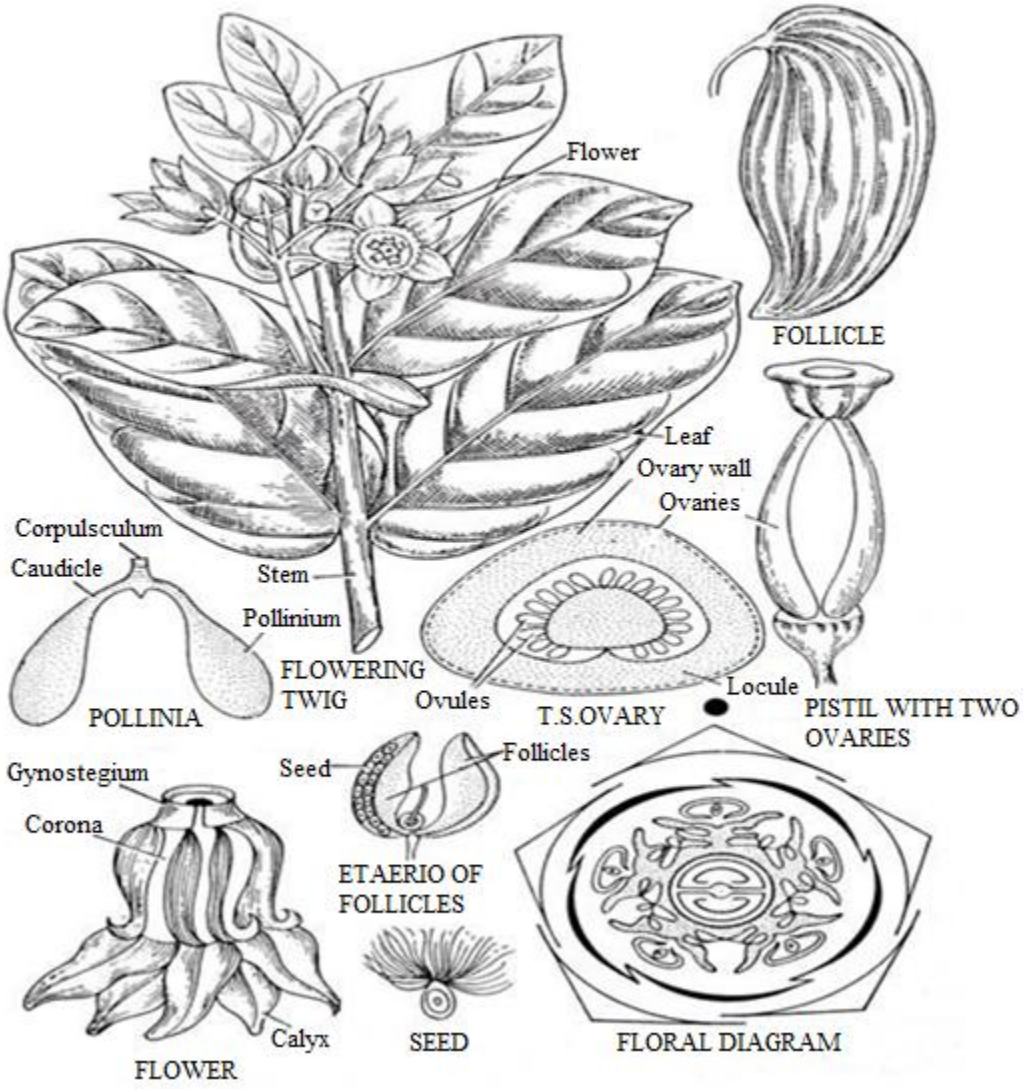

Fig. 6.13 Floral details of *Calotropis procera*

6.6 SUMMARY

Now student can sum up the important criteria of the families studied in this unit.
The Rosaceae are an assemblage of fairly advanced and primitive characters, they are included in order Rosales by most of the botanists. Although Rosaceae are more natural assemblage, most of the tribes (subfamilies) are treated as independent families.

The Fabaceae are included in the order Rosales by Bentham and Hooker, Engler and Prantl, etc. divided the family into three subfamilies- Papilionaceae, Caesalpinieae and Mimoseae. Most of

the recent taxonomists treat them as three distinct families, Papilionaceae, Caesalpiniaceae and Mimosaceae respectively, include them in single order Leguminales (Hutchinson, 1959, 1969) or Fabales (Takhtajan, 1969, 1980). Of the three families (Hutchinson, 1969) b considered caesalpinaceae as the most primitive family. According to him it is closer to Rosaceae and seems to be derived from the rosaceous stock.

According to APG II, the Asclepiadaceae is a former plant family now treated as a subfamily (subfamily Asclepiadoideae) in the Apocynaceae (Bruyns 2000). Bentham and Hooker divided the family into two subfamilies.

In the subfamily Periploceae (*Hemidesmus, Cryptostegia*), the filaments are free. The anthers are coherent and apprised to the expanded stylar head. The pollen is granular and united into tetrads, the pollen of the one half of the two adjacent anthers discharge on the spathulate translator arising from the style head and alternating with the anthers.This subfamily has been raised to the status of separate family Periplocaceae by some botanists. (Hutchinson, 1959, 1969).

In the subfamily Euasclepiadeae (*Calotropis, Asclepias*), the filaments are connate in a short fleshy column Androecial members adnate; united with the gynoecium forming a gynostegium with it, coherent (via the filaments, forming a short sheath around the style. The pollen grains are united in two waxy masses (pollinia) in each cell. The pollinia are united in pairs by caudicles (retinaculae) of various shapes to a gland (Corpusculum) which lie on the stigma.

The Asclepiadaceae is considered as closely related and advanced over the Apocynaceae and usually included in order Gentianales along with Apocynaceae.

6.7 GLOSSARY

Bipinnate – Twice pinnate, the primary leaflets being again divided into secondary leaflets.
Caducous – Falling off very early as compared to similar structures in other plants.
Capsule – A dry dehiscent fruit produced from a compound pistil, e.g. fruit of a tobacco, *Catalpa*, *Dianthus*.
Cyme – A more or less flat-topped determinate inflorescence whose outer flowers open last, e.g. *Sambucus*, elderberry.
Extrorse- Facing outward from the centre of flower referred for anthers
Hairy – Pubescent with long hairs.
Hermaphrodite (bisexual)- The flower having both male and female reproductive organs
Hypanthium-Fused basal portion of sepals, petals or stamens around ovary

Inferior – Beneath, below; said of an ovary when situated below the apparent point of attachment of stamens and perianth.

Milky sap – Whitish in color, often thicker than water.

Multiple fruit – A fruit formed when the pistils of separate flowers form a single structure with a common axis (e.g. *Morus*, mulberry)

Oblique – Lop-sided, as one side of a leaf base larger, wider or more rounded than the other.

Opposite – Describing leaves that are situated in pairs at a node along an axis.

Panicle – An indeterminate inflorescence whose primary axis bears branches of pedicelled flowers (at least basally so); a branching raceme.

Papilionaceous- pea-flowered; flowers which are zygomorphic with imbricate petals, one broad upper one, two narrower lateral ones and two narrower lower ones, the latter usually coherent or connate by their margins; the flowers of Papilionaceae

Pedicel – Stalk of a single flower in an inflorescence.

Peduncle – Stalk of a flower or inflorescence.

Pinnate – Compound, with leaflets or pinnae arranged feather-like on either side of a common axis or rachis.

Polygamous – Bearing unisexual and bisexual flowers on the same plant.

Pome – A type of fleshy, indehiscent fruit represented by the apple, pear and related genera, resulting from a compound ovary.

Prickle – An excrescence of bark that is small, weak, and spine-like.

Pollination-Transference of pollen grain from anthers to stigma

Raceme – A simple indeterminate inflorescence, having a single long axis, with pedicelled flowers.

Schizocarp – A dry dehiscent fruit that splits into two halves, e.g. *Acer* (maple).

Syncarpous- United carpels, compound ovary *e.g. Citrus*

Staminode- Sterile stamen with reduced anther

Tendril – A modified stem or leaf, usually filiform, branched or simple, that twines about an object providing support.

Thorn – modified stem/branch; since a stem comes from a bud, thorns are located above leaves. Examples include apple, pyracantha and *Cotoneaster* **Unisexual** – Bearing either stamens or pistils but not both.

Trifoliate – Three-leaved, e.g. *Trillium*.

Umbel – An indeterminate inflorescence, usually but not necessarily flat-topped with the **pedicels** and **peduncles** (termed rays) arising from a common point, resembling the stays of an umbrella.

Pubescent- downy; covered with short, soft, erect hairs

Zygomorphic-Asymmetrical, irregular

6.8 SELF ASSESSMENT QUESTIONS

6.8.1 Multiple Choice Questions

1. Pulses are group of plants belonging to family (or sub-family)

(i) Caesalpinaceae (ii) Rosaceae
(iii) Papilionaceae (iv) Asclepiadaceae

2. In Papilionaceae the placentation is

(i) Parietal (ii) Axile
(iii) Marginal (iv) Free central

3. Which one of the following is known as Milkweed family

(i) Caesalpinaceae (ii) Rosaceae
(iii) Papilionaceae (iv) Asclepiadaceae

4. Pome type of fruit is characteristic of family

(i) Caesalpinaceae (ii) Rosaceae
(iii) Papilionaceae (iv) Asclepiadaceae

5. Botanical name of Soybean is

(i) *Vicia faba* (ii*) Glycine max*
(iii) *Vigna mungo* (iv) *Pisum sativum*

6. Translator mechanism is found in which of the following families

(i) Caesalpinaceae (ii) Rosaceae
(iii) Papilionaceae (iv) Asclepiadaceae

7. Descending imbricate condition of corolla is general criterion of which one of the following families

(i) Ranunculaceae (ii) Caryophyllaceae
(iii) Rutaceae (iv) Fabacea (Papilionaceae)

8. Which one of the following families belongs to series Bicarpellatae of Gamopetalae as proposed by Bentham & Hooker-

(i) Asclepiadaceae (ii) Rosaceae
(iii) Caryophyllaceae (iv) Rutaceae

9. Botanical name of the Shisham is

(i) *Pterocarpous* (ii) *Dalbergia sissoo*

(iii) *Shorea robusta* (iv) *Aegle marmelos*

10 Gynostegium is found in

(i) Rutaceae (ii) Rosaceae

(iii) Asclepiadaceae (iv) Caryophyllaceae

6.8.1 Answers Key:

1- iii	2- iii	3- iv	4- ii	5- ii
6- iv	7- iv	8 -i	9- ii	10- iii

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6.11 TERMINAL QUESTIONS

1. What do you understand by papilionaceous corolla?
2. Give economic importance of family Fabaceae.
3. Write descriptive note on floral variation of Rosaceae.
4. Give characteristic floral feature of family Asclepiadaceae.
5. Write short notes on the following:

(i) Pollinia (ii) Gynostegium (iii) Pome (iv) Follicle (v) Lomentum (vi) Legume

6. Write about Economic importance of Rosaceae.

7. Give comparative account of taxonomic characters of different subfamilies of family Fabaceae (Leguminosae).

UNIT-7 SOLANACEAE, ACANTHACEAE AND LAMIACEAE

Contents

7.1 OBJECTIVES

In the present unit students will be able -

- to introduced themselves with families -Solanaceae, Acanthaceae and Lamiaceae. According to Bentham and Hooker all these families come under Division- Gamopetalae, Series -Bicarpellatae with different orders. Solanaceae belongs to Order Polemoniales, Acanthaceae to Personales while Lamiaceae comes under order Lamiales.
- to know the Detailed description of the General distribution, Systematics, General characters, Important genera and Economic Importance *etc.* of families Solanaceae, Acanthaceae and Lamiaceae.
- to understand the phylogenetic and evolutionary relations of the families.

Figures of some of the important genera of the concerning families are also given here for correlating this text to the surrounding nature.

7.2 INTRODUCTION

Student has already studied characteristic features of division Gamopetalae and its series Bicarpellatae. In this unit (Unit-7) you will be familiar with three families *i.e.* Solanaceae, Acanthaceae and Lamiaceae of their concerning orders *viz.* Polemoniales, Personales and Lamiales respectively.

Division Gamopetalae and its Series Bicarpellatae

Division- Gamopetalae is characterized by having corolla of united petals. It is divided into three series

(i) Inferae (ovary inferior), (ii) Heteromerae (ovary usually superior, stamens as many or twice of the corolla segments, carpels more than two), (iii) Bicarpellatae (ovary superior, stamens as many or fewer than the corolla, carpels usually two)

It consists of four orders:

Gentianales- Already studied in Unit-6 (Family Asclepiadaceae)

Polemoniales-Leaves generally alternate and exstipulate, flowers regular, stamens as many a corolla lobes.(Family Solanaceae)

Personales- Flowers usually zygomorphic, corolla often billipped, stamens generally fewer than corolla lobes, ovules many in each locule. (Family Acanthaceae)

Lamiales- Corolla usually billipped, stamens usually didynamous or sometimes 2, ovary 2-4 locular with usually 1 ovule in each locule, fruit a drupe or nutlets. (Family Lamiaceae)

7.3 FAMILY- SOLANACEAE (POTATO FAMILY)

The **Solanaceae**, or **nightshades**, are an economically important family of flowering plants. The family ranges from annual and perennial herbs to vines, lianas, epiphytes, shrubs, and trees. It includes a number of important agricultural crops, medicinal plants, spices, weeds, and ornamentals. Many members of the family contain potent alkaloids, and some are highly toxic,

Diagnostic characteristics: Herbs or shrubs with usually alternate, simple and exstipulate leaves, flowers solitary or cymes, calyx often persistent and enlarged, 5-cleft corolla or corolla lobes 5, plaited or valvate in bud, stamens 5 on corolla tube, anthers conniving, sometimes open by pore, ovary bilocular with many ovules in each locule, placentae swollen and septum oblique, fruit a berry or capsule

Distribution pattern: The family has a worldwide distribution, being present on all continents except Antarctica. The greatest diversity in species is found in South America and Central America. Solanaceae commonly called 'Brinjal family'. It includes about 90 genera and 2000 species.. There are around 15 genera and 90 species found in India occurring chiefly in the Himalayas and Southern and Eastern parts of India

Well known examples are mostly cultivated species such as *Solanum tuberosum* (Potato) *Nicotiana tabacum* (Tobacco), *Lycopersicon esculentum* (Tomato), *Capsicum frutescens* (Red pepper), *Solanum melongena* (egg plant or brinjal).

7.3.1 Systematics

Bentham & Hooker	**Engler & Prantl**	**Hutchinson**
Dicotyledons	Dicotyledoneae	Dicotyledons
Gamopetalae	Sympetalae	Herbaceae
Bicarpellatae	Tubiflorae	Solanales
Polemoniales	Solanaceae	Solanaceae
Solanaceae		

According to Bentham and Hooker the Polemoniales consists of five families, they are Polemoniaceae, Hydrophyllaceae, Boragineae, Convolvulaceae and Solanaceae. Engler and Prantl have placed all these families in order Tubiflorae into small groups (orders). He placed Solanaceae Convolvulaceae and Solanaceae in the order Solanales. Hutchinson has also shown the close systematic relationship of the Geraniales with the Convolvulaceae.

7.3.2 General Characteristics

Habit: Mostly annual herbs (*Solanum nigrum*), undershrubs (*Solanum melongena*). Some are shrubs (*Solanum torvum*) rarely trees (*Solanum grandiflorum*) and climbers (*Solanum seaforthianum*).

Root: Fibrous or tuberous Taproot, branched.

Stem: In most species stem is Herbaceous or woody, smooth and branched but sometimes it is prickly or spinous. The spines are modified branches; In *Solanum tuberosum* underground stem tubers are formed.

Leaves: Simple, Petiolate, exstipulate, alternate or opposite, entire (*Petunia*), simple, lobed or pinnatifid (*Solanum*), they are pinnately compound in *Lycopersicon* and *Solanum tuberosum.* In the inflorescence portion the leaves often become sub-opposite or opposite.

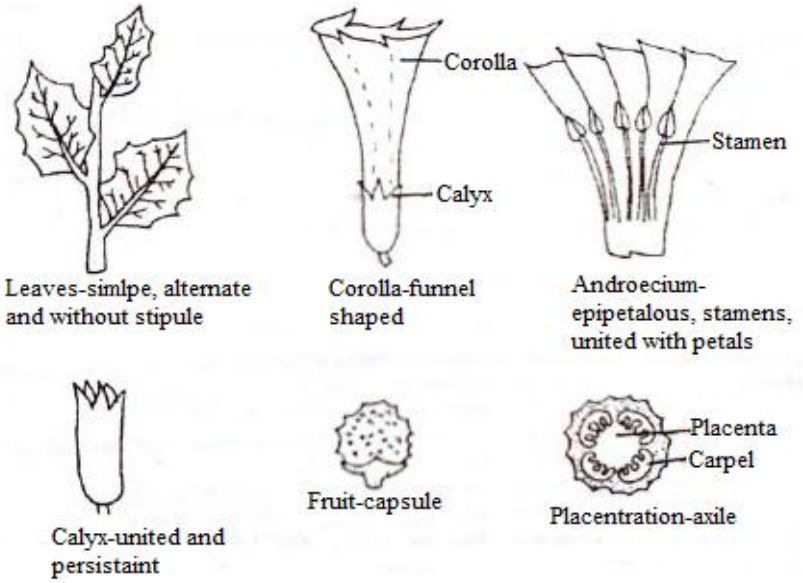

Fig. 7.1 Vegetative and floral parts of Solanaceous plant

Inflorescence: The flowers are often borne in Cymes which are lateral, axillary or terminal. In some species of *Solanum* the cymes are extra-axillary appearing to rise from the middle of an internode. The flowers are solitary and axillary in *Datura* and clustered in *Withania*.

Flower: The flowers are ebracteate, actinomorphic (Zygomorphic in *Salpiglossis*), bisexual (unisexual in *Withania coagulans*), pedicellate, pentamerous and hypogynous.

Calyx: Sepals 5, gamosepalous (five-lobbed or five partite), persistent (in the fruit condition also) green; often much enlarged in the fruit, valvate aestivation in bud.

Corolla: Petals 5, gamopetalous, rotate or companulate (*Physalis*)) or infundibuliform (*Petunia*) trumpet- shaped (*Datura*). The limb is usually five-lobed or rarely ten-lobed as in *Datura* Twisted or valvate aestivation.Sometimes the corolla is strongly zygomorphic and may become bilabiate (*Schizanthus*).

Androecium: The stamens are usually 5, polyandrous and epipetalous on the corolla tube and alternate with the lobes. They are commonly of unequal height. In Zygomorphic forms there are only four in *Salpiglossis* or two *Schizanthus* fertile stamens and remaining are represented by staminodes. The anthers are often conniving (*Solanum*), dithecous, introrse and dehiscing by longitudinal slits or by apical pore free or united, basifixed.

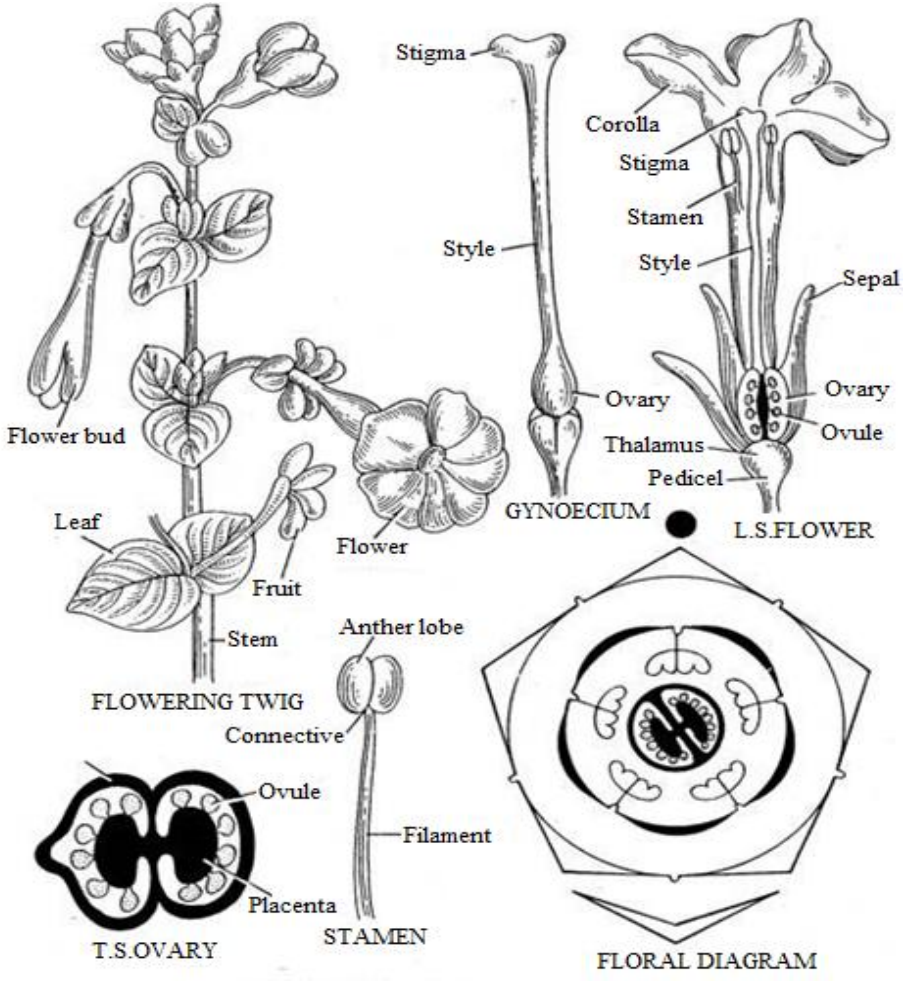

Fig.7.2 Floral details of *Petunia nyctaginifolia*

Gynoecium: Bicarpellary (the number of carpels often increase in *Lycopersicon* and *Capsicum* , syncarpous, The ovary is superior and bilocular (sometimes in *Datura* and *Nicandra* the number of locules increases to three to five by formation of pseudoseptum (false septum) with numerous ovules in each locule (few in *Cestrum*) on axile placentation.. The placentae are often swollen and the septum is oblique. In *Capsicum* the ovary becomes unilocular in the upper region by receding of placentae and appears to be parietal. The style is linear and the stigma is capitate or shortly lobed. A hypogynous nectariferous disc is usually present at the base of the ovary.

Fruit: Fruit is a berry which is sometimes (*Physalis*) enclosed within an inflated bladder-like calyx or it is capsule which dehisces by valves (*Datura*) or circumcise above the middle.

Seed: Numerous, compressed, discoid or subreniform, endospermic with curved or straight embryo.

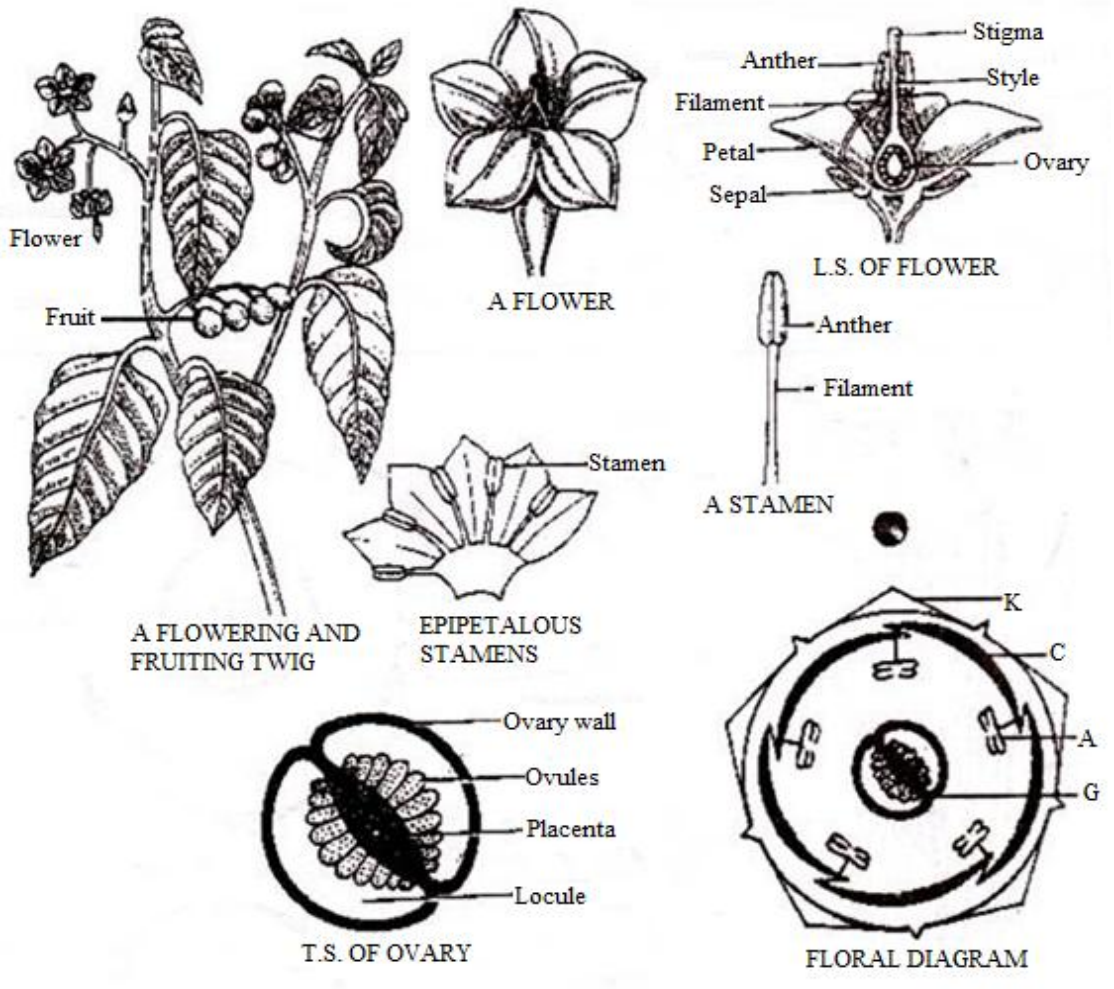

Fig.7.3 Floral details of *Solanum nigrum*

Pollination: Usuallty conspicuous flowers of the solanaceae are visited by insects for nector secreted by a hypogynous disc. In *Solanum tuberosum* usually self pollination occurs.

Floral formula

Solanum	**Ebr**	⊕	♂♀	$K_{(5)}\ \overset{\frown}{C_{(5)}}\ A_5\ \underline{G}_{(2)}$
Salpiglossis	**Ebr**	%	♂♀	$K_{(5)}\ \overset{\frown}{C_{(5)}}\ A_4\ \underline{G}_{(2)}$

7.3.3 Important genera: *Solanum tuberosum* (Potato), *Nicotiana tabacum* (Tobacco), *Lycopersicon esculentum* (Tomato), *Capsicum frutescens* (Red pepper) *Solanum melangena* (egg plant or brinjal), *Solanum nigrum* (Makoi), *Cestrum nocturum* (Rat-ki-rani), *Hyoscyamus niger* (henbane), *Cestrum nocturnum, Withania somnifera* (Ashwagandha).

7.3.4 Economic importance

The solanaceae are of great economic importance. They yield food, drugs, tobacco and many ornamentals.

1- As food stuff: Genus *Solanum*, which contains the potato *S. tuberosum*, in fact, another common name of the family is the "potato family", the tomato (*S. lycopersicum syn. Lycopersicon esculentum*), and the eggplant or aubergine (*S. melongena*).

Another important genus, *Capsicum*, produces both chili peppers and bell peppers. The dried fruits of *Capsicum annum* (Chillies or red pepper, Mirch) are the principal source of chilli powder of commerce used as spice in India. *C. frutescens* is used in making hot sauces and as a vegetable.

Fruits of *Physalis* produce the so-called ground cherries, *Physalis (4-jet-Ground-Cherry), it produces an edible fruit. This fruit is enclosed in a bladder like calyx called husk. So it is called husk tomato.*

2- Tobacco: Nicotiana tabacum (tobacco) has great commercial value. It leaves are dried and made into tobacco. This tobacco is used for making cigarettes.

3- As Medicinal plants: *Many members of this family produce powerful alkaloids e.g. Atropa belladona (Belladona) which are the source of atropine. It is* used for making belladona plasters. Atropine is a medicinal extract. *These are used in many medicines such as overcoming spasm of involuntary muscles, dilating pupils and relieving pain. It is valuable antidote in case of poisoning by opium.*

The dried leaves and flowering tops of Datura stramonium (Dhatura) are source of drug stramonium used chiefly in spasm of the bronchioles in asthma and in treatment of parkinsonism.

It contains alkaloids daturines and atropine. One of the chief ingredients of the Ayurvedic preparation, *Kanaka Asava* used as sedative and intoxicant.

The dried leaves and flowering tops of Hyoscyamus niger (henbane) used as sedative in nervous affections and irritable condition of asthma and whooping cough.

The fruits of *Withania somnifera* (Ashwagandha) constitute the Ayurvedic drug Ashwagandha prescribed for hiccup, female disorders, cough and rheumatism. Another species *Withania coagulans* (Indian rennett) is used in asthma, chronic complaints of lever, colic and as blood purifier.

4- Ornamental Plants: Many plants are cultivated in the gardens for their beautiful flowers. Such as *Petunia, Nicotiana alata, Cestrum nocturnum* (Rat-ki-rani, night queen or night jasmine), *Cestrum diurnum* (Din- ka-raja or day jasmine), *Salpiglossis and Solanum* etc.

7.4 FAMILY- ACANTHACEAE (ACANTHUS FAMILY)

Family Acanthaceae is varyingly placed under order Personales (Bentham & Hooker and Hutchinson), Tubiflorae (Engler and Prantl) and Scrophulariales (Takhtajan, Cronquist). It is usually divided into 4 subfamilies Nelsonioidae, Mendoncioideae, Thunbergioideae and Acanthoideae. Subfamily Nelsonioidae is very close to family Scrophulariaceae and its genera are included in that family by several workers. Subfamily Mendoncioideae and Thunbergioideae are intermediate between Bignoniaceae and Acanthaceae and are usually considered as independent families)

Diagnostic characteristics: Plants in this family have simple, opposite, decussate leaves with entire (or sometimes toothed, lobed, or spiny) margins, and without stipules simple leaves arranged in opposite pairs, with cystoliths (enlarged cells containing crystals of calcium carbonate) in streaks or protuberances in the vegetative parts. The bisexual flowers are frequently bilaterally symmetrical and are usually enclosed by leaf like bracts, often coloured and large. Sepals and petals number five or four each and are often fused into tubular structures. There are usually two or four stamens that extend beyond the mouth of the flower, often with one to three staminodes (sterile stamens). The pistil is superior (i.e., positioned above the attachment point of the other flower parts) and generally consists of two fused carpels (ovule-bearing segments) enclosing two locules (chambers), each of which has two to many ovules in two rows

along the central axis of the ovary.The fruits are often exploding capsules containing seeds borne on hooks on the placenta.

Distribution pattern: This family of dicotyledonous flowering plants has almost 250 genera and about 2500 species. Most are tropical herbs, shrubs, or twining vines, some are epiphytes. Only a few species are distributed in temperate regions. A species well-known to temperate gardeners is bear's breeches (*Acanthus mollis*), a herbaceous perennial plant with big leaves and flower spikes up to 2 m tall. Tropical genera familiar to gardeners include *Thunbergia* and *Justicia*.

7.4.1 Systematics

Bentham & Hooker	**Engler & Prantl**	**Hutchinson**
Dicotyledons	Dicotyledoneae	Dicotyledons
Gamopetalae	Sympetalae	Herbaceae
Bicarpellatae	Tubiflorae	Personales
Personales	Acanthaceae	Acanthaceae
Acanthaceae		

Sometimes the genera *Mendoncia* and *Gilletiella*, and *Thunbergia, Pseudocalyx, Meyenia* and *Pounguia* are placed in separate families, Mendonciaceae and Thunbergiaceae respectively (Airy Shaw, 1973). The family is generally considered to have been derived from the Scrophulariaceae or stocks ancestral to them.

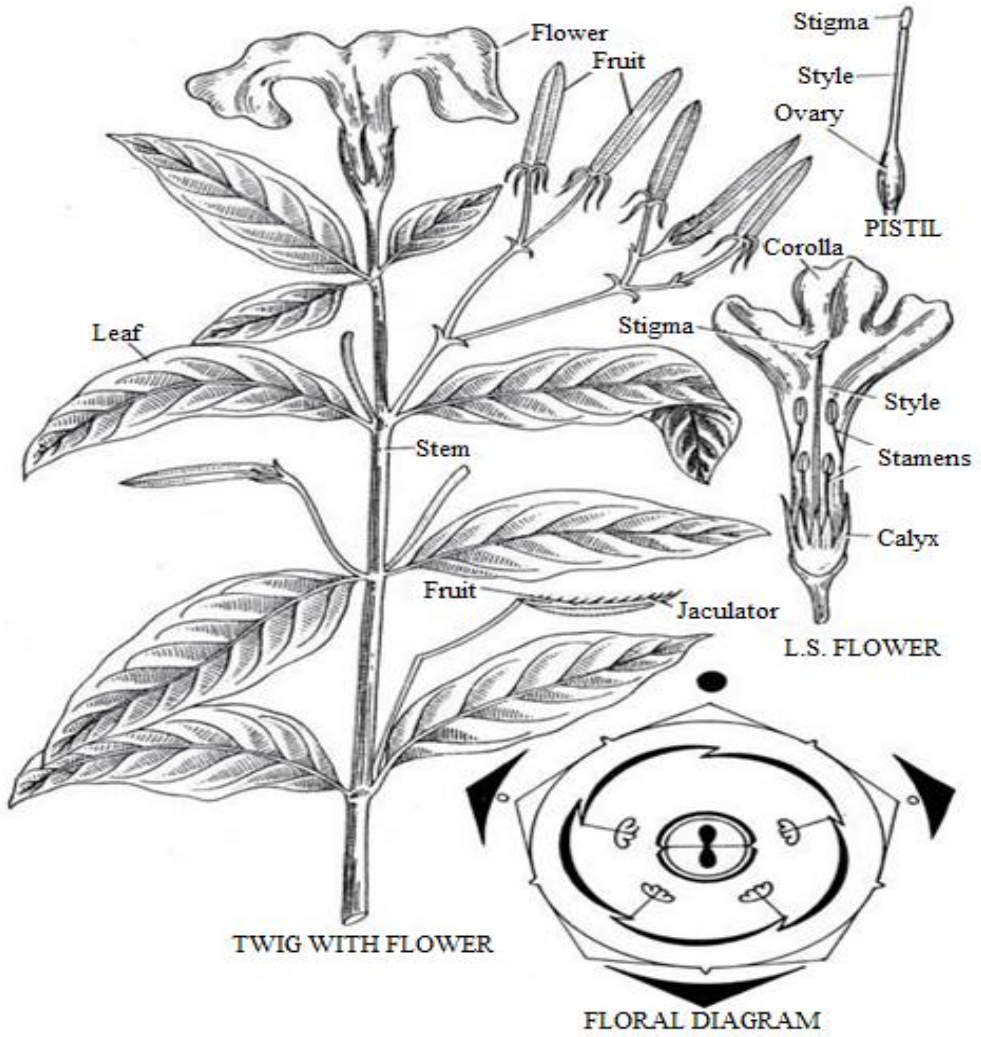

Fig.7.4 Floral details of *Ruellia prostrata*

7.4.2 General Characteristics

Habit: They are mostly annual or perennial herbs, undershrubs or shrubs or sometimes climbing as species of *Thunbergia* and *Mendonica Justicia*. Hydrophytic, or helophytic (including a few mangroves), or mesophytic (many in damp places in tropical forests), or xerophytic (*Barleria*), trees (rarely, but including a few mangroves).

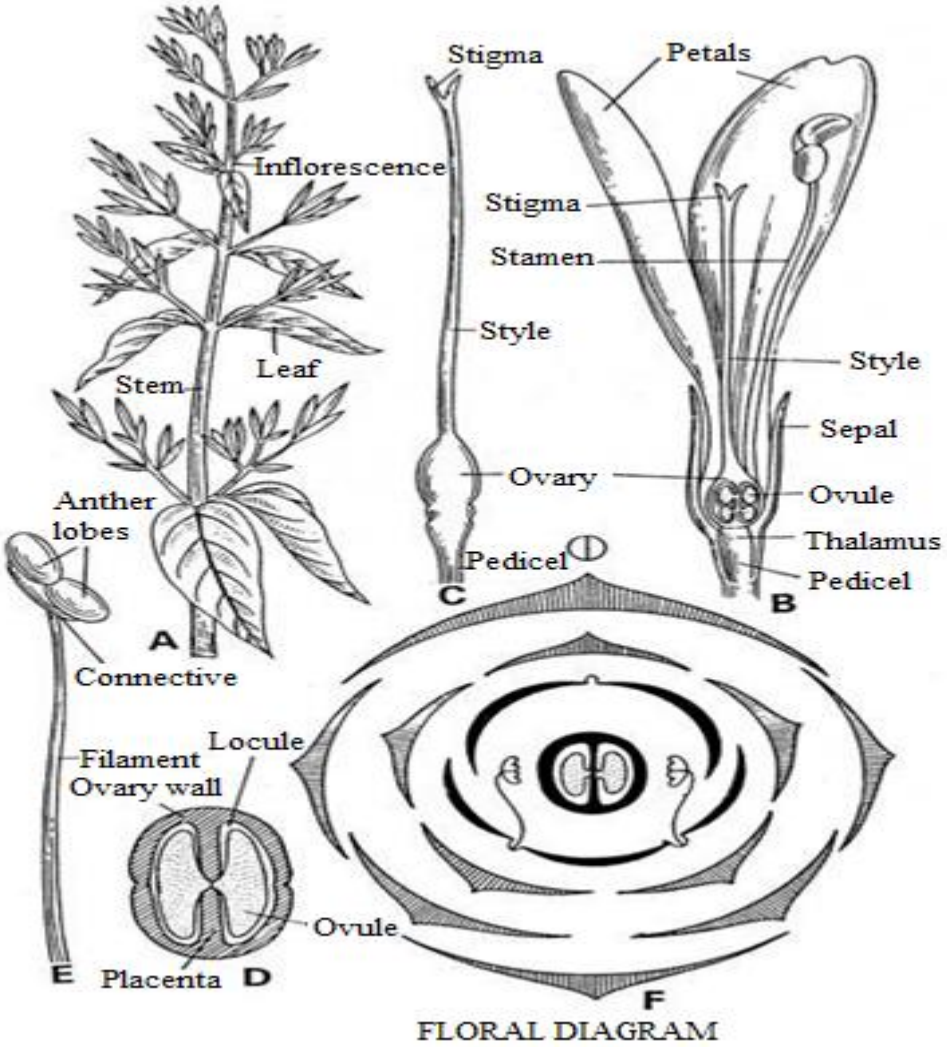

Fig. 7.5 Floral details of *Peristrophe bicalyculata*

Stem: well developed (usually), or much reduced. The herbs annual to perennial, there is basal aggregation of leaves, or without conspicuous aggregations of leaves. Self supporting when climbing, stem twiners, or root climbers or scrambling.Stem of the climbing species show anomalous secondary growth. Cystoliths very commonly present (showing as streaks in the lamina). They are very characterstic and are useful in distinguishing various genera and tribes.

Leaves: Leaves opposite decussate, simple exstipulate. Lamina margins entire

Inflorescence: Inflorescences commonly dichasial cymes, becoming monochasial in the ultimate branches, and frequently condensed in the leaf axils. The cymes are often condensed into axillary whorls (*Hygrophila*) or dense spikes (*Adhatoda*, *Daedalacanthus*) the flowers are axillary solitary in *Thunbergia.*

Flowers: Flowers are bracteates, bracteolate (the bracts and bracteoles often showy), perfect (sessile in *Adathoda*), perfect hermaphrodite zygomorphic and hypogynous, somewhat irregular tetracyclic.

Calyx: 5 sepals or it is usually five-partite and the calyx –segments are imbricate or valvate in bud. In *Peristrophe* the sepals are free. In *Thunbergia* the calyx is reduced to a narrow ring.

Corolla: The corolla **is** gamopetalous with a long or short tube. The limb is sometimes almost equally five-lobed as in *Thunbergia* and R*uellia* but usually it is two –lipped or rarely one –lipped as in *Acanthus* where upper lip is completely absent. When corolla is bi-lipped the upper lip is usually erect and bifid and the lower lip is horizontal and trifid. The aestivation of the corolla is imbricate or contorted.

Androecium: The stamens are more often four and didynamous and frequently two as in *Blepharis, Acanthus* and *Justicia*. The one to three missing stamens are frequently staminodes. In *Pentstemonacanthus* all the stamens are fertile (rarely), inserted near the base of the corolla tube, or midway down the corolla tube, or in the throat of the corolla tube, Anthers bilobed with often one smaller lobe than the other, connective often long, introrse, longitudinal dehiscence.

Gynoecium: Bicarpellary, syncarpous, superior, ovary 2-locular. Ovules 2 to many anatropous to campylotropous in each locule, Placentation axile, style narrow and long, stigma 2, of which anterior one is often larger, usually with hypogynous nectar secreting disc.

Pollination: Pollination entomophilous, flowers are suited to insect pollination because of coloured bilabitate corolla and abundant nectar in hypogynous disc, Protandry favours cross-pollination.

Friuts and seeds: Fruit usually a capsule, loculicidal to the very base, rarely a drupe (*Mendonica*) seed one to many, of which the funiculus develops into a hook like *retinaculum* or *jaculator*, seed often non-endospermic

General Floral Formula

Br	brl	⊕ ♀	$K_{(5)\ \text{or}\ 5}\ C_{2/3}\ A_{2\ \text{or}\ 4}\ \underline{G}_{(2)}$

7.4.3 Important Genera:

Acanthus ilicifolius-A mangrove plant with prickly and handsome flowers, *Barleria*- A medicinal shrub bearing two long thorns at each node., *Adathoda vesica* (syn. *Justicia adathoda*), *Ernathemum, Peristrophe, Rueliia, Thunbergia* are some common plants of family Acanthaceae found in our country.

7.4.4 Economic Importance: Species of several genera are cultivated as garden ornamentals and medicines

Ornamentals*:* A number of species are used as ornamentals of the garden. These include:
Thunbergia (clock-vine) - *T. grandiflora, T. alata, T. coccinefra*
Ernanthemum- E. nervosum, E.bicolor, E.reticulata
Barleria- B. polytrichia, B. cristata
Justicia gendarusa
Peristrophe,
Ruellia ruberosa

Medicines: A few species provide some well known drugs used in indigenous system of medicine. The leaves and roots of *Adhatoda vasica* (Vasaka) provide a well known drug used for bronchitis, asthma and cough.

The roots and leaves of *Hygrophila spinosa* are used for jaundice and rheumatism.

The leaves and roots of several species of *Barleria* such as *B.bauxifolia, B.cristata, B.longifolia, B.prionitis (kalabansa) and B.strigosa* are used for cough and inflammations.

Peristrophe bicalyculata is used as antidote of snake bite.

Rungia parviflora- The juice of its leaves is given to children in small-pox.

7.5 FAMILY: LAMIACEAE (MINT FAMILY)

The original family name is **Labiatae**, so given because the flowers typically have petals fused into an upper lip and a lower lip (*labia* in Latin). **Labiatae** (the **mint** or **deadnettle** family) are a family of flowering plants. The plants are frequently aromatic in all parts and include many widely used culinary herbs, such as basil, mint, rosemary, sage, savory, marjoram, oregano, hyssop, thyme, lavender.

Diagnostic characteristics: The flowers are bilaterally symmetrical with 5 united petals, 5 united sepals. They are usually bisexual and verticillastrate (a flower cluster that looks like a whorl of flowers but actually consists of two crowded clusters). Although this is still considered an acceptable alternative name, most botanists now use the name "Lamiaceae" in referring to this family. The leaves emerge oppositely, each pair at right angles to the previous one (called decussate) or whorled. The stems are frequently square in cross section, but this is not found in all members of the family, and is sometimes found in other plant families.

Distribution pattern

The mint family is rather large containing **180 genera and 3500 species** of worldwide distribution. The Mediterranean region is the chief centre of distribution. In India the family is represented by about **64 genera and 380 species** occurring chiefly in comparatively dry areas and moderate altitudes. The two chief centers of distribution are South India and North Western India. The familiar examples include Mentha *(Mentha spicata*), Holy basil (*Ocimum sanctum)* and Sage *(Salvia spp).*

7.5.1 Systematics

Bentham & Hooker	**Engler & Prantl**	**Hutchinson**
Dicotyledons	Dicotyledoneae	Dicotyledons
Gamopetalae	Sympetalae	Herbaceae
Bicarpellatae	Tubiflorae	Solanales
Polemoniales	Solanaceae	Solanaceae
Solanaceae		

Bentham and Hooker have included five families in order Lamiales. They are Myoporineae, Selagineae, Verbenaceae, Labiatae and Plantagineae. Engler and Prantl have included (excluding Selagineae) in order Tubiflorae. Hutchinson has included the families Myoporaceae, Selagineae, Globulariaceae and Labiatae in the order Lamiales and the Verbenaceae in the Verbenales.

7.5.2 General Characteristics

Habit: They are mostly annual or perennial herbs, sometimes shrubs (as some species of *Ocimum* and *Orthosiphon*) or rarely small trees as *Leucosceptrum*. Species of *Mentha* and *Lycopus* are marsh plants which persist by perennial rhizomes. *Rosamarinus* and some other taxa are xerophytic.

Roots: Tap root

Stem: The stems of the herbaceous species are often quadrangular.

Leaves: The leaves are Petiolate, opposite and decussate (Whorled in *Dysophyla*) simple, exstipulate and the blade is from entire to finely multisect in some species of *Salvia*. They are abundately loaded with epidermal glands secreting volatile aromatic oils, which impart characterstics odour.

Inflorescence: The inflorescence is usually a dichasial cyme which often becomes cincinal in its later branching. These cymes occur in the leaf axils and often form a whorl of flower at each node. This type of inflorescence is often called Verticillaster (opposite axillary cymes). Rarely

the flowers are solitary in the axils of leaves or bracts and form a racemose inflorescence *(Scutellaria*). Each flower is usually subtended by a bract and a pair of bracteoles.

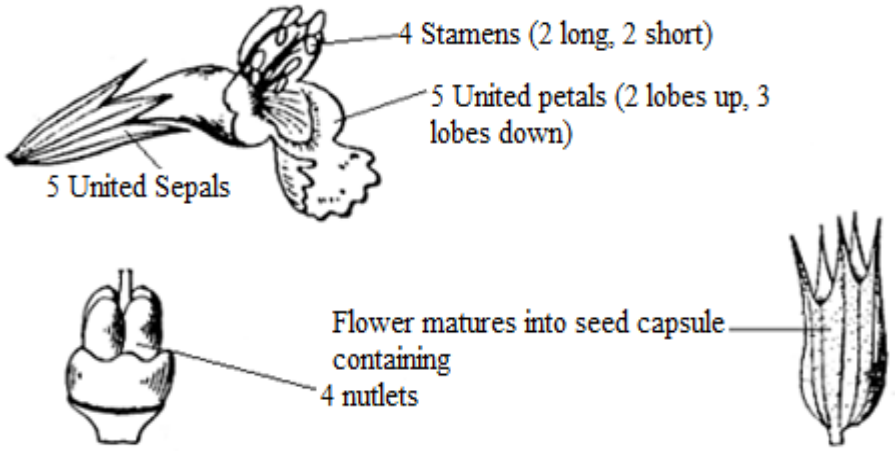

Fig. 7.6 Floral structure of Lamiaceae (Typical mint flower)

Flower: The flowers are bracteates, perfect, hermaphrodite, zygomorphic (rarely actinimorphic as in *Mentha*) Pedicillate, complete. Pentamerous, hypogynous.

Calyx: composed of 4 or 5(usually) sepals, persistent fused, show various degree of union, tubular or funnel-shaped, sometimes as in *Salvia*, *Ocimum* and several other taxa, it is two-lipped. The aestivation is valvate or rarely imbricate.

Corolla: 4 or 5 petals, gamopetalous and is differentiated into a tube and a limb. The tube is straight or bent and often widens upward. The limb is usually two-lipped **(**bilabiate). In the lower lip of *Lamium* the median lobe is most developed. In *Ocimum* and related genera such as *Salvia* the upper lip is composed of two posterior petals, while the remaining three form lip which is four-fid formed by four petals while the remaining fifth anterior petal forms the lower lip which is hardly longer than the upper lip. In *Teucrium* the limb is one-lipped as all the five lobes are pushed on the lower side. The corolla lobes are contorted or imbricate in the bud.

Stamens: The stamens are usually four, stamens didynamous and inserted on the corolla tube . The anterior pair of stamen is usually longer. The fifth (posterior) stamen is sometimes represented by staminode but it is usually suppressed. In *Lycopus, Salvia, Mosla* and some other genera only two stamens (anterior pair) are fertile whereas the other two (posterior pair) are reduced to staminodes. The filaments are usually free but they are connate in *Coleus*. The anthers are dithecous, introrse and dehisce lengthwise. In *Salvia* the two anther cells are separated by the development. The posterior cell alone is fertile epipetalous, basifixed.

Gynoecium: The gynoecium is bicarpellary and syncarpous. The ovary is superior, deeply four lobed, bilocular or apparently becoming four-lobed by the formation of false septa. There are two anatropous ovules in each locule (only one ovary is tetra-locular). The style is very characterstic of the family. It arises from the base of ovary in between the four locules and is known as **gynobasic style.** The stigmatic papillae of bilobed stigma are situated at the tip of the style arms. The placentation is axile. A hypogynous disc is present at the base of ovary. It is usually four-lobed and the anterior pair of lobes which are more developed secrete nectar.

Fruits: The fruit is of four one-seeded nutlets enclosed by the persistent calyx.

Seed: Non-endospermic.

Pollination: Entomophilous

General Floral Formula

%	♂	$K_{(5)}\ \overline{C_5\ A_4}$ or 2 $\underline{G}_{(2)}$

Ocimum	**Br**	%	♂ ♀	$K_{(1/4)}\ \overline{C_{(4/1)}\ A_{2+2}}\ \underline{G}_{(2)}$
Salvia	**Br**	%	♂ ♀	$K_{(3/2)}\ \overline{C_{(2/3)}\ A_2}\ \underline{G}_{(2)}$

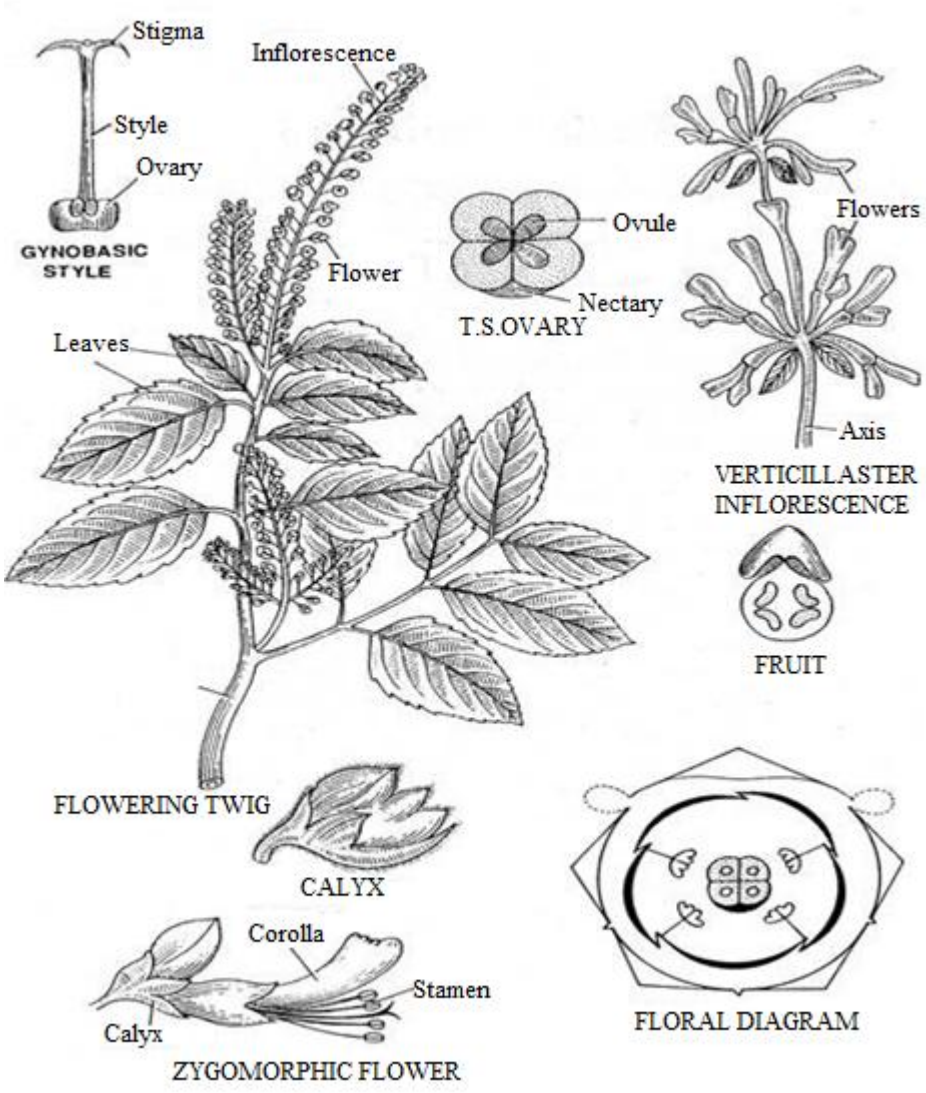

Fig 7.7 Floral details of *Ocimum sanctum*

7.5.3 Important species: *O.americanum syn. O.canum* (Ram tulsi), *O. gratissimum* (Shrubby basil), *O. basilicum* (sweet basil, Kali basil), *O. sanctum* (Holy basil, tulsi). *Mentha piperata* (Vilayati pudina), *M. arvensis* (Field mint), *M. spicata* (pahari pudina), *Ocimum kilimandscharicum, Lavandula officinalis* (Lavandula), *Rosmarinus officinalis* (Rosemarry), *Salvia splendens* (Scarlet sage), *S. leucantha, S. coccinea, S. officinal*is and *Coleus blumei* are common plants grown in India.

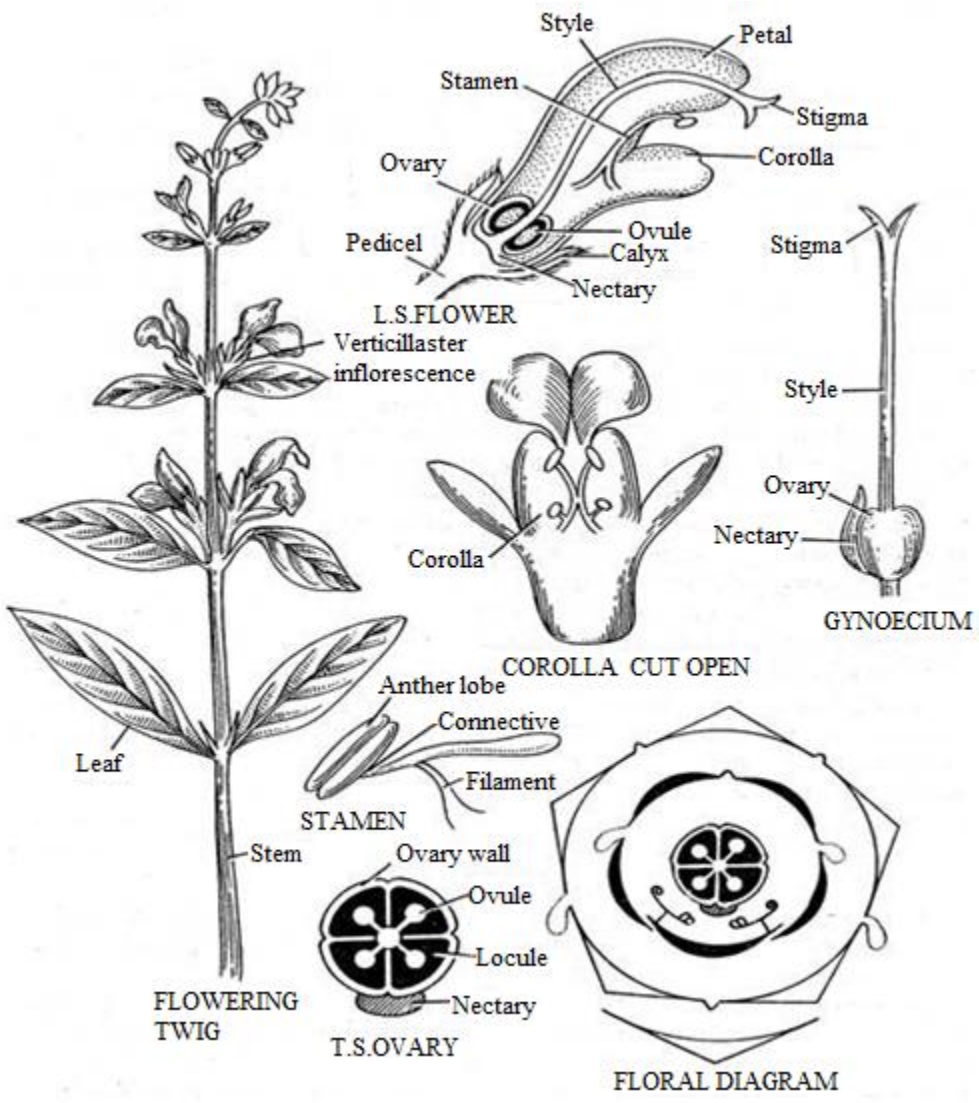

Fig.7.8 *Salvia officinalis* Linn.

7.5.4 Economic Importance:

The lamiaceae are valuable chiefly as a source of volatile essential oils which are used for flavouring for perfumery and for medicines and as garden ornamentals.

Medicinal plants: Many plants of this family give drugs. Several species of *Ocimum* (Basil) such as *O.americanum syn. O.canum* (Ram tulsi), *O. gratissimum* (Shrubby basil), *O. basilicum* (sweet basil, Kali basil) and *O. sanctum* (Holy basil, tulsi) yield essential oils used in medicines and perfumery.

Peppermint is obtained from *Mentha piperata.* It is used in perfumery and the oil obtained from its leaves used medicinally as stimulant, carminative. *M. arvensis* (Field mint) and *M. spicata* (pahari pudina) are used in flavouring food products.

O. sanctum (Holy basil, tulsi) is used as remedy for cold and cough. *Ocimum kilimandscharicum* contains camphor.

Perfumes: Many plants contain abundant volatile aromatic oils like *Lavandula officinalis* yields lavender oil, *Rosmarinus officinalis* yields rosemary oil.

Condiments: *Mentha* and *Ocimum* are used as condiments.They are used in digestive disorders and as stomachic problems

Beverages: *Ocimum canum* gives mucilaginous seeds. These are used in beverages as tukhmalanga.

Ornamental plants: Several species of *Salvia* (Sage) – *S. splendens* (Scarlet sage), *S. leucantha, S. coccinea, S. officinali*s and *Coleus blumei* are cultivated for their beautiful flowers.

7.6 SUMMARY

Now student can sum up the important criteria of the families studied in this unit (Unit-7). In the present unit student were introduced with families Solanaceae, Acanthaceae and Lamiaceae. According to Bentham and Hooker all these families come under Division- Gamopetalae and Series Bicarpellatae with different orders. Solanaceae belongs to Order Polemoniales, Acanthaceae of Personales while Lamiaceae comes under Lamiales.

The **Solanaceae**, or **nightshades**, are an economically important family of flowering plants. The family ranges from annual and perennial herbs to vines, lianas, epiphytes, shrubs, and trees, and includes a number of important agricultural crops, medicinal plants, spices, weeds, and ornamentals. Many members of the family contain potent alkaloids, and some are highly toxic, but many cultures eat nightshades, in some cases as staple foods. The family belongs to the order Solanales in the asterid group dicotyledons (Magnoliopsida). The Solanaceae consists of about 98 genera and some 2,700 species, with a great diversity of habitat, morphology and ecology.

Another family Acanthaceae is varyingly placed under Personales (Bentham & Hooker and Hutchinson), Tubiflorae (Engler and Prantl) and Scrophulariales (Takhtajan, Cronquist). It is usually divided into 4 subfamilies Nelsonioidae, Mendoncioideae, Thunbergioideae and Acanthoideae. Subfamily Nelsonioidae is very close to family Scrophulariaceae and its genera are included in that family by several workers. Subfamilies Mendoncioideae and

Thunbergioideae are intermediate between Bignoniaceae and Acanthaceae and are usually considered as independent families). Plants in this family have simple, opposite, decussate leaves with entire (or sometimes toothed, lobed, or spiny) margins, and without stipules. Simple leaves arranged in opposite pairs, with cystoliths (enlarged cells containing crystals of calcium carbonate) in streaks or protuberances in the vegetative parts. The bisexual flowers are frequently bilaterally symmetrical and are usually enclosed by leaf like bracts, often coloured and large. Sepals and petals number five or four each and are often fused into tubular structures. There are usually two or four stamens that extend beyond the mouth of the flower, often with one to three staminodes (sterile stamens). The pistil is superior (i.e., positioned above the attachment point of the other flower parts) and generally consists of two fused carpels (ovule-bearing segments) enclosing two locules (chambers), each of which has two to many ovules in two rows along the central axis of the ovary. The fruits are often exploding capsules containing seeds borne on hooks on the placenta.

The last family of this unit is Lamiaceae also well known as Labiatae. The flowers are bilaterally symmetrical with 5 united petals, 5 united sepals. They are usually bisexual and verticillastrate (a flower cluster that looks like a whorl of flowers but actually consists of two crowded clusters). Although this is still considered an acceptable alternative name, most botanists now use the name "Lamiaceae" in referring to this family. The leaves emerge oppositely, each pair at right angles to the previous one (called decussate) or whorled. The stems are frequently square in cross section, but this is not found in all members of the family, and is sometimes found in other plant families. The style is very characterstic of the family. It arises from the base of ovary in between the four locules and known as gynobasic style. The stigmatic papillae of bilobed stigma are situated at the tip of the style arms. The placentation is axile.

7.7 GLOSSARY

Adnate: The Fusion of unlike parts (anthers and filament)
Basifixed: Fixed to the filament (stalk) at the base
Berry: A superior (rarely inferior) indehiscent, usually many seeded, fleshy or pulpy fruit developingf from single carpel or more commonly from a syncarpous pistil with axile or parietal placentation e.g. tomato
Bilabiate: Two lipped zygomorphic gamopetalous corolla, *e.g. Justicia, Ocimum, Salvia*
Capsule – A dry dehiscent fruit produced from a compound pistil, e.g. fruit of a tobacco, *Catalpa, Dianthus*.
Cyme – A more or less flat-topped determinate inflorescence whose outer flowers open last, e.g. *Sambucus*, elderberry.

Monochasial (Uniparous) cyme: Having a cymose inflorescence with one axis at each branching

Dichasial (Biparous) cyme: Dichotomously branched cymose inflorescence

Didynamous: In an androecium four stamens in two pairs, one pair shorter than the other .

Dithecous: Two-celled anther

Epipetalous: Stamens borne on the petals or corolla tube *e.g. Justicia, Solanum*

Extrorse- Facing outward from the centre of flower referred for anthers

Gamosepalous: With coherent sepals

Imbricate: A mode of aestivation in which one member of whorl outside all the other (*i,e.* its margins are free) and one inside all the others (both margins are overlapped), the other overlap by one margin only

Jaculator: Structural modification of the funiculus develops into a hook like structure on which the seeds rest.

Locule: Chambers, the ovary may be unilocular (*Ranunculus*), bilocular (*Solanum*), trilocular (*Allium*), tetralocular (*Ocimum*), Pentalocular (*Hibiscus*) or multilocular (*Citrus*)

Oblique – Lop-sided, as one side of a leaf base larger, wider or more rounded than the other.

Opposite – Describing leaves that are situated in pairs at a node along an axis.

Pedicel – Stalk of a single flower in an inflorescence.

Peduncle – Stalk of a flower or inflorescence.

Persistent: Remaining attached till maturation

Personate: Zygomorphic, gamopetalous corolla with two lips

Pinnate – Compound, with leaflets or pinnae arranged feather-like on either side of a common axis or rachis.

Pollination-Transference of pollen grains from anthers to stigma

Raceme – A simple indeterminate inflorescence, having a single long axis, with pedicelled flowers.

Syncarpous- United carpels, compound ovary

Staminode- Sterile stamen with reduced anther

Verticillaster: Much condensed cymes occur in the leaf axils and often form a whorl of flower at each node. This type of inflorescence is often called Verticillaster (opposite axillary cymes) characterstic of Labiatae.

7.8 SELF ASSESSMENT QUESTIONS

7.8.1 Multiple Choice Questions

1. In Labiateae (Lamiaceae) the fruits are usually

(i) Follicle (ii) Nutlets
(iii) Capsule (iv) Achene

2. Botanical name of Chilli (Red hot pepper) is
(i) *Solanum tuberosum* (ii) *Lycopersicon esculentum*
(iii) *Capsicum frutescens* (iv) *Nicotiana tabacum*

3. Gynobasic style is the characteristic of the family
(i) Lamiaceae (ii) Acanthaceae
(iii) Solanaceae (iv) Poaceae

4. Persistent calyx (in fruit) is characteristic feature of which one of the following families
(i) Lamiaceae (ii) Acanthaceae
(iii) Solanaceae (iv) Poaceae

5. *Withania somnifera* is commonly called as
(i) Sarpgandha (ii) Ashvagandha
(iii) Rajnigandha (iv) Rat-ki- rani

6. *Adathoda vasica* belongs to which one of the following families
(i) Lamiaceae (ii) Acanthaceae
(iii) Solanaceae (iv) Poaceae

7. Berry or septicidal fruit is charactersic feature of family
(i) Lamiaceae (ii) Acanthaceae
(iii) Solanaceae (iv)Poaceae

8. Epipetalous and didynamous stamens and presence of staminode is characterstic feature of which one of the following families
(i) Lamiaceae (ii) Acanthaceae
(iii) Solanaceae (iv) Poaceae

9. A hook like projection known as ‘jaculator’in which the seed rest is found in
(i) Lamiaceae (ii) Acanthaceae
(iii) Solanaceae (iv) Poaceae

10. Botanical name of Pudina is
(i) *Salvia officinals* (ii) *Ocimum sanctum*

(iii) *Coleus bruni* (iv) *Mentha arvensis*

7.8.1 Answers Key:

1- ii	2- iii	3- i	4- iii	5- ii
6- ii	7- iii	8 -ii	9- ii	10- iv

7.9 REFERENCES

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7.11 TERMINAL QUESTIONS

1. What do you understand by verticillaster inflorescence.
2. Describe economic importance of family Solanaceae.
3. Write descriptive note on floral features of Acanthaceae.
4. Give characteristic features of family Lamiaceae.
5. Write short notes on the following:
(i) Jaculator (ii) Gynobasic style (iii) Capsule (iv) Bi-lipped corolla (v) Economic importance of genera *Solanum* (iv) Berry
6. Describe family Solanaceae in semi-technical taxonomic language.
7. Give comparative account of taxonomic characters of families Acanthaceae and Lamiaceae.

UNIT-8 ORCHIDACEAE, LILIACEAE AND POACEAE

Contents

8.1 OBJECTIVES

After reading this unit student will be able-

- to know introductory account on monocotyledons and its three families *Viz.* Orchidaceae, Liliaceae and Poaceae.
- to know Detailed description on General distribution, their Systematics, General characters, Important genera and Economic Importance *etc.* of families Orchidaceae, Liliaceae and Poaceae will be studied.
- to give an outline of the phylogenetic and evolutionary relations of the families will be enlightened. Figures of some of the important genera of the concerning families are also given here for correlating this text to your surrounding nature.

8.2 INTRODUCTION

In previous unit's student have already studied characteristic features of dicotyledons. Now, student will get familiar with three monocotyledon families i.e. Orchidaceae, Liliaceae and Poaceae.

Bentham and Hooker (1862-1883) recognized 34 families under monocots and divided them into varying number of series. Takhtajan (1969) divided class Liliatae (or Monocotyledons) into 69 families. Cronquist (1981) included 65 families under class Liliopsida (Monocots) whereas Thorne (1983) treated Monocotyledons (=Liliidae) as a subclass of class Angiospermae (Annonpsida) and discussed 53 families under this subclass.

According to Bentham and Hooker 7 series of Monocotyledons are Microspermae, Epigynae, Coronarieae, Calycineae, Nudiflorae, Apocarpeae, Glumaceae.

Family Orchidaceae comes under Series- Microspermae, Liliaceae under Series- Coronarieae while Poaceae is included under Series- Glumaceae.

Series- Microspermae is characterized by the presence of Epigynous flowers, inferior ovary, parietal placentation and very small and numerous non-endospermic seeds. It includes three families, e.g. Orchidaceae.

Series- Coronarieae is characterized by coloured or petaloid perianth, superior ovary and endospermic seeds. It includes 8 families. *e.g.* Liliaceae.

Series Glumaceae is characterized by small, scale like or chaffy perianth or no perianth, Large scaly bracts, flowers in spikelets or heads, ovary unilocular with one ovule in locule and seeds with abundant and starchy endosperm. It includes 5 families. e.g. Poaceae.

8.3 FAMILY: ORCHIDACEAE (ORCHID FAMILY)

Diagnostic characters

Perennial herbs, epiphytes or saprophytes, may be terrestrial; flower zygomorphic, hermaphrodite, epigynous, resupinated; perianth 6 in two whorls, the posterior segment of the inner whorl developed as lip or labellum; presence of peculiar structure-labium, column and rostellum; Stamens 1-2, one or two staminodes pollen grains united into pollinia; gynoecium tricarpellary, inferior unilocular with parietal placentation; the fertile stamen is adherent to the style and forms it with the column or gynostemium, which projects more or less in the centre of the flower; stigma 2 or 3 lobed, in some two fertile and one sterile and modified into rostellum.

Distribution

Orchidaceae is one of the largest families of the flowering plants. It is represented by about 900 genera and 20,000 species, which are cosmopolitan in distribution primarily distributed in tropical areas. It is second largest angiospermic family of Indian flora. It is represented by about 130 genera and over 800 species, distributed mainly in Eastern Himalaya, Western Himalaya and Western ghats.

8.3.1 Systematics

Bentham and Hooker	**Engler & Prantl**	**Hutchinson**
Monocotyledons	Monocotyledoneae	Monocotyledoneae
Microspermae	Microspermae	Orchidales
Orchidaceae	Orchidaceae	Orchidaceae

Orchidaceae is treated as family by Bentham and Hooker. It was placed under a separate order Orchidales by majority of the later workers including Hutchinson (1959), Takhtajan (1969) and Cronquist (1981). Thorne (1983) however placed Orchidaceae under the suborder Orchidineae of order Liliales.

Several taxonomists consider Orchidaceae to be the most advanced and highest evolved among Monocotyledons. The characters which support this view include (i) reduction in number of stamens (ii) resupinate epigynous ovary (iii) presence of rostellum (iv) non-endospermic seeds (v) Herbaceous habit, and (vi) presence of several epiphytes.

8.3.2 General Characteristics

Habit: They are perennial, terrestrial, succulent, scapose herbs; many are epiphytic or saprophytic, sometimes climbers *e.g*., *Vanilla*. The tropical species are mostly epiphytes while those occurring in the temperate zone are largely terrestrial.

The terrestrial forms (*Orchis*) are sympoidal. In most of them the internodes are often swollen which serve as storage reservoir of food. Other develop thick or fleshy adventitious roots forming a large tuber acting as perrenating body.

The epiphytic forms (*Cypripedium, Cymbidium*) are mostly sympoidal or sometimes monopodial. They develop aerial roots which have an outer layer of water absorbing tissue, the 'Velamen'.

Their internal tissue is green which helps in photosynthesis. Most of the epiphytic forms drop their leaves during dry season. They usually develop on fleshy pseudo-bulb each year. Those not having pseudobulb have fleshy leaves, which store water and other reserves.

The saprophytic forms (*e.g. Neottia*) do not develop green leaves. They produce a much branched fleshy rhizome with or without roots, which absorbs food material from humus.

Root: Adventitious, tuberous (*Orchis*), fleshy climbing or aerial. Main roots always absent.

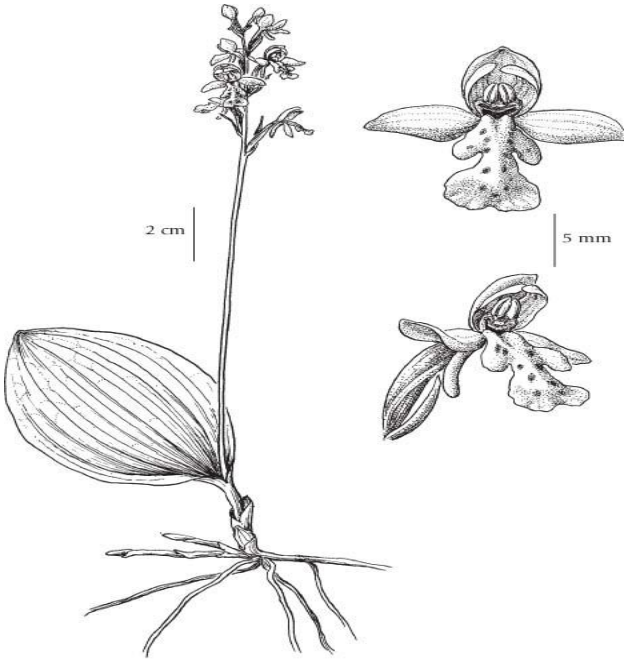

Fig 8.1 *Amerorchis rotundifolia*

Stem: Erect sometimes climbing or trailing, annual in terrestrial forms, perennial in epiphytic forms; generally thickened into rhizomes or pseudobulbs (*Phajus*, *Bulbophyllum*), bearing aerial assimilatory roots (*Taeniophyllum*).

Leaves: Simple alternate sometimes opposite or whorled, usually fleshy, linear to ovate, sheathing base, sometimes reduced to achlorophyllous scales.

Inflorescence: Solitary (*Cypripedium*) or are borne in racemes, spike raceme or panicle (*Oncidium*).

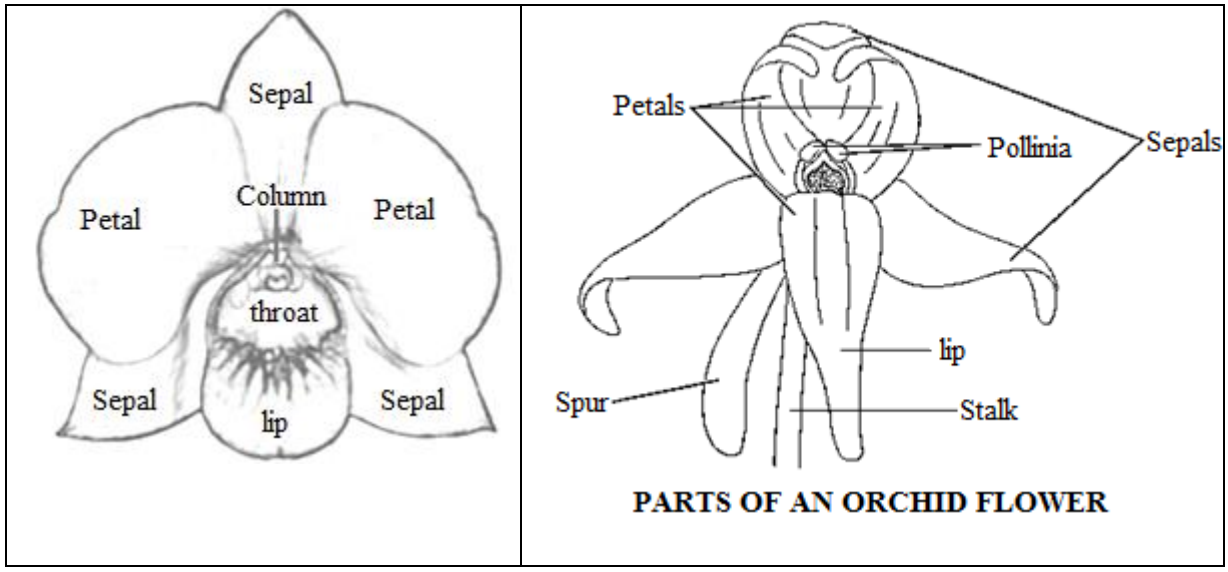

Fig. 8.2 Floral details of typical Orchidaceae flower

Flower: Flowers are of variable and peculiar shape, size and beautifully coloured, often showy, bracteates, complete, zygomorphic, bisexual or rarely unisexual, epigynous, trimerous, mostly resupinate *i.e.* twisted to 180^0 or upside down.

Perianth: Usually 6 tepals in two whorls of 3 each, outer 3 tepals (representing calyx) green, the three outer tepals are alike in appearance. They are imbricate or subvalvate in bud. Inner three tepals coloured (representing corolla), dissimilar- the 2 lateral or wings alike, the third posterior tepal is highly modified in shape, size and colour often projected basally into a spur, called the **labellum or lip**. It is broad, shoe-like spur, tubular, star-shaped or butterfly shaped or variously branched and contributing most to the oddity and beauty of the flower.

The labellum is actually the uppermost (posterior) petal but looks as if located on the lower side of the flower in most orchids. It comes to lie on the anterior side of the flower due to twisting (or resupination) of the inferior ovary through 180^0 (in many flowered orchids) or by the bending back of pedicel over the apex of the stem (as in single flowered orchids).

The most characterstic part of the orchid flower is gynandrium or column which is highly complex structure formed by the adnation of stamens, style and stigma.

Androecium: It is represented by usually one or sometimes two sessile anthers. In monandrous forms there is an only single fertile stamen, terminal on the column. This stamen is considered to represent the anterior member of the outer whorl, the two other (lateral) stamens of this whorl and also all the tree of the inner whorl are entirely absent. The two lateral members of the outer whorl are sometimes represented by staminodes (*Epipactis*).

In diandrous forms (*Cypripedium*) there are two fertile stamens belonging to the inner whorl and they are lateral to the column. The median member of the outer whorl (which is fertile in monandrous forms) is represented by large staminode. The outer staminal member is completely absent. Anthers are dithecous, introrse; pollen granular or coherent in each cell into one, 2 or 4 stalked pollen masses which are mealy waxy or bony masses or pollinia. One end of the pollinium is extended into sterile structure, the caudicle.

A connection between ovary and stamen is made by the beak-like sterile stigma, occupyning almost the centre of the column, sometimes the staminodes are also present.

Gynoecium: Tricarpellary, syncarpous, ovary inferior, unilocular , parietal placentation, rarely trilocular and axile placentation (*Apostasia*); stigmas 3 of which 2 lateral are often fertile, the third stigma is sterile forming a small beaked outgrowth-the rostellum lying in the centre of column between the anther and the fertile stigma. In *Cypripedium* and *Paphiopedium*, all the 3 stigmas are functional.

In Monandrous the column has two fertile stigmas and a specialized organ the rostellum, which represents the third stigma. Sometimes (*e.g. Habenaria*) a portion of the rostellum is modified into a viscid disk (*Viscidia*) in which pollinia are attached.

In diandrous forms there is no rostellem and all the tree stigmas are simple and fertile.

Fruit: Fruit usually a capsule opening laterally by three to six hygroscopically sensitive valves containing a very large number of seeds.

Seed: Numerous, very small, non-endospermic seeds, which are distributed easily by wind.

Pollination: Flowers of Orchidaceae are admirably adapted to insect pollination (Entomophilous). Insects are attracted by beautiful form, colour and fragrance of flowers and the nectar secreted in the sac or spur or labellum in several taxa. In others where spur has no free nectar the insect has to bore the tissue of spur to reach the sweet sap contained in the labellum.

The resupination of flowers brings the labellum into a position where it makes an effective landing place for the insects.

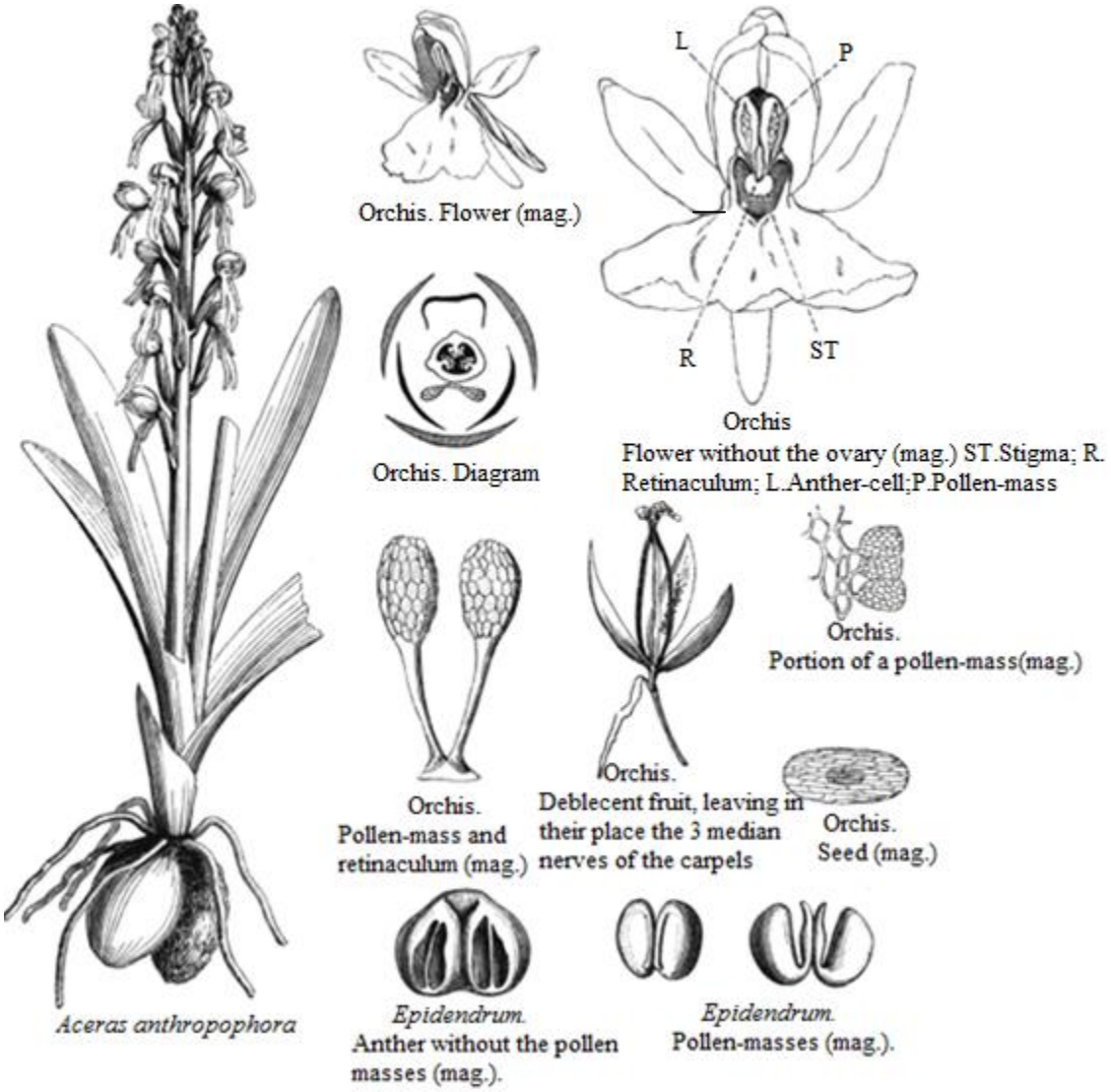

Fig 8.3 Floral details of some orchids

General Floral Formula

$$Br \quad \% \quad \male\!\!\female \quad P_{3+3}\, A_{1-2}\, \underline{G}_{(3)}$$

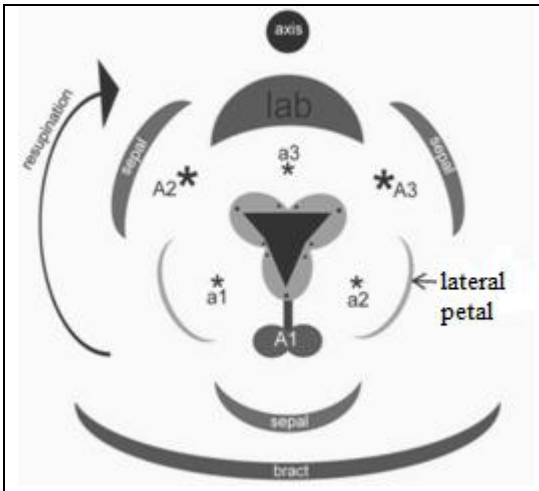

Fig 8.4 Floral Diagram of Monandrous orchid

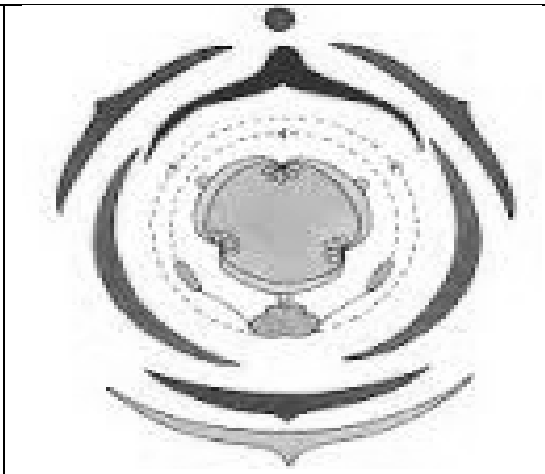

Fig 8.5 Floral Diagram of Diandrous orchid

8.3.3. Important Genera

The familiar examples are Ladyslipper (*Cypripedium sp*,), Vein orchid (*Habenaria* spp), Vanda (*Vanda* spp.) *Epidendrum* (Green fly orchid), *Oncidium* (butterfly orchid), *Odontoglossum* (lady orchid).and *Cattleya spp.* are one of the most popular florist orchids.

8.3.4 Economic Importance: Orchidaceae are important for their ornamental values chiefly. Beside this they are also valuable for flavouring and as medicines.

1-Ornamentals-Many orchids are cultivated in the green houses for their beautiful sweet-scented flowers of various forms, shapes with highly attractive labellum of various hues and bright colours. The orchid flowers are in great demand and are much more sought after than any other flowers. Hence they are extensively grown from a commercial point of view. Some commonly grown orchids are- *Cypripedium* (lady's slipper), *Epidendrum* (Green fly orchid), *Habenaria* (fringe orchid), *Oncidium* (butterfly orchid), *Vanda*, *Vanilla*, *Odontoglossum* (lady orchid).

2-Food- During scarcity the tuberous roots of *Habenaria susannae* and *Orchis latifolia* are used as food and also 'Salep' of commerce which is used as farinaceous food and nervine tonic. It is also used as sizing material in silk industry.

3-Flavour-The capsules of *Vanilla planifolia*, *V. fragrans* yield commercial "Vanilla" a flavouring agent for chocolate and confectionary.

4- Medicinal- The root-stocks of *Eulophia epidendraeas* are used as vermifuge.

5- Dyes- The leaves of *Calanthe veratrifolia* contain a glycoside "indicant", which on hydrolysis yields "indigo blue".

8.4 FAMILY: LILIACEAE

It is commonly called "Lily Family". Liliaceae is regarded as a typical monocot family and represents the basic monocot stock from which many families have arisen.

Diagnostic characteristics: Herbs rarely shrubs, stem underground rhizome, corn or bulb; leaves alternate, flowers actinomorphic, trimerous, hypogynous, perianth segments 6 in two whorls of 3 each, free or fused; stamen 3+3, epiphyllous, antiphyllous; gynoecium tricarpellary, syncarpous, ovary superior, axile placentation, two to many ovules per loculus; fruits capsule or berry; seeds endospermic.

Distribution: A large family, cosmopolitian in distribution. They are abundantely found in temperate and tropical regions. It includes 250 genera and 4000 species, which are worldwide in distribution. In India it is represented by 169 species. The plants are usually annual and perennial herbs. In our country it chiefly occurs in Himalayas. The familiar examples are Onion (*Allium cepa*), Lily (*Lilium spp*.), Dracaena *(Dracaena spp*.), Asparagus (*Asparagus spp.*).

8.4.1 Systematics

Bentham and Hooker	**Engler & Prantl**	**Hutchinson**
Monocotyledons	Monocotyledoneae	Monocotyledons
Coronarieae	Liliflorae	Corolliferae
Liliaceae	Liliaceae	Liliales
		Liliaceae

Bentham and Hooker divided the family into 20 tribes. Engler and Krause divided the family into 12 subfamilies. The family has close affinity with Amaryllidaceae from which it can be distinguished by the presence of superior ovary and absence of corona. It is also close to Juncaceae as in both the seeds have albumen but differs in petaloid perianth. The family on account of marked variability in cytological, embryological, and anatomical structures appears to be polyphyletic in origin.

8.4.2 General Characteristics

Habit: Mostly herbs (*Asphodelus*), Perennating by rhizome (*Aloe*), bulbs (*Lilium*, *Tulipa*, *Allium*), tree (*Dracena*), climber (*Asparagus*, *Smilax*), xerophytic plants like *Yucca*, *Aloe*; cladodes in *Asparagus* and *Ruscus*.

Root: Fibrous, adventitious, sometimes tuberous (*Asparagus*)

Stem: herbaceous or woody, solid or fistular, underground; aerial, climbing or erect; underground stem may be corm, bulb or rhizome. In *Ruscus* and *Asparagus* aerial stems bear phylloclades (modified leaf like branches), corm (*Colchicum*); secondary growth in *Yucca* and *Dracena*.

Leaves: Alternate, opposite or whorled, basal (*Allium* and *Lilium*) or cauline, exstipulate, sessile or petiolate, sheathing leaf base; shape is variable, scale like (*Asparagus*), thick succulents and mucilaginous in *Aloe*, broad in *Phormium tenax*. In *Smilax* stipulate and stipules are modified into tendrils, venation is usually parallel but reticulate in *Smilax* and *Trillium*.In *Asparagus* and *Ruscus* leaves are reduced to scale.

Inflorescence: Variable inflorescence, solitary (*Tulipa*, *Fritillaria*), panicled raceme (*Asphodelus*), cymose umbel (*Allium* and *Smilax*), solitary axillary (*Gloriosa*).

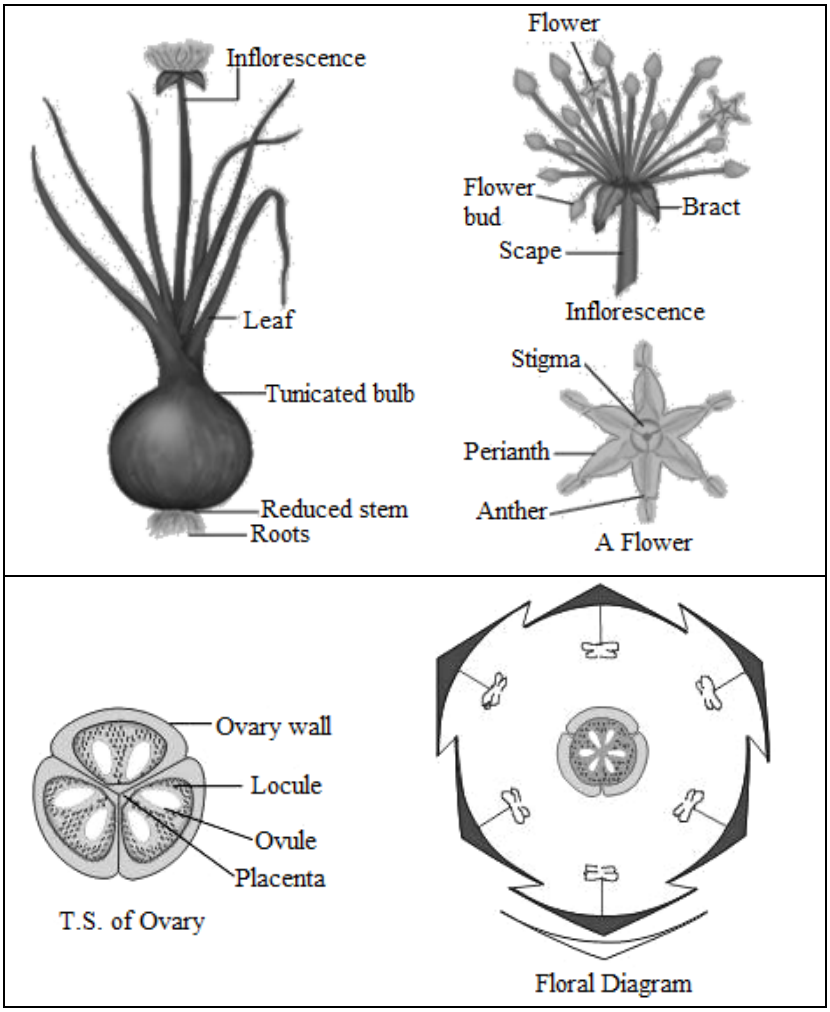

Fig 8.6 Floral details of *Allium cepa* (Onion)

Flower: Pedicellate, bracteate actinomorphic, or zygomorphic (*Lillium*, *Hemerocallis*), hermaphrodite or unisexual in *Smilax*, *Ruscus*; hypogynous, complete or incomplete (in unisexual flowers), trimerous rarely 2 or 4- merous (*Maianthemum*, *Paris*)

Perianth: 6 tepals arranged in two whorls of three each, polyphyllous (*Lilium*, *Tulipa*) or gamophyllous (*Aloe*, *Asparagus*) and of various shapes, petaloid or sepaloid, imbricate in bud, usually valvate in aestivation, perianth may be scarious or membranous.

Androecium: Stamens usually 6 arranged in two alternate whorls of three members each. They are always opposite to the tepals and sometimes adnate to perianth or 3 (*Ruscus*), 8 in *Paris*; polyandrous, epiphyllous, filaments long, anthers versatile or basifixed, dithecous, introrse or extrorse. In *Ruscus* outer whorl of stamens is reduced to staminodes.

Gynoecium: Tricarpellary, syncarpous, ovary superior or half inferior, trilocular or unilocular with two ovules, axile placentation, style simple; stigma trilobed or 3-parted. Usually the ovary has three septal nectarines one on each septum.

Fruit: Usually a loculicidal or septicidal capsule (*Asphodelus*) or a berry (*Asparagus*, *Smilax*)
Seed: Endospermic; endosperm horny or cartilaginous.

Pollination: Entomophilous rarely self-pollination.

General Floral Formula

$$\text{Br} \quad \oplus \quad \varsigma \quad P_{3+\,3 \text{ or } (3+3)}\ A_{3+3}\ \underline{G}_{(3)}$$

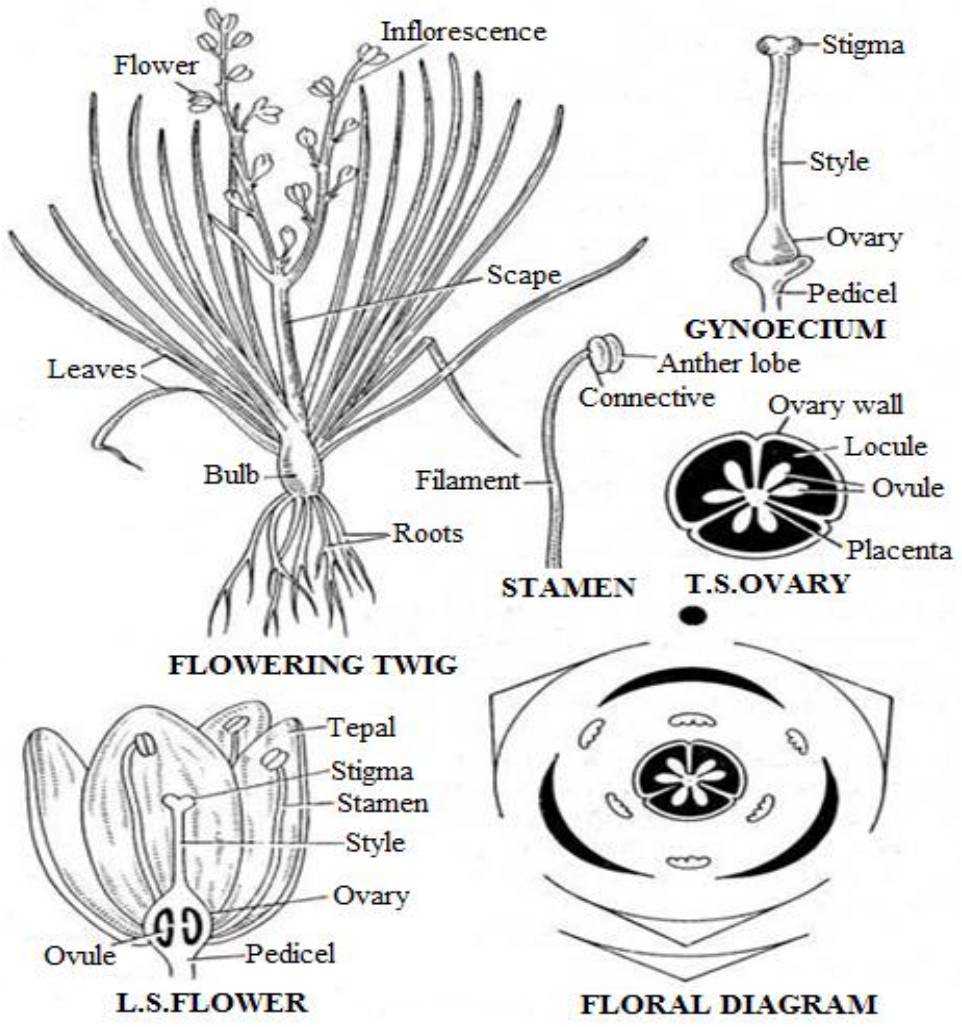

Fig. 8.7 *Asphodelus tenufolius* Cav. Verna.-Piazi

8.4.3 Important Genera

The familiar examples are Onion (*Alium cepa*), Lily (*Lilium spp*.), Dracaena *(Dracaena spp*.), Asparagus (*Asparagus spp.*).

8.4.4 Economic Importance: Family Liliaceae provides food, drugs, fibre and plants of ornamental values.

1-Edibles- *Allium cepa* (Onion) is popular as vegetable and also for flavoring and pickling. The fresh juice possesses bactericidal properties, *Allium sativum* (Garlic) is largely cultivated as an important spice and condiment crop. It is used as tonic, stimulant to stomach, as vermifuge and good for heart. Fleshy shoots of *Asparagus officinalis* are used as vegetable.

2- Medicinal- *Smilax, Aloe, Gloriosa, Veratrum, Colchicum, Scilla,* and *Urginea* yield useful drugs. Rat poison is obtained from *Urgine* and the bulbs of *Scilla*. *Aloe vera* yields "Aloin" used in treatment of piles and fissure. The roots of *Asparagus racemosus* yields a tonic. Corms and seeds of *Colchicum luteum* are useful in rheumatism and liver diseases. An alkaloid 'Cochicine' is obtained used to induce polyploidy in plant breeding.

3-Fibres- *Yucca* and *Phormium tenax* yield fibre of commerce used in cordage

4-Resin-*Dracaena* and *Xanthorrhoea* yield resin. From the acrid resin of *Xanthorrhoea* sealing wax is prepared.

5-Ornamentals-The common cultivated garden plants are *Tulipa, Lillium, Gloriosa, Aloe, Ruscus, Dracaena, Asparagus, Yucca, Hemerocallis etc.*

8.5 FAMILY: POACEAE (THE GRASS FAMILY)

The Poaceae or Gramineae is the large and nearly ubiquitous family of monocotyledonous flowering plants known as grasses. The Poaceae includes the cereal grasses, bamboos and the grasses of natural grasslands and cultivated lawns (turf) and pastures. Grasses have stems that are hollow except at the nodes and narrow alternate leaves borne in two ranks. The lower part of each leaf encloses the stem, forming a leaf-sheath.

Diagnostic characteristics

Mostly herbs, stem jointed, fistular, cylindrical, leaves simple, alternate, sheathing, sheath open , ligulate, inflorescence compound spike, flowers zygomorphic, hypogynous, protected by **palea**, perianth represented by 2-3 minute scales (**lodicules**), stamens 3 , versatile, carpel one, styles 2 or 3, stigma feathery, basal placentation, fruit caryopsis, testa fused with pericarp.

Distribution: Family Poaceae is one of the largest families in monocots consisting of 620 genera and about 6000 species. Members are cosmopolitan in distribution. The plants represent all the 3 ecological types as hydrophytes, xerophytes and mesophytes. Around 900 species are present in India.

8.5.1 Systematics

Bentham and Hooker	**Engler & Prantl**	**Hutchinson**
Monocotyledons	Monocotyledoneae	Monocotyledons
Glumaceae	Glumiflorae	Glumiflorae
Poaceae	Poaceae	Poaceae

The family Poaceae closely resembles the family Cyperaceae and the two families have been placed in the same order Glumiflorae by Engler and Prantl and Glumaceae by Bentham and

Hooker. Hutchinson (1964) and other modern botanists placed the family into two separate orders the Cyperales and Graminales on the basis of many differences *viz.* 1. Leaf sheath 2. Jointed and unjointed stem 3. Single bract and lemma and palea 4. Seed coat etc. Hutchinson (1959) believes that the origin of grasses took place on parallel line with Cyperaceae .

8.5.2 General Characteristics

Habit: Mainly herbs (annuals or perennials) or shrubs. Some are trees like (*Bambusa*, *Dendrocalamus*) which attain a height of 30 meters or more in Asiatic bamboos

Root: Adventitious, fibrous, branched or stilt (as in maize).

Stem: Underground rhizome in all perennial grasses. The aerial stems terminated by inflorescences are known as culm with distinct nodes and internodes, cylindrical, internode usually hollow or sometimes solid (*Zea*), herbaceous or woody .

Leaves: Basal leaves are crowded in a tuft but the leaves on the culm are alternate, simple, exstipulate, sessile, ligulate. Each leaf is usually composed of two parts the sheath and the blade (lamina). The sheath which forms leaf base encircles the culm forming tubular sheath, sheath open, The blade which is the upper portion of leaf usually flat or sometimes convolute, long, entire, hairy or rough, linear, parallel venation. At the junction of sheath and blade on the inner surface a ligule is present which is a delicate membranous outgrowth varying much in form in different genera.

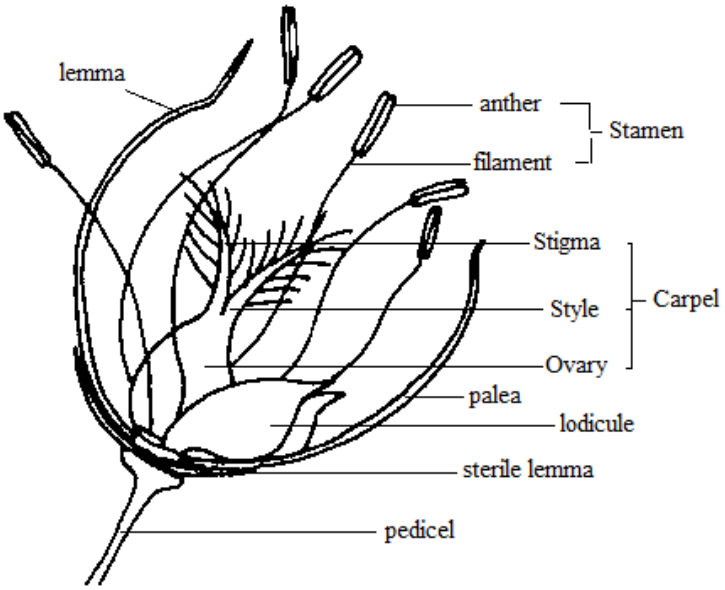

Fig 8.8 Typical spikelet of family Poaceae

Inflorescence: The inflorescence terminates the culm and its branches. The basic unit of inflorescence is called spikelet. The spikelets are sessile or pedicelled few to several and are combined in various ways into spikes (*Triticum*), racemes (*Paspalum*) or panicles (*Avena.*) The spikes or racemes are solitary, digitate or scattered along the main axis (rachis).

Each spikelet consists of very short axis called rachilla on which one to many sessile or short stalks are borne. The florets may be arranged in alternate or opposite manner on the central axis. At the base of rachilla two sterile scales called glumes are present. The glumes are present one above the other on opposite sides. The lower one is called first glume and the upper is called second glume. Both the glumes are boat shaped and sterile. Sometimes (*Panicum*) there are more than two empty glume. The sterile glumes are followed by a variable number (1-50) of **fertile or flowering glumes or lemma**. They are often greenish, keeled or rounded. The lemma frequently bears a long , stiff hair (awn) and awned or awnless. A membranous binerved or bikeeled structure is present in between the fertile glume and the rachilla the structure known as **palea** which is partially or wholly enclosed by the fertile glume. The palea morphologically represents bracteole below the flower. Each floret has inferior palea or lemma and above it a superior palea.

Flower: Small, inconspicuous, bracteate, bracteolate, sessile, incomplete, bisexual or unisexual (*Zea mays*), irregular, zygomorphic, hypogynous, cyclic.

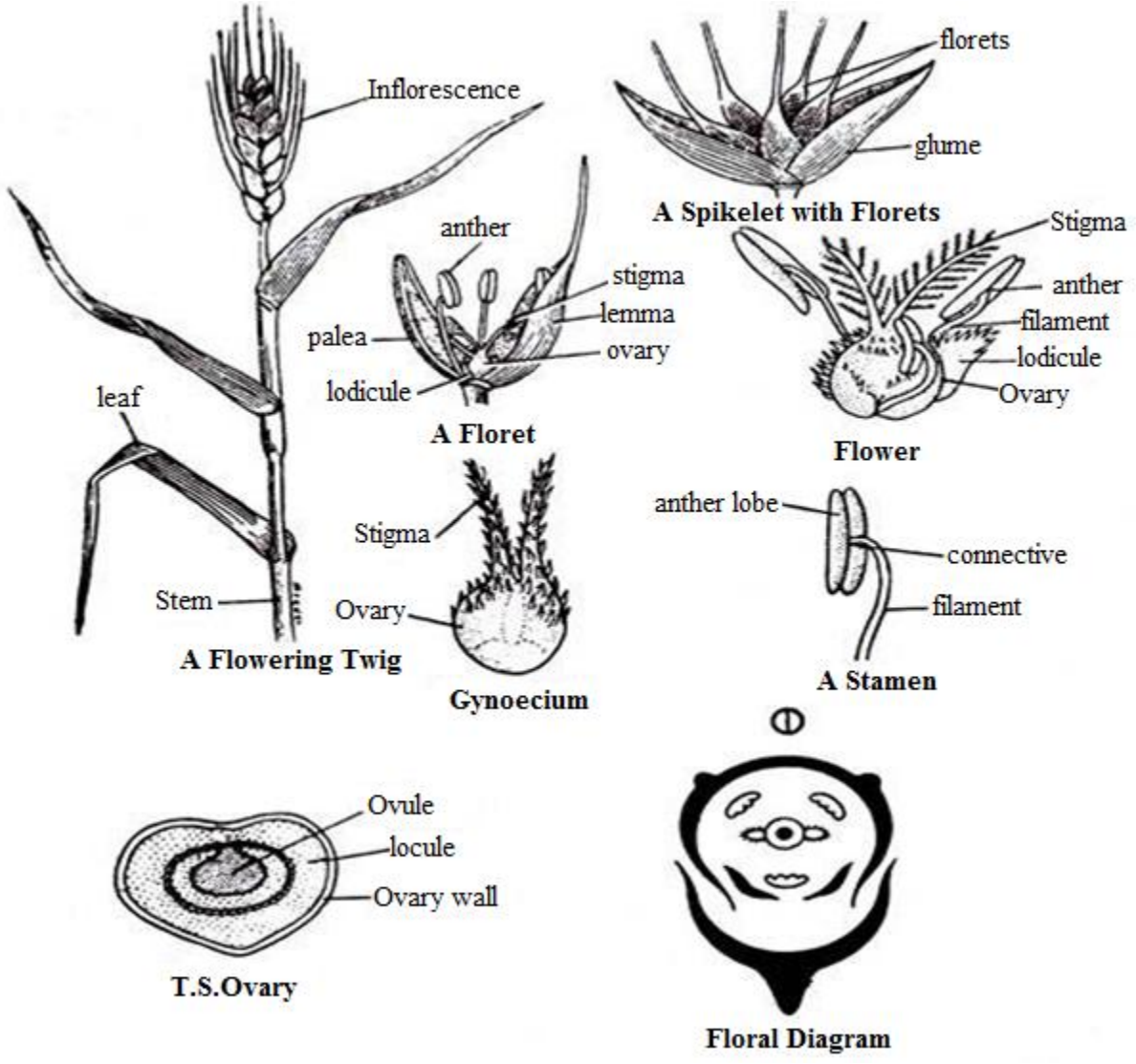

Fig 8.9 Floral details of *Triticum aestivum* (Wheat) *Verna.* Gehun

Perianth: It is highly modified and much reduced and usually represented by two minute or fleshy and hyaline membranous scale-like structures called **lodicules**. The lodicules are situated above and opposite the superior palea or may be absent or many (*Ochlandra*) or three or two.

Androecium: Stamens usually three, sometimes six (*Bambusa*, *Oryza*) rarely one (species of *Festuca*). Rarely numerous stamens (*Pariana*) Polyandrous, filaments are long and free, basifixed, anthers dithecous, versatile and linear, extrorse, pollen grains dry.

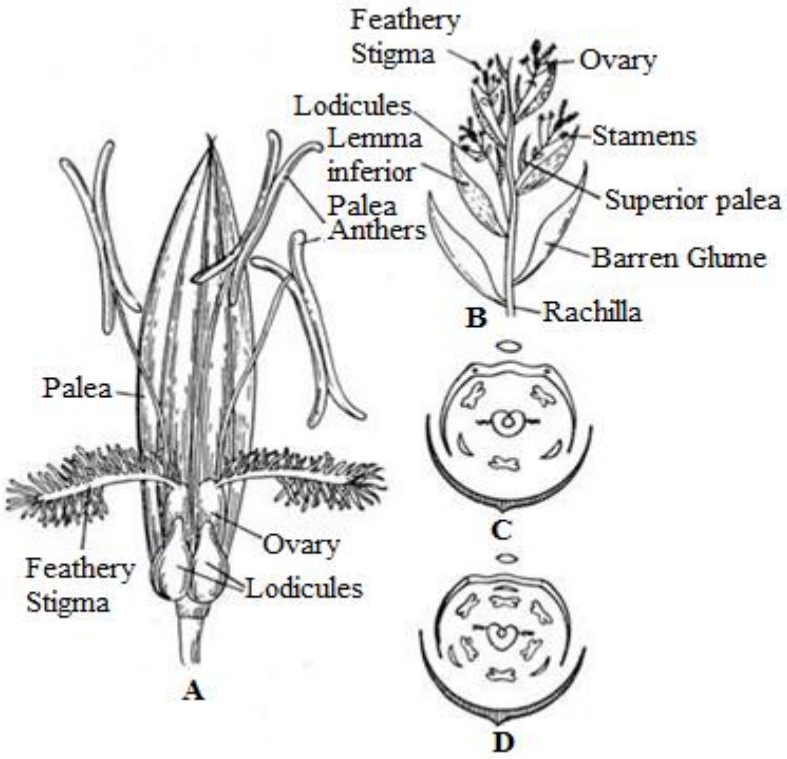

Fig. 8.10 A- Spikelet of *Festuca* sp.; B- spikelet of grass; C- Floral diagram of grass; D- floral diagram of *Bambusa*

Gynoecium: Monocarpellary (presumed to be three of which two are aborted), ovary superior unilocular with single anatropous ovule adnate to the adaxial side of the ovary, basal placentation, style short or absent, bifid (trifid in *Bambusa*), feathery or papillate and branched, stigma plumose.

Fruit: A caryopsis with pericarp completely united with the seed coat, rarely a nut (*Dendrocalamus*) or a berry (*Bambusa*).

Seed: Endospermic with a single cotyledon called **Scutellum** which is shield-shaped and pressed against the endosperm.

General Floral Formula

$$\% \ \male\female \ P_{0 \text{ or } 2 \text{ (Lodicules)}} \ A_{3 \text{ or } 6} \ \underline{G}_{1}$$

8.5.3 Important Genera

*Triticum aestivum (*wheat*), Zea mays* (corn), *Avena sativa, Oryza sativa* (rice), *Bambusa* (bamboo), *Saccharam officinarum* (Sugarcane), *Hordeum vulgare* (Barley), *Secale cereale* (rye), *Sorghum vulgare* (Jowar), *Pennisetum typhoides* (Bajra), *Cynodon dactylon, Panicum, Cymbopogon, Poa*

8.5.4 Economic Importance

Family Poaceae stands first and foremost in respect of economic importance in whole of angiosperms. The staple food grain of the population of world is derived from *Oryza sativa* (Rice) and *Triticum aestivum* (Wheat). They are cultivated from time immemorial. Economic categories of the family are as follows.

Food: All the cereals and millets belong to this family. These form the basic food of mankind. These plants are *Triticum sp* (Wheat). *Avena sativa* (Oats), *Zea mays* (Corn), *Oryza sativa* (Rice). *Hordeum vulgare* (Barley), *Scale cereale* (rye), *Sorghum vulgare* (Jowar), *Pennisetum typhoides* (Bajra), *Setaria italica* (Italian millet), *Panicum miliaceum (*commom millet), *Eleusine coracana* (Finger millet, Ragi)

Fodder plants: Most of the fodder of the animals belongs to this family. Many grasses such as *Cynodon dactylon, Panicum, Cymbopogon* and *Poa* are grown as fodder. The dried stems and leaves of the cereal crops are used as fodder for the cattle.

Sugar: Sugar is obtained from the juice of *Saccharum officinarum* (sugar cane).

Aromatic oils: Many grasses yield aromatic oil which are used in perfumery viz. *Vetiveria zizaniodes* (Khus-khus) yield vetiver oil from the roots, *Andopogon odoratus* (Ginger grass), *Cymbopogon citratus* (Lemon grass) and *Cymbopogon martinii* also yield aromatic oil. *Cymbopogon throws* (lemon grass) gives lemon grass oil. This oil is used in perfumes and soap industry for making infusions.

Paper industry: Some species of grasses and Bamboos are used for making paper.

Alcohol and beverages: Ethyl alcohol and many other beverages are prepared form cereals. For example, wine is prepared from rye, corn and rum from molasses of sugar cane.

Ropes: Fibre is obtained from the leaves of *Saccharum munjo*. This fibre is used for making ropes.

Uses of Bamboo: *Bambusa* (bamboo) is used as building material. Bamboos are used for thatching huts, making boats, carts, pipes etc. Their spilt stems are woven into mats, fans, hats and 'course umbrella'. Their leaves are given to horses for curing cough and cold.

8.6 SUMMARY

Monocotyledons are usually characterized by the presence of one cotyledon, fibrous and adventitious root arising from the base of stem , narrow leaves with parallel veins, herbaceous stem, irregular distribution of the vascular bundles in the stem, trimerous flower and perianth often not clearly divisible into calyx and corolla.Family Orchidaceae comes under Series- Microspermae, Liliaceae under Series- Coronarieae while Poaceae is included under Series- Glumaceae.

Family Orchidaceae is characterized by Perennial herbs, epiphytes or saprophytes may be terrestrial; flower zygomorphic, hermaphrodite, epigynous, resupinated; perianth 6 in two whorls, the posterior segment of the inner whorl developed as lip or labellum; presence of peculiar structure-labium, column and rostellum; Stamens 1-2, one or two staminodes pollen grains united into pollinia; gynoecium tricarpellary, inferior, unilocular with parietal placentation; the fertile stamen is adherent to the style and forms it with the column or gynostemium, which projects more or less in the centre of the flower; stigma 2 or 3 lobed, in some two fertile and one sterile and modified into rostellum.

Several taxonomists consider Orchidaceae to be the most advanced and highest evolved among monocotyledons. The characters which support this view include (i) reduction in number of stamens (ii) resupinate epigynous ovary (iii) presence of rostellum (iv) non-endospermic seeds (v) Herbaceous habit, and (vi) presence of several epiphytes.

Liliaceae is regarded as a typical monocot family and represents the basic monocot stock from which many families have arisen. Herbs rarely shrubs, stem underground rhizome, corm or bulb; leaves alternate, flowers actinomorphic, trimerous, hypogynous, perianth 6 in two whorls of 3 each, free or fused; stamens 3+3, epiphyllous, antiphyllous; gynoecium tricarpellary, syncarpous, ovary superior, axile placentation, two to many ovules per loculus; fruits capsule or berry; seeds endospermic.

The family Liliaceae has close affinity with Amaryllidaceae from which it can be distinguished by the presence of superior ovary and absence of corona. It is also close to Juncaceae as in both the seeds have albumen but differs in petaloid perianth. The family on account of marked variability in cytological, embryological, and anatomical structures appears to be polyphyletic in origin.

The Poaceae (Gramineae) are the large and nearly ubiquitous family of monocotyledonous flowering plants known as grasses. Grasses have stems that are hollow except at the nodes and narrow alternate leaves borne in two ranks. The lower part of each leaf encloses the stem, forming a leaf-sheath.

Mostly herbs, stem jointed, fistular, cylindrical, leaves simple, alternate, sheathing, sheath open , ligulate, inflorescence compound spike, flowers zygomorphic, hypogynous, protected by **palea**, perianth represented by 2-3 minute scales (**lodicules**), stamens 3, versatile, carpel one, styles 2 or 3, stigma feathery, basal placentation, fruit caryopsis, testa fused with pericarp.

The family Poaceae closely resembles the family Cyperaceae and the two families have been placed in the same order Glumiflorae by Engler and Prantl and Glumaceae by Bentham and Hooker. Hutchinson (1964) and other modern botanists placed the family into two separate orders the Cyperales and Graminales on the basis of many differences *viz.*, 1. Leaf sheath, 2. Jointed and unjointed stem, 3. Single bract and lemma and palea, 4. Seed coat etc. Hutchinson (1959) believes that the origin of grasses took place on parallel line with Cyperaceae.

8.7 GLOSSARY

Achene- Small, dry, indehiscent, one-seeded fruit seed separating from ovary wall
Adventitious root – growing from stems or leaves
Alternate – leaves occur single at each node and so arranged that a line drawn on the stem through the leaf base
Anemophilous pollination- Adapted for wind pollination
Basifixed: Fixed to the filament (stalk) at the base
Bract- a leaf or scale in whose axil an inflorescence, flower or floral organ is produced
Caryopsis- A seed like fruit resembling achene, seed coat firmly united to the wall of ovary
Cauline- leaf borne on the main stem
Dormant bud- inactive bud due to season i.e. winter or summer
Dorsifixed- when filaments appear to be inserted at the back of the anther
Endosperm- The tissue that stores food outside the embryo. It originates from union of second sperm nucleus with the secondary nuclei
Entomophilous- Adapted for insect pollination
Fibrous- slender and usually tough
Hairy- surface with hair
Herbaceous- Die at the end of season's growth
Lanceolate- narrow and tapering towards the end
Ligule- The extension at the top of the leaf sheath of grasses. In Poaceae the collar like extension of the leaf sheath clasping the stem above the attachment of the blade

Linear- very narrow without parallel margins
Lobed stigma- stigma having lobes
Nut- Like achene but pericarp hard, tough, woody protecting seed
Opposite – Two leaves at a node on opposite sides
Panicle- Indefinitely branching, long pedicelled, loosely branched compound raceme or corymb
Parallel venation- Veins run parallel to each other Compound inflorescence, stem branches two or more
Radicle- leaf borne on reduced stem and appears to come from root
Ramal- Leaf borne on the branches
Sheath- basal portion of grass or sedage leaves surrounding the stem
Spike- A central axis bearing sessile flowers along its sides
Staminode- Sterile stamen with reduced anther
Stipules- scale like attachment at the base of the petiole.
Versatile- When the filament is attached to the back of the anther by a fine point so that the anther swings freely e.g. grasses
Zygomorphic – Flower divisible into two equal parts in one plane only.

8.8 SELF ASSESSMENT QUESTION

8.8.1 Multiple Choice Questions

1. In Poaceae the fruits are usually
(i) Follicle (ii) Nutlets
(iii) Capsule (iv) Caryopsis

2. Botanical name of onion is
(i) *Solanum tuberosum* (ii) *Lycopersicon esculentum*
(iii) *Allium cepa* (iv) *Nicotiana tabacum*

3. Resupination *i.e.* twisting to 180^0 or upside down is characterstic feature of which one of the following families
(i) Liliaceae (ii) Acanthaceae
(iii) Orchidaceae (iv) Poaceae

4. A plant that belongs to Liliaceae in which stipules are modified into tendrils is
(i) *Gloriosa* (ii) *Yucca*
(iii) *Lilium* (iv) *Smilax*

5. The inflorescence of Paddy is
(i) racemose (ii) catkin
(iii) panicle (iv) verticillaster

6. In Poaceae the Lodicules are
(i) petals (ii) perianth leaves
(iii) sepals (iv) bracts

7. Genus *Colchicum* belongs to which one of the following family
(i) Lilaceae (ii) Acanthaceae
(iii) Orchidaceae (iv) Poaceae

8. The highly modified tepal of orchidaceous flower is called
(i) lip or labellum (ii) standard
(iii) spur (iv) wings

9. Gynandrium or column, which is the most characteristic part of orchid flower is formed by
(i) Stamen (ii) Style and stigma
(iii) Perianth (iv) by adnation of stamen, style and stigma

10. Which one of the following family stands first and foremost in respect of food and fodder
(i) Asteraceae (ii) Poaceae
(iii) Liliaceae (iv) Brassicaceae

8.8.1 Answer Key:

1- (iv)	2- (iii)	3- (iii)	4- (iv)	5- (iii)
6- (ii)	7- (i)	8- (i)	9- (iv)	10- (ii)

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8.11 TERMINAL QUESTIONS

1. Write descriptive note on economic importance of family Poaceae.
2. Describe economic importance of family Liliaceae.
3. Write descriptive note on floral features of Orchidaceae.
4. Give characteristic features of family Poaceaae.
5. Write short notes on the following:
   (i) Lodicules
   (ii) Gynostegium
   (iii) Labellum
   (iv) Lemma and Palea
   (v) Resupination
6. Describe family Liliaceae in semi-technical taxonomic language.
7. Give comparative account of Monandrous and diandrous types of orchids

LABORATOTY COURSE: BOT(N)-201 & 201L

UNIT-1 IDENTIFICATION OF LOCALITY OF AVAILABLE PLANTS BELONGING TO THE FAMILIES AND THEIR DESCRIPTION IN SEMI TECHNICAL LANGUAGE

Contents

1.1 OBJECTIVES

After reading this section you will know, how to-

- Carry out plant identification
- Describe the locality of available plants
- Describe the meaning of semi technical language
- Describe the families in semi technical language.

1.2 INTRODUCTION

The flowering plants, also known as Angiospermae or Magnoliophyta, are also considered to be the most diverse group of land plants constituting about 443families. Angiosperms are distinguished from gymnosperms on the basis of specific characteristics including flowers, endosperms and the fruit production. An angiospermic plant produces seeds within an enclosure (a fruit). The term "angiosperm" comes from the Greek word (*angeion*, "case" or "casing", and *sperma*, "seed") meaning "enclosed seeds".

Angiosperms might be differentiated from other seed plants in several ways. The characteristic feature of angiosperms is the flower. Flowers show remarkable variation in form and elaboration, and provide the most trustworthy external characteristics for establishing relationships among angiosperm species. Mostly, the floral apparatus arise terminally on a shoot or from the axil of a leaf. Occasionally, a flower arises singly in the axil of an ordinary foliage leaf. Typically, the flower-bearing portion of the plant forms a more or less elaborate branch system called inflorescence.

Traditionally, the flowering plants are divided into two groups as: Dicotyledoneae or Magnoliopsida and Monocotyledoneae or Liliopsida.

Among 443 families of flowering plants, 42 families are referred as the most-diversified on the basis of species. These 42 families are Asteraceae, Fabaceae, Rubiaceae, Poaceae, Lamiaceae, Euphorbiaceae, Melastomataceae, Myrtaceae, Apocynaceae, Cyperaceae, Malvaceae, Araceae, Ericaceae, Gesneriaceae, Apiaceae, Brassicaceae, Piperaceae, Acanthaceae, Rosaceae, Boraginaceae, Utricaceae, Ranunculaceae, Lauraceae, Solanaceae, Companulaceae, Arecaceae, Annonaceae, Caryophyllaceae, Orobanchaceae, Amranthaceae, Iridaceae, Aizoaceae, Rutaceae, Phyllanthaceae, Scrophulariaceae, Gentianaceae, Convolvulaceae, Proteaceae, Sapindaceae, Cactaceae, and Araliaceae.

Plant identification is the process of matching a specimen plant to a known taxon. With the help of dichotomous keys or multi-access keys the plant identification is made. Plant identification has been evolved over hundreds of years and depends to a large extent on what criteria and whose system is used. Plant identification implies comparisons of certain

characteristics and then assigning a particular plant to a known taxonomic group, ultimately arriving at a species. **Taxonomy is the branch of botany which deals with plant identification, nomenclature and classification.** The term, first coined by French botanist A. P. de Candolle (1813). Carl Linnaeus used the term 'Systematics' which now includes identification, nomenclature and evolutionary relationships.

1.3 LOCALITY OF AVAILABLE PLANTS

Locality of available plants can be described on the basis of place, spot, or district etc. with reference to plant's availability. As we very well know that innumerable plants grow on the earth. At first we do not know the names of plants growing around us. In fact, most of us never bother to even look around. But we should have a curiosity to know about the variations of these plants. For this, first we have to follow the identification of these plants.

1.3.1-Identification

Usually Identification is a basic activity and one of the primary objectives of systematics. Practically, it involves both classification and nomenclature. Identification is simply the determination of the similarities or differences between two species, i.e., two species are the same or they are different. Here first we will try to compare an unknown plant with a named specimen and then determine that both are the same or showing differences by following classification. If unknown belongs to the same group (species, genus, family. etc.) as a known specimen, the information is stored in classification systems which become available and applicable to the material at hand. Therefore we can say that identification and classification involve comparison and judgment and require a definition of criteria of similarities .

In terms of reliability or accuracy the best method of identification is expert determination. Here let us discuss methods of plant identification:

Methods of Plant Identification:

Here let us know the methods which are used for the description and identification offlowering plants:

First Method:

In this method we have to follow the determination of the families to which the unknown plant belongs. By knowing the name of the family we can turn the keys to genera for determining the generic name and then for the specific identity of the plant to the species key.

Second Method:

In this method we will utilize the latest floras and check list of the particular region. These comprise usually an index to the plants known for the locality and generally provide pertinent habit, distribution and frequency of plants.

Third Method:

The identification of plant is done by studying monographs or revisionary works for the particular family or genus.

Plant Characters before its identification are studied on the following lines:

1. Habit and habitat of plant is studied in natural surroundings only. Then the plant nature is studied whether is herbaceous, or woody; annual or perennial.
2. Plant roots are observed(Tap root or adventitious root/ Branched or unbranched)
3. Leaf phyllotaxy and its venation
4. Inflorescence type – Racemose or cymose or special type as Capitulum (e.g. Asteraceae), Cyathium (e.g. Euphorbiaceae), Verticillaster (e.g. Lamiaceae) etc.
5. Flower – actinomorphic or zygomorphic.
6. Presence of epicalyx (e.g. Malvaceae).
7. Number of sepals and petals or tepals, their aestivation.
8. Petals free (e.g. Polypetalae) or fused (e.g. Gamopetalae).
9. Number of stamens and their position – antipetalous (e.g. Chenopodiaecae) alternipetalous or obdiplostamonous, (e.g. Caryophyllaceae). Staminal tube (e.g. Malvaceae).
10. Number of carpel/carpels, free or fused, style – gynobasic (e.g. Lamiaceae); shape of stigma, ovary unilocular or multilocular.
11. Type of placentation.
12. Kind of fruit.
13. Seed of particular plant is also studied (with reference to Number of seeds in fruit.; Endospermic or non-endospermic; Number of cotyledons.

Different parts of the flower are represented by different symbols which form a formula called floral formula.

Various parts of flower in floral formula are represented as follows:

Br	=	Bracteate
Ebr	=	Ebracteate
Brl	=	Bracteolate
$\oplus$	=	Actinomorphic
Φ	=	Zygomorphic

♂	=	Male
♀	=	Female
⚥	=	Hermaphrodite
K	=	Calyx
C	=	Corolla
P	=	Perianth
A	=	Androecium
G	=	Gynoecium

Here we will also learn about few more representations as if the number of sepals are 5 represented as K_5(polysepalous). $K_{(5)}$ represents that 5 sepals are fused and termed as gamosepalous. $C_5A(\alpha)$ indicates that many fused stamens are epipetalous. For representation of superior ovary a line should be below the gynoecium i.e. G and the inferior ovary is represented by **G** Different whrols of floral parts can be described as C_{5+5} means 10 petals are arranged in two whrols of 5 each.

Floral Diagram

The floral diagram is the most essential and most important after drawing the other necessary diagrams (like a part of the plant, structure of the flower, L.S. of the flower, a stamen, carpel, and T.S. of the ovary) for the given plant. It expresses the number, fusion, symmetry and other similar characteristics of the floral parts in a flower.

Different floral parts in a flower are always expressed in a circular manner. In the different concentric circles of a floral diagram, the sepals should be drawn in the outermost circle. The sepals are followed by petals, stamens and carpels towards inner sides, respectively. Gamosepalous or polysepalous condition is made by joining the sepals or making them free. Same is the case with petals. Position of sepals and petals must be drawn in the respective circles corresponding to their actual position in section. A small circle above the floral diagram represents the mother axis. In zygomorphic flower the mother axis is shown as Φ while in actinomorphic flower it is drawn as 0. The bract, if present, is drawn below the floral diagram while the bracteoles are shown on the sides.

For drawing the floral diagram it is necessary to note whether a sepal or space between two sepals stands towards mother axis. We must start from this particular sepal and mark the position of other sepals. Petals must be drawn alternate to sepals. In actinomorphic flowers all sepals and petals must be of same size. But in case of zygomorphic flowers unequal sized sepals or petals are drawn. Spur in a sepal or petal must be drawn in the form of a loop.

In case of epipetalous condition, the stamens must be joined to petals with a line. Stamens are shown by transverse section of anthers. In obdiplostamonous condition the stamens of outer whorl must be drawn opposite to petals. Introrse stamens are shown facing towards gynoecium while extrorse towards petals. Use a cross (x) or asterisk (*) sign in place of a staminode (sterile stamen), if present. The gynoecium must be drawn in the form of transverse section of the ovary.

1.3.2-Description in Semi Technical Language

After learning the methods for describing and identification of the flowering plants in our locality we will discuss the taxonomic description of families in semi technical language for the identification of locality available plants.

1.3.2.1-Taxonomic Description of Families

1- Ranunculaceae (Butter cup or Crow Foot family)

Ranunculus scleratus L. (Fig.1.1.)

Vegetative Characters:

Habit: Annual herb

Root: Tap roots, branched

Stem: Erect, stout, branched, glabrous and solid, cultivated varieties posses reduced stem.

Leaf: Simple, petiolate, exstipulate (stipules if present are membranous), trilobed, multicostate reticulate venation.

Floral characters:

Inflorescence: Cymose

Flower: Bracteate, bracteolate (2), complete, hermaphrodite, pedicellate, spirocyclic, actinomorphic, pentamerous, hypogynous.

Calyx: Sepals 5, polysepalous, petaloid, imbricate or quincunical aestivation. Sepals are reflexed from the base.

Corolla: Petals 5, polypetalous, bright yellow, spreading from the base, imbricate aestivation. At the base of each petal there is the presence of greenish pocket shaped nectar.

Androecium: Stamens numerous, spirally arranged over the receptacle, polyandrous. Filaments are long and yellow. Anthers are long, basifixed, dithecous, extrose.

Gynoecium: Polycarpellary, apocarpous. Carpels are arranged spirally over an oblong receptacle. Superior ovary, unilocular.Single ovule in each locule with basal placentation. Style is very much reduced or absent and fimbriate stigma.

Fruit: An etario of achenes.

Floral formula:

Br, Brl, $\oplus$, σ, K_5, C_5, Aα,Gα.

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**

b. 1. Presence of two cotyledons in each seed
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**

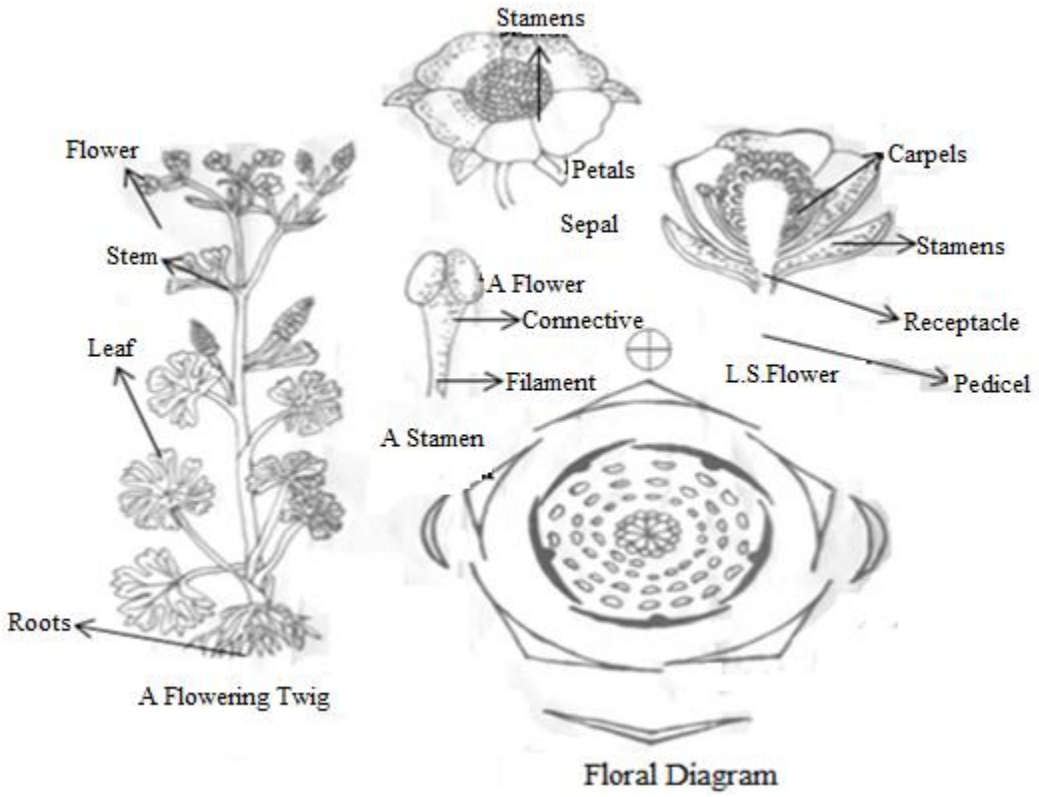

Fig.1.1 *Ranunculus scleratus* L.

c. 1. Petals are free---------- **Polypetalae**

d. 1. Dome shaped thalamus
   2. Superior ovary----------**Thalamiflorae**

e. 1. Many stamens
   2. Carpels are many and free---------- **Ranales**

f. 1. Herbaceous habit

2. Leaves exstipulate
3. Numerous spirally arranged stamens---------**Ranunculaceae**

g. 1. Many free spirally arranged stamens
2. Basal placentation----------***Ranunculus***

2-Caryophyllaceae **(The pink family)**

***Stellaria media* Cyrill. (The Chick weed) (Fig.1.2)**

Vegetative Characters:

Habit: A wild, annual herb

Root: Tap roots, branched

Stem: Herbaceous, aerial, erect or decumbe nt, cylindrical, branched, solid having swollen nodes, hairy when young, 6" to 2' long and green.

Leaf: Ramal and cauline, simple, opposite decussate, exstipulate, upper sessile but lower petiolate, entire linear or lanceolate, reticulate venation.

Floral characters:

Inflorescence: Dichasial cyme.

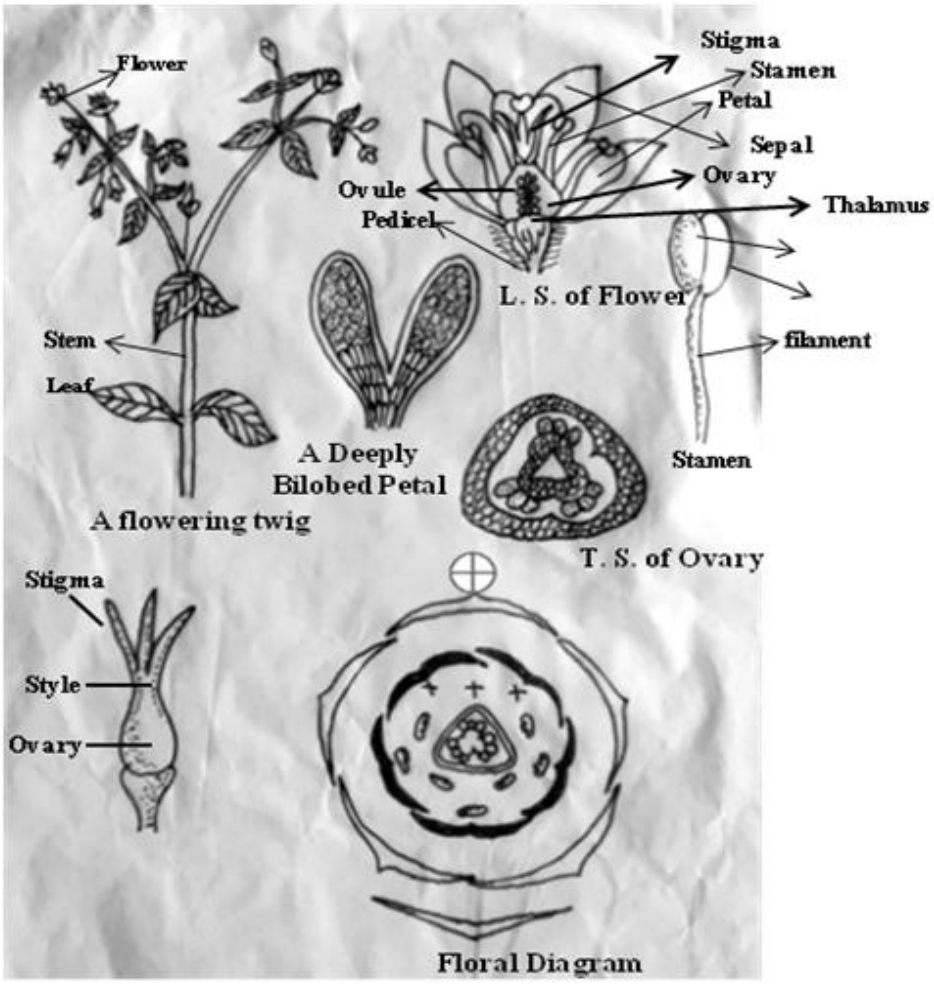

Fig.1.2: *Stellaria media* cyrill.

Flower: Bracteate, complete, hermaphrodite, pedicellate, pedicel glabrous, cyclic, actinomorphic, pentamerous, hypogynous, small and white.

Calyx: Sepals 5, polysepalous, oblong or lanceolate, quincuncial aestivation. Sepals are acute, hairy and green.

Corolla: Petals 5, polypetalous, deeply bilobed, white, imbricate or valvate aestivation.

Androecium: Stamens 10 or are reduced to 5 or 8 and rest abortive into staminodes. These are arranged in two whorls, polyandrous, obdiplostamonous. Filaments slender and are of equal length, dithecous, basifixed or sometimes dorsifixed, introrse. In some flowers all the 5 stamens of outer whorl are reduced or absent.

Gynoecium: Tricarpellary, syncarpous. The ovary is superior, unilocular with many ovules. Free central placentation is found. Style is reduced and stigma three.

Fruit: A capsule.

Seed: Brown, flat, endospermic

Floral formula:

Br, Brl, $\oplus$, $\male\female$, K_5, C_5, A_{5+5}, $G_{\underline{(3)}}$

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons in each seed
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**
c. 1. Petals are free---------- **Polypetalae**
d. 1. Dome shaped thalamus
   2. Superior ovary----------**Thalamiflorae**
e. 1. Stamens definite
   2. Free central placentation ----------**Caryophyllinae**
f. 1. Opposite decussate leaves
   2. Inflorescence dichasial cyme
   3. Obdiplostamonous condition---------**Caryophyllaceae**
g. 1. White coloured small flowers
   2. Tricarpellary gynoecium
   3. Reduced stamens and style----------***Stellaria media***

3-Rutaceae (The Orange family)

***Citrus aurantifolia* Swing** *(C. mediaVar acida)* **(Fig.1.3)**

Vegetative Characters:

Habit: A cultivated tree.

Root: Tap roots, branched

Stem: The stem is woody, erect, branched, solid and cylindrical. Stem is green in colour.**Leaf:** Mostly compound, opposite and alternate, exstipulate. The leaves are characterized by oil glands. In *Citrus* the leaf is apparently simple but the winged petiole is articulated to the lamina, which indicates that it is really one leaflet of a compound leaf.

Floral characters:

Inflorescence: Axillary cyme or solitary axillary. The flowers may also remain arranged in axillary or terminal corymbs.

Flower: A prominent disc present below ovary, ebracteate, complete, hermaphrodite, pedicellate, actinomorphic, pentamerous, hypogynous, cyclic. White coloured scented flowers are developed.

Calyx: Consist of 5 sepals, gamosepalous and valvate aestivation is found.

Corolla: Petals 5, polypetalous, sometimes are fused at base. Aestivation is imbricate. Petals are white in colours.

Androecium: Stamens are indefinite and attached to disc (Polyadelphous). Bases of filaments are fused. Anthers are two celled, dorsifixed or basifixed, introrse.

Gynoecium: Penta to multicarpellary, syncarpous. The ovary is superior, multilocular one or more ovules in each locule. Axile placentation is found. Style is single and short with yellow and capitate stigma. A nectariferous disc is present below the ovary.

Fruit: Hesperidium.

Seed: Non-endospermic

Floral formula:

Ebr, $\oplus$, $\mathbb{Q}$, $K_{(5)}$, C_5, Aα(Polyadelphous),$\underline{G_{(5 \text{ to } \alpha)}}$

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons in each seed
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**

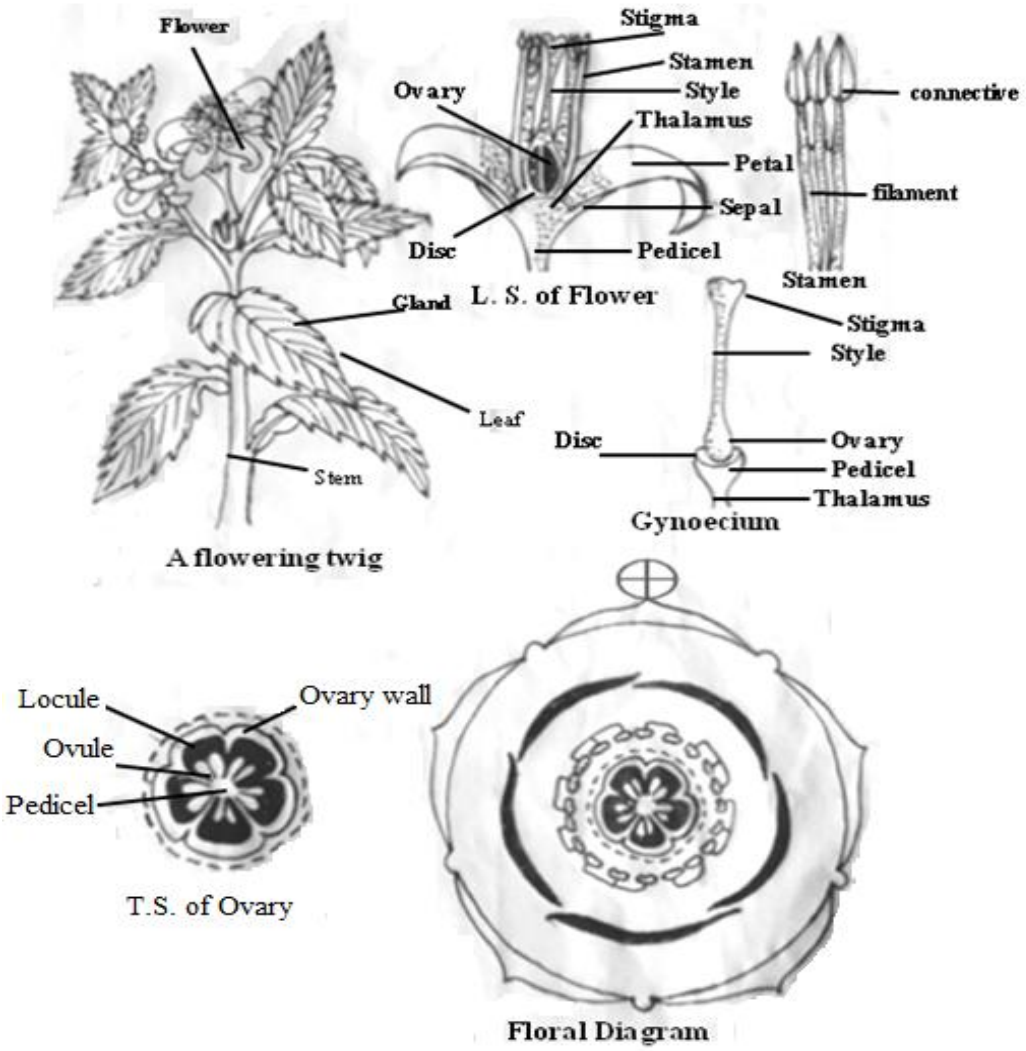

Fig.1.3: ***Citrus aurantifolia*** **Swing**

c. 1. Petals are free---------- **Polypetalae**
d. 1. Discoid thalamus
   2. Flowers are hypogynous----------**Disciflorae**
e. 1. Ring shaped disc below the ovary
   2. Pendulous ovules
   3. Non endospermic seed----------**Geraniales**
f. 1. Usually shrubs or trees
   2. Leaves with aromatic glands
   3. Many polyadelphous stamens
   4. Fruit hesperidium----------**Rutaceae**
g. 1. White coloured flowers

2. Leaf with swollen leaf base----------***Citrus***

4-Rosaceae (The Rose Family)

***Prunus persica* L. (Peach = Aru) (Fig.1.4)**

Vegetative Characters:

Habit: A cultivated small tree.

Root: Tap roots, branched.

Stem: The stem is woody but herbaceous at upper portions, erect, branched, cylindrical, smooth and solid. Upper portion of Stem is green in colour but lower brownish.

Leaf: Usually simple or compound, opposite, alternate, exstipulate, subsessile, oval to lanceolate, acute, unicostate reticulate venation.

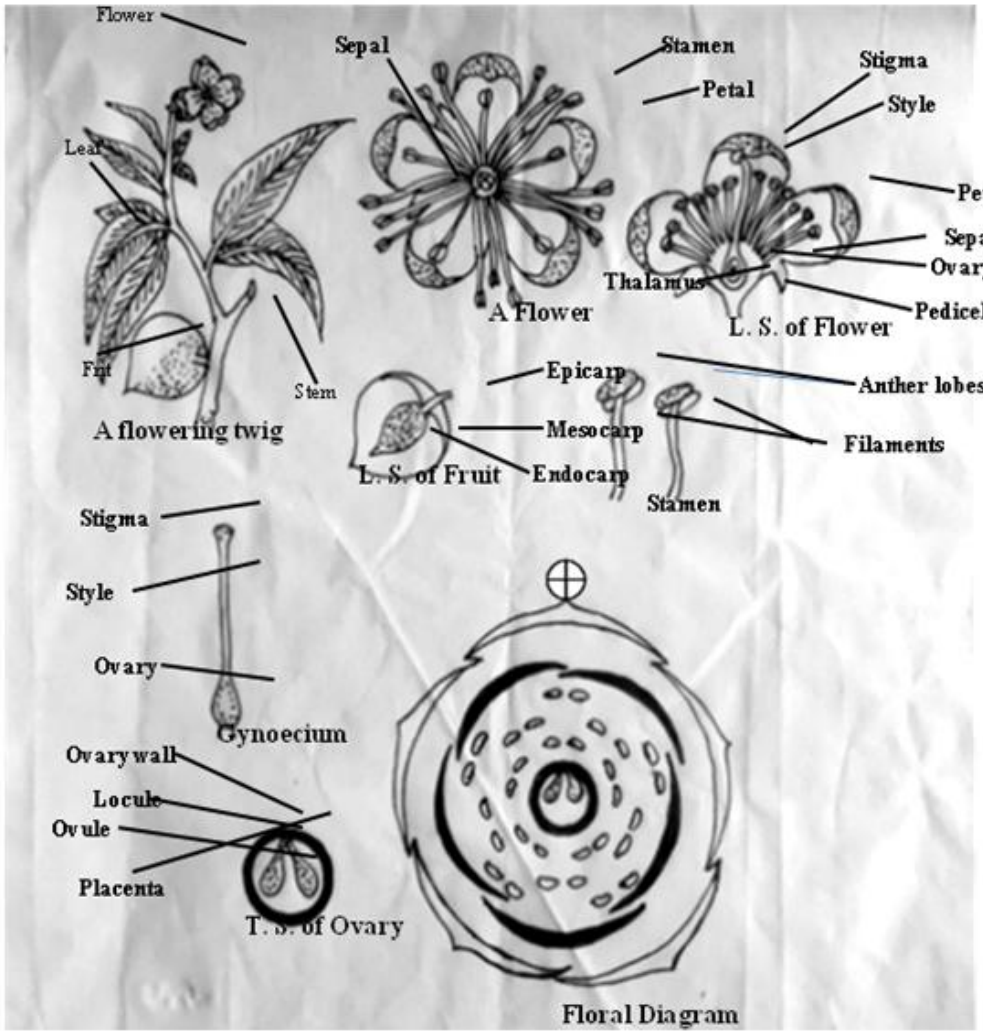

Fig.1.4 *Prunus persica L.*

Floral characters

Inflorescence: Solitary axillary or in cymose clusters, crowded towards dwarf branches.
Flower: A cup shaped thalamus is found. Ebracteate, subsessile or pedicellate, complete, hermaphrodite, actinomorphic, pentamerous, perigynous pink coloured flower.
Calyx: Consist of 5 sepals, gamosepalous and quincuncial. The valvate aestivation is found. The calyx tube becomes campanulate, green.
Corolla: Petals 5, polypetalous, rosaceous, pink. Aestivation is imbricate.
Androecium: Polyandrous, dithecous, dorsifixed, introrse. Consist of many stamens (15-60) which are arranged in whorls. The stamens are antisepalous in outermost whorl.
Gynoecium: Monocarpellary. The ovary is semi-inferior, unilocular, two ovules (pendulous) in the locule. Marginal placentation is found. Style is long and with capitate stigma.
Fruit: Drupe.
Seed: One, Non-endospermic
Floral formula:

Ebr, $\oplus$ ♂♀ $K_{(5)}$, C_5, $A\alpha$,$G\underline{1}$

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**
c. 1. Petals are free---------- **Polypetalae**
d. 1. Cup shaped thalamus
   2. Semi inferior ovary----------**Calyciflorae**
e. 1. Alternate simple leaves
   2. Gamosepalous calyx----------**Rosales**
f. 1. Rosaceous corolla
   2. Perigynous flowers
   3. Many stamens arranged in whorls----------**Rosaceae**
g. 1. Fruit is drupe
   2. Two pendulous ovules
   3. Pink flowers----------***Prunus persica***

5-Fabaceae (The Pea Family)

***Pisum sativum* (Pea) (Fig.1.5)**

Vegetative Characters:

Habit: Annual climbing herb, cultivated in gardens as an ornamental.

Root: Branched, nodulated, tap roots bearing nitrogen fixing bacteria in the roots.

Stem: The stem is herbaceous, aerial, weak, branched, flattened, climbing, green and glabrous.

Leaf: Simple or pinnately compound, imparipinnate, alternate, petiolate. Each leaflet is opposite, sessile, ovate, entire, acute and showing unicostate reticulate venation. Upper leaflets are modified completely into tendrils.

Floral characters:

Inflorescence: Usually of racemose or solitary axillary.

Flower: Zygomorphic, bisexual, complete, pentamerous, bracteate, hypogynous or perigynous.

Calyx: Consist of 5 sepals, gamosepalous. The valvate aestivation is found.

Corolla: Petals 5, polypetalous, papilionaceous. There is a large upper posterior petal (largest) called standard or vexillum, two lateral petals called the wings and two anterior or innermost petals more or less fused to form a boat shaped structure called the keel or carina. This kind of corolla is called the papilionaceous or butterfly shaped corolla. The descending imbricate aestivation is found. Petals are beautifully coloured.

Androecium: Stamens 10, usually diadelphous (into two groups i.e. 9+1). Nine fuse to form a sheath round the pistil while 10^{th} is free.

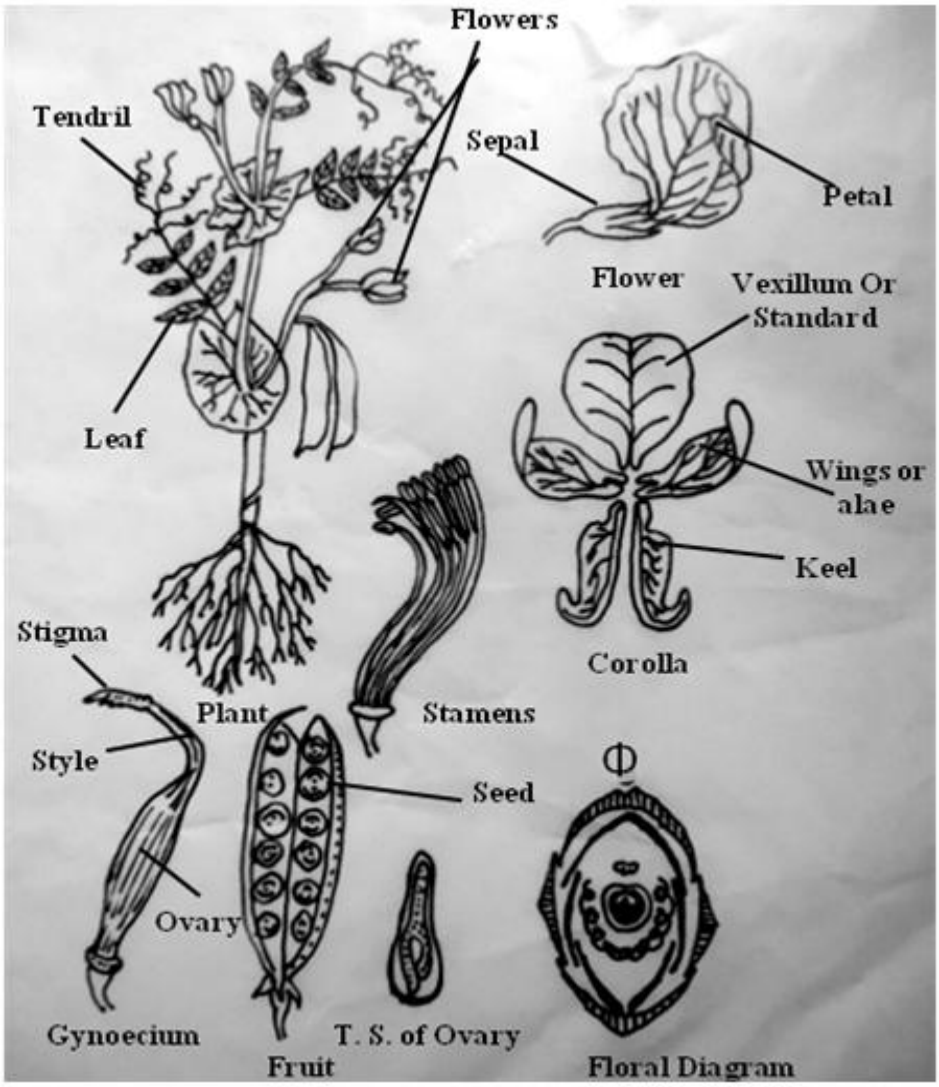

Fig. 1.5: ***Pisum sativum***

Gynoecium: Monocarpellary. The ovary is superior, unilocular. Marginal placentation is found. Style is long and bent at base, stigma flattened and hairy.

Fruit: Legume or pod.

Seed: Non-endospermic

Floral formula:

Br, %, ♂, K_5, $C_{1+2+(2)}$, $A_{9+1}\underline{G1}$

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons

2. Flowers are pentamerous
3. Reticulate venation----------**Dicotyledons**

c. 1. Petals are free---------- **Polypetalae**

d. 1. Calyx gamosepalous
2. Cup shaped thalamus----------**Calyciflorae**

e. 1. Alternate and stipulate leaves
2. Diadelphousstamens----------**Rosales**

f. 1. Climbing plant
2. Zygomorphic flowers
3. Papilionaceous corolla----------**Papilionaceae**

g. 1. Fruit is legume or pod
2. Presence of tendrils
3. White flowers----------***Pisum sativum***

6-Asclepiadaceae (The Milk Weed Family)

***Calotropis procera* (Ait.) R. Br. (Fig.1.6)**

Vegetative Characters:

Habit: A shrubby weed covered with soft, white, wooly tomentum and contains milky latex.

Root: Well branched, tap root.

Stem: The stem is herbaceous but lower portion soft and woody.Stem is erect, branched, cylindrical, solid, covered with white wooly tomentum; contains milky latex.

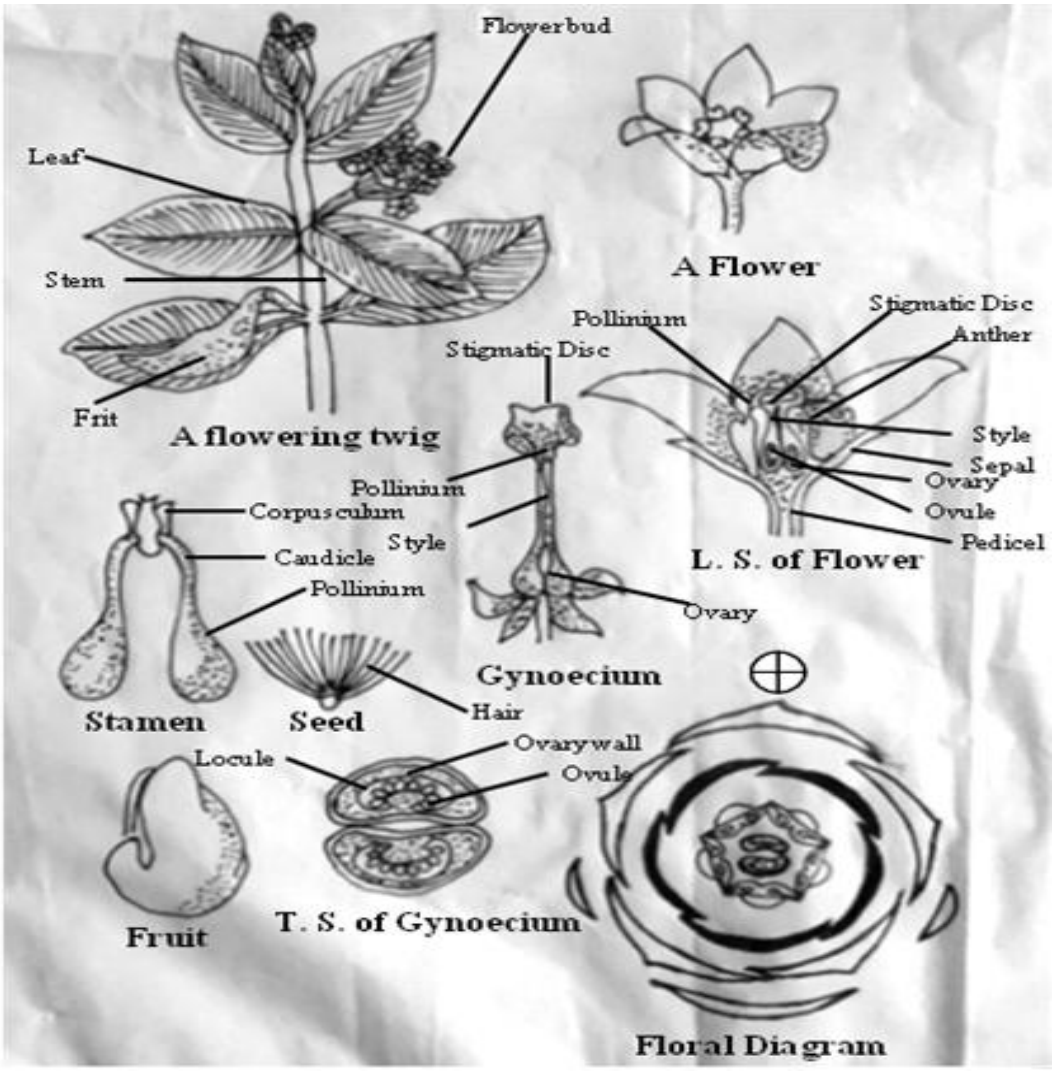

Fig.1.6: ***Calotropis procera*** **(Ait.) R.Br.**

Leaf: Ramal and cauline, simple, opposite decussate, exstipulate, sessile or subsessile; ovate to oblong, base auriculate. Leaves are entire, acute; under surface covered with wooly tomentum contain milky latex and showing unicostate reticulate venation.

Floral characters:

Inflorescence: Axillary umbellate cyme.

Flower: Bracteate, two bracteoles, pedicellate, complete, hermaphrodite, actinomorphic, pentamerous and hypogynous. Flowers are purplish red to white and having very strong smell.

Calyx: Consist of 5 sepals, polysepalous and are slightly fused at the base.

Corolla: Petals 5, gamopetalous, campanulate. The valvate but sometimes twisted aestivation is found. Petals are beautifully coloured with pink or whitish with purplish spots.

Androecium: Stamens 5, sometimes epipetalous and are connected with the stigma which is thus known as gynostegium. Each stamen is in the form of two pollinia. Stamens form translators which consist of two pollinia connected with the corpusculum with the help of their individual retinaculae or caudicles. A fleshy scale like laterally compressed coronary outgrowth arises from the back of each stamen.

Gynoecium: Bicarpellary, superior.Ovaries are separated at the base and many ovules in each locule. Marginal placentation is found. Two styles are united apically with the stigma to form a pentangular disc called stigmatic disc.

Fruit: Follicle

Seed: Many, hairy and endospermic

Floral formula: Br, Brl, $\oplus, ♀$, K_5, $C_{(5)}$, $A_{(5)}$,G_2

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**
c. 1. Gamopetalous condition----------**Gamopetalae**
d. 1. Bicarpellary, superior ovary----------**Bicarpellatae**
e. 1. Opposite decussate leaves.
   2. ***5*** lobed calyx and corolla----------**Gentianales**
f. 1. Leaves and stem with latex
   2. Presence of gynostegium
   3. Marginal placentation----------**Asclepiadaceae**
g. 1. Fruit is follicle
   2. Presence of translators
   3. Plant parts covered with soft hair----------***Calotropis procera***

7-Solanaceae (The Potato Family)

Datura stramonium (Fig.1.7)

Vegetative Characters:

Habit: Annual herb

Root: Tap roots, branched, not very deep.

Stem: The stem is herbaceous, erect, green, dichotomously branched

Leaf: Usually simple, alternate but opposite in upper parts, exstipulate, petiolate, ovate, entire, acute.

Floral characters:

Inflorescence: Solitary terminal or solitary axillary.

Flower: Bracteate, pedicellate, complete, hermaphrodite, pentamerous, actinomorphic, hypogynous, large.

Calyx: Consist of 5 sepals, gamosepalous persistent. The valvate or twisted aestivation is found.

Corolla: Petals 5, gamopetalous and modified into trumpet shape, white. Aestivation is twisted.

Androecium: Consist of 5 stamens, epipetalous, polyandrous. Filaments are long and anthers basifixed.

Gynoecium: Bicarpellary, syncarpous, bilocular. Carpels are obliquely placed. The placenta is swollen with superior ovary and false septum provides a tetralocular appearance. There are many ovules in each locule. Axile placentation is found. Dome shaped stigma with long style. **Fruit:** Spiny capsule opening by four valves.

Seed: Many, Nacrotic and poisonous

Floral formula:

Ebr, $\oplus$, φ , $K_{(5)}$, $\overset{\frown}{C_{(5)}}$, A_5,$G(\underline{2})$

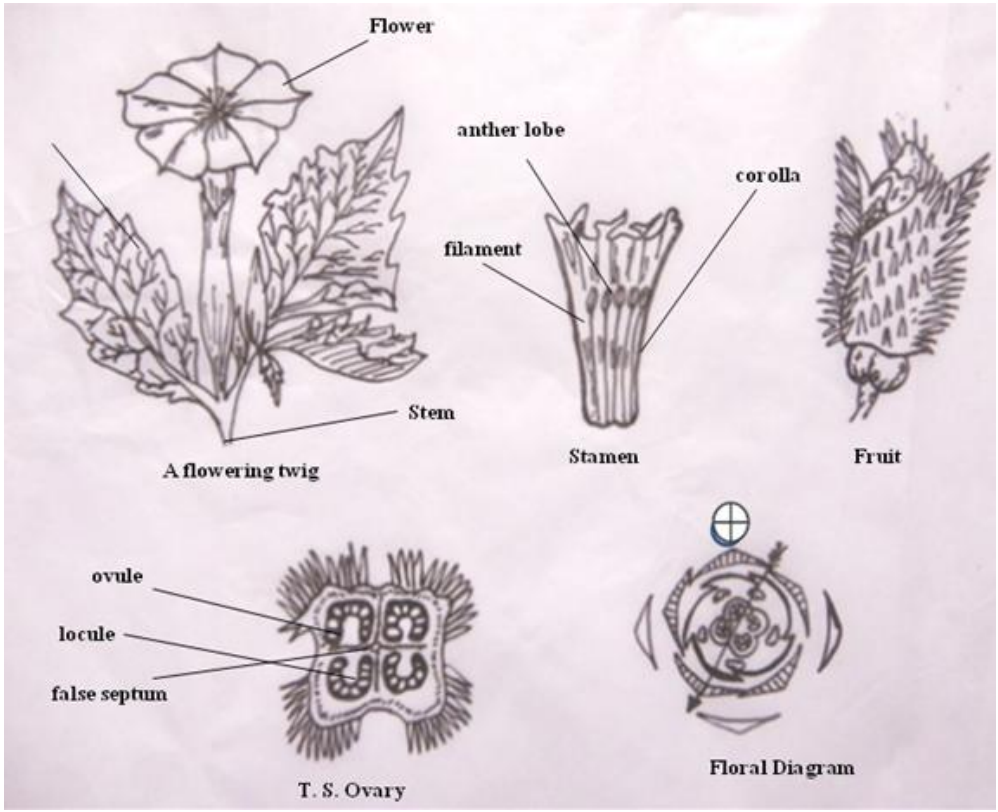

Fig.1.7: ***Datura stramonium***

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons
   2. Flowers are pentamerous
   3. **Reticulate venation**----------**Dicotyledons**
c. 1. Gamopetalous condition---------- **Gamopetalae**
d. 1. Bicarpellary, syncarpous, superior gynoecium
   2. Axile placentation ----------**Bicarpellatae**
e. 1. Leaves exstipulate
   2. Epipetalous stamens----------**Polemoniales**
f. 1. Carpels are obliquely placed
   2. Swollen placenta
   3. Dome shaped stigma with long style ----------**Solanaceae**
g. 1. Spiny capsule opening by four valves
   2. Many ovules in each locule
   3. Nacrotic and poisonous ----------***Datura stramonium***

8-Acanthaceae **(The Acanthus Family)**

Adhatoda vesica **Nees. (Fig.1.8)**

Vegetative Characters:

Habit: Annual herb

Root: Tap roots, branched.

Stem: The stem is herbaceous, erect, branched, cylindrical, solid, swollen nodes, green to pale-green in colour.

Leaf: Ramal and cauline, simple, exstipulate, opposite, decussate, petiolate, lanceolate to ovate, entire, pale green in colour. Unicostate reticulate venation is found.

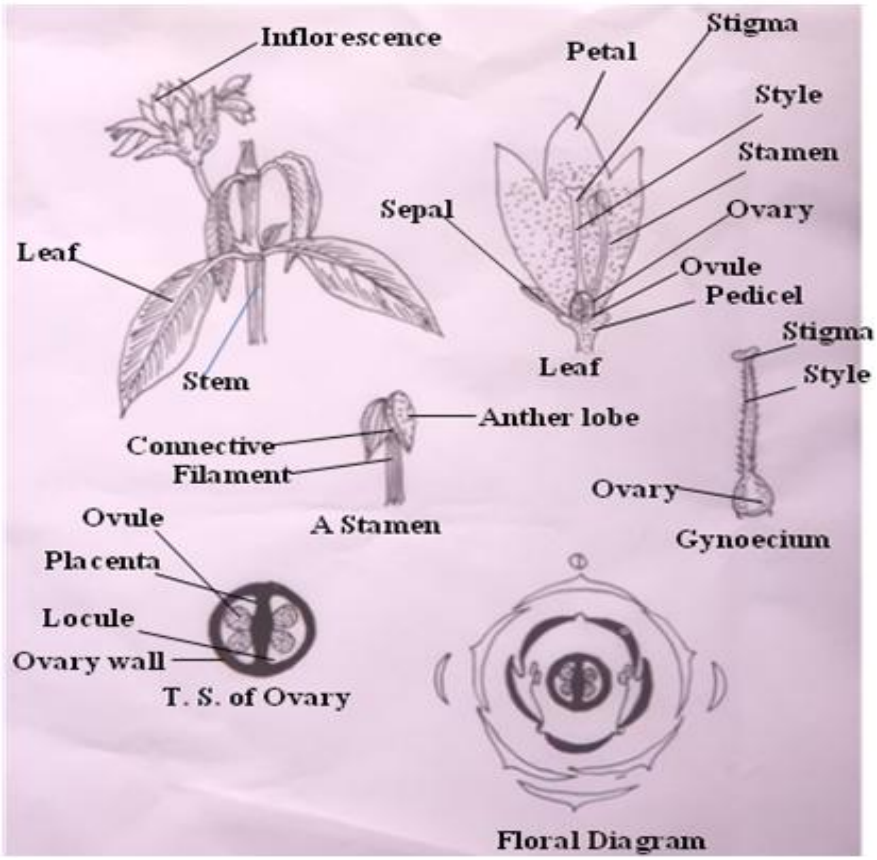

Fig.1.8: ***Adhatoda vesica*** **Nees.**

Floral characters:

Inflorescence: Axillary racemose spike.

Flower: Bracteate (leafy bracts), bracteolate (the bracteoles are leafy and enclosed the bud), sub sessile, complete, hermaphrodite, pentamerous, zygomorphic, hypogynous, large and white.

Calyx: Consist of 5 sepals, polysepalous but are slightly conate at the base, quincunical, pale green in colour. The aestivation is mostly imbricate.

Corolla: Petals 5, gamopetalous, Petals are conate in bilipped corolla, 2/3 bilabiate personate, consisting of a posterior curved lip of two petals and an anterior lip of three petals. Anterior most middle petal of anterior lip is raised and strongly nerved, white in colour.

Androecium: Consist of 2 stamens, epipetalous, polyandrous, dithecous, basifixed and introrse. External anther lobe is higher than inner.

Gynoecium: Bicarpellary, syncarpous, bilocular. Carpels are medianly placed. There are one to two ovules in each locule. Axile placentation is found. Slightly bifid stigma with simple long hairy style.

Fruit: Capsule

Seed: Large non endospermic seed with hooks also called jaculators.

Floral formula:

Br, Brl, Φ, ♂♀ , $K_{(5)}$, $C_{(2/3)}$, A_2,G(2)

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**
c. 1. Gamopetalous condition---------- **Gamopetalae**
d. 1. Bicarpellary, superior ovary
   2. Axile placentation ----------**Bicarpellatae**
e. 1. Zygomorphic flowers
   2. Bilabiate personate corolla ----------**Personales**
f. 1. Opposite decussate leaves
   2. Flowers are bilipped
   3. Seeds with jaculators ----------**Acanthaceae**
g. 1. Inflorescence racemose spike
   2. Stamens are two in number
   3. Unequal sized anther lobes----------***Adhatoda vasica***

9-Lamiaceae (The Mint Family)

***Ocimum basilicum* Linn. (Ban Tulsi) (Fig.1.9)**

Vegetative Characters:

Habit: A cultivated, aromatic, tall herb

Root: Tap roots, branched.

Stem: The stem is herbaceous but becomes woody below, quadrangular, erect, branched, hairy, green, aromatic.

Leaf: Ramal and cauline, simple, exstipulate, opposite decussate, petiolate, ovate, serrate, hairy. Unicostate reticulate venation is found.

Floral characters:

Inflorescence: Verticillaster.

Flower: Bracteate, ebracteolate, pedicellate, complete, hermaphrodite, zygomorphic, hypogynous, bilabiate, small, aromatic.

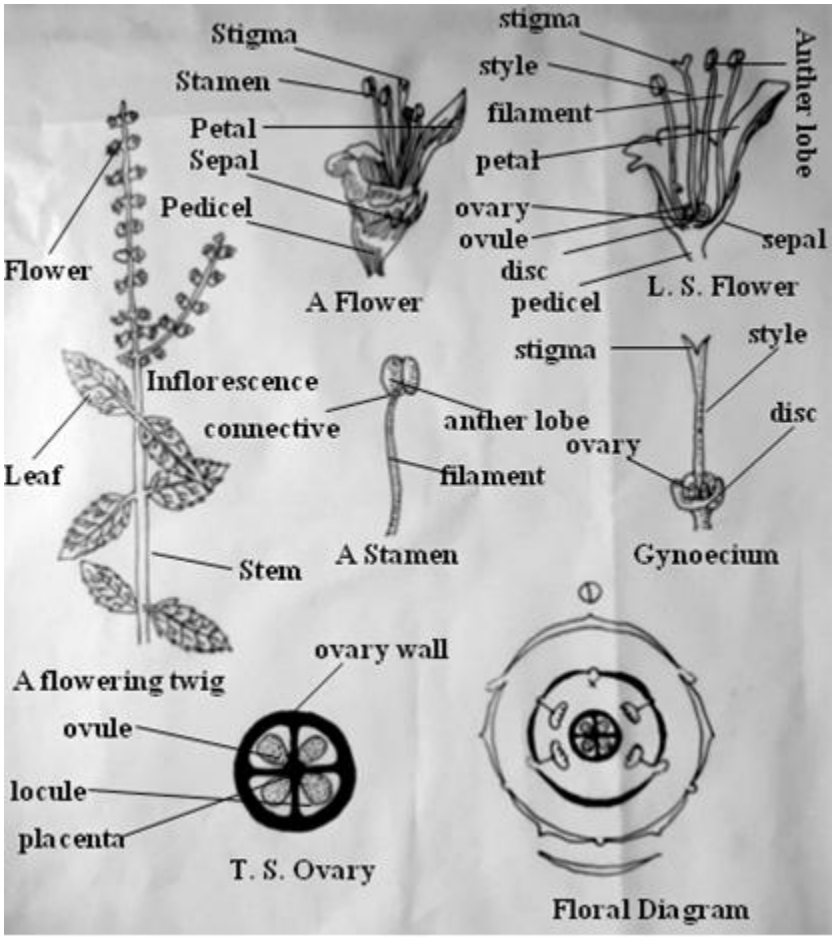

Fig.1.9: *Ocimum basilicum* Linn.

Calyx: Consist of 5 sepals, ¼ bilipped consisting of upper posterior lip of one big lobe and anterior lip of 4 lobe; gamosepalous and violet green in colour. The aestivation is valvate.

Corolla: Petals 5; arranged in 4/1 form, bilabiate, consisting of upper posterior lip of 4 lobes and lower anterior lip of 1 lobe; gamopetalous, white or pink coloured. Valvate aestivation is found.

Androecium: Consist of 4 stamens, epipetalous, polyandrous and didynamous. The posterior stamen is lacking. Anther lobes broad and are slightly separated, dithecous, dorsifixed, introrse.

Gynoecium: Bicarpellary, syncarpous, bilocular in very early stages but later on becomes quadrilocular due to the formation of false septum. Each locule with one locule and axile placentation is found. Ovary is superior and 4 lobed. Style is long and gynobasic and come up between 4 parts of the ovary. Stigma is bifid. A four-lobed hypogynous disc is present below the ovary.

Fruit: Schizocarpic (carcerulus), made up of four nutlets.

Seed: Four- non endospermic.

Floral formula:

Br, Ebrl,Φ , ♂♀, $K_{(1/4)}$, $\overset{\frown}{C_{(4/1)}}$, A_{2+2},$\underline{G(2)}$

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**
b. 1. Presence of two cotyledons
   2. Flowers are pentamerous
   3. Reticulate venation----------**Dicotyledons**
c. 1. Gamopetalous condition---------- **Gamopetalae**
d. 1. Bicarpellary, syncarpous, superior gynoecium
   2. Axile placentation ----------**Bicarpellatae**
e. 1. Plant is herb
   2. Leaves are opposite decussate
   3. Flowers are zygomorphic, bilipped
   4. Fruit Schizocarpic ----------**Lamiales**
f. 1. Angular stem
   2. Scented or aromatic leaves
   3. Inflorescence verticillaster----------**Lamiaceae**
g. 1. Stamens didynamous
   2. Gynobasic style
   3. Ovary tetralocular
   3. Calyx ¼ and corolla 4/1---------- ***Ocimum basilicum***

10-Orchidaceae **(The Orchid Family)**

Orchis latifolia **(Fig.1.10)**

Vegetative Characters:

Habit: Mostly terrestrial succulent, herbs, epiphytic or saprophytic.

Root: Adventitious roots, tuberous.

Stem: Normally the stem is erect, sometimes climbing or trailing.

Leaf: Simple, entire alternate or rarely opposite to whorled, oval or linear, parallel venation, often fleshy.

Floral characters:

Inflorescence: Racemose, mostly spike.

Flower: Bracteate often very showy, hermaphrodite, zygomorphic, epigynous, A few modifications are due to hyper trophy, adhesion or suppression.

Perianth: Six tepals in two whorls, free or variously combined usually fleshy.The posterior segment of inner whorl is always more developed and known as labellum. Mostly labellum remains provided with a spur, secreting nectar. Labellum comes to the anterior because of the twisting ovary and serves as the landing stage for insects.

Androecium: Consisting of 3 stamens uniting with the pistil to form the gynoecium. There is one functional stamen, anther two celled, opened by longitudinal slits. The pollen grains are united to form pollina.

Gynoecium: Tricarpellary (consist of three carpels), syncarpous, ovary inferior and unilocular (rarely trilocular). Parietal placentation is found. Three stigma, out of which two lateral ones receptive or fertile, third one is sterile and transformed into small beaked outgrowth the restillum.

Fruit: Capsule

Seed: Minute non endospermic.

Floral formula:

$\Phi, ♂♀$, P_{3+3} or $_{(3+3)}$, $A_{3or\ 2,}G(\underline{3})$

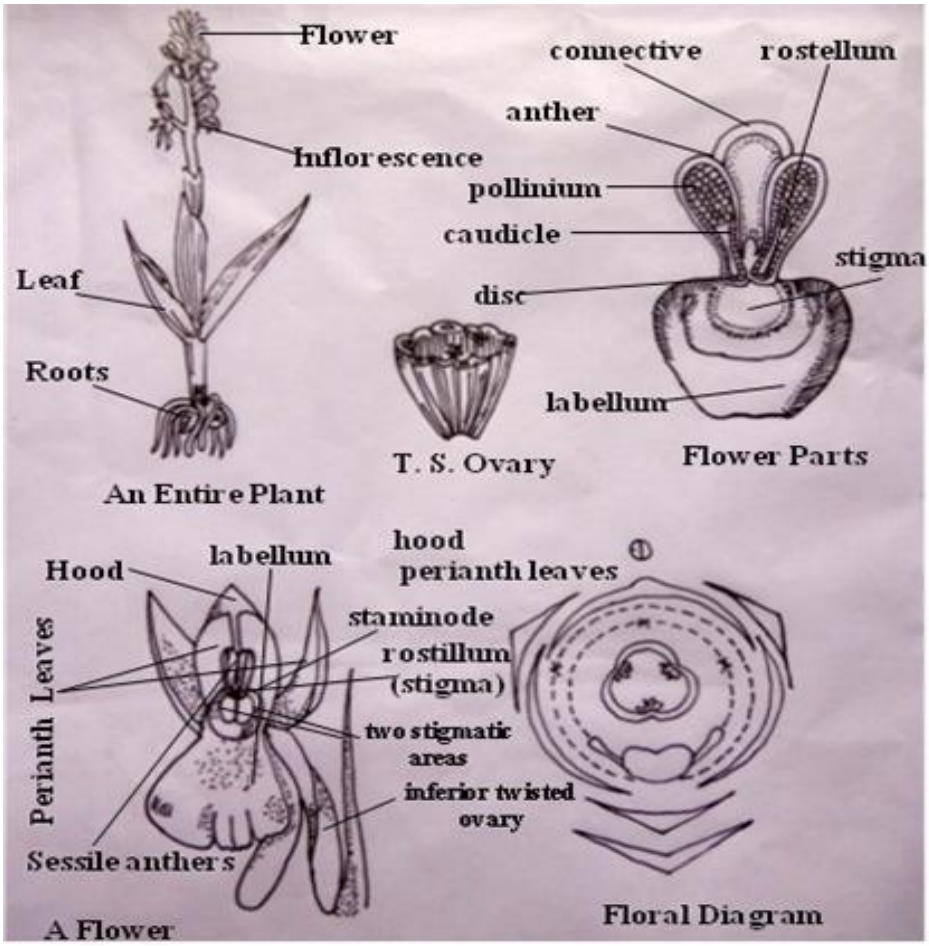

Fig.1.10: ***Orchis latifolia***

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**

b. 1. Presence of one cotyledons
   2. Flowers are trimerous
   3. Parallel venation----------**Monocotyledons**

c. 1. Perianth leaves 3+3
   2. Petalloid perianth----------**Coronarieae**

d. 1. Leaves are alternate or rarely opposite to whorled
   2. Racemose inflorescence----------**Orchidales**

e. 1. The stem is erect, sometimes climbing
   2. Fleshy leaves
   3. Anther two celled, opened by longitudinal slits --------**Orcihdaceae**.

g. 1. Stamens uniting with the pistil to form the gynoecium
   2. The pollen grains are united to form pollina.

3. Ovary inferior and unilocular
4. Minute non endospermic ---------- ***Orchis latifolia***

11-Poaceae (The Grass Family)

***Triticum aestivum* L. (Fig.1.11)**

Vegetative Characters:

Habit: An annual cultivated, cereal crop.

Root: Fibrous, adventitious roots.

Stem: Herbaceous, erect, cylindrical, unbranched but rarely branched. Nodes and internodes are very clear, fistular, rough and green.

Leaf: Simple, sessile, alternate have long linear blade. A membranous ligule is present at the junction of blade and leaf base. Linear to lanceolate. Multicostate parallel venation.

Floral characters:

Inflorescence: Spike of spikelets. Each spikelet consists of a pair of glumes. There are many inferior palea or lemma, superior palea and enclosing the lodicules, stamens and gynoecium.

Flower: Bracteate (lemma or inferior palea), bracteolate (superior palea), sessile, complete, hermaphrodite, zygomorphic, hypogynous, small and inconspicuous. Lemma is prolonged into a long **awn**.

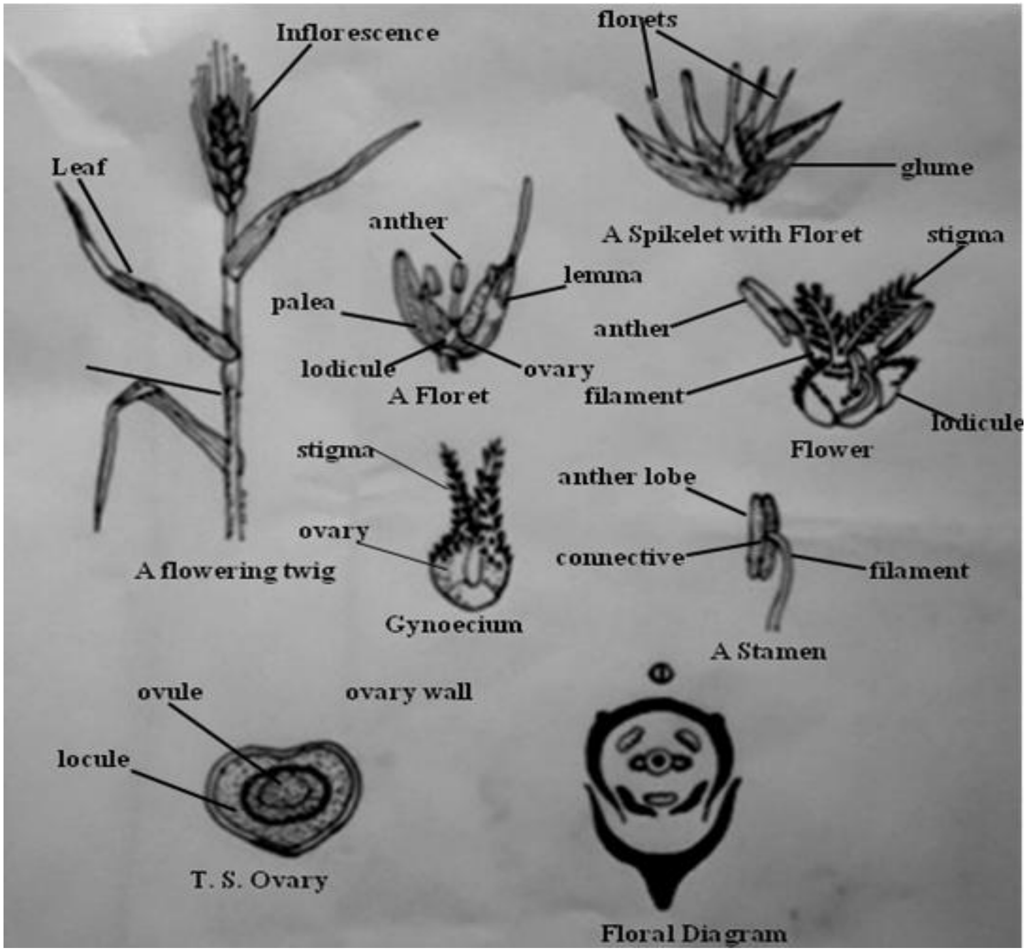

Fig.1.11: ***Triticum aestivum* L.**

Perianth: Perianth absent, however the lodicules may be considered as highly reduced perianth.
Androecium: Consisting of 3 stamens, polyandrous, one anterior and two posterolaterally placed. Long filament is come out of the flower, dithecous, versatile, introrse.
Gynoecium: Monocarpellary, syncarpous, ovary superior. Unilocular with single ovule. There are two styles. There are two feathery stigmas arising from lateral parts of the pistil.
Fruit: Caryopsis.
Seed: Endospermic.
Floral formula:

Br, Brl, Φ , ⚥ , $\overparen{P_2}$, $A_{3,}$ $G_{\underline{1}}$

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall----------- **Angiosperms**
b. 1. Presence of one cotyledons

2. Flowers are trimerous
3. Parallel venation----------**Monocotyledons**

c. 1. Sessile, naked flowers
2. Highly reduced perianth
3. Presence of glumes----------**Glumiflorae**

d. 1. Inflorescence is spike of spikelets
2. Fruit caryopsis
3. Awned flowers---------- ----**Poaceae**.

g. 1. Stem is jointed and hollow
2. Leaves with ligule
3. Inflorescence is spike
4. Feathery stigma---------- ***Triticum aestivum***

12-Liliaceae (The Lily Family)

Asphodelus tenuifolius **(Fig1.12)**

Vegetative Characters:

Habit: An annual herb.

Root: Fibrous, adventitious roots.

Stem: Condensed, underground and reduced, fistular.

Leaf: Simple, Radical, sessile, exstipulate, leaf base sheathing, long, acicular, entire, acute, fleshy, hollow, multicostate parallel venation.

Floral characters:

Inflorescence: Racemose raceme with its erect flower, cylindrical, fleshy, long peduncle or scape.

Flower: Bracteate, ebracteolate, pedicillate, complete, hermaphrodite, actinomorphic, trimerous, small and white.

Perianth: 6 Tepals, arranged in two whorls of 3 each, polyphyllous, petalloid, oblong. Tepals are white in colour and midrib brownish and ridged. Valvate aestivation is found. **Androecium:** Consisting of 6 stamens, arranged in two whorls of 3 each, polyandrous, epiphyllous and are attached just opposite to each perianth lobe. Filaments are of unequal size as the larger of outer whorl than that of inner whorl, dithecous, versatile, introrse, white.

Gynoecium: Tricarpellary, syncarpous, trilocular superior ovary. There are two ovules in each locule. Trifid yellowish stigma on filiform style

Fruit: A capsule

Seed: Endospermic.

Floral formula:

Br, EBrl⊕ ,⚥, P_{3+3}, $A_{3+3,}$G (3)

Identification and Systematic Position:

a. 1. Seeds enclosed within ovary wall---------- **Angiosperms**

b. 1. Presence of one cotyledons
   2. Flowers are trimerous
   3. Parallel venation----------**Monocotyledons**

c. 1. Ovary superior
   2. Petalloid perianth----------**Coronarieae**

d. 1. Leaves are radical
   2. Racemose raceme with flowers on long peduncle
   3. Perianth leaves 3+3
   4. Stamens 3+3 ----------**Liliaceae**

g. 1. Leaves are acicular and fleshy
   2. White coloured flowers
   3. Fibrous adventitious roots---------- ***Asphodelus tenuifolius***

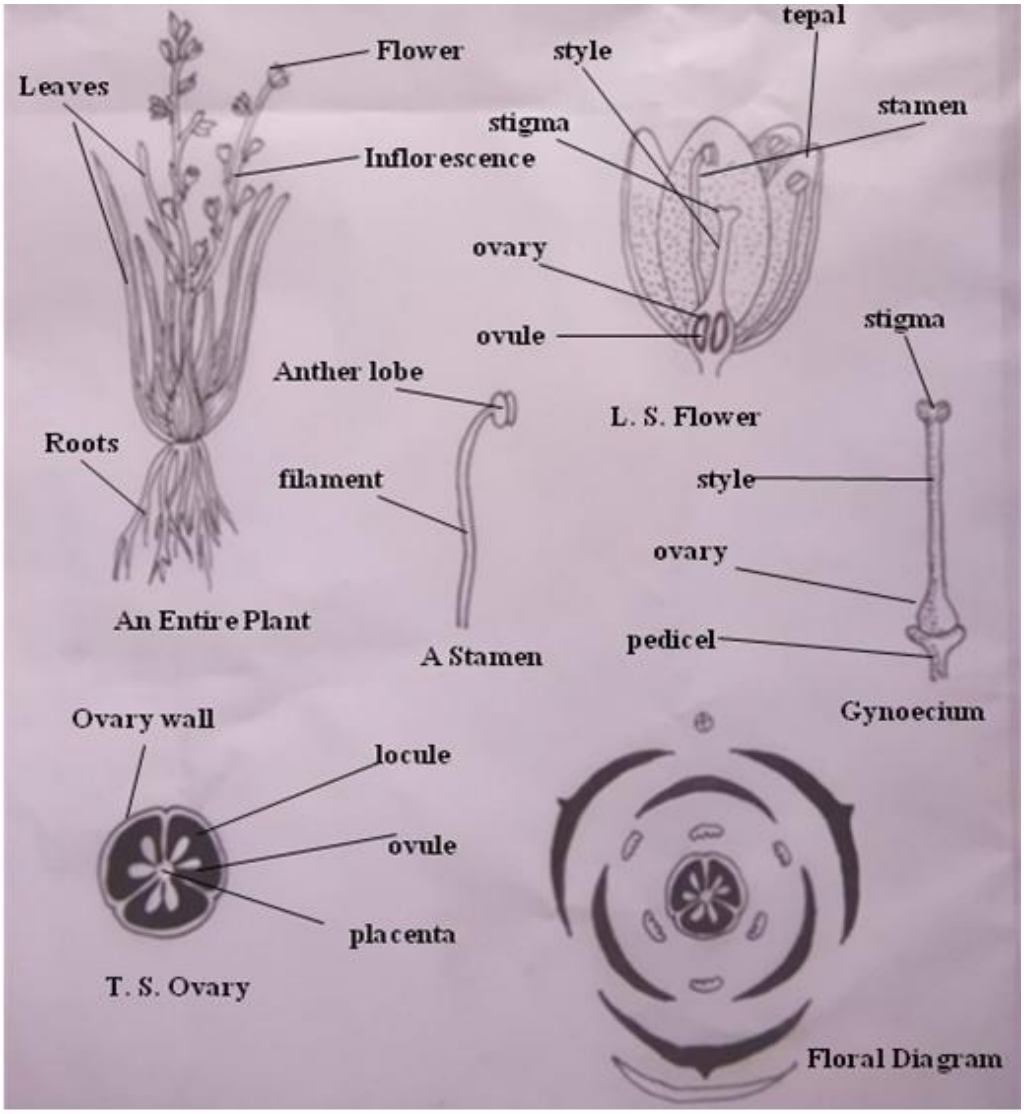

Fig.1.12: ***Asphodelus tenuifolius***

1.4 SUMMARY

1. With the huge variety of plants surrounding us, it is extremely essential to pinpoint a particular plant of our interest by noting the similarities or differences with other plants. Thus it becomes extremely necessary that the plant is first identified, given a proper name so that we can communicate our ideas about it, and also know the group to which the plant belongs.
2. Taxonomy means classification following certain rules or, principles. But it is very important to note that a plant's name is the key to its literature, and grouping can only be possible when

its identity is revealed and is named for the sake of convenience and communication of ideas about it.

3. The term taxonomy was first introduced to the plant science in 1813 by A. P. de Candolle, which was about the plant classification. But later this term became more inclusive and at present it includes identification of plants, their nomenclature and classification. Traditionally taxonomy was based largely on gross morphological features of a plant.
4. The three functions of taxonomy include, identification, nomenclature and classification. Its main aim is to provide a convenient method of identification and communication about a taxon and provide a classification which is based on natural affinities of plant as far as possible.
5. The word **'taxon'** (taxa) was first used by a German Biologist Adolf Meyer in 1926 for animal groups. It was later proposed for the plant system in 1948 by Herman J. Lam. It is a taxonomic group of any rank, e.g. family, genus, species, subspecies, etc.
6. Identification of a taxon is a prerequisite for any study based on it. It is the determination of a taxon based on overall similarities and differences with other taxa. Identification is generally done by comparing representative specimen of a given taxon with the help of key descriptions, illustrations, etc.
7. In the present chapter we have described 12 families in semi technical language and now we are going to summarize the identification of these 12 families as per in the syllabus as following:-
   - **Ranunculaceae:** Herbs or climbing shrubs; Tetra-Pentamerous flowers; Gynoeciumα-1; fruit simple or etario of achenes
   - **Caryophyllaceae:** Herbs; stem with swollen nodes; leaves sessile, opposite; Flowers bracteate, bracteolate, pentamerous; Actinomorphic, sepals persistent; corolla caryophyllaceous; Androecium$(A)_{5+5}$; free central placentation
   - **Rutaceae:** Shrubs, trees; leaves with glandular dots; stamens 8-10, obdiplostamonous or many and polyadelphous; disc nectar secreting; fruit hesperidium
   - **Rosaceae:** Alternate and stipulate, pinnately compound leaves; flowers pentamerous; calyx persistent; stamens many; Rosaceous corolla; perigynous; polycarpellary, apocarpous gynoecium; fruit etario of achenes
   - **Fabaceae:** Climbing plants; zygomorphic flowers; papilionaceous corolla; monocarpellary ovary; marginal placentation; Androecium- A(9)+1, diadelphous
   - **Asclepiadaceae:** Leaves opposite, Leaves and stems with latex; Actinomorphic flowers; epipetalous stamens; presence of gynostegium; marginal placentation; corolla not hypocrateriform; staminal corona is present
   - **Solanaceae:** Leaves alternate, exstipulate; actinomorphic flowers; carpels obliquely placed; swollen placenta; corolla rotate or campanulate; several ovules in each locule, axile placentation; fruit berry

- **Acanthaceae:** Opposie decussate leaves; flowers bilipped; corolla bilabiate personate; Androecium – A_2 or 2+2; seeds with jaculators (hooks)
- **Lamiaceae:** Angular stem; scented and aromatic leaves; zygomorphic flowers; inflorescence verticillaster; style gynobasic; ovary four locular; stamens didynamous
- **Orchidaceae:** Perennial herbs with unbranched stem; zygomorphic flowers; presence of labellum; anther highly modified; presence of gynostegium.
- **Poaceae:** Stem with two stichous ligulate leaves, inflorescence spike or spikelets, awned flowers, flowering glumes2 as lemma and palea, G(2), stigma 2, fruit caryopsis.
- **Liliaceae:** Leaves radical, inflorescence racemose raceme with flowers on long peduncle, perianth leaves 3+3, stamens 3+3, some with staminodes, fruit capsule.

1.5 GLOSSARY

Achene – A small, dry, one-seeded, indehiscent fruit (one that doesn't split open)
Acuminate – The shape of a tip (apex) or base of a leaf or perianth segment where the part tapers gradually and often in a concave manner.
Acute – Evenly narrowed into a point at an angle of less than 90 degrees.
Adventitious – Arising from an unusual or irregular position, such as roots along a stem.
Alternate – Arrangement of leaves or parts one at a node, as leaves on a stem. For comparison, opposite or whorled
Ament – A catkin, or scaly spike.
Angiosperm – Having seeds borne within a pericarp.
Anther – Pollen-bearing part of a stamen, borne at the top of a filament.
Apetalous – Without petals, e.g. flowers of grasses.
Apex – The tip or terminal end.
Apical – Describes the apex or tip.
Auriculate – Having ear-like appendages, as the projections of some leaf and petal bases.
Axil – The angle between a stem and an attached leaf.
Axis – The main stem.
Axillary – Borne or carried in the axil.
Berry – A fleshy, indehiscent, pulpy, multi-seeded fruit resulting from a single pistil, e.g. tomato.
Bipinnate – Twice pinnate, the primary leaflets being again divided into secondary leaflets.
Bloom – A waxy coating sometimes found on a stem, leaf, flower or fruit surface, usually of a grayish cast and easily removed.
Bract – A much-reduced leaf, often scale-like and usually associated with a flower or inflorescence
Caducous – Falling off very early as compared to similar structures in other plants.

Calyx – The outer whorl of perianth, composed of the sepals, usually green in color and smaller than the inner set.
Capsule – A dry dehiscent fruit produced from a compound pistil,
Catkin – A spike-like inflorescence, comprised of scaly bracts subtending unisexual flowers, often somewhat flexuous and pendulous,
Ciliate – Marginally fringed with hairs, often minutely so, and then termed "ciliolate."
Compound leaf – A leaf of two or more leaflets.
Connate – Describing similar structures united or fused together.
Corolla – Inner whorl of the perianth, between the calyx and the stamens; a collective term for the petals of a flower.
Cotyledon – The primary leaves of the embryo, present in the seed. One of the first leaves to appear after germination (there may be more than 1).
Cyme – A more or less flat-topped determinate inflorescence whose outer flowers open last.
Dehiscent – Splitting open. The term is commonly applied to anthers or seed pods.
Determinate – Describes an inflorescence in which the terminal flower blooms first, thereby halting further elongation of the flowering stem.
Dimorphic – Having two forms.
Drupe – A fleshy, indehiscent fruit whose seed is enclosed in a stony endocarp, e.g. date, cherry.
Entire – Having a margin without teeth or lobes.
Filiform – Long and very slender; thread-like.
Fruit – Technically a ripened ovary with its adnate parts, the seed-containing unit characteristic of all Angiosperms.
Genus – A group of species possessing fundamental traits in common but differing in other lesser characteristics; a taxonomic grouping of similar species (pl. genera); similar genera are grouped into families.
Glabrous – Not hairy.
Glandular – Bearing glands.
Hairy – Pubescent with long hairs.
Imperfect – A flower that lacks either stamens or pistils.
Inferior – Beneath, below; said of an ovary when situated below the apparent point of attachment of stamens and perianth.
Inflorescence – The arrangement of flowers on the axis.
Lanceolate – Much longer than wide, broadest below the middle and tapering to the apex.
Latex – Milky sap.
Margin – The edge of a leaf.
Marginal – Pertaining to the margin.
Native – Inherent and original to an area; pre European influence in the United States..

Node – A joint on a stem, represented by point of origin of a leaf or bud; sometimes represented by a swollen or constricted ring, or by a distinct leaf scar.

Nut – A dry, indehiscent, 1-celled, 1-seeded fruit having a hard and bony mesocarp, the outermost endocarp may be fibrous or slightly fleshy.

Opposite – Describing leaves that are situated in pairs at a node along an axis.

Ovate – Egg-shaped in outline, broadest below the middle.

Pedicel – Stalk of a single flower in an inflorescence.

Peduncle – Stalk of a flower or inflorescence.

Perianth – A collective term embracing both the calyx and corolla

Pericarp – A term used by some to designate a fruit; technically, the ovary wall.

Pinna – The leaflet of a compound leaf; in ferns, the primary division attached to the main rachis; feather-like.

Raceme – A simple indeterminate inflorescence, having a single long axis, with pedicelled flowers.

Reflexed – Bent abruptly backward or downward.

Schizocarp – A dry dehiscent fruit that splits into two halves.

Sepal – A single segment of a divided calyx.

Sessile – Without a stalk.

Simple – Said of a leaf when not compound, of an inflorescence when unbranched.

Solitary – Borne singly, not paired or clustered.

Species – A natural group of plants composed of similar individuals which can produce similar offspring; usually including several minor variations.

Spike – A unbranched, elongated, simple, indeterminate inflorescence whose flowers are sessile; the flowers may be congested or remote.

Spikelet –The floral unit, or ultimate cluster, of a grass inflorescence comprised of flowers and their subtending bracts.

Stamen – Male or pollen-bearing organ of a flower, composed of filaments and anthers.

Stipule – A basal appendage of a petiole, usually one at each side, often ear-like and sometimes caducous.

Tendril – A modified stem or leaf, usually filiform, branched or simple, that twines about an object providing support.

Tepal – A segment of perianth not differentiated into calyx or corolla

Terminal – At the tip or distal end.

Umbel – An indeterminate inflorescence, usually but not necessarily flat-topped with the pedicels and peduncles (termed rays) arising from a common point, resembling the stays of an umbrella.

Undulate – Wavy, as in a leaf margin.

Unisexual – Bearing either stamens or pistils but not both.

Valvate – Meeting at the edges without overlapping, as leaves or petals in the bud.
Whorl – Arrangement of three or more structures arising from a single node.
Woolly – Having long, soft, more or less matted hairs; like wool.

1.6 SELF ASSESSMENT QUESTION

1.6.1 Short Answer Type Questions:

1. Who coined the term classification for the first time?
2. Who used the term systematics?
3. What K (5) stands for?
4. What does the mean of C_{5+5}?
5. Which family is known as crow foot family?
6. Which type of placentation is found in *Ranunculus*?
7. Which family is known as the orange family?
8. In which year the taxonomy was first introduced to the plant science?
9. Who used the term Taxon for the plant system previously?

1.6.2 Fill in the Blanks:

1. Traditionally taxonomy was based largely on ----------of a plant.
2. The three functions of taxonomy include**-------, ---------- and----------.**
3. Tetra-Pentamerous flowers is the characteristic feature of **----------.**
4. In Fabaceae the --------placentation is found.
5. Presence of gynostegium is the feature of----------.
6. ⚥ stands for**----------.**
7. Superior ovary is represented by ----.
8. *Stellaria media* Cyrill. is commonly known as**----------.**
9. Nine stamens fuse to form a sheath round the pistil while 10^{th}stamenis free might be represented by -----.
10. Presence of two cotyledons is the characteristic feature of ----------
11. In Papilionaceae corolla are.
12. Flowers of ***Orchis latifolia*** **are----------.**

1.6.1 Answers Key:

1. A. P. de Candolle **2.** Carl Linnaeus, **3.** Five sepals are fused (gamosepalous), **4.** Ten petals are arranged in two whrols of 5 each, **5.** Ranunculaceae, **6.** Basal placentation, **7.** Rutaceae, **8.**1813, **9.** Herman J. Lam

1.6.2. Answers Key: 1. Morphological features, 2. Identification, nomenclature and classification, 3. Ranunculaceae, 4. Marginal, 5. Orcidaceae, 6. Hermaphrodite, 7. G 8. The Chick weed, 9. A_{9+1}., 10. Dicotyledons, 11. Butterfly shaped, 12. Zygomorphic

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1.9 TERMINAL QUESTIONS

1. Describe the flowering plants with special reference to their availability in Uttarakhand.
2. Describe the process of identification.
3. With the help of floral diagram and formula describe following families:
    a. The chick weed family
    b. The orange family
    c. The pea family
    d. The rose family
    e. The milk weed family
4. Describe the floral description of available plant of Acanthus family in Uttarakhand.
5. Describe the Mint family.
6. Define placentation. Write some important points for following placentation types:
    a. Basal placentation
    b. Marginal placentation
    c. Axile placentation
7. Describe the vegetative and floral characters of orchid family member of your locality.

UNIT-2 COLLECTION OF PLANT SPECIMENS-HERBARIUM AND LIVE SPECIMENS

Contents

2.1 OBJECTIVES

After reading this section you will know-

- What is plant specimen
- How to collect plant specimens
- What is Herbarium
- How to prepare Herbarium
- The description, collection and preservation techniques of specimens for herbarium
- To describe, collect and maintain the live plant specimens for both pure and applied studies

2.2 INTRODUCTION

In this unit we will try to know about plant specimen and its types, which are mostly used as an example of a species or a type for scientific study or display. The specimens may be in the form of whole plant or plant parts. These are usually in dried form by mounting on a sheet of paper but depending upon the material, may also be stored in boxes or kept in preservatives. The specimens in a herbarium are often used as reference material in describing plant taxa.

Plant collection is the prerequisite for preparing the plant specimens for the purposes of research, cultivation, or as a hobby. Plant specimens may be kept alive, but are more commonly dried and pressed to preserve the quality of the specimen. Plant collection is an ancient practice with records of a Chinese botanist collecting roses over 5000 years ago. Herbaria are collections of preserved plants samples and their associated data for scientific purposes. The largest Herbarium in the world exists at the **National Museum of Natural History** in **Paris, France**.

The main museum is located in Paris, on the left bank of the River Seine. It was founded in 1793 during the French Revolution, but was established earlier in 1635. As of 2017, the museum has 14 sites throughout France, with four in Paris, including the original location at the royal botanical garden; the Garden of Plants (The Jardin des Plantes) is the main botanical garden in France.

Plant samples in herbaria typically include a reference sheet with information about the plant and details of collection. This detailed and organized system of filing provides horticulturist and other researchers alike with a way to find information about a certain plant, and a way to add new information to an existing plant sample file.

The collection of live plant specimens from the wild, sometimes referred to as **plant hunting**, is an activity that has occurred for centuries. The earliest recorded evidence of plant hunting was in 1495 BC when botanists were sent to Somalia to collect incense trees for Queen Hatshepsut. In historical past botanical adventurers were made to explore the world to find exotic

plants and their domestication often at considerable personal risk. These plants usually ended up in botanical gardens or the private gardens of wealthy collectors.

A herbarium is a collection of pressed and dried plant specimen, mounted on sheets bearing a label, arranged according to a sequence and available for reference study. The specimens kept by a herbarium may be whole plants or parts of plants. Each dried plant is labeled with essential data usually descriptive and ecological collection data, as well as the name of the collector(s) and the date of collection. Herbarium specimens are stored in protective cabinets in a dry location. They are classified and arranged to allow easy access.

A herbarium of a particular region represents the diversity and distribution of the region's vegetation and its history. At a herbarium, we can identify plants by matching unnamed plants with named specimens in the collection. We can also compare different species from one area, or individuals of the same species, from a range of different sites.

A Botanical garden is a place for growing wide range of plants labelled with their name and also is an educational institute for scientific workers and general public or laymen to awake their interest in plant life .In reality the botanical garden may be an independent institution or affiliate of an organization or research institution for carrying out botanical researches and dissemination of scientific knowledge. In botanical garden there should be a herbarium, library, art and photographic studies, lecture theater and should have recreational facilities.

2.3 COLLECTION OF PLANT SPECIMENS

The collection encompasses all major groups of plants (bryophytes, ferns, gymnosperms and angiosperms) as well as algae and lichens. The scope of the collection is worldwide, but with special strengths in the neotropics, North America, Pacific oceanic islands, the Philippines, and the Indian subcontinent. Many of the plant groups represented in National Herbarium rank among the finest and/or largest in the world. The flowering plant families of Acanthaceae, Asteraceae, Bromeliaceae, Gesneriaceae, Melastomataceae, andPoaceae have benefited from a long history of research and study as well as current specialist support. Other flowering plant groups that enjoy active support include Araceae, Commelinaceae, Onagraceae, Passifloraceae, Sapindaceae, Sterculiaceae, Theaceae, and Zingiberales.

We should be very clear during the collection of plant specimens with some important points as given below:

1. Select vigorous and typical specimens.
2. Avoid insect-damaged plants.
3. Choose individuals that show the variation in leaf, flower and fruit size.
4. It may be important to show morphological variation, involving the collection of individuals of different sizes or ages.

5. Collect at least two sets of specimens (duplicates) and give number to each set.
6. Keep one set for your reference, and send the duplicate numbered set to the Herbarium for identification or as a voucher if required.

A good specimen includes stems, leaves, flowers and fruits. Basal parts of grasses, sedges, ferns and bulbous plants are essential for identification. Underground parts e.g. tubers, rhizomes are important for some plant groups. The plant material should be fertile i.e. in flower or fruit (both if possible), as these characteristics are often vital for identification.

2.3.1-Herbarium

A herbarium consists of preserved plant specimens, each with a label bearing documentary information. Specimens are used as references for comparison and identification with unknown samples.

Herbarium (plural: **herbaria**), the term can also refer to the building or room where the specimens are housed, or to the scientific institute that not only stores but uses them for research (live also).

The credit goes to an Italian taxonomist Luca Ghini (1490-1556) for his initiative efforts with reference to explore the Herbarium concept. The oldest traditions of making herbarium collection have been traced to Italy. During 1532, Luca Ghini and his student Gherardo Cibo created herbarium which is also kept in Rome in the form of oldest preserved herbarium. During this period Luca Ghini visited various parts of Italy for collecting many plant specimens and the first herbarium of world was established in 1545 in University of Padua, Italy. Most of the early herbaria were prepared with sheets bound into books. It was continued till the time of Carolus Linnaeus who came up with the idea of maintaining them on free sheets that allowed their easy re-ordering within cabinets. Nowadays the plants are mounted on single sheet and arranged according to the classification. Main objectives of collecting plants in the field and preserving them in herbarium with their proper documentation including notes that give maximum information about the plants.

2.3.1.1 Specimen preparation for Herbarium

The technique of specimen preparation for herbarium is as follows:

2.3.1.1.1 Plant Collection

Specimens must be collected in every stage of their growth and reproduction as well as from different localities and habitats (Fig.2.1). We should be very conservative during collection and collect only what we need. It is a good idea to use the following rule of thumb:

1. Never collect a plant when we can see fewer than 6 individuals in the area.
2. Select vigorous, typical specimens.
3. Avoid insect-damaged plants.

4. Make sure the plant has flowers and/or fruits.
5. It may be a good idea to collect extra flowers and fruit for identification purposes.
6. Sterile plants are very difficult to identify.
7. Roots, bulbs, and other underground parts of herbaceous (non-woody) plants should be carefully dug up, and the soil removed with care.
8. When collecting shrubs and trees, clip one or two small branches.
9. Plants too large for a single sheet may be divided and pressed as a series of sheets. It is good practice to collect in duplicate. This means that if possible, we should collect sufficient material to make more than a single herbarium specimen.

Fig. 2.1 Selection of a specimen (Try to collect both flowers and fruit also if available)

For collection of the plants one should go out on excursion several times in a season. We should have commonly used equipment during excursion practice. A list of these equipments is being given below:

- Scissor to cut and trim specimens (Fig.2.2).
- A khurpi for digging up roots and underground stems
- A knife

Fig.2.2 For collection secateurs are used for clean cut of the stem

- A vasculum for keeping the collected plants and their twigs
- A pair of forceps
- Day press that is light enough to carry around. This should include a few cardboard corrugates, and sheets of newspaper.
- A field press with many more corrugates and more newspapers.
- Spare corrugates and newspaper and some sheets of foam for pressing bulky items
- GPS for recording an accurate latitude and longitude. Alternatively, mark the position on a topographic map.
- A field notebook and pencil. This can be a pocket-sized notebook or a book of pre-printed specimen labels may be used.
- Large and small plastic bags to hold specimens temporarily
- Small brown paper bags for collecting fruits, seeds, bryophytes and lichens
- A hand lens
- Tie-on tags, often called jeweller's tags
- Felt tipped pens and pencils for numbering collection and writing notes
- A camera/phone for photographing the form of the plant, flower colour and its natural habitat.

2.3.1.1.2 Pressing of Specimens

After the collection procedure it is necessary to quickly dry the plants under firm pressure to retain plant colors and the plant arrangement (Fig.2.3).

Fig.2.3 Procedure of pressing the specimen

The specimen should be carefully displayed on the pressing sheets (blotters or newspaper sheets) just to avoid the folding or hiding of parts (Fig.2.4). This process is to be carried out immediately because once a plant wilts; it will not make an attractive mount. A supply of corrugated cardboard sheets (cut to fit your press) is also needed. As we fill our press, alternate the cardboard sheets and folded paper (beginning and ending with a sheet of cardboard) to keep the specimens flat and speed the drying process (sometime blotter sheets can be placed between the newspaper and cardboard to speed the drying process).

Fig.2.4 Procedure of putting the specimen in day press

We should check the plant closely to make sure all soil is removed from the roots and remove excess moisture with a paper towel. If the plant is less than 12 inches long, place it in the folded newspaper. Arrange the stems, leaves, roots and flowers exactly as you want them to appear on the mount. Flowers should be pressed open. Both the upper and lower surfaces of flowers and leaves should be displayed. If the plant is longer than 12 inches, it will be necessary to fold the plant in the shape of a V, N or W.

Re-examine the plant after it has been pressed for 24 hours. This will be our last opportunity to do some rearranging while the plant is still flexible. Proper observations are needed by changing the newspaper or blotter paper every day until the plant is thoroughly dry. We should remember one important thing that succulent (fleshy) plants will take much longer time to press. Plants can be removed from the press in seven to 10 days. Keep the plants in folded newspaper until you are ready to mount them.

2.3.1.1.2 Mounting of Specimens

After drying, the specimens are ready for mounting. For mounting, herbarium sheets, standard (white) tag or poster board are recommended. Although herbarium sheets of standard size (29 x 41±1cm) usually have to be ordered, poster board can be purchased at most stores selling office and school supplies. Herbarium sheets are usually made up of heavy hand made card sheets that are well known for their long durability. Several adhesives (A transparent glue i.e. Elmer's glue) are used for attaching specimens to the sheet. For holding heavy or woody specimens, strips of brown gummed paper might be used as additional aid.

The specimen should be placed upright with the roots near the bottom and should provide an attractive look. We can also use small strips of gummed cloth for this purpose. Scotch tape (Cellulose tape) is not recommended. An example of the label that should be used on mounts (and the instructions on how to fill it out) is given below.

2.3.1.1.3 Herbarium Labels

After mounting the specimen a label is glued on the lower right hand corner of sheet. The label provides information taken from the field note book. The format and size of label varies but usually it is about 4.5x7.5 cm. Label have all the information about Botanical name, Local name, Locality, Time, Characters, collector's name etc. In addition, the label should include at least the following data:

1. A heading indicating the name of institution from where specimen is originated and the region of collection
2. The name of the family
3. The botanical name of the plant with authority
4. The locality of collection
5. The data of collection (***Nearest landmark, Elevation, Aspect*** **etc.)**
6. The habitat
7. The name of collector
8. The collectors field number
9. The venacular name and local uses

2.3.1.1.3 Filing of Herbarium Sheets

The mounted and properly identified plant specimens are usually stored according to an accepted classification (Bentham and Hooker's classification) in special wooden or steel cabinets (Fig.2.5) with special concern to protect them from dust and insects.

The plants should be filed in a logical order that makes it easy to find a specific specimen. By filing all specimens according to family and arranging the family members in alphabetical order by genus and species, it will be much easier for us to find a specific specimen whenever it is required for further study. As we have learned that the herbarium specimens are permanent collections, therefore they require proper care. Herbarium specimens must be protected against damages caused by fungi and insects. Therefore such damages can be controlled completely by periodical fumigation with chemicals or poisoning the responsible factors with a solution of mercuric chloride or lauryl pentachlorophenate. It might be usually a good idea to store a few moth balls with plant specimens to protect them from insects. Dichloro-diphenyl-trichloroethane (DDT) can also be used as an insect repellent.

Fig.2.5 Storage the mounted and properly identifies plant specimens

2.3.1.2 Important Herbaria

The greatest herbarium of the world is well known as the Royal Botanic Garden at Kew, England, possessing about six million specimens. A few good herbaria are also there in our country. The biggest herbarium of our country is known as the Indian Botanic Garden, Calcutta, possessing about one million specimens. The herbarium of the Forest Research Institute, Dehradun has about 3, 00,000 specimens. The herbaria of Agricultural College and Research Institute, Coimbatore and National Botanical Gardens, Lucknow, have about 200,000 and 40,000 specimens respectively. There are about 25,000 specimens in the herbarium of the Divisions of Mycology and Plant Pathology at Indian Agricultural Research Institute, New Delhi. The herbarium of the Division of Botany at I.A.R.I. New Delhi, contains about 3000 specimens.

Here we will discuss in brief about some important herbaria of India.

2.3.1.2.1 Forest Research Institute (FRI), Dehradun:

Today, it comprises of three sections, viz., systematic botany, wood anatomy and plant physiology. This division today maintains a botanical garden, an arboretum, having one of the richest live collections of both indigenous and exotic tree species, and a bambusetum, containing germ plasm of forty species of indigenous and exotic bamboos. It was started by Gamble (1890), and today the herbarium of the FRI has grown to become one of the largest herbarium of Asia. Today it holds 3, 25,000 authenticated plant specimens, including 1300 type specimens, as well as a carpological collection.

2.3.1.2.2 Herbarium of the Indian Botanic Gardens, Calcutta:

It was established in 1787. It is directed by the State of West Bengal, Department of Agriculture, Animal Husbandry and Forest. It is also known as Central National Herbarium Kolkata. More than 2,500,000 species mainly phanerogams and ferns of India and neighbouring countries of South and South East Asia are kept in this herbarium .

2.3.1.2.3 Herbarium of the National Botanic Gardens, Lucknow (N.B.R.I):

It was founded in 1948 and taken over by the Council of Scientific and Industrial Research (CSIR), New Delhi, Government of India in 1953. The number of specimens is about half million. The garden has been established by C.S.I.R. as a Central Garden for India with the number of species about 1, 00,000.

2.3.1.2.4 Herbarium of the Division of Botany, Indian Agricultural Research Institute, (I.A.R.I.), New Delhi:

It was established in 1901 and maintained by Government of India. The number of specimens is about 5, 000mainly from North India. There are introduced plants of economic value and wild relatives of crop plants.

2.3.1.2.5. Herbaria of Botanical Survey of India:

- Eastern circle Herbarium, Shillong of BSI was established in 1956. It has the number of specimens about 10, 000, 00.
- Southern circle Herbarium, Coimbator of BSI was established in 1874 and has the number of specimens about 2, 00,000.
- Western circle Herbarium, Pune of BSI was established in 1956. In this herbarium the number of specimens is about 50,000.
- Northern Circle Herbarium, Dehradun was established in 1956 and holds the about 60,000specimens.
- Central Circle Herbarium, Allahabad was established in 1955. It has the number of specimens about 45,000.

2.3.2-Live Specimens

Long before the term "biodiversity" was used, botanical gardens carried out activities that are now associated with biodiversity. For the collection of live specimens botanical gardens are being established. Botanical gardens took part in describing new species and studied them to discover their potential uses in industry, horticulture or for research. Gardens also conserved species of rare wild plants (or *ex situ* conservation, meaning outside of their natural habitat).

In botanical gardens we can conserve endangered plant species through live collections as well as through seed banks. These benefit pollinators like butterflies, honeybees, bats, and birds, which play an important role in the pollination of crops. According to the International Agenda for Botanic Gardens in Conservation (IABGC) (2000), ***Botanic gardens*** are institutions holding documented collections of living plants for the purposes of scientific research, conservation, display and education."

A botanical garden must be a public institution committed to long-term maintenance of its collections. Botanical gardens have a unique environment to raise public awareness and help people understand the importance of biodiversity, educate people about the threats it currently faces and make them realize that nature conservation is everyone's job. This is why it is so important for gardens to maintain interpretation programs, host school groups and present exhibitions. The major role of botanical gardens in biodiversity conservation is ***ex situ* conservation**. *Ex-situ* conservation (growing wild plants outside their natural environment) has many advantages, but should not be seen as an objective in itself. It is referred to be as one important element of a comprehensive strategy to conserve species in their environment. *Ex situ* conservation helps to attain this objective by providing material to reintroduce plants into degraded areas or to reinforce existing populations.

Botanical gardens have three main objectives:

- The first and best known objective is recreation. Exhibitions, plant sales, picnics under the trees and relaxing in a natural environment are some of the possibilities that botanical gardens offer both residents and tourists.
- The second very important objective of botanical gardens is education. This includes summer camps for kids, school group tours, interpretation, classes and seminars as well as publications and other ways of sharing information between botanical gardens and horticulture and botany professionals.
- Finally, gardens have a scientific objective. Today, fields of study are even broader, from molecular research in the lab to ecological field work. Conservation and study of local plants should also be given emphasis.

At present there are more than 600 botanical gardens all over the world. Major botanical gardens of the worlds and India are being described here under:

2.3.2.1.1 Royal Botanical Garden, Kew

The Royal Garden at Kew was founded in 1759; initially as part of the Royal Garden set aside as a physic garden. William Aiton (1741–1793) was the first curator. Initially, Royal Botanic Garden, Kew (1759) was set up to cultivate new species returned from expeditions to the tropics. In 1841 William J. Hooker was appointed as Director and under his guidance the garden was extended from 20 to 250 acres. At present it has been extended upto 300 acres. It contains herbarium including 5,000,000 specimens.

2.3.2.1.2 The Royal Botanic Garden Sydney Australia

The first botanical garden in Australia was founded early in the 19th century. The Royal Botanic Garden, Sydney is a major botanical garden located in the heart of Sydney, New South Wales, Australia. It was founded in 1816 and the garden is the oldest scientific institution in Australia as well as one of the most important historic botanical institutions in the world.

2.3.2.1.3 The Dunedin Botanic Garden, New Zealand

The Dunedin Botanic Garden is New Zealand's first botanic garden and holds the status of six star Garden of International significance. It was established in 1863. In 2010 it was recognised as a Garden of International significance for its excellence as a public garden as well as for its botanical collections. An important aspect of The New Zealand Native plant collection is the cultivation of rare and endangered native plant species.

2.3.2.2 Indian Botanical Gardens

2.3.2.2.1 The Acharya Jagadish Chandra Bose Indian Botanic Garden

The Acharya Jagadish Chandra Bose Indian Botanic Garden (previously known as Indian Botanic Garden) is situated in Shibpur, Howrah near Kolkata. It is commonly known as the Calcutta Botanical Garden, and previously as the Royal Botanic Garden, Calcutta. The garden exhibits a wide variety of rare plants and a total collection of over 15,000 live specimens spread over 273 acres of land. It is now under Botanical Survey of India.The garden was also called the East India Company's Garden or the 'Company Bagan'.

The great Banayan Tree is the main attraction of the garden that **forms the second largest canopy in the world,** which is about 250 years of age and have over 1600 aerial roots. It is well known for a palm house, orchid house, medicinal plants, ferns and cacti. *Victoria regia*, a giant water lilly is also the beauty of the garden.

2.3.2.2.2 Lloyd's Botanical Garden

Lloyd's Botanical Garden, or Darjeeling Botanical Garden, is abotanical garden in Darjeeling in the Indian state of West Bengal. It was established in 1878 as an extension of Royal Botanical

Garden Calcutta on 40 acres (160,000 m^2) of land. The land was donated by William Lloyd, in whose name the botanical garden has been named as, Lloyd's Botanical Garden. The Darjeeling Botanical Garden preserves several species of bamboo, oak, magnolia, wild geranium, rhododendron etc. It has a rock garden, orchidarium and separate sections for conifers and indegenous plants.Gardens is well known for its collection of orchids (in the Orchid House) and different herbs.

2.3.2.2.3 Lalbagh Botanical Garden

Lalbagh or Lalbagh Botanical Garden, meaning *The Red Garden* in English or Mysore State Botanical Garden, Bangalore is one of the best botanical garden in South India. The garden was named as Lalbagh by Hyder Ali, the ruler of Mysore in 1760. During 1799-1819 maximum exotic plants were introduced in this garden by Major Waugh. Lalbagh was given the status of a Government Botanical Garden in 1856.

The botanical garden is enriched with numerous native and exotic flora of wide ranging diversity. Today, nearly 673 genera and 1,854 species of plants are present in this garden.

2.3.2.2.4 National Botanical Garden Lucknow

This Botanical Garden is situated in the heart of Lucknow, the capital of Uttar Pradesh province, and covers an area of 25 ha along the southern bank of the River Gomti. The garden was established by Nawab Saadat Ali Khan (1784-1814) as a Royal Garden. It was established in its new form in 1946 by Prof. K. N. Kaul and today is well known as NBRI(National Botanical Research Institute) Lucknow. It shows the diversity of plants, comprising a collection of 6,000 indigenous, ornamental and exotic taxa.

The plant wealth of the Botanic Garden is displayed in the arboretum, conservatory, cactus and succulent house, palm house, bonsai section, fern house and new conservatory.

2.3.2.2.5 Saharanpur botanical garden

The Saharanpur botanical garden (presently known as Horticultural Experiment and Training Centre, Saharanpur) is a very beautiful garden since British period. John F. Duthie (1845-1922) an English botanist and explorer collected plants from Kumaun, Kashmir and gangetic plain. He compiled the “Flora of upper gangetic plains” with the help of his garden staff.

2.4 SUMMARY

1. The term herbarium was given by Linnaeus. Plant samples can be dried or preserved in liquid. Plant samples can also be kept alive in greenhouse or garden.

2. A herbarium consists of preserved plant specimens, each with a label bearing documentary information. Herbaria are repositories for vascular plants, bryophytes, lichens, algae, and fungi.
3. Specimens are used as references for comparison and identification with unknown samples.
4. The method of preparation and storage depends on the type of plant being processed. Most specimens are mounted on standard herbarium sheets.
5. They include reproductive and vegetative organs, features critical to identification.
6. Some herbarium specimens are known as a 'voucher specimens'. Voucher specimens serve as a basis of scientific study.
7. Voucher specimens are collected from taxa that are the subject of research or investigation, generally resulting in a publication in a scientific journal or report. The herbarium specimens bear labels with adequate data on habit and habitat, common name, native uses etc.
8. Herbarium specimens are permanent records of a particular locality. Therefore, we should be more careful during the selection and collection of plant samples.
9. Thereafter herbarium specimens should be properly prepared, preserved and maintained.
10. For the collection of live specimens botanical gardens are being established.
11. In botanical gardens we can conserve endangered plant species through live collections as well as through seed banks.
12. A botanical garden must be a public institution committed to long-term maintenance of its collections.
13. Botanical gardens have a unique environment to raise public awareness and help people understand the importance of biodiversity.
14. Gardens carry out interpretation programs, host school groups and present exhibitions.
15. The major role of botanical gardens is biodiversity conservation as ***ex situ*** **conservation**.

2.5 GLOSSARY

Plant specimen: An individual animal, plant, piece of a mineral, etc. used as an example of its species or type for scientific study or display.
Herbarium: a reference collection of pressed, dried (preserved), botanical specimens.
Preservation: The act of keeping something the same or of preventing it from being damaged
Maintenance: the process of preserving a condition or situation or the state of being preserved.
Species: the narrowest taxonomic grouping; a group of closely related animals or plants that are capable of interbreeding.
Mounting: A backing, setting, or support for something.
Acquisition: An asset or object bought or obtained, typically by a library or museum.
Cultivation: The process of promoting the growth of a biological culture.

Ancient practice: The practice was more common in ancient times than it is now
Jardin des Plantes: Garden of plants is the main botanical garden in France.
Botanical garden: A garden for the exhibition and scientific study of collected plants, usually in association with green houses, herbaria, laboratories etc.
Filing: A filing is when a legal document becomes part of the public record.
Domestication: The process of adapting wild plants for human use.
Reference material: Reference materials are various sources that provide background information or quick facts on any particular topic.
Vigorous: grows with great enthusiasm.
Vascular plant: a plant with vascular tissues (xylem and phloem)
Bulbous plant: plant growing from a bulb
Repositories: a place where things are stored and can be found.
Sterile plants:the plant does not produce seeds
Conservation: The protection of animals, plants, and natural resources
Voucher specimens: a specimen maintained in a collection or herbarium that is associated with specific research or referred to in a report; may include type specimens, or specimens from a flora or consultant

2.6 SELF ASSESSMENT QUESTIONS

2.6.1 Short Answer Type Questions

1. What is the name of largest Herbarium in the world?
2. How plant specimens can be kept alive.
3. Where a label must be mentioned in each mount.
4. What procedure is to be followed after the collection?
5. Why specimens should be displayed on the pressing sheets?
6. What standard size should be of herbarium sheets?
7. What basic information should be mentioned in herbarium label.
8. Which chemical might be used as an insect repellent for the safety of herbarium.

2.6.2 Fill in the Blanks

1. ----------may be in form of whole plants or plant parts.
2. ----------is the acquisition of plant specimens for the purposes of research
3. ----------was founded in 1793 during the French Revolution
4. -------is a collection of preserved plants, usually in dried form, used for botanical research.
5. ---------and his student created herbarium which is also kept in Rome in form of oldest preserved herbarium.

6. --------is used for digging up roots and underground stems
7. ----------is used for recording an accurate latitude and longitude.
8. The greatest herbarium of the world is well known as the---------- at Kew, England.
9. The biggest herbarium of our country is known as the ---------.
10. For the collection of live specimens ----------are being established.
11. The ----------is a major botanical garden located in the heart of Sydney, New South Wales, Australia.
12. ----------, a giant water lilly is also the beauty of the Calcutta Botanical Garden
13. John F. Duthie was appointed as Superintendent of ----------

2.6.1 Answers Key:

1. National Museum of Natural History in Paris.
2. Plant specimens can be kept alive in botanical gardens.
3. A label must be in the lower right hand corner of each mount.
4. Pressing is to be followed after the collection.
5. Specimens should be carefully displayed on the pressing sheets (blotters or newspaper sheets) just to avoid the folding or hiding of parts.
6. Standard size of herbarium sheets should be of 29 x 41±1cm.
7. Basic informations should be mentioned in herbarium label with specimens such as Botanical name, Local name, Locality, Time, Characters and collectors name
8. Dichloro-diphenyl-trichloroethane (DDT) is used as an insect repellent for the safety of herbarium.

2.6.2 Answers key: 1. The specimens; 2. Plant collecting**; 3.** National Museum of Natural History**; 4.** A herbarium**;** 5. Luca Ghini**; 6.** A khurpi**; 7.** GPS**; 8.** Royal Botanic Garden; 9. Indian Botanic Garden, Calcutta; 10. Botanical gardens**; 11.** Royal Botanic Garden Sydney; 12. *Victoria regia**;* **13.** Saharanpur Botanical Garden

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2.9 TERMINAL QUESTIONS

1. Write an essay on the collection of plant specimens.
2. Describe the collection and preservation techniques of specimens for herbarium.
3. Write a detailed account of herbarium.
4. Write a short essay on the major botanical gardens of world.
5. Describe the role of botanical gardens.
6. Describe the Indian botanical gardens.

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