V SEMESTER
PAPER-V TAXONOMY AND ECONOMIC BOTANY
UNIT-1 CLASSICAL TAXONOMY

AIMS, OBJECTIVES AND IMPORTANCE OF TAXONOMY

Plants and animals both have a great significance and unparalleled impact on human life. Most of our needs are fulfilled with plants such as foodstuffs, medicinal products, and fodder resources. So the plants whether harmful or beneficial are intimately associated with daily life and that's why it becomes necessary to have an orderly and scientific approach for the study of plants. There are millions of plants in which upto some extent there are differences or similarities but none of them are identical. Thus the individuals showing similarities are placed in smaller groups known as species and these species are placed in larger groups known as genera. The basic knowledge of plants is the first necessity and provides idea about their morphological variations.

Various usage of plants in everyday life necessitated formulation of standard terminology for description of various parts as an aid to identification and nomenclature. The systematized study of plants and animals has benefitted all those who are related to forestry, medicine, paper industry and food etc., as it helps them to procure proper material. This is also associated with the study of plant and animal diseases as they affect human economy.

Modern Work is saturated with extensive development of hybrid plants since they are more useful for people as providing better fruit, seed and flower products, and without the knowledge of taxonomy **hybridization** is not possible. The study of plants also helps in soil conservation as their special features are employed to minimize the loss of soil, and increase the soil fertility. Next comes agriculture and horticulture. Both are interrelated branches of science and have a direct bearing on taxonomy.

Fossil identification is possible only when adequate literature on the living plants and animal is available. Identification of preserved specimens is sometimes difficult because of their fragmentary and ill-preserved nature. But the information about them evolves the evolutionary sequence and helps in furtherance of establishing connecting links amongst various taxa.

Plant taxonomy has a long history. It gave birth to several phases of botany but remains exciting, interesting and important because there is a direct link between fascinating species of plants and its inhabitants. Taxonomic studies have major objective-the learning of the kinds of plants and animal on earth, their names, their distinctions, their affinities, their distribution and habit. In the beginning, the science of taxonomy was the study of small fragments of plants which were collected, labelled and put on record. The information, accumulated from these studies is fundamental to the scientific knowledge of the inventory of the earth's plant resources.

A second objective of taxonomy is the assemblage of knowledge gained. This is usually in the form of treatises useful to fellow scientists and to civilization in general.

But the knowledge thus gained is sterile unless it is transferred to others for study.

Thus the floras and fauna are published to account for the plants and animals of a given area. Manuals are prepared so that the plants and animal of an area may be more readily identified and named; revisions, and monographs are published so that one may know the extent and delimitations of a particular group and its components.

Distributional studies are published so that others may know of range extensions, corrections and interrelationships of the taxa within an area. All the products of taxonomic research add to the resources and are available to scientists. They are essential to any study of the natural resources of raw materials possibly suited to man's needs in a multiplicity of activities, for example, forest products, medicine, food, ornamentals, agriculture and industry.

BRIEF HISTORY OR INTRODUCTION TO EVOLUTION OF CLASSIFICATION:

In India, botanical science had its origin in a very remote age with the development of agriculture, when Indians of the Vedic Period (2000 B.C. – 800 B.C.) cultivated various food crops. In the Vedic literature

several technical terms are used in the description of plants and plant parts. Both the external features and the anatomy were studied.

One of the most ancient works dealing with plant life in scientific manner is the Vrikshayurveda (science of plants and plant life), compiled by Parasara even before the beginning of the Christian era, and which formed the basis of botanical teaching and the medical studies in ancient India.

This ancient work deals with the morphology and anatomy of the plant organs, nature and properties of soil, description and distribution of forests in the country, etc.

Ibn Sina (Avicenna) (980 – 1037A.D.) also a Persian, compiled a book Canon of Medicine containing numerous medicinal plants, which was much valued and had more than twenty editions in the sixteenth century.

There can be three different possible types of systems of classification, the artificial, the natural and the phylogenetic classifications:

1. Artificial System:

In artificial system of classification only a few characters of the plants are being considered, for example, the grouping of plants into herbs, shrubs and trees or the sexual system of Linnaeus based on number of stamens and styles.

2. Natural System:

In the natural system all the important characters of the plant are being considered, and the plants are classified according to their related affinities. This system reflects the situation as it is thought to exist under natural conditions, e.g., Bentham and Hooker's system (1862-83).

3. Phylogenetic System:

In phylogenetic system, the plants are classified according to their evolutionary and genetic affinities. But it seems a bit difficult to classify the plants perfectly on the basis of evolutionary tendencies due to imperfection of fossil records, and therefore, at present the plants are classified partly according to natural and partly according to phylogenetic basis.

The systems of classification proposed by Engler in 1886, by Hutchinson in 1926, and by Tippo in 1942 are phylogenetic. The plant taxonomy begins with the Greeks.

Types of Systems of Classification:

Ancient Systems of Classification:

From Theophrastus to Linnaeus:

Theophrastus (370-285 B.C.), the father of Botany, classified plants on the basis of form and texture. In his Historia Plant-arum he had classified and described about 450 cultivated plants. He had classified them as herbs, under-shrubs, shrubs and trees.

Dioscorides (64 A.D.) of Christian era prepared a 'Materia Medica' and described many plants of medicinal value, but his descriptions were imperfect and classification of little importance.

Pliny (23-79 A.D) also a botanist of Christian era had written seventeen volumes on the subject and gave many details of the cultivation of gum and spices yielding plants. He had described medicinal plants in three volumes of his great work, 'Historia Naturalis' (77 A.D.), largely compiled from Greek authors.

Albertus Magnus (1193-1280), for the first time distinguished between monocotyledons and dicotyledons on the anatomical basis with the help of crude lenses available at that time. In his De vegetalis he had described many plants and methods of gardening and orcharding.

Otto Brunfels (1464-1534), could recognise for the first time between perfecti and imperfecti groups of plant kingdom on the basis of the presence and absence of flowers. Sometimes it is also said that modern study of systematic botany has started from the time of Brunfels.

Jerome Bock (1498-1554), classified the plants as trees, shrubs, and herbs but he tried to follow the natural system of classification and brought many plants close to each other according to their related affinities.

William Turner (1512), is the acknowledged 'Father of English Botany' and was the author of several botanical works. He wrote the first English Herbal. In this work the arrangement is alphabetical and the woodcuts are inferior to those of Brunfels. The work was published in three parts.

The Herbal of Valerius Cordus (1561) of Wittenberg showed a great advance and is a landmark in descriptive botany.

Andrea Caesalpino (1519-1603), an Italian botanist and physician, wrote a set of sixteen volumes on plants. The first volume was philosophical describing some minor differences of cultivated and wild plants, trees and shrubs, shrubs and herbs and some medicinal plants. In the other fifteen volumes he divided the plant kingdom into fifteen heterogeneous groups.

In his work De plants published in 1583, he classified about 1500 plants chiefly on the basis of the characters of the seed and embryo. He classified the plants first on the basis of their habit (trees and herbs) and then subdivided them on the basis of their characters of the seed and embryo.

He classified the plants first on the basis of their habit (trees and herbs) and then subdivided them on the basis of their characters of the seeds and fruits. He also used the characters like the presence or absence of bulbs, presence of latex and number of locules, etc.

He prepared a herbarium of 768 plants which still exists as one of the oldest herbaria. Caesalpiono's work was remarkable in that time to classify the whole plant kingdom but it also lacked in many ways.

The most important of the British herbals was written by John Gerard (1545-1612) entitled Herbal or General Historie of Plante. This was published in London in 1597. The groups of plants recognised are based on well-marked characters of general form, manner of growth and economic uses.

They started with supposed simpler forms, grass-like plants with narrow leaves, and advanced through the broader-leaved bulbous and rhizomatous monocotyledons to dicotyledonous herbs, culminating in shrubs and trees, the latter being regarded as the most perfect.

Jean Bauhin (1541-1613), a Swiss physician, wrote an illustrated Historla Plantarum Universalis which was published after his death in 1650-51 in three volumes, which contained the descriptions of about 5,000 plants with 3,500 illustrations.

G. Bauhin (1560-1624), a Swiss botanist and brother of Jean Bauhin wrote "An Introduction to Botany" in which he described about 6,000 species of plants. He also made considerable advance in the frequent use of binomial nomenclature.

He described many plants with generic and specific names. His great work 'Phytopinax' of 1596 is great contribution of Botany. Many of the plant descriptions of Bauhin's work are very much alike modem description of species.

M. de Lobelius (1538-1616), he differentiated between monocotyledons and dicotyledons chiefly on the basis of leaves. He clearly recognized certain natural affinities in plants. His great work 'Kruydtboeck' was published in 1581, which contains many excellent illustrations.

Robert Morison (1620-1683), published his Plantarum Historia Universalis at Oxford in 1680. His system much resembles that of Caesalpino. Woody plants are kept distinct from herbaceous, and the latter are divided into fifteen sections based partly on habit and partly on characters derived from the fruit and seed.

Morison had the distinction of publishing the first systematic monograph of a limited group. This was his Plantarum Umbelliferarum Distribution Nova, issued in Oxford in 1672. The arrangement is based on the form of the fruit, which is still employed for the classification of Umbelliferae.

John Ray (1628-1705), an English botanist contributed much and the foundation of modern Botany was laid. His most important work was the 'Historia Plantarum' which was published in three volumes between 1686 and 1704. He clearly showed the importance of the monocotyledonous and dicotyledonous nature of the embryo from the point of view of related affinities and classification.

J.P. de Tournefort (1656-1708), is said to be the founder of the concept of modem genera. Though generic names were used before, yet Tournefort was the first to provide genera with descriptions and placed them definitely apart from species.

He classified the plants on the basis of presence and absence of petals. He called the plants with petals as Petalodes and without petals as Apetali. His famous work Elements de Botanique was published in 1684 which was later translated into Latin.

Camerarius (1665-1721), a German botanist could demonstrate for the first time the sexuality in the flowering plants on the experimental basis. He proved experimentally that pollen is absolutely necessary for fertilization and seed formation in the life history of plants.

Modern Systems of Classification:

From Linnaeus to Hutchinson:

Carolus Linnaeus (1707-1778), a great Swedish botanist and said to be the father of modem botany was born in 1707. From the time of Linnaeus actually the concept of modern botany began. He followed the binomial system of nomenclature and described hundreds of plants from different parts of the world.

He also revised many older genera and gave great stability to species. He published a number of important works, e.g.. Genera Plantarum, Species Plantarum, Flora Lapponica, etc., in which he described hundreds of plants known in that time. Linnaeus proposed an artificial sexual system of classification containing twenty-four classes.

The plants were classified on the basis of number, cohesion, length and certain other characters of stamens. The outline of the classes of his system was published in his Systema Naturae in 1735, and again in General Plantarum in 1737 along with all the known plants of that time arranged systematically.

B.de Jussieu (1699-1777) and A.L.de Jussieu (1748-1836). These two French botanists at the end of eighteenth century proposed a scheme of classification which was based upon the sexual system of Linnaeus but in an improved form B. de Jussieu made many changes in the classification of Linnaeus and more or less gave a new form to it, but this was never published. His nephew, A.L. de Jussieu modified his uncle's plan with many changes and published it in his own way, in his famous work "Genera Plantarum" in 1789.

He included fifteen classes and more than one hundred orders (now known as families) in his system. His system was chiefly based on the number and position of cotyledons and adhesion of petals.

A.P. de Candolle's system was definitely superior to Jussieu's system of classification including about 161 orders (families) of plants as compared with 167 families of Jussieu and Linnaeus respectively. The last edition of de Candolle's "Theorie elementaire" was published by his son Alphonse de Candolle in 1844, which contained 213 orders or families.

Robert Brown (1773-1858), his name seems fairly large in the chronicles of systematic botany, because he has often been referred to as botanicorum facile princeps. Brown was the first keeper of the Botanical Department of the British Museum.

In 1810 Brown published his Prodromus Florae Noval Hollandiae, containing descriptions of Australian plants collected by Banks and Solander. In 1827 Brown published a paper entitled, 'The female flower in Cycadaceae' and Coniferae, and in this he announced the important discovery of the distinction between Angiosperms and Gymnosperms.

John Lindley (1799-1865), an English botanist, proposed a system of classification and published "Introduction to the Natural order of Plants".

Stephen Endlicher (1804-1849), was a prominent systematist of the first half of the nineteenth century. His scheme of classification was published in "Genera Plantarum Secundum Ordines Disposita" in 1836-40 which was widely used in the continental countries.

Henri Baillon (1827-1895), Henri Baillons' Histoire des plantes (1867-1895), a work of thirteen volumes, contains useful descriptions of the families and genera of flowering plants. Its chief merits, however, are the splendid illustrations with accurate dissections. He also published monographs on Euphorbiaceae and Buxaceae, etc. accompanied by beautifully reproduced plates.

In 1851, Hofmeister carried out many brilliant researches and established the existence of alternation of generations in lower as well as in higher plants. Following the researches of Hofmeister in 1859, Charles Darwin published his famous doctrine of evolution "Origin of Species".

The doctrine of evolution was known to every educated man in the world, which brought revolutionary changes in solving the problem of classification of plants and animals.

Bentham and Hooker, the well-known English systematists, established an important system of classification which appeared in the last half of the nineteenth century. George Bentham (1800-1884) and Sir

Joseph Dalton Hooker (1817-1911), two English botanists, whose researches were carried over at the great herbarium of the Royal botanical garden at Kew.

After the death of his father Sir W.J. Hooker, Sir Joseph Dalton Hooker was director of the Kew gardens for twenty years.

Bentham and Hooker published a joint system of classification, containing 202 orders (families) in a monumental work "Genera Plantarum" (1862-1883) which became most popular classification in European countries except France for many years.

The system of classification by Bentham and Hooker is based on that of De Candolle's and Jussieu's systems, but it is a great improvement over those and other previous schemes.

Eichler's System of Classification:

In 1883, a system of classifying the flowering plants was proposed by A.W. Eichler (1839- 1887) is also remarkable because of its resemblance with widely accepted Englerian system.

The "series" in Eichler's system can easily be compared with modem 'order' and whereas the 'orders' of Eichler's system may be referred to modem families. The inclusion of the Hysterophyta as an "anhang" in the sub-class Choripetalae is the indication that in those days the position of angiospermic parasites was not at all clear. This group includes Loranthaceae, Rafflesiaceae and the Balanophoraceae.

Eichler also included one non-parasitic family Aristolochiaceae in this group. Eichler's system also separates the Gymnosperms from their usual position between the Dicotyledons and Monocotyledons (as proposed by Bentham and Hooker) and raised the group to equivalent group with the angiosperms and lower than the monocotyledons.

Engler and Prantl's System of Classification:

Adolf Engler (1844-1938), a German botanist who served as Professor of botany in the University of Berlin for thirty years and director of Botanical Gardens from 1889 to 1921. His phylogenetic system of classification was first published as a guide to the botanical garden of Breslau in 1892.

Later on the system expanded in a monumental work called "**Die Naturlichen Pflanzebfamilien**" with means for the identification of the genera of whole plant kingdom.

This publication continued with numerous volumes, many supplements, syllabi and revisions from 1895 to the present day. This system has been the dominant one of the plant classification in most of the scientific world since 1900. Most of the prominent herbaria of the world are arranged according to this system. This great work was completed in the collaboration of his associate worker Eugen Prantl (1849-1893).

According to this system the families were arranged in accord to the increasing complexity of the flower, fruit and seed development.

C.E. Bessey, an American botanist (1845-1915) proposed a system of classification based on Bentham and Hooker's system. According to Bessey the Ranales were the primitive angiosperms from which two branches were given out whith gave birth to Monocots and Dicots. The system proposed by C.E. Bessey has never been accepted and adopted to any great degree in the world.

Richard von Vettstein (1862-1931), an Austrian botanist also proposed a system of classification parallel to Engler and Prantl's system with minute differences. In this system the unisexual and naked flowers are considered more primitive than bisexual and flowers with perianth. He considered dicots to be more primitive than monocots.

Hans Hallier (1868-1932), a German botanist proposed a system based on phylogenetic relationships parallel to Besseyan system with minor alternations. He considers dicots to be older and more primitive than monocots.

A.B.Rendle (1865-1938), an English botanist has also classified the flowering plants in his two-volumes **"The classification of flowering plants"**. Vol. I contains Monocots and Vol. 11 contains Dicots. His system resembles Englerian system with very minor differences.

Oswald Tippo, of the University of Illinois published an outline (1942).of a projected phylogenetic classification. This system, however, was not his original, but was a compilation, a synthesis of several principles of Smith and Eames. The classification of non-vascular plants was that followed by G.M. Smith (1938) and the basic arrangement of vascular plants was that proposed by A.J. Eames (1936).

Tippo studied and synthesised the palaeobotanical data and compared these data with the data obtained through the study of living plants.

He emphasized the dependence on the vegatative characters such as plant form, branching and vascular anatomy in arriving at the natural grouping of major groups. This system emphasises that the Pteridophyta is not a homogeneous group and that there is no distinct line of differentiation between Pteridophyta and Spermatophyta.

John Hutchinson (1884-1972) an English botanist has given the latest information about the phylogenetic classification of angiosperms which has been published in his famous work, "Families of Flowering Plants" recently in 1959.

Formerly this work was published twice in 1926 and 1934. Hutchinson's classification is more closely related to that of Bentham and Hooker's and Bessey's systems of classification than that of Engler and Prantl's system.

According to Hutchinson, the primitive polypetalous forms have been diverged from the very beginning along two separate lines. One of the lines still retains the arboreal habit whereas the other one has adopted the herbaceous habit. The first order of his arboreal line is Magnoliales and the first order of herbaceous line is Ranales. Hutchinson has divided the angiosperms into two large groups 1. Herbaceae and 2. Lignosae.

The group Herbaceae contains the herbaceous representatives and the group Lignosae contains the woody representatives. He has proposed that the families having apetalous flowers have been derived partly through the Magnoliales and partly through the Ranales.

Current Systems of Classification:

Cronquist's System:

Arthur Cronquist (1919) of U.S.A. presented a comprehensive system of classification in 1968 and thereafter its revised version in 1981. His system is parallel to that of Takhtajan's system in so many respects.

He divided the angiosperms in two classes-Magnoliopsida (=Dicotyledons) and Liliopsida (=Monocotyledons). Magnoliopsida is further divided into six sub-classes, viz., Magnoliidae, Hamamelidae, Caryophyllidae, Dilleniidae, Rosidae and Asteridae; Liliopsida has five subclasses, viz., Alismatidae, Arecidae, Commelinidae, Zingiberidae and Liliidae.

The division Magnoliophyta has two classes, viz., Magnoliopsida (= Dicotyledons) and Liliopsida (= Monocotyledons). There are six sub-classes, sixty four orders, 318 families, and about 165,000 species in Magnoliopsida (=Dicotyledons) whereas in Liliopsida (= Monocotyledons) there are five sub-classes, nineteen orders, 65 families and about 50,000 species.

Takhtajan's System:

Armen Takhtajan, an academician of Leningrad, Russia, presented a system of classification of angiosperms for the first time in 1942, and thereafter its revised versions in 1954, 1966, 1969 and 1980 respectively. Takhtajan's approach is quite similar to that of Cronquist. According to him the angiosperms are of monophyletic origin and evolved from some ancient group of gymnosperms.

Dahlgren's System:

Rolf Dahlgren, a botanist of Copenhagen, Denmark published a system of classification of angiosperms in 1975, and thereafter a revised and improved version in 1980, 1981 and 1983 respectively. He has taken into consideration the utmost possible information.

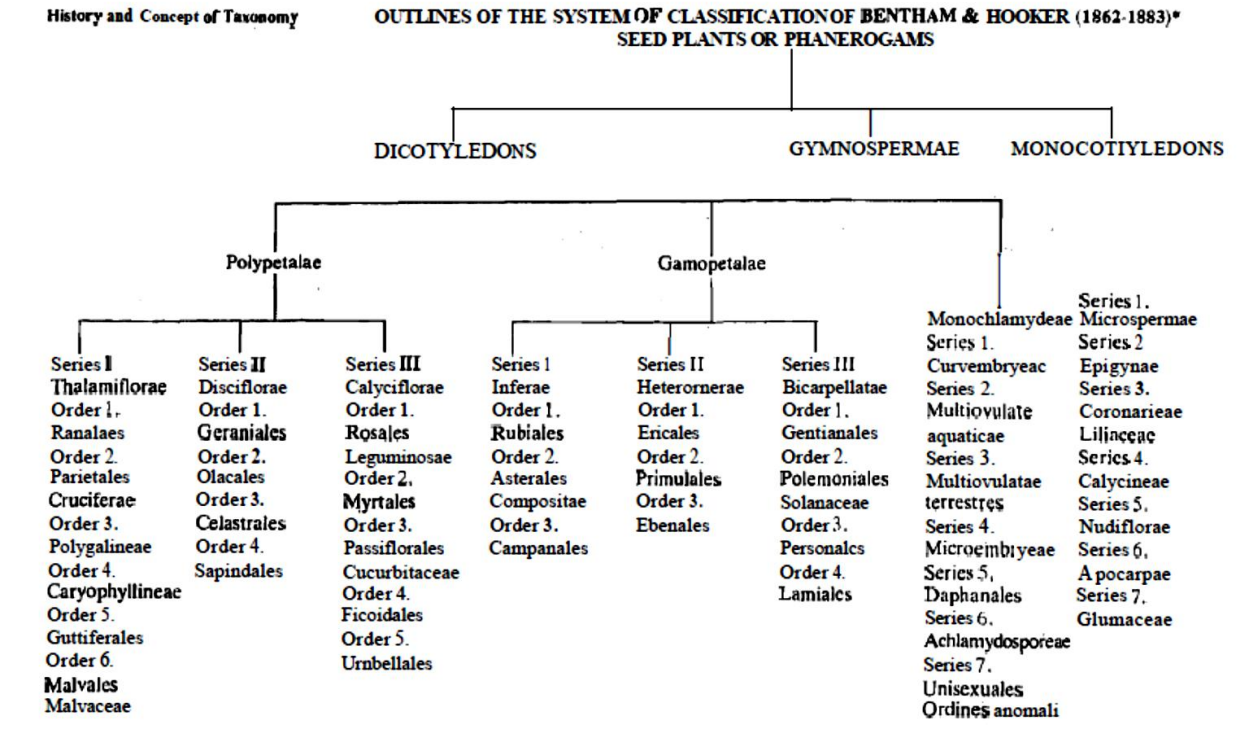
Thome's System:

Robert F. Thome of California U.S.A., published a system of classification in 1968. Thereafter a revised outline of this system was published in 1981 and 1983 respectively. This system has been used to express the phylogenetic relationships among the higher taxa of flowering plants. The modem trends of taxonomy have been taken into consideration in the depiction of more accurate relationships of different taxa.

He has laid much emphasis on phytochemical approach. The other modern approaches such as palynology, seed morphology, anatomy, embryology, host-parasite relationships, plant geography, paleobotany, microstructure and cytology have been utilized in the differentiation of taxa. According to Thome the Angiospermae are monophyletic in origin.

He has divided the flowering plants into two sub-classes (1) Dicotyledoneae (Annonidae) and (2) Monocotyledoneae (Liliidae). There are 19 superorders in Dicotyledoneae and 9 superorders in Monocotyledoneae.

AN OUTLINE OF BENTHAM AND HOOKER'S CLASSIFICATION IS GIVEN BELOW:



Merits and Demerits of Bentham and Hooker's System of Classification:

Merits:

Though this system is not very natural, yet it is very easily workable, and is important from the point of view of its field applications. The system has been worked out as a result of very careful comparative examination of all the known genera of phanerogams.

There are 202 orders (now known as families) beginning with Ranunculaceae and ending in Gramineae. This system was accepted by entire British Empire, U.S.A. and other European countries. Even today many botanists follow this classification because of its simplicity. This classification makes the basis for the arrangement of plants in Kew Herbarium and other important herbaria of Commonwealth Countries.

A special feature of this system is the addition of the Disciflorae and a curious arrangement of dividing certain groups on the basis of aquatic or terrestrial characteristics.

In this system, the greater emphasis has been given on the contrast between free and fused petals, e.g., the Dicots are divided into the three groups Polypetalae, Gamopetalae and Monochlamydeae.

In Monocots, the stress is being given to the relative position of ovary and perianth characteristics.

Demerits:

The greatest disadvantage of this system is the retention in the group Monochlamydeae, a number of orders which show affinities with those in which a biseriate perianth is the rule.

The position of Gymnosperms between Dicots and Monocots is only for convenience rather than an indication of affinities.

This system of classification is based mainly on single and mostly artificial characters, with the result the closely related families are widely separated from each other.

The extreme simple nature of the parts of certain orders such as Salicineae, Cupuliferae, etc. indicates an affinity with an early group or groups which are now extinct. Such orders would therefore have no near allies in existing orders with an elaborate arrangement of the flower parts.

In Polypetalae, the orders (families) with inferior ovary are placed afterwards, whereas in Gamopetalae they are treated before than those with superior ovary.
In Monocots, much stress is being given to the relative position of the ovary and the perianth characters in determining the affinities, than seems justified by the comparative study of the orders. For example, the families Iridaceae and Amaryllidaceae exhibit greater affinities to Liliaceae than to Scitamineae and Bromeliaceae with which they are allied in this system because of common characters of epigyny.
Thus the treatment of Monocots in general, except for position of Glumaceae is not proper.

THE GENERAL OUTLINE OF THE SYSTEM PROPOSED BY ENGLER AND PRANTL IS GIVEN BELOW:

System of Classification Engler and Prantl
PLANT KINGDOM

Division I
II
III
–
–
XII Embryophyta Siphonogamia
Angiospermae

Gymnospermae
1. Cycadofilicales

Monocots
11 Orders
45 Families

Dicots
44 Orders
258 Families

1. Pandanales
Typhaceae
2.
3.
4.
5.
6.
7.
8.
9.
10.
11. Microspermae

Archichlamydeae
33 Orders
206 Families
1– Verticillatae
2–
3-
4–
5-
–
–
–
–
–
–
32 – Umbelliflorae
Cornaceae

Sympetalae
11 Orders
52 Families
1. Ericales
– Cletheraceae
–
–
11. Campanulales
Asteraceae

Merits and Demerits of Engler and Prantl's System of Classification:
Merits:
According to this system, the large artificial group of Bentham and Hooker's system, the Monochlamydeae has been completely abolished, and its families have been distributed among the related forms with free petals in the large series of this (Engler's) system, the Archichlamydeae.
The Sympetalae of this system corresponds to the Gamopetalae of Bentham and Hooker's system.
In this system the Gymnosperms are treated separately.

The families with inferior ovary have been treated in the last, both in Archichlamydeae and Sympetalae. The advancement is marked from the hypogyny to complete epigyny. Engler considered the orchids to be more highly evolved than the grasses.

Demerits:

In this system the Amentiferae or catkin bearers, (e.g., Salicaceae, Juglandaceae, Betulaceae, etc.) have been regarded as most primitive and precede petaliferous families, (e.g. Ranunculaceae and Magnoliaceae). The Amentiferae are a reduced rather than a primitive group. According to Bessey and others the polypetaly was earlier, and apetaly was derived from it through modification.

The acceptance of the derivation of dichlamydeous flowers (perianth in two series) from monochlamydeous ones (perianth in single series) is objectionable.

The other demerits of this system (Engler's) are:

Derivation of parietal placentation from axile placentation.

Derivation of free-central placentation from parietal placentation.

Derivation of bisexual flowers from unisexual flowers.

Derivation of entomophily from anemophily.

In this system Monocots have been considered to be more primitive than Dicots, which does not correspond to the present day knowledge.

CONCEPT OF SPECIES

Species are often defined as a group of individuals with similar characteristics, where they can interbreed to produce fertile offsprings, typically by sexual reproduction. To differentiate between types of living organisms, species are used as the principal natural unit in biology.

Four most important concepts on species are:

- **Typological Species Concept:**

In this concept, there are a number of varieties of living organisms of finite types that exist on the earth. These types don't have any relationship with each other. These types are termed as species. This inequality is regarded as an unimportant and irrelevant phenomenon.

Aristotle and Plato stated about this concept in their philosophies. In the year of 1954 and 1956, Cain regarded the Typological species concept as the morpho species concept. As the members of the species or a taxon can be identified by their essential characteristics, a group of scientists refers to this as essentialist species concept.

Morpho species concept defines the species can be differentiated from other species by their physical features and can be identified by their morphological attributes. So, this is called as the morphological species concept.

- **Nominalistic Species Concept:**

Nominalistic species concept is the concept of Occam and his followers, who believed that nature produces individuals only. Species are man's own creation and they have no definite existence in nature. They are just mental concepts. Species have been invented so that we may refer to great numbers of individuals collectively. In France during the 18th century, this concept was in demand and even now is used by some botanists.

- **Biological Species Concept:**

In the middle of 18th century, a fresh concept called biological species concept appeared. This concept was accepted in the later half of the nineteenth century after Darwin's "Origin of Species" was published (in 1859). So, this is also known as Newer Species concept. K. Jordan first formulated this concept in 1905. Later in 1940, Mayr supported this concept. As per this concept, "a species is a group of interbreeding natural population that is reproductively isolated from other such groups". Mayr described that the members of a species show the following properties:

1. **Reproductive community:** For the purpose of reproduction the individuals of a species recognize each other as potential mates.
2. **Ecological Unit:** The species members differ from each other due to many attributes but all the members cooperatively form a unit. They interact with other species as a unit in any environment.

3. **Genetical unit:** Species consists of a large, inter-communicating gene pool, although the individual is simply a non-permanent vessel holding a small part of the contents of the gene pool for a short period of time.

- **Evolutionary Species Concept:**

The flaws of biological species concept had led the paleontologists to formulate the evolutionary species concept.

1. **Simpson (in 1961)** had defined it as "an evolutionary species is a lineage (an ancestral- descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies".
2. **Wiley (in 1978)** had provided a revised definition of evolutionary species concept. He stated that "an evolutionary species are a single lineage of ancestral-descendant population which draws its identity from other such lineages and has its own evolutionary tendencies and historical fate".

TAXONOMIC HIERARCHY

The sheer complexity of organisms seems so bewildering that some people believe, life to be unfathomable by the rational mind. Biologists constantly chip away at this notion by exploring and discovering real explanation for phenomena. Our ability to solve these natural mysteries would be severely handicapped, however, without another hierarchy of organization that creates meaningful order out of the overwhelming variety of organisms to be studied. This orderly system enables us to distinguish clearly between different types of organisms. Also it allows us to classify and assign names to the almost two million known types of living organisms as well as their extinct ancestors.

Most classification systems group smaller units into successively larger ones. The number of features shared by members of small units. For instance, ostriches, owls, hummingbirds, and sparrows are quite different animals, but they share more features with one another then they do with whales, cats, mice or deer. By calling them birds, and the second group mammals, we direct attention to certain significant features that serves to unite members of the group and distinguish them from members of other groups.

In the system used today, based on the work of the great Swedish biologist Carolus Linnaeus (1707-1778), each species is assigned two names, one identifying the species itself and the other the genus to which the species belongs known as binomial nomenclature. A genus is a group of species that are closely related (the plural of genus is genera and its adjectival form is generic).

In the Linnean system, the species are grouped into higher taxonomic categories. The .number and limits of these categories are somewhat arbitrary, but there are some guiding rules. One is purely practical, if every species were put into its own genus, or conversely, all were lumped into one genus, the genus would not carry any information not already present in the designation of species. A second consideration is the relative amount of similarity or dissimilarity among the organisms. A higher taxonomic category may have a single species in it if that species is very different from all other species. Some genera, on the other hand, have hundreds of species in them. Similarly, a family the next higher unit, can contain a single genus or many of them. A family can contain only a single species if that species is judged to be sufficiently different from all other species. But again families must contain, on the average, a number of genera if they are to be useful in describing a different level of similarity among organisms than that expressed with genera. In animal classification the names of families are identified by idea endings. Thus Formicidae is the family that contain all ant species, while Hominidae contains humans and few of our fossil relatives. Family names are based on a member genus. Formicidae is based on ***Formica*** (remove the 'a' and add 'idea'), and Hominidae is based on Homo Families are in turn grouped into orders, orders into classes, classes into phyla (singular I phylum) and divisions (for plants) and phyla and divisions into kingdom. Thus various units of classification-kingdom, phylum, class and so on-are called taxonomic categories and together they make up the taxonomic hierarchy (Fig. 3.5). Let us take an example and see how three well known organisms fit into the system (Table 3.1).

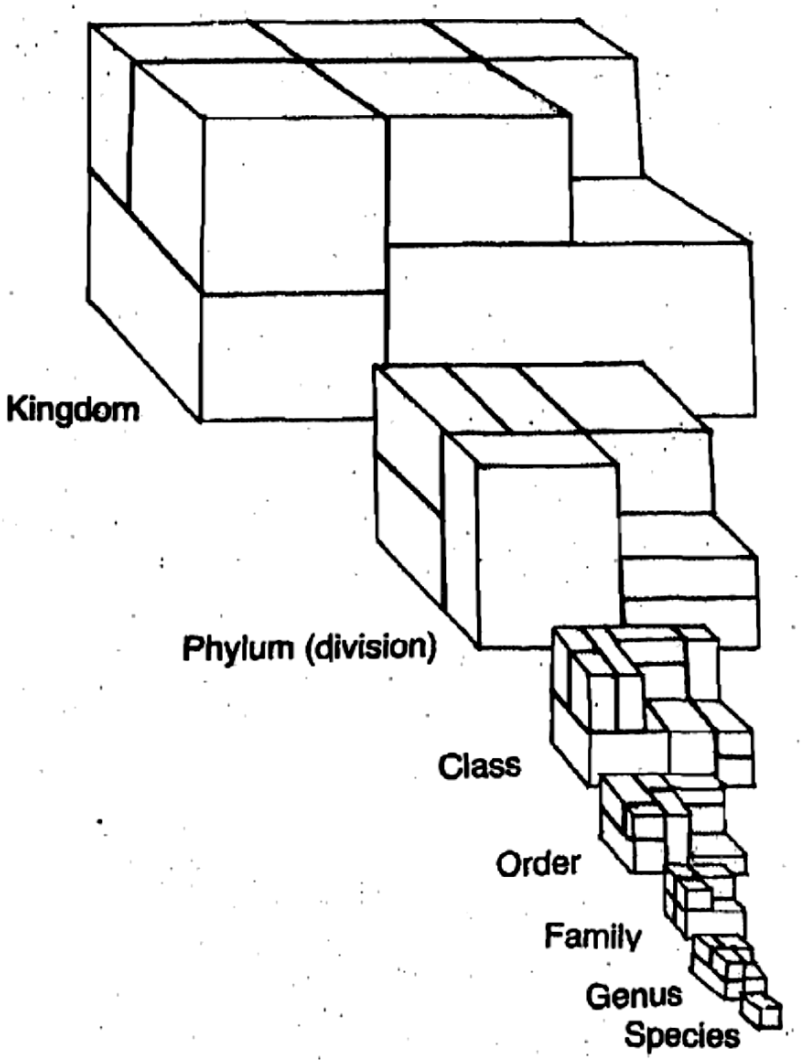


Fig. 3.5 : Taxonomic levels in the classification of life. Members of the same group at a particular level (taxon) are more related to each other than they are to members of the other groups in the same taxon. For example, all the organisms in the same genus resemble each other more than they do members of the other genera in that family. The smallest group, the species, consists of the most closely related organisms. At the other end of the spectrum ere the kingdoms, the largest, most encompassing groups that contain the greatest number of organisms.

Table 3.1 : Examples of Animal and Plant Classification

Taxonomic group	Animal Examples		Plant Example
Kingdom	Animal	Animal	Plant
Phylum	Annelida	Chordata	Tracheophyta
Class	Oligochaeta	Mammalia	Angiospermae
Order	Terricolae	Primates	Ranales
Family	Lumbricidae	Hominidae	Ranunculaceae
Genus	*Lumbricus*	Homo	*Ranunculus*
Species	*L.terrestris*	H. *sapiens*	*R.acris*
Common name	earth worm	Human	meadow buttercup

BIOSYSTEMATICS
PLANT NOMENCLATURE

Naming of Plants: - 1. Common Names 2. Scientific Names 3. Binomial Nomenclature 4. Generic Name 5. Specific Epithet.

Naming of Plant # 1. Common Names:

It is the name given to a plant by people in a particular area or locality. It is the vernacular name or local name. In a multilingual country like India, where there are several languages, almost all plants have local names, which differ from language to language, and even from dialect to dialect.

Thus, a particular plant may have several names in a particular country. This makes things extremely difficult, when a person speaking a particular language wants to communicate about a plant to a person speaking a different language. Hence, common names have proved to be misleading and inadequate for wider use throughout the country or the whole world.

Naming of Plant # 2. Scientific Names:

Plants should be named in such a way so that it can be used internationally. In order to overcome the problems raised by common names, botanists have given scientific names to all the known plants, for international communication.

The first problem, which they faced while giving scientific names to plants was to select the language which can give a clear cut meaning and which would not change. Although Latin is a dead language now, it was agreed by botanists of the world that scientific names should be in Latin particularly for the following three reasons:

• Firstly, this language is not being used by any country or nation at present.

• Secondly, most of the European languages are derived from Latin

• Thirdly, in the past European scholars learned their subjects in Latin. It was a widely used language throughout the European countries and a lot of botanical literature has been written in Latin.

Since Europe, and particularly Greece, has dominated the whole world in the field of science during 1600 to 1850 A.D., Latin is now a language of botany and other allied sciences. However, the script is Roman.

Naming of Plant # 3. Binomial Nomenclature:

In the early attempts of naming plants, plant names used to be long, as a single name used to be followed by one to many descriptive terms or adjectives, giving rise to multiple terms or polynomials which have been used by many taxonomists including Linnaeus (1753), in his Species Plantarum, and he used additional trivial names for these polynomials.

After Linnaeus system of trivial names, later workers however found it more convenient to adopt the binomial system consisting of two Latinized words, a generic name followed by a specific epithet (a trivial name). Thus, in the binomial system, a botanical name of a species is a combination of a generic name and a specific epithet.

As for example, the botanical name of sunflower is Helianthus anus. The first word (Helianthus) designates the genus of the plant, while the second word (anus) designates the species of this genus. The generic name is usually a substantive (noun), while the second term or specific epithet is an adjective or noun.

Naming of Plant # 4. Generic Name:

The Generic name is usually a noun and singular, which is spelled or written with a capital letter.

Generic names have different types of origin:

(a) A genera may be named in honour of a botanist or horticulturist or may be a patron of botany. For e.g. *Linnaea* has been named in honour of the famous botanist Linnaeus.

(b) Some generic names are of poetic or mythological origin. For e.g. *Nymphaea* denotes the lovely water-nymphs.

(c) Many generic names denote some characteristic feature of the plants. For e.g. *Liniodendron* or lily tree is named after the shape of the flowers of the Tulip Tree.

(d) There is another category of generic names in which the name is aboriginal in origin i.e. the names existed in the lands where the plants were discovered but later they were given Latin names. For e.g. *Betula* is an old Greek name for Birch.

Naming of Plant # 5. Specific Epithet:

The specific epithet is often an adjective and it is written with a small initial letter unlike the generic name. However, if the specific epithet is derived from common names, or from a generic name, or from a person's name, the initial letter of the epithet may be a capital letter.

In the typed or hand written manner, both the generic names and specific epithet should be underlined, while if printed it should be in italics or boldface.

Like a generic name, a specific epithet may also have several origins:

(a) It may be in honour of a person.

(b) It may be derived from some special characteristic of the plant.

(c) It may be derived from a geographical location where the plant grows.

(d) It may originate from an old common name.

(e) It may be named arbitrarily.

Nomenclature (L. Nome = Name; Calere = To Call):

The term nomenclature means the scientific naming of organisms according to an established system. The naming of plants on a scientific basis is called botanical or plant nomenclature. In earlier days common or vernacular names were in use which generally changes with change of language. Later in the haunt of one common internationally accepted name for a species, scientific names (Technical names) have been introduced in form of polynomial, binomial and trinomial systems of nomenclature.

(a) Polynomial Nomenclature:

Before 1750, taxonomists started using a string of descriptive Latin words to designate a species. For example, in the herbal of Clusius (1583) a species of willow is named Salix pumila angustifolia altera.

However polynomial nomenclature was discarded for two reasons:

(i) It was lengthy and difficult to remember

(ii) It often differs from scholar to scholar based on the characters chosen by them.

(b) Trinomial Nomenclature:

Mayer (1953) introduced the concept of sub-species which meant the geographically defined aggregates of local populations. The naming of a species, especially the animals, up to sub-species level is called trinomial nomenclature, e.g. Homo sapiens sapiens, Homo sapiens Neanderthals. Botanists don't consider trinomial nomenclature.

ICBN: INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE

History of ICBN:

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

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

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

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

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

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

Principles of International Code of Botanical Nomenclature, (ICBN):

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 route 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.

The Principles were laid down in 1983.

Preamble of ICBN 1983:

1. Botany requires 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 that of 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 regulating 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. Nomenclature of Bacteria is governed by the ICNB. 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; provisions for the names of hybrids appear in Appendix I.
8. The only proper reason for changing a name is 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.

8 Main Rules of Nomenclature

Nomenclature: Rule # 1. Nomenclatural Type: The nomenclatural type is that constituent element (a specimen, or a description or a figure) of a taxon to which the name is permanently attached. This need not be the most typical or representative element but is the original material on which the description of the taxon is based.

Following kinds of types are recognized: (a) Holotype: Specimen or other element designated by the author or used by him as the nomenclatural type.

(b) Isotype: This is a duplicate of the holotype.

(c) Syntype: When more than one specimen are cited by the author without mentioning which is the holotype, each specimen is designated as a Syntype.

(d) Paratype: Specimens cited along with the holotype are designated as Para- types.

(e) Lectotype: This is a substitute of the holotype when that is lost and is to be selected from the isotypes. When no holotype was designated by the author a specimen from the original material is selected to be the Lectotype.

(f) Neotype: When all original materials are missing a Neotype is selected from other materials.

(g) Topotype: Specimen of a species collected at the same locality as the holotype.

Nomenclature: Rule # 2. Rule of Priority: In the case of a family or a taxon below the rank of a family the earliest legitimate name should be considered as valid (or correct). For this purpose 1st May 1753 is taken as the earliest date for all plants excepting the Fungi, some Algae, and the Musci other than the Sphagnaceae. This means the names appearing in Linnaeus's Species Plantarum are the earliest names for the purpose of consideration of the Rule of Priority; those published earlier are not to be given priority.

Nomenclature: Rule # 3. Names of Taxa: The name of a species is a binary combination consisting of the name of the genus followed by a single specific epithet. The name of a genus is a substantive in the singular number. The specific epithet is an adjective and is of the same gender as the generic name, or is a noun in apposition to the generic name. The specific epithet must not exactly repeat the generic name.

The name of an infra-specific taxon is a combination of the name of a species and an infra-specific epithet connected by a term denoting its rank. The name of a genus or of a taxa of higher rank is spelt with a capital initial letter.

All specific and infra-specific epithets should be written with a small initial letter. Formerly it was the custom to spell the epithets with a capital initial letter where the epithets were derived from the names of persons, or were vernacular names, or were former generic names. This is not followed at present.

The name of a family is derived from the name of the genus which is the type for the family. The name of a subfamily, a tribe or a sub-tribe is derived from the name of the type-genus belonging to that subfamily, tribe or sub-tribe.

Endings of the names of taxa above the rank of genus should be in the manner noted below:

Order —"ales" (e.g. Rosales)

Suborder —”ineae” (e.g. Rosineae)
Family —”aceae” (e.g. Rosaceae)
Subfamily —”oideae” (e.g. Rosoideae)
Tribe —”eac”
Subtribe —”inae”
A few family-names although not complying with the above rules are treated as valid because of long usage as such.

These are noted below with their alternative names:

Palmae (Arecaceae from Areca)
Gramineae (Poaceae from Poa)
Cruciferae (Brassicaceae from Brassica)
Leguminosae (Fabaceae from Faba)
Guttiferae (Clusiaceao from Clusia)
Umbelliferae Apiaceae from Apium)
Labiatae (Lamiaceae front Lamium)
Compositae (Asteraceae from Aster).

Nomenclature: Rule # 4. Effective and Valid Publication: Any printed matter when widely circulated is regarded as effectively published. It is sufficient, if the printed matter is distributed at least to the botanical institutions with libraries accessible to botanists generally. The date of effective publication is the date on which the printed matter became available.

Valid publication of a name of new taxon is necessary to have it effectively published, to have a correct form and to be accompanied by a description or diagnosis or a reference to a previously published description. For the name of a new taxon to be valid it is necessary that the description or the diagnosis should be in Latin.

Those published earlier to 1st Jan. 1935 are considered valid even if the description or diagnosis were not in Latin. In the case of Algae the date has been fixed as 1st Jan. 1958 instead of 1st Jan. 1935, In the case of recent Algae, the Latin description or diagnosis of a new taxon must be accompanied by an illustration or figure.

Publication of a new name of the rank of family or below on or after 1st January, 1958 is not considered valid if the type is not indicated.

The name of a taxon below the rank of a genus is not validly published unless the name of the genus or species to which it is assigned is validly published.

He who first validly published the name of a taxon is the author of that name. It is necessary to cite the name of the author after the name of the taxon.

Nomenclature: Rule # 5. Retention of Specific and Infra-specific Epithets:

When a species is transferred to another genus without change of rank the specific epithet must be retained. If the name of a genus is changed being illegitimate, the binary combinations for all the species under that genus should be changed also and in doing so the new generic name should be used retaining the older specific epithets.

This rule applies equally to infra-specific taxa. A specific epithet is not illegitimate merely because it was originally published under an illegitimate generic name; it is to be taken into consideration for purpose of priority.

Nomenclature: Rule # 6. Rejection of Names:

A name is to be rejected if it is used in different senses and for that reason has become a source of error. A name is to be rejected if it is based on a type consisting of two or more entirely discordant elements. A name is to be rejected also if it is based on a monstrosity.

Nomenclature: Rule # 7. Splitting of a Genus:

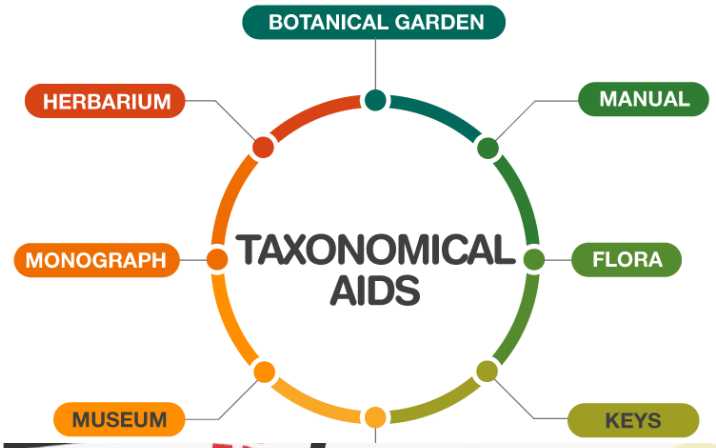
When a genus is divided into 2 or more genera the original generic name must be retained for one of the smaller genera which includes the type species of the undivided genus. This rule applies equally to cases of division of species.

Nomenclature: Rule # 8. Synonym and Basionym:

All names of a taxon other than the valid names are synonyms of that taxon. When the name of a species or of an infra-specific taxon is changed the synonym of which the epithet is to be taken for the valid name, is Basionym for that taxon.

TAXONOMICAL AIDS (TOOLS FOR STUDY OF TAXONOMY)

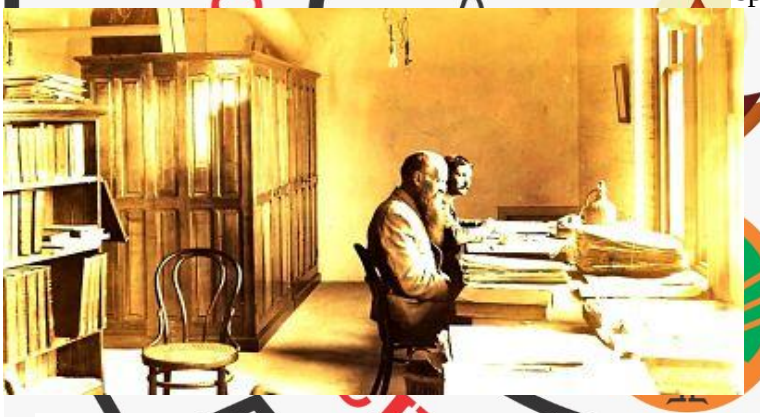
Techniques, Procedures and Stored Information that are useful in Identification and classification of organisms are called taxonomic aids. They are required because taxonomic study of plants, animals and other organisms are basic to almost all branches of biological studies for their proper identification and finding their relationships with others. Herbarium, botanical gardens, museum, and key are important tools used in identification of plants and animals.



Herbarium

Herbarium is a place where dried and pressed plants specimens, mounted on sheets are kept systematically according to a widely accepted system of classification. Herbarium is a repository or store house for future use. Every institute teaching botany, school, college or university, has a small or large herbarium. Very large herbaria are maintained by botanical gardens and institutes connected with plant systematic.

Every student of botany is required to collect plant specimens and prepare herbarium sheets.



Specimen (Herbarium Sheet) is of Different Types

Holotype: Herbarium sheet on which the first description of plant is based.

Lectotype: In case of holotype is lost, second herbarium sheet prepared from the original plant is called lectotype.

Neotype: In case holotype and original plant is lost then herbarium sheet prepared from some other plant of same

Syntype: In case holotype and original, plant is lost then many herbarium sheet prepared from many plants of same species is called syntype.

Isotype: Duplicate of holotype - In presence of holotype a second herbarium sheet prepared from the original plant is called isotype.

Paratype: Additional herbarium sheet used in the first description of plant is called para type. It is prepared from some other plant of same species having some variations.

Botanical Gardens

Botanical gardens efficiently large size tract where plants of different type and areas of grown for scientific and educational purposes. The first real mechanical garden was developed by Theophrastus (370-285 B.C.). Of course, garden was part of Indian Chinese and roman cultures. "Hanging Garden" of Babylon were considered to be wonders of ancient time. Modern day Botanical Gardens contains beside outdoor plants, greenhouse, library, research laboratory herbarium with documented collections of various taxa. There is an international association of botanical gardens (established in 1962) which coordinate research and exchange of plant materials.

Some major botanical Gardens of the world are:
1. Main botanical garden Moscow: Occupying an area of 360 hectare and nearby 21000 varieties of plants are cultivated here. **2. Jardim Botânico, Rio de Janeiro, Brazil:** It's home to nearby 6500 plant species and it is occupying an area of 140 hectare apx. **3. Royal Botanical Garden, Kew London:** Largest garden with collection of over 40,000 species of plants. **4. Kebun Raya (Botanical Garden) Bojor Java**: Spread over an area of 200 acres, the garden has section with **virgin rain forest**. **5. Indian Botanical Garden Sibpur, Kolkata:** It is the largest botanical garden of Asia spread over 273 acres which is famous for its Great Banyan tree, Palm house, Succulent Plants, Indian Grasses etc.

The important functions of botanical gardens are:

(i) Growing important plants of local flora.

(ii) Keeping record of local flora.

(iii) Providing living plant material for systematic work.

(iv) Supplying seeds and materials for different aspect of a Botanical research.

(v) Growing and maintaining rare and endangered plant.

Museum

The word museum comes from the greek word *mouseion.* In ancient Greek *mouseion* was the temple of Muses, the goddess of arts and sciences. Museum is an institution where artistic and educational materials

are exhibited to the public. The materials available in exhibition for study is called collections. A Collection may include scientific specimen, works of art and exhibits and information on history of technology.

There are five main kind of museums namely art museum, history museums, applied science museums, natural science museums and general museums.

Function of Museums

Museums Performs the following functions:

- **Acquisition of materials.** Every new object that a museum adds to its collection is called Acquisition. Museum acquire object in several ways, of which field collection is one of the most useful. The scientific and technician go outside to gather specimens and data on particular subject which is with the scope of the museum.
- **Recording of Materials.** Each acquisition is listed carefully by specialist staff. As soon as objects are received, the data, the source, the method of acquisition and other available information are entered in to record register.
- **Preservation of Materials.** The primary purpose of museum is to preserve selected objects are received. Curators (person in charge of museum) know that no specimens will last forever. What museums undertake to do is to prolong the lifetime of the objects. Preservation in a museum consists of two steps:

  (i) Specimens must be put into a condition that that checks deterioration.

  (ii) The specimens must be protected.
- **Research:** One important use of museum is to extract as much knowledge as possible from the specimens. Many museums published scholarly journals, series of papers and books to make available result of research on collections.
- **Exhibitions of Materials:** Various members of museum staff prepare acquisitions for exhibitions. The specimens selected for exhibition are put on a view in numerous ways. The choice of approach and techniques depends on the purpose of exhibits.
- **Education.** A Number of universities conduct some courses in certain subjects as museum university advantage of the collections. Thus museums help in spreading education.

Key

This is a taxonomical aid where plants and animals are recognized based on contrasting characteristics known as keys. Two contrasting keys are generally kept as a pair, thus leading to acceptance of once and rejection of another.

HERBARIUM AND ITS TECHNIQUES

A Herbarium is defined as a collection of plants that usually have been dried, pressed, preserved on sheets and arranged according to any accepted system of classification for future reference and study.

In fact, it is a great filleting system for information about plants, both primary in the form of actual specimens of the plants, and secondary in the form of published information, pictures and recorded notes.

Methods of preparation of herbarium specimens:

The preparation of a herbarium involves:

(i) Field visits,
(ii) Collection of specimens
(iii) Drying,
(iv) Mounting on a herbarium sheet,
(v) Preservation,
(vi) Labelling and

(vii) Proper storage.

(a)

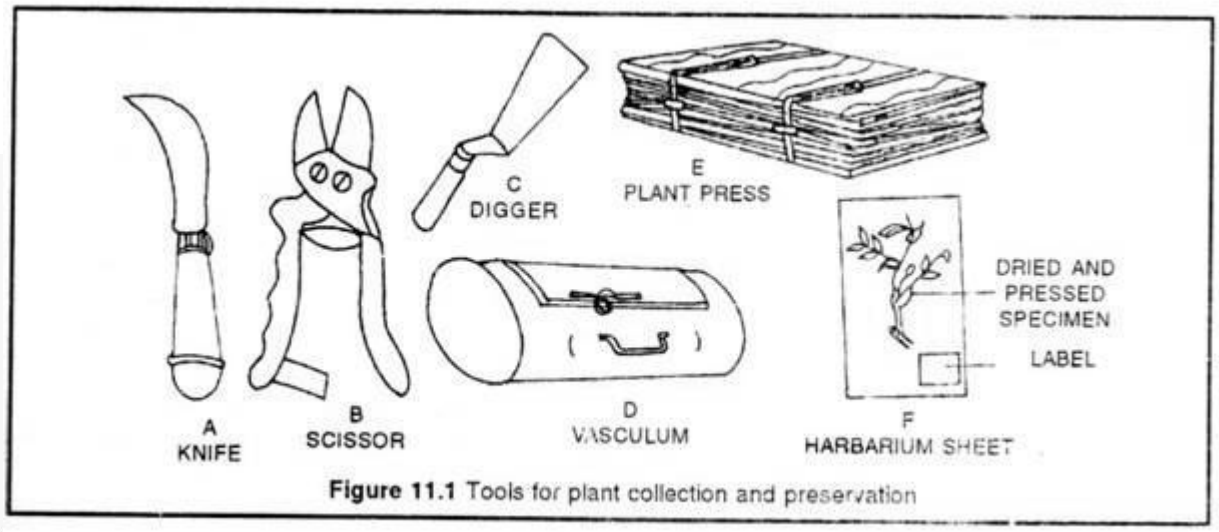


Figure 11.1 Tools for plant collection and preservation

Field visits and specimen collection: A complete specimen possesses all parts including root system, flowers and fruits. Therefore, regular field visits are necessary to obtain information at every stage of growth and reproduction of a plant species. In the fields, the tools required are mainly trowel (digger) for digging roots, scissors and knife for cutting twigs, a stick with a hook for collection of parts of tall trees, a field note book, polythene bag, old newspaper and magazines.

To avoid damage during transportation and preservation at least 5-G specimens of a plant should be collected. The collected specimens are transported in a vasculum (specimen box) to prevent wilting, lively collected specimen must be tagged with a field number and necessary information should be recorded in a field note book.

(b) Pressing and drying: The specimens are spread out between the folds of old newspapers or blotting sheets avoiding overlapping of parts. The larger specimen may be folded in 'N' or 'W' shapes. The blotting sheets with plant specimen should be placed in the plant press for drying. After 24 to 48 hrs the press is opened.

(c) Mounting: The dried specimens are mounted on herbarium sheets of standard size (41 x 29 cm). Mounting is done with the help of glue, adhesive or cello-tape. The bulky plant parts like dry fruits, seeds, cones etc. are dried without pressing and are put in small envelops called fragment packets. Succulent plants are not mounted on herbarium sheets but are collected in 4% formalin or FAA (Formalin Acetic Alcohol).

(f) Preservation: The mounted specimens are sprayed with fungicides like 2% solution of mercuric chloride.

(e) Labelling: A label is pasted or printed on the lower right hand corner. The label should indicate the information about the locality, altitude, habit, date and time of collection, name of collector, common name, complete scientific name etc.

(f) Storage: Properly dried, pressed and identified plant specimens are placed in thin paper folds (specimen covers) which are kept together in thicker paper folders genus covers), and finally they are incorporated into the herbarium cupboards in their proper position according to a well known system of classification. In India Bentham and Hooker's system of classification is used for this purpose. Type specimens are generally stored in separate and safe places.

Important Herbaria of the world

Name	Number of Herbarium Specimens
Royal Botanical Gardens, Kew (London)(largest herbarium)	6.5 million

Museum of natural history (Paris)	Over 6.0 million
Conservatories at jardin botanical institute de Geneve (Geneva)	over 5.0 million
V.L. Komarov Botanical Institute of Azerbaijan	4.0million
New York botanical Garden (New York)	4.0 million
Central national herbarium (India)	2.0 million
Madras herbarium, Coimbatore (MH), India	1,50,000
Herbarium of National Botanical Research Institute, Lucknow, India	80,000

FLORAS AND THEIR IMPORTANCE

Meaning of Flora:

"Flora is a systematic account of plants of a defined geographical area and provides keys and descriptions of plants for identification".

Primary Flora helps in identification of species. It also provides other data like local or vernacular name, distribution, botanical name used, description of a particular plant.

The flora contains description and other details of the plants of the region, i.e., it is listing of plants of the region or area.

Flora Writing:

(i) Firstly the area is to be identified to study the flora, e.g., it may be district, comissionary and so on.
(ii) Geography of the identified area is to be defined and the map is to be presented.
(iii) Get all relevant environmental information of the area. 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.)
(iv) Identify floristic zones or ecological habitats within the area.
(v) Extensive field survey for study of vegetation and collection of all plants time to time.
(vi) Field book is to be maintained for the plants collected including its field number and description, local name, frequency, phenology etc.
(vii) All the specimens (plants) 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.
(viii) Nomenclature of the species with the help of monograph of Flora with the names which are confirmed by ICBN.
(ix) Author citation is to be checked for a new species.
(x) Provide botanical keys for identification of all families, genera and species.
(xi) Description of the species should be in accordance with the actual specimen collected from the area.
(xii) New species found, if any, should be described and published following the norms of ICBN.
(xiii) Generally in a flora the families are arranged according to an accepted classification. It was Bentham and Hooker's system mostly but in recent times some of flora adopt 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

Utility of Flora:

Flora is a valuable document for college and university 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 companies, 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.

STATE LEVEL BOTANICAL GARDEN: LALBAGH, BANGALORE

The Lalbagh Botanical Garden, Bangalore is of royal origin and was started initially as a private garden in an area of 40 acres by Hyder Ali, one of the most famous rulers of old Mysore in 1760. Initially designed in Mughal style, on the model of an extensive garden at Sira in Tumkur near Bangalore, this garden was further developed by Hyder Ali's son Tippu Sultan and subsequently by the British and Indian doyens of horticulture by extension of area and addition of a number of plant species. Of them, Major Waugh, Dr. Wallich, William Munroe, Sir Mark Cubbon, Dr. Cleghorn, William New, A. Blck, John Cameron, Krumbeigal, Rao Bahadur H.C. Javaraya, K. Nanjappa and Dr. M.H. Marigowda, as the Superintendents of the garden, have made noteworthy contributions to the development of Lalbagh.

Lalbagh is currently under the aegis of the Directorate of Horticulture, Government of Karnataka. The Directorate is housed amidst the splendid environs of the botanical garden. Lalbagh was given the status of a Government Botanical Garden in 1856, and since then, it has been an internationally renowned centre for scientific study of plants and botanical artwork and also conservation of plants. Formal and informal styles dominate the garden in perfect harmony, which is a testimony to the beauty of nature. Today, the garden is a lush green paradise with an area of 240 acres in the heart of the city.

The Garden

Lalbagh, for its unique achievement in nurturing the concept of horticulture and aiding the development of horticulture, has earned a pride of place among the gardens of the world and it has come to be regarded as one of the best gardens in the East for its layout, maintenance, scientific treasure and scenic beauty. It is the place of legends and beauty, a place of rarity and wonder, a place of paradise and landmarks. It is an important genetic resource centre for introduction, acclimatization and maintenance of plants; it envisages documentation of the variations available in plants of ornamental and economic value. It is an important centre of dissemination of scientific, technical and popular information on plants including offering of regular courses. It aids the development of horticulture in the state. It is a valuable adjunct to botanic study in educational institutions, a vital lung space of Bangalore, a place of beauty that provides healthy recreation to the public and it provides a venue for people to get close to plants and nature.

The garden with well-laid out roads, paths, open spaces, shade and a good collection of many types of plant species attracts a large number of visitors. Lalbagh is well protected with stone walls as enclosures and it has four approach gates. The main gate is at the North facing towards Subbaiah circle, the West gate is towards Basavanagudi, the South gate is towards Jayanagar and the East gate is towards the Double Road.

Plant wealth

The botanical garden is enriched with numerous native and exotic flora of wide ranging diversity, use and interest. This has been achieved by way of introduction; acclimatization and multiplication of plants obtained from various parts of the world since its inception in 1760. Today, nearly 673 genera and 1,854 species of plants are found in Lalbagh. The collection of the plants has made it a veritable treasure house of plants.

Some of the exotic species introduced from different parts of the world include *Agathis sp., Amherstia nobilis, Araucaria sp., Averrhoa bilimbi, Bambusa sp., Bixa orellana, Brownea grandiceps, Castanospermum australe, Cola acuminata, Corypha umbraculifera, Couroupita guianensis, Cupressus sp., Eriobotrya japonica, Magnolia sp., Swietenia mahagoni* etc. Indigeneous species such as *Artocarpus heterophyllus, Bombax ceiba, Butea monosperma, Cassia fistula , Dillenia indica, Ficus sp., Lagerstromia speciosa, Michelia champaca, Mesua ferrea, Nelumbo nucifera* etc., can be seen. In addition, a number of ornamental and economic plant species both of exotic and indigenous origin can be found in Lalbagh.

NATIONAL BOTANICAL GARDEN: INDIAN BOTANICAL GARDEN, SIBPUR

Acharya Jagdish Chandra Bose Indian Botanic Garden, previously known as the Indian Botanic Garden houses an old Banyan tree (*Ficus Bengalensis*) that is more than 250 years old. The tree has over 2880 prop roots and covers an area of about 1.50 hectares. According to the archives, the Great Banyan Tree was born by a bird's dropping and it grew on a Phoenix Tree (date palm). The strong roots of the Banyan Tree strangulated the date palm tree and the date palm tree was gradually killed.

A wonder of the plant kingdom, the circumference of the canopy is about 450 metres which makes it look like a miniature forest and occupies a position in the Guinness Book of World Records.

The Botanic Garden is spread over an area of 273 acres and is now operated by the Botanical Survey of India (BSI). It is one of the oldest and largest green reserves of its kind in South East Asia. It was founded in the year 1787 during the time of the East India Company by suggestion of Colonel Robert Kyd who was an amateur Botanist and Secretary to the Board in the Military department of Fort William.

Robert Kyd was the first honorary Superintendent of the Botanic Garden. Other than him, major contributors to the development of the garden included William Roxburgh, Dr George King and Thomas Anderson.

The Garden is situated a mere 8 kilometres away from the city centre of Kolkata on the West bank of River Hooghly in Shibpur, Howrah. We took a cab from the city to the Garden and were delighted to find that to reach the Garden, we had to go over the historic Howrah Bridge. Alas! Stopping on the bridge was not allowed though but we managed to click a picture from the cab itself.

Botanic Wonder

The latest census conducted at the Indian Botanic Garden in 2007 revealed 14000 species of trees and 13,722 plants of which 500 specimens are considered rare, according to Dr. H.S. Debnath, director of Indian Botanic Garden.

The entire Garden is split into sections where trees from various regions within India and also from the other countries had been planted. I was from these gardens that the tea now grown in Assam and Darjeeling was first developed. Trees of the rarest kinds, from Nepal, Brazil, Penang, Java and Sumatra can be found here. There are towering Mahogany trees, an avenue of Cuban Palms and an Orchid House. Mango and Tamarind trees shade the grassy lawns.

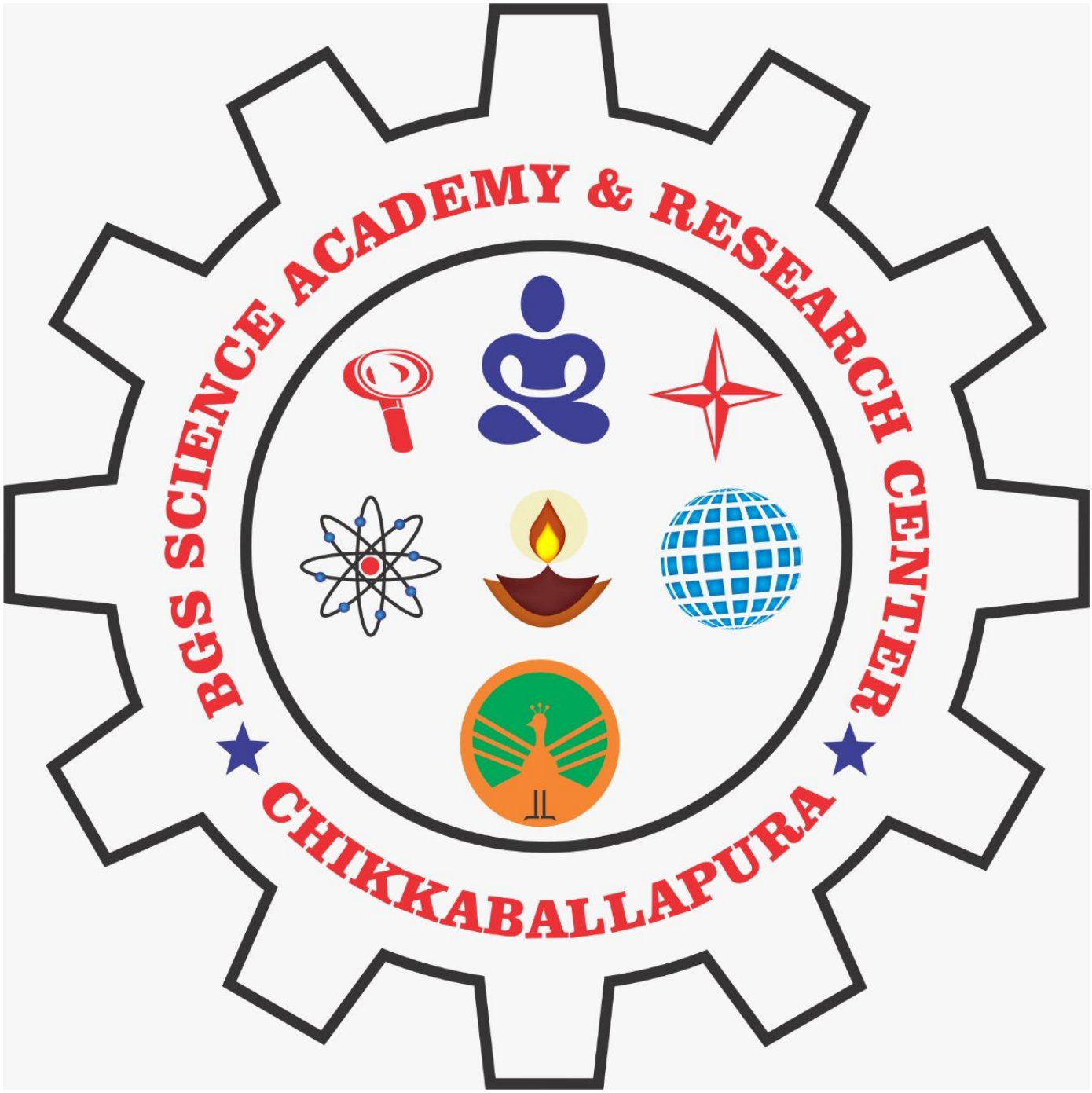
Some of the prized possessions of this garden include 26 species of Bamboos, 140 cultivars of Bougainvillea, 109 species of Palms, several Screw pines and a splendid collection of Cacti.

Double Coconut Palm Tree

Some remarkable botanic species found in the Garden

- *Phoenix rupicola* – This is a rare endemic Palm, with only two populations surviving today, one is in the Eastern Himalayas and the other in this garden having a population of five plants.
- Double Coconut Palm Tree – The double coconut palm tree produces the largest seed in the world and has a life span of 1200 years. This tree has been in the garden since 1894 and is a female tree.
- Century Palm – This is another rare Palm tree that produces seeds only once in a lifetime and dies.
- *P. Unguifer* – This is a rare and endemic threatened screw pine found in Mungpoo Hills, Darjeeling. This tree is also present in the garden.
- *Euryale ferox*– This is an aquatic plant found in the garden lakes. The roasted edible seeds of this plant are sold in the market as "Taal Makhana".
- Cannon Ball Tree or *Couroupita guiansesis*– The fruits of this tree look like Cannon Ball, hence this name. In western countries, the pulp of the fruit is used to feed pigs and poultry.
- Bread Fruit Tree or *Artocarpus communis* – When the fruit of this tree is baked or roasted in the fire, it has a starchy texture and fragrance of freshly baked bread hence the name bread fruit tree.
- Mad Tree or *Pterygota alata* var. *Irregularis* – Each leaf produced by this tree is different in shape and size from the other.
- Sausage Tree or *Kigelia Pinanata* Dc – This tree bears a large sausage or pumpkin shaped fruits hanging from long thread like peduncles making the tree look very unique.
- Rashogolla Tree or *Chyrsophyllum cainito* – The fruit of this tree is big and white in color and has a round shape and sweet taste just like the favourite and famous Bengali Sweet Rasgulla.

RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY



RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

INTERNATIONAL BOTANICAL GARDEN: ROYAL BOTANIC GARDENS, KEW

The Royal Botanic Gardens in Kew, situated within the built-up area of Greater London, holds a special place in the hearts of its numerous admirers. Every year more than a million people come to the Garden, some as regular visitors, others among them many from overseas, making a botanical pilgrimage for which there may be only one opportunity in a lifetime. The popularity to which all this attests is largely based on the reputation for the exceptional ornamental beauty of Kew as ' gardens for pleasure. 'Many have heard of the rural aspect of its bluebell woods, extensive lawns and tranquil lake. For others the principal attractions will be the spectacular rose gardens, the glorious Azaleas or the unusual plants in the rock garden. Few will fail to be fascinated by the exotic tropical collections in the greenhouses-including orchids, insectivorous plants and giant water lilies. With close on 50000 species and varieties of plants in the gardens, there is little chance of visitors being disappointed by lack of variety. The tender collections at Kew include plants introduced from most regions of the warm, temperate, subtropical and tropical parts of the world. The great diversity of plant life discovered on the early voyages of explorations gave a huge stimulus to the development of exotic collections in Europe. Hence Kew's greenhouse collections, formed over the past two centuries, have evolved largely under the twin spurs of plant introduction and the technical development of the plant house. The greenhouses at Kew provide a wide range of environments for their floral inhabitants. Plants from the tropics to the arctic, from rain forest to desert and from salt flat to mountain top- all have a place in Kew. To provide for this diversity of requirements the collections are broadly divided into two main groups, herbaceous and woody, with the latter occupying the larger structures. Whether it be plants weird and wonderful in their growth or behavior, or those useful to man, those from tropical forests, or desert cactus or trees of British woodlands are all there at Kew. In addition to these living plants, there are botanical exhibits in the Museums and Orangery. One of the principal roles of Kew garden is public environmental education and it is admirably suited to this and the best teachers are the plants themselves in their infinite variety. One cannot walk far in the gardens without noticing the names, since labels hang from every tree or are positioned among the plants. Knowledgeable visitors carefully scrutinize these labels, but the problem is that a few of the plants growing in botanic gardens possess a common name. Public museum displays have to tell a story using words, pictures and botanical objects in an evolutionary way that is interesting and intelligible both to the ordinary visitor and to the student. They are rich treasure houses containing timbers and resins, fruits and seeds, fibers and textiles, paintings, photographs and models and much more. The Living Collections Division arranges several special exhibits in the green houses. These include displays of orchids and carnivorous plants. In the open air there are several educational displays with appropriate labelling. Kew and Wakehurst offer unique and unlimited opportunities for learning about plants in all their aspects. Different aspects of Kew are shown by arrangement to groups of students. Some 5000 people a year are given guided tours. An increasing number of booklets and guides are available for purchase. The handouts and quiz sheets have proved to be very popular especially with school parties as they give children an incentive to study the exhibits in order to complete their sheets, leading to a perfect environmental education process. A visit to this garden provides an insight into the working of Kew and it gives young people ideas of their own careers and some means of appreciating the value of plant life to the world. The combined living collection of the Royal Botanic Gardens, Kew and Wakehurst Place containing more than 30,000 different kinds of plants is the largest and most diverse in the world with one in ten of all flowering plant species. This provides an exceptionally rich resource for educations visits. Profound study of the biological characters of plants ensured the selection of the most valuable plants for practical use. The plants grown at Kew and at Wakehurst Place, totaling nearly 50000 species and varieties, constitute one of the world's most comprehensive collections of living specimens maintained for scientific study. There are representatives from almost every habitat, including arctic tundra, temperate low land, tropical rain forest and equatorial desert.

CYTOTAXONOMY:

It is classification based on information provided by comparative cytological studies, number of chromosomes, structure and meiotic behaviour of chromosomes. It is known that fewer and larger chromosomes have been formed in many cases by fusion of smaller chromosomes. Herbaceous plants have larger chromosomes than those of woody plants. Naturally, herbaceous plants are more advanced than the woody plants.

In many genera the same basic chromosome number has been found in different species, e.g., 12 in Solanum species and 9 in Chrysanthemum species.

Human beings have 46 chromosomes while apes have 48. A reduction in number of chromosomes have been achieved through whole arm translocation between two acrocentric chromosomes. Apparently, humans have evolved from ape-like ancestors. Pairing of chromosomes during meiosis helps to bring out relationships between species.

Characteristic # 1. Chromosome Number:

The number of chromosomes in a species is usually constant and this makes it an important taxonomic character. However there are exceptions where chromosome number varies. These changes usually occur in chromosomes during the process of division, and these changes may affect the gene sequence, their number or even there may be loss of chromosomes themselves.

The perpetuation of this slow process, results in the evolution of new chromosomal races. The chromosome number shows a wide range in vascular plants. The lowest chromosome number in flowering plants is recorded in *Haplopappus gracilis* (Asteraceae) [2n = 4] and the highest in *Poa litorosa* (Poaceae) [2n = 265]. *Ophioglossum* species (Pteridophyte) has the highest number of chromosomes in the plant kingdom (2n = 1240). This great diversity of chromosome numbers and their relative constancy within populations and species provide an important character for taxonomic groupings of large number of plants.

Characteristic # 2. Chromosome Size:

The individual chromosomes of some taxa show marked differences in shape and size at mitotic metaphase. The size of chromosome varies greatly in different families and also amongst members of the same family. The monocotyledons usually have larger chromosomes than the dicotyledons. In general, woody plants have smaller chromosomes than their herbaceous relatives.

Nearly all the members of the families of Araceae, Commelinaceae, Cyperaceae, Dioscoreaceae and Zingiberaceae possess small chromosomes. Iridaceous members reveal small to medium sized chromosomes, while taxa of Amaryllidaceous exhibit large sized chromosomes. Members of the family Liliaceae are characterized by the presence of all types of chromosomes.

Chromosome length is usually used to characterize the size of the karyotype. However sometimes chromosome volume, expressed as a function of DNA content, is used for this purpose. The chromosome length in most plants varies from 0.5-30 µ.

Chromosome size is not related to the phylogeny of angiosperms in general but is characteristic of only certain groups and families.

Phylogenetic reduction in chromosome size, was first of all described by Delaunay in the genus *Muscari* of Liliaceae. In this genus, species with greater morphological specialization possessed smaller absolute chromosome size as compared to the relatively primitive species.

Reduction in chromosome size has also been reported in *Crepis* and in *Dianthus*. Similarly phylogenetic increase in chromosome size has been reported in the family Poaceae, in *Galium* and in *Godetia*.

The two genera *Trillium* and *Paris* possess the largest chromosomes and are definitely specialized in their vegetative characteristics, and are considered to have descended from Uvularieae, the members of which have also large chromosomes but nevertheless smaller in contrast to those found in *Trillium* and *Paris*.

The evolutionary significance of chromosome size was further elaborated by Stebbins.

The co-adaptive nature of genetic system in plants was first pointed out by Darlington. He suggested that chiasma frequency often depended on the length of the chromosomes, the larger chromosomes means high

chiasma frequency resulting in high recombination index while small chromosomes mean low chiasma frequency resulting in low recombination index.

Therefore, there is a trend to linking of small chromosome size with multiplicity in their number as in tree species.

Characteristic # 3. Chromosome Morphology:

Apart from the number and size of the chromosomes of many genera and families of flowering plants, conspicuous differences in appearances of the karyotype of the chromosomes have also been found in species having the same chromosome number. The chromosomes are best discernible at mitotic metaphase.

The karyotype of the chromosomes can be characterized on the following basis:

a. Relative length of the arms of chromosomes

b. Position of the centromere

c. Presence of satellites

Accordingly the chromosomes can be characterized as following types:

I. Symmetrical :

A karyotype consisting of chromosomes all essentially similar to each other in size and with median or sub-median centromeres and with two equal arms are termed as a symmetrical chromosomes.

Depending on the position of the centromere they may be of further two types (Fig. 8.12):

(i) Metacentric or V-shaped — Chromosomes with median centromere.

(ii) Sub-metacentric or L-shaped — Chromosomes with sub-median centromere.

Karyotypes of this nature are the most common ones and Levitzky considered them as generalized types. For example, the chromosomes in the karyotype of the primitive genus *Helleborus* (Ranunculaceae), differ little from each other in size and most of them are V-shaped with median or sub median centromeres.

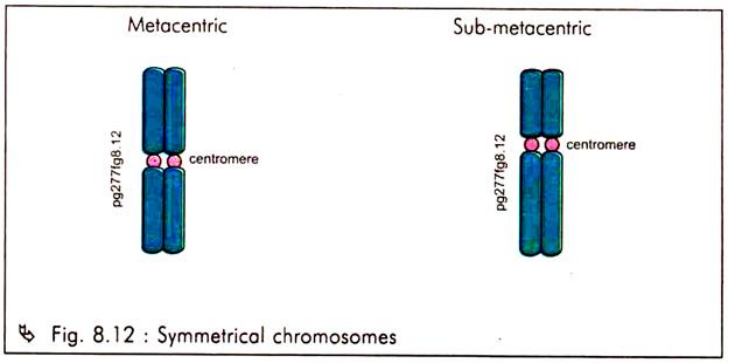


Fig. 8.12 : Symmetrical chromosomes

II. Asymmetrical:

This type of karyotype possess many chromosomes with sub-terminal or terminal centromeres, or great differences in size between the largest and the smallest chromosomes, or both. Depending on the position of the centromere they may be further of two types (Fig. 8.13):

(i) Acrocentric or J-shaped — Chromosomes with sub-terminal centromere.

(ii) Telocentric or I-shaped — Chromosomes with terminal centromere.

Karyotypes of this nature are considered as specialized types. For example, in the advanced genera *Aconitum* and *Delphinium* (Ranunculaceae), the flowers have the largest number of J-shaped chromosomes.

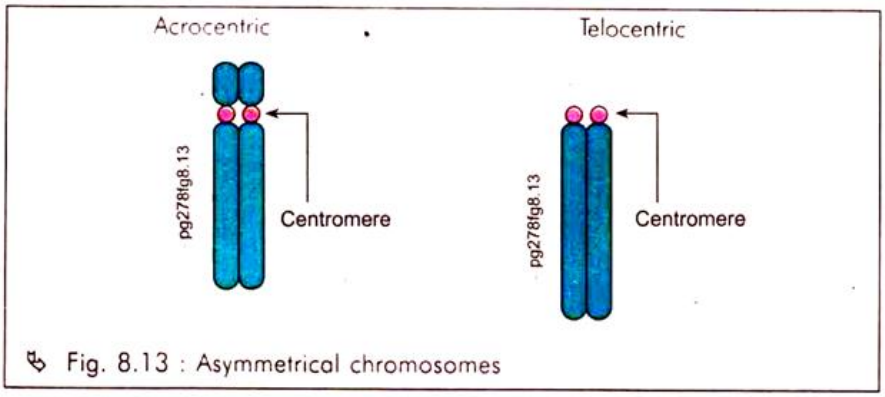


Fig. 8.13 : Asymmetrical chromosomes

III. Secondary Constrictions and Satellites:

The karyotypes can also be differentiated on the basis of secondary constrictions, which are small bead-like appendages. Occasionally they occur at the terminal ends of one or more pairs of chromosomes in many species and are known as satellites (Fig. 8.14).

These structures are widely distributed in the plant kingdom, which shows that they are a valuable, if not essential, part of the chromosomal complement. However, very little is known about the evolutionary changes in the satellites and nucleoli.

Generally, the asymmetrical karyotypes are most common in plants, which are usually specialized morphologically, while symmetrical ones are found in more or less generalized plants, but also occur in morphologically specialized ones too.

The reason for this increasing asymmetry in karyotype evolution is not known. However, Stebbins (1950) suggested that unequal translocations and inversions involving the centromere seem to be responsible for this.

Generally symmetrical karyotypes are taken to reflect primitive status of taxa, while various specialized types (asymmetrical karyotypes), are considered to have been derived, from the symmetrical karyotypes.

However, Jones has challenged this view by postulating that symmetrical karyotypes originally evolved from asymmetrical ones by end-to-end fusion of telocentric chromosomes. This reverse trend of specialization, i.e. from telocentric chromosomes to metacentric ones, has been demonstrated in certain members of the Commelinaceae.

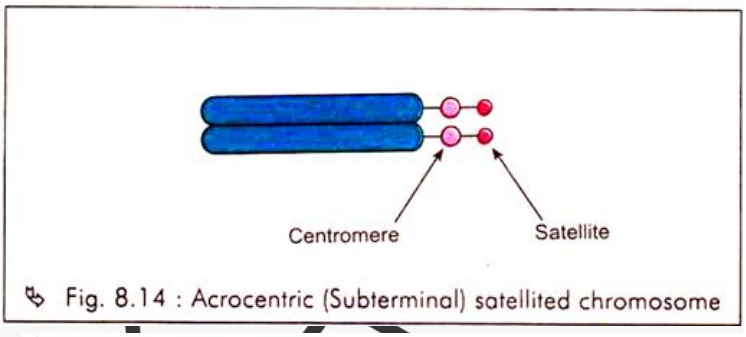


Fig. 8.14 : Acrocentric (Subterminal) satellited chromosome

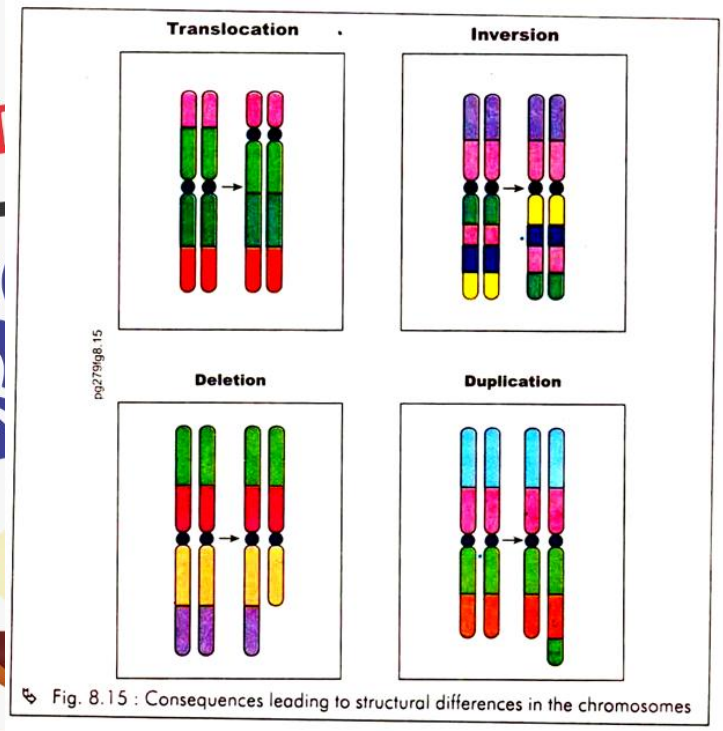


Fig. 8.15 : Consequences leading to structural differences in the chromosomes

Characteristic # 4. Chromosome Behaviour at Meiosis:

A study of chromosome behaviour at meiosis can provide some valuable information about the relationship of populations and species. Pairing behaviour at meiosis is mostly determined by chromosome number and chromosome homology.

The kind and degree of pairing can:

1. Show whether hybridization has occurred – The degree of chromosome homology, in hybrids is an indication of the degree of relationship of the parental species.

2. Indicate structural differences in the parental chromosomes – Meiotic pairing behavior in hybrids can also point to structural differences in the chromosomes of its parents.

CHEMOTAXONOMY (BIOCHEMICAL SYSTEMATICS):

The system of classification is based on characteristics of various chemical constituents of organisms like amino acids, proteins, DNA sequences, alkaloids, crystals, betacyanins, etc. Chemical constituents of plants are generally specific and stable.

They do not change easily. Ancient medical men based their identification of plants on fragrance, taste and other chemical characteristics. Crystals of calcium oxalate like raphides are restricted to 35 families. Similarly, certain alkaloids are restricted to a few related families, e.g., benzylisoquinoline alkaloid in Papaveraceae, Berberidaceae and Ranunculaceae.

Significance of Chemotaxonomy:

The occurrence and distribution of the various types of chemical substances present in plants prove to be of taxonomic significance. However, it should be noted that, all kinds of chemical substances present in plants do not reveal information useful to the taxonomist. Phytochemical characters of taxonomic significance have been classified into three types.

These include:

a. Primary constituents:

These include the macromolecular compounds directly taking part in metabolism and include proteins, nucleic acids, chlorophyll and polysaccharides. All chemical materials synthesized by an organism reflect the information in DNA, RNA and proteins. These latter molecules have been termed as semantides. Semantides, thus contain useful information of taxonomy and phylogeny.

b. Secondary constituents:

They include compounds lacking nitrogen and not involved directly in plant metabolism i.e., simple phenolic compounds like caffeine, benzoic and nicotinic acids and polyphenolic compounds like flavonoids, terpenes, coumarines, alkaloids and pigments of which flavonoids are most widely studied with respect to plant systematics.

c. Miscellaneous substances:

However, no suitable classification of the chemical characters and their use in taxonomy is developed so far. On the basis of their molecular weight, Jones and Luchsinger (1987) has divided the natural chemical plant products useful in taxonomy, into two major groups.

d. Micro-molecules:

They are low molecular weight compounds with a molecular weight of 1000 or less, e.g. amino acids, alkaloids, fatty acids, terpenoids, flavonoids, etc.

e. Macromolecules:

They include the high molecular weight compounds with a molecular weight of over 1,000, e.g. proteins, DNA, RNA, complex polysaccharides, etc.

(a) Proteins:

Among the various semantides, proteins serve as the most important tool in chemotaxonomy.

For example:

a. Johnson and Hall (1965) have demonstrated the phylogenetic affinities in Trichinae by the process of protein electrophoresis.

b. This process also helped in establishing a close relationship between Vicia and Lathyrus.

c. Interspecific variations among eight species of Cassia (Caesalpiniaceous) were evaluated on the basis of seed protein and mitochondrial DNA RFLP by gel electrophoresis as well as pollen protein patterns.

(b) Nucleic Acids:

The potentiality of the huge amount of phylogenetic information comprising the base sequences of cellular nucleic acids has been recognized relatively recently.

Nuclear DNA and RNA:

The relative homology of DNA or RNA of various plants is useful in a taxonomic study and as a possible screening method for inter-fertility of species.

(c) Amino Acids:

There are two groups of amino acids present in plant cells.

They are:

Protein amino acids:

They are the building blocks of proteins and are released on hydrolysis of proteins. They are universally distributed in plant tissues. Amino acids present in the free form in various plant cells has also been used as a taxonomic factor in some cases.

For example, Shellard and Jolliffe studied the free amino acid composition of the pollen of 11 different grass species, and found it to be similar in all the species. Generally total free amino acids are usually higher in pollen than in leaves or other plant tissues.

Hence, free amino acid composition of pollen has been used to study the homology between various species, e.g. Asteraceae, Cassia, etc.

Following are a few examples of the taxonomic significance of specific non-protein amino acids present in different groups:

III. The amino acid azetidine-2-carboxylic acid is extremely restricted in its distribution, being present in the Agavaceae, Amaryllidaceous and Liliaceae. This amino acid is also reported from the legumes *Delonix* and *Peltophorum*.
IV. *Lathyrus* species could be grouped under seven infra-generic groups on the basis of the association of amino acids within the seeds. Each group is characterized by a different amino acid or group of amino acids.
V. Species of the section Gummiferae of the genus *Acacia* can be recognized easily on the basis of the amino acid contents of their seeds.
VI. Four infra-generic groups have been recognized in the genus *Vicia* on the basis of distribution of amino acids.
VII. Free amino acid, lathyrine is so far known only in the genus *Lathyrus* and this supports the present circumscription of the genus.

(d) Flavonoids:

Of all the various secondary constituents, flavonoids have been the most widely exploited phytochemical constituent in chemotaxonomic studies. They are phenolic glycosides consisting of two benzene rings linked together through a heterocyclic pyrene ring.

Many phylogenetic inferences have, been based on these characters in various groups. Following are a few examples:

The flavonoid systematics of the genus *Perideridia* (Umbelliferae), was studied by Giannasi and Chuang, who found that although the 16 species studied by them had the same flavonoids, they could be categorized into three discrete groups.
I. Those producing only flavonols.
II. Those with flavonols mainly and a few flavones.
III. Those which produce flavones predominantly.
Analysis of flavonoids of leaf of Liliaceae, Juncaceae, Cyperaceae and Poaceae by Williams suggest that all these families have arisen from Liliaceous ancestors.

(e) Betalins:

Betalins differ from flavonoids and other phenolic compounds in that they contain nitrogen in them. They are however functionally equivalent to phenolics.

Some examples of the taxonomic value of betalins are mentioned below:

The betalins are confined to ten families of angiosperms (which contain only betalin but no anthocyanin) i.e., Chenopodiaceae, Portulacaceae, Aizoaceae, Cactaceae, Nyctaginaceae, Phytolaccaceae, Stegnospermaceae, Basellaceae, Amaranthaceae and Didieraceae, which have been placed under a single, order Centrospermae. Centrospermae also includes two anthocyanin-containing families, Molluginaceae and Caryophyllaceae. Mabry had suggested the transfer of the anthocyanin- containing families, Molluginaceae and Caryophyllaceae, to a distinct order Caryophyllales, restricting the Centrospermae to betalain-containing groups alone.

(f) Alkaloids:

Alkaloids are a heterogeneous group of organic nitrogen containing bases, often with a heterocyclic ring. The true alkaloids have a nitrogen-containing heterocyclic nucleus derived from a biogenetic amine and they can be related structurally to parent bases such as isoquinoline, pyridine, piperidine and tropane.

Over 5000 alkaloids have been reported from angiosperms mostly from the Dicotyledons, as for example:

I. Families like Berberidaceae, Fabaceae, Ranunculaceae and Solanaceae are especially rich in alkaloidal species. Other families include Annonaceae, Fumariaceae, Hydrastidaceae, Menispermaceae, etc.
II. The members of the Papaveraceae synthesize isoquinoline alkaloids always including protopine, those of the Fabaceae lupin alkaloids, while Solanaceae have tropane derivatives Asteraceae and Poaceae; on the other hand, produce many different types of alkaloids.
III. Sometimes alkaloids have a very narrow distribution. For example morphine is restricted to *Papaver somniferum* coniie to a few Apiaceae and strichnine to a few species of *Strychos*.

(g) Terpenoids:

These are a biogenic group of volatile compounds, which are mostly polymerized isoprene residues (isoprene unit -2-methyl 1, 3 butadiene).

Some specific terpenoids are found in certain families, e.g. sesquiterpene lactones in Asteraceae, cucurbitacins in Cucurbitaceae and asperuloside in Rubiaceae.

Some of the chemotaxonomic applications of terpenes are mentioned below:

Sesquiterpene lactones are common in the family Asteraceae, in which the oxidation level of these sesquiterpenes is sometimes specific to a tribe, subtribe or even a genus.

The absence of sesquiterpenes in the Astereae may be rare. It has been found that if Ambrosia and its allies viz /va, Franseria and Xanthium are removed from the Heliantheae, then the residual elements are similar to the Helenieae in terms of lactone distribution.

(h) Iridoid Compounds:

They are monoterpenoid cyclopentanoid lactones, which represent a separate class of taxonomically significant compounds. The distribution of iridoid compounds has attracted the attention of plant taxonomists as a character of systematic importance in recent times and is considered to be an evolutionary marker.

The significance of the monoterpenoid cyclopentanoid lactones called iridoids has been reviewed by Bate-Smith and Swain. Among these compounds, asperuloside is particularly common in the Rubiaceae. Aucubin is frequently noted in the Cornaceae, Scrophulariaceae, Orobanchaceae and some closely related families.

(i) Oils, Fats and Waxes:

Along with the proteins and carbohydrates, lipids or fats form the bulk of the organic matter of plant tissue and are therefore a potential source of taxonomic evidence.

Fatty acids specific to particular plant groups may be of taxonomic significance. For example, ximenyric acid is found in the Olacaceae and Santalaceae, petroselinic acid is almost completely restricted to the Umbelliferae and erucic acid to Cruciferae. Certain species of the Flacourtiaceae are characterized by the presence of chaulmoogric acid and some related acids.

(j) Steroids:

Steroids may be considered as derivatives of a fused and fully saturated ring system called cyclopentanoperhydrophenanthrene or sterane, which is formed by the fusion of 3 cyclohexane rings in non-linear or phenanthrene manner and a terminal cyclopentane ring. True steroids possess two methyl groups and are mostly alcohols or esters.

In plants they serve the role of water-proof, being located in the plant cutins. Steroids have also proved to be of some taxonomic significance in some taxa. As for example, their distribution has proved helpful in the taxonomy of the genera of tribe Veratreae of family Liliaceae. According to Kupchan, these genera contain the steroid veratum.

(k) Polysaccharides:

Polysaccharides perhaps offer the greatest hope for taxonomic evidence because of their complexity and diversity. But so far they have been examined from a systematic viewpoint only, particularly due to the difficulties in the procedures for isolation and fractionation of these compounds.

I. Quercitol is exceptionally common in the Menispermaceae, although it is found elsewhere. Though it is present in all 35 species of Quercus, it is absent from *Castanea* and *Fagus* of the Fagaceae.

II. Sorbitol distribution is in accordance with the taxonomy of the Rosaceae, supporting the transfer of *Ulmaria* to the Rosoideae (usually without sorbitol) from the Spiraeoideae (which contains genera with sorbitol).

III. Similarly, Pinitol is widespread but is particularly common in the Caryophyllaceae. It is found only in the genera Magnolia under the Magnoliaceae, but absent in closely related families.

NUMERICAL TAXONOMY:

It evaluates resemblances and differences or primitiveness and advancement through statistical methods based on a large number of characters obtained from all disciplines of biology.

This is followed by assigning them number and codes of computer like plus (+), minus (-), θ (data not available), followed by computer analysis. It establishes the numerical degree of relationship among individuals. The relationship or affinity values are then used to erect taxonomic categories.
However, its effectiveness depends upon the judgement of the biosystematics in selecting characters and current knowledge about them.

1. Meaning of Numerical Taxonomy:
Numerical taxonomy or taximetrics, nowadays frequently and perhaps more appropriately referred to as phenetics, refers to the application of various mathematical procedures to numerically encoded character state data for organisms under study.
Thus, it is the analysis of various types of taxonomic data by mathematical or computerized methods and numerical evaluation of the similarities or affinities between taxonomic units, which are then arranged into taxa on the basis of their affinities.
According to Heywood the numerical taxonomy may be defined as the 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.
The period from 1957 to 1961 saw the development of first methods and of theory of numerical taxonomy. Plants as we all know are classified based on their characters. It was Michel Adanson, a French botanist, who for the first time put forward a plan for assigning numerical values to the similarity between organisms and proposed that equal weightage should be given to all the characters while classifying plants. He used as many characters as possible for the classification, and such classifications came to be known as Adansonian classifications. Numerical taxonomy was however largely developed and popularized by Sneath and Sokal. The application of Adansonian principles and use of modern methods and electronic data-processing techniques, have helped in the evolution of several new classifications of plants during the past few decades.

2. Principles of Numerical Taxonomy:
Numerical taxonomy involves two aspects:
(a) Construction of Taxonomic Groups:
i. In numerical taxonomy, first, individuals are selected and their characters spotted out. There is no limitation to the number of characters to be considered. However, the larger the number of characters, better is the approach for generalization of the taxa.
ii. The resemblances among the individuals are then established on the basis of character analysis, which can often be worked out with the help of computers, the accuracy of which depends on the appropriateness in character. The best way to delimitate taxa is, to utilize maximum number of characters, with similar weightage given to all of them.
(b) Discrimination of the Taxonomic Groups:
When the taxonomic groups chosen for the study show overlapping of characters, discrimination should be used to select them. Discrimination analysis can be done by various techniques, specially devised for such purposes. Numerical taxonomy is thus, based on certain principles, also called neo Adansonian principles.
Following seven principles of numerical taxonomy have been enumerated by Sneath and Sokal:
(i) The greater the content of information in the taxa, and more the characters taken into consideration, the better a given classification system will be.
(ii) Every character should be given equal weightage in creating new taxa.
(iii) The overall similarity between any two entities is a function of the individual similarities in each of the many characters, which are considered for comparison.
(iv) Correlation of characters differ in the groups of organisms under study. Thus distinct taxa can be recognized.
(v) Phylogenetic conclusions can be drawn from the taxonomic structure of a group and from character correlations, assuming some evolutionary mechanisms and pathways.
(vi) The science of taxonomy is viewed and practiced as an empirical science.

(vii) Phenetic similarity is the base of classifications.

3. Merits of Numerical Taxonomy:

According to Sokal and Sneath, numerical taxonomy has the following advantages over conventional taxonomy:

a. The data of conventional taxonomy is improved by numerical taxonomy as it utilizes better and more number of described characters. The data are collected from a variety of sources, such as morphology, chemistry, physiology, etc.

b. As numerical methods are more sensitive in delimiting taxa, the data obtained can be efficiently used in the construction of better keys and classification systems, creation of maps, descriptions, catalogues, etc. with the help of electronic data processing systems. Numerical taxonomy has in fact suggested several fundamental changes in the conventional classification systems.

c. The number of existing biological concepts have been reinterpreted in the light of numerical taxonomy.

d. Numerical taxonomy allows more taxonomic work to be done by less highly skilled workers.

4. Demerits of Numerical Taxonomy:

Numerical taxonomy can however prove to be disadvantageous from the following points of view:

a. The numerical methods are useful in phenetic classifications and not phylogenetic classifications.

b. The proponents of "**biological**" species concept, may not accept the specific limits bound by these methods.

c. Character selection is the greatest disadvantage in this approach. If characters chosen for comparison are inadequate, the statistical methods may give less satisfactory solution.

d. According to Steam, different taxonometric procedures may yield different results. A major difficulty is to choose a procedure for the purpose and the number of characters needed in order to obtain satisfactory results by these mechanical aids. It is necessary to ascertain whether a large number of characters would really give satisfactory results than those using a smaller number.

5. Applications of Numerical Taxonomy:

Numerical taxonomy has been successfully applied in the following studies:

a. Study of similarities and differences in bacteria, other micro-organisms and several animal groups.

b. Delimitation of several angiospermic genera like Oryza, Sarcostemma Solarium, and other groups including Farinosae of Engler and a few others.

c. In the study of several other angiospermic genera including Apocynum, Chenopodium, Crotalaria, Cucurbita, Oenothera, Salix, Zinnia, wheat cultivars, Maize cultivars, etc.

d. Phytochemical data from seed protein and mitochondrial DNA RELP studies has been numerically analyzed by Mondal et al. to study the interspecitic variations among eight species of cassia L .Based on the results of electrophoretic patterns, the degree of pairing affinity (PA) or similarity index was calculated by the following formula, according to the method of Sokal & sneth and Romero Lopes et al.:

$$PA = \frac{\text{Bands common to species A and B}}{\text{Total bands in A and B}} \times 100$$

Separate dendograms expressing the average linkage were computed using the cluster method UPGMA, which showed that the eight species could be placed into two categories or clusters (Fig. 9.6) with *C. alata*, *C. siamea*, *C. fistula* and *C. reginera*, all being trees or large shrubs and characterized by the absence of foliar glands on petiole or rachis and presence of dense axillary terminal racemes greater than 30 cm long, being clustered into one group, whereas the other four species, i.e., *C. occidentalis, C. sophera, C. mimosoides* and *C. tora*, forming the other cluster, all being herbs or undershrub's and characterized by the presence of short corymbose racemes less than 10 cm long and with foliar glands, either on petiole or rachis.

APPLICATION OF COMPUTER IN PLANT TAXONOMY

Computers in Identification

Over the years, computers have been increasingly used in data collection, processing and integration. They have also found use in a big way in scanning and identifying human ailments, which has greatly helped health management programmes. Computers have also found use in plant identification, whereby we no longer need trained botanists for this task. The following main approaches are used in computer identification:

Computer-Stored Keys

Dichotomous keys are constructed in the usual manner, fed into a computer and run using an appropriate program, which may be appropriately designed for step-wise processing of the key through a dialogue between the user and the computer. The computer program starts with the first couplet of the key, enquires about the attribute in the unknown plant and on the information provided, and handles the key asking relevant questions until finally the actual identification is achieved.

Computer-Constructed Keys

Appropriate programs may be developed which can construct a taxonomic key based on the taxonomic information about the taxa, in the same way and based on the same logic which is used by man to construct keys manually. Such keys permanently stored in a computer can be handled as above for the step-wise process of identification.

Simultaneous Character-Set Identification

Taxonomic keys are an aid to rapid identification and always provide only a provisional identification, confirmation being achieved only after comparison with a detailed description of the specific taxon. This comparison with the detailed description is not done in the first place, as comparing the description of the unknown plant with the description of all taxa

of the group or the area would be laborious, time consuming and often impossible. Such a comparison can be achieved through a computer in a matter of seconds. With such an approach, the whole set of characters of the unknown plant may be fed into the computer simultaneously, and a computer program used to compare the description with the specific group and to suggest the taxon with which the description matches. In case complete information is not available, the computer program may be able to suggest possible alternate identifications.

Automated Pattern Recognition Methods

Computer technology has now developed to the extent that fully-automated identification can be achieved. The computer fitted with optical scanners can observe and record features, compare the same with those already known and make important conclusions. Programs and techniques are already available for human diagnosis, including chemical spectra and photomicrographs of chromosomes, abnormality in human tissues and even in vegetation and agricultural surveys.

Interactive Keys

Last two decades have seen the development of sophisticated computer based programs designed to collect, integrate and use it for organising descriptions and associated taxon data and also help in the identification of taxa through user friendly interfaces. Some of the Major ones are briefly described here.

DELTA System

The DELTA System is an integrated set of programs based on the DELTA format (**DEscription Language for TAxonomy**), which is a flexible and powerful method of recording taxonomic descriptions for processing by a computer. DELTA, a shareware program, has been adopted as a standard for data exchange by the International Taxonomic Databases Working Group. It enables the generation and typesetting of descriptions and **conventional keys**, conversion of DELTA data for use by **classification programs**, and the construction of **Intkey packages** for interactive identification and **information retrieval**. The System developed in the Natural Resources and Biodiversity Program of the CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) Division of Entomology over a period of 30 years between 1971 and 2000 M. J. Dallwitz, T. A. Paine and E. J. Zurcher, is in use world-wide for diverse kinds of organisms, including fungi, plants, and wood. The programs are continually refined and enhanced in response to feedback from users.

The **DELTA program Key** generates conventional identification keys. Characters are selected by the program for inclusion in the key based on how well the characters divide the remaining taxa. This information is then balanced against subjectively determined weights, which specify the ease of use and reliability of the characters.

DELTA data can be readily converted to the forms required by programs for phylogenetic analysis, e.g., Paup, Hennig86 and MacClade. The characters and taxa for these analyses can be selected from the full dataset. Numeric characters are converted into multistate characters, as numeric characters cannot be handled by these programs. Printed descriptions can be generated to facilitate checking of the data.

NaviKey

Navikey is a simple Java based interactive identification key, a free program, which works on Delta flat files (chars, items and specs-present in your folder if you have developed a database ready for identification through Intkey, as detailed in preceding paragraphs). NaviKey v. 4 is developed in the frame of BIOTa Africa project (An International Research Network on biodiversity, sustainable use and conservation) by Dieter Neubacher and Gerhard Rambold sustainable use and conservation) by Dieter Neubacher and Gerhard Rambold (University of Bayreuth, Germany), based on an earlier version (NaviKey v. 2.3 by Michael Bartley and Noel Cross, Harvard University Herbarium, Boston, USA). The program can be downloaded from www.NaviKey.net and can be used both as standalone application or as web application. After downloading the and unzipping the file, the folder will have several files on your computer. Simply add the three flat files of your project to this folder. For using it as standalone application simply click NaviKey.jar, and it will open up the identification window with four panels, like Intkey. Character panel is upper left window, but right upper panel shows character states, lower right panel the matching items panel showing matching or remaining taxa (click any taxon to get its full description) and the lower left panel the query criteria panel: display of previous (used) character state selections. NaviKey also allows checkbox matching options to: (a) Restrict view on used characters and character states of remaining items. (b) Retain items unrecorded for the selected characters. (c) Retain items matching at least one selected state of resp. characters. (d) Use extreme interval validation, and (e) Use overlapping interval validation. NaviKey does not display the list of excluded taxa but the total number of taxa and number remaining are displayed. The use of software as web application is very convenient. Just fill in the title and subtitle of the project being developed in NaviKeyAppletWebpageTemplate. html using html editor (say Frontpage), upload the whole folder to your website, and provide a link to NaviKey.html page. As this page opens, the java application gets loaded and the program is ready for interactive identification.

NaviKey identifications are available for several families and genera of Flora of China and genus *Arisaema* (Guy Gusman & Eric Gouda) and Flowering Plant Families of Jamaica (Gerald Guala & Jimi Sadle).

XID (Expert Identification Systems)

XID Services Inc. produces commercial software with emphasis on biological sciences and is one of the leading providers of expert identification systems for major universities and botanical gardens in United States. XID offers two identification packages: **Pankey**, a DOS based identification program, and ***XID Authoring Systems***, Windows based databases and Program for Identification. The XID Authoring System allows authors to create their own "smart key" or random-access expert system for the identification of plants, animals, or any other object. The elegant simplicity of the XID System makes it extremely user friendly and is as useful for school teacher as for the professional scientist.

XID System allows the user to randomly select characteristics that are consistent with their specimen and skill level. If the user cannot decide upon a characteristic, he/she may query the program, which will provide a list of suggestions in order of ease of use, effectiveness, and items remaining. In general, much more data is included on each item/species than is necessary to identify it. With this abundance of data, the user can identify any of the items/species using the characteristics most obvious and easy to describe. With each characteristic entered by the user, the program eliminates all species that do not have the combination of features entered.

XID also offers 1000 **Weeds of North America** CD ROM. This is the most comprehensive weed identification reference ever published in North America. Contains 140 grass-like and 860 broadleaf weeds, features include Interactive key, color photos of all species, illustrated glossary of terms, page number references to over 40 weed reference books, searchable geographic data, and State level distribution maps.

Lucid Systems

Lucid software (Lucid3) is a commercial powerful and widely acclaimed Lucid Professional identification and diagnostic software developed by Centre for Biological Information Technology, The University of Queensland, Brisbane Australia. The Lucid3 system comprises a Builder and Player for creating and deploying effective and powerful identification and diagnostic keys. It allows creation of interactive, random-access keys that can be deployed over the World Wide Web or CD. The key when used for the identification of an unknown specimen progressively eliminates entities that do not match the chosen features until only one or a few possible entities remain. Further information and images can be accessed to confirm the identification.

The basic elements of a Lucid3 key are: a list of entities; a list of features and states that may be used to describe those entities; a matrix of score data for the features associated with each of the entities for the features; and various attachments (images, web pages, etc.) for the entities and features, to provide extra information to users.

The Lucid3 Builder provides all the tools necessary to create the entity and feature lists, encode the score data, and attach information files to items. The package in addition includes Lucid Phoenix, a computer based dichotomous or pathway key Builder and Player that enables traditional paper-based identification keys to be published on the Internet or CD. Phoenix keys are interactive, can be enhanced with multimedia, and delivered across the Internet seamlessly. Additional Fact Sheet Fusion software is a tool to facilitate the rapid generation of standardised fact sheets in HTML (Hyper Text Markup Language) or XML (eXtensible Markup Language).

ActKey

ActKey is a web based interactive identification program developed by Hong Song of the Missouri Botanical Garden. This Java-based program uses MySQL as the database server, and can handle data sets in DELTA, MS Excel, MS Access and Lucid formats. ActKey identification is available for the floras of China, North America, Madagascar, Borneo, at the Harvard University Herbaria Editorial Center, and hosted at **eFlora website**. Examples include several keys to the large and medium-sized genera of China (also in Chinese); the genera of Brassicaceae of the world by Ihsan Al-Shehbaz; *Salix* (Salicaceae) of North America by George W. Argus (also in Chinese); angiosperm families by B. Hansen and K. Rahn (also in Chinese and Spanish); Trilliaceae (*Trillium* and *Paris*) of the world by Susan B. Farmer, the generic tree flora of Madagascar by George Schatz, and the trees & shrubs of Borneo by James K. Jarvie & Ermayanti, respectively.

Meka

MEKA (pronounced "mecca") is an interactive Multiple-Entry Key Algorithm to enable rapid identification of biological specimens, now designed to run under Windows. The program, distributed free, is developed by Christopher Meacham, Jepson Herbarium, Berkeley, CA. The user picks character states that are present in the specimen from a list of possibilities. As the character states are scored by picking them, MEKA eliminates taxa that no longer match the list of scored character states. Different windows display different aspects of the underlying database. As the identification progresses the windows are updated automatically. An index screen makes it easy to find and score particular classes of character states. MEKA does not lead the user in a fixed stepwise progression through a series of questions. Instead, the user can perform identifications by scoring character states in any order. This makes it possible to identify specimens that are much more fragmentary than is possible with dichotomous keys. New Windows version includes a conversion function that can convert any MEKA key to the SLIKS (Stinger's Light Weight Interactive Key Software) format developed by Gerald Guala for Web-based identification. Thomas J. Rosatti has developed many Meka keys to California plants, and Prof. Knud Ib Christensen of the Botanic Garden of the University of Copenhagen key to Old World *Crataegus*.

SLIKS software is a small free Javascript program developed to facilitate the use of interactive keys. SLIKS is written in simple Javascript and runs over the web or locally on your machine. Users can download their own copy or use it from your web site. It runs through the web browser, so it is essentially platform independent.

IdentifyIt

IdentifyIt is identification software of comprehensive commercial **Linnaeus II** multifunctional research tool developed by ETI BioInformatics, for systematists and biodiversity researchers. It facilitates biodiversity documentation and species identification. Linnaeus II supports the creation of taxonomic databases, optimizes the construction of easy-to-use identification keys, expedites the display and comparison of distribution patterns, and promotes the use of taxonomic data for biodiversity studies. There are three 'modules' of Linnaeus II: the 'Builder' to manage your data and to create an information system, the 'Runtime' engine to publish completed information systems on CD-ROM/DVD-ROM, and the 'Web Publisher' to publish your completed project as a Web site.

The package offers three identification modules: **Text Key™**—an electronic version of written dichotomous keys, The **Picture Key™**—similar to the Text Key but picture-based, and **IdentifyIt™**, the most powerful identification tool. It is a multiple-entry key based on a matrix of taxa, characters, and character states. Unlike the Species and Higher Taxa, which hold text descriptions of the taxa, in IdentifyIt taxa are described in a more structured format: as a series of character states. This allows you to easily obtain answers to specific questions like, "Which species are red and/or white".

Pl@nt Net

Pl@nt Net is a tool to help to identify plants with pictures. It is developed by scientists from four French research organisations: Cirad, INRA, Inria and IRD and the Tela Botanica Network, with the financial support of Agropolis fondation. It is organised into different databases for ornamental and wild plants Major databases include Useful Plants, useful plants of Tropical Africa, Useful Plants of Asia, Western Europe, Canada, USA, and several other region. Among other features, this free app helps identifying plant species from photographs, through a visual recognition software. Plant species that are well enough illustrated in the botanical reference database can be easily recognized.

Electronic Lists, Pictorial Online Identification

In addition to these interactive Keys Illustrations of plants from various parts of the World as also the illustrations of economic plants are put up at various websites hosted by different institutions, particularly one supporting Virtual herbaria and eFloras. These illustrations are available for help in identification.

Several **electronic lists** are maintained by listservers. **Taxacom** is one such list very active on taxonomic matters, subscribed to by numerous active taxonomists all over the world. There is a regular exchange on matters of taxonomic interest. Any member with a problem can seek opinions from all members simultaneously. An unknown plant can be identified by sending its description to the list. Still better, a photograph or illustration of the unknown plant can be put up on a website with information to the members. The members may go to the website, observe the photograph or illustration and send their comments to the member concerned or the list itself. Many users are being benefitted through this web-based interaction.

Last few years have seen the spurt of internet-based exchange of information. **Efloraofindia** (formerly **Indiantreepix**) https://sites.google.com/site/efloraofindia/ is one of the biggest non-commercial website, based on photographic collection of plants. It is documenting flora of India that is being discussed on efloraofindia google e-group https://groups.google.com/forum/indiantreepix, devoted to creating awareness, helping in identification, discussion and documentation of Indian Flora. It also has the largest database on net on Indian Flora with more than 12,000 species (along with more than 3,00,000 pictures). It also includes species from other parts of world.

Flowers of India, another website at http://www.flowersofindia.net/, devoted to Indian Flowering plants has separate databases with links to different species having photographs, description, common names and regional names, arranged according to botanical names (sorted alphabetically or familywise) or common names. Plants of different categories such as Flowering trees, Orchids, Medicinal Plants, Garden Flowers, Bulbous plants, Himalayan Flowers can be accessed through separate links. New images are being continuously added after confirmation by experts. **Vascular plant image library** (http//botany.csdl. tamu.edu/FLORA/gallery.htm) was developed originally with support from Texas Higher Education coordinating Board as a part of Digital Flora of Texas. Links are provided family wise to the images of plant species in databases including Flowers of India, CalPhotos, Flora of Chile, Missouri plants, Floral images, Plants of Hawaii, Oregon Flora image project, and several individual image collections. **CalPhotos** is a huge database developed under a project of BSCIT of University of California, Berkeley, and contains more than 640,793 images of plants, animals, fossils, peoples and landscapes around the world. Nearly 360,414 images of plants can be browsed alphabetically and searched through easy criteria such as scientific name, common name, location, country and photographer.

Poaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Monocotyledonae
Order: Glumiflorae
Family: Poaceae
Characters of Poaceae:
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 or 3 minute scales (lodicules); stamens 3, versatile; carpel one, style 2 or 3, stigmas feathery, basal placentation; fruit caryopsis; testa fused with pericarp.
Common Plants of this family: *Triticum aestivum* (Bread wheat), *Oryza sativa* (Rice), *Zea mays* (Maize), *Hordeum vulgare* (Barley), *Sorghum vulgare* (Jowar), *Avena sativa* (Oats), *Pennisetum typhoides* (Bajra), *Saccharum officinarum* (Sugarcane), *Dendrocalamus*

Distribution of Poaceae:
The family is commonly known as grass family. It is one of the largest among the angiospermic families. It consists of 656 genera and 9975 species. The members are cosmopolitan in distribution. The plants represent all the 3 ecological types as hydrophytes, xerophytes and mesophytes. In India it is represented by 239 genera and 850 species.
A. Vegetative characters:
Habit:
Herbs, annuals or perennials or shrubs, sometimes tree like (*Bambusa*, *Dendrocalamus*).
Root:
Adventitious, fibrous, branched, fascicled or stilt (*Zea mays*).
Stem:
Underground rhizome in all perennial grasses, cylindrical, culm with conspicuous nodes and internodes, internodes hollow, herbaceous or woody, glabrous or glaucous, vegetative shoots are arising from the base of aerial stem or from underground stems are called tillers. Suckers and stolons are also found.
Leaves:
Alternate, simple, distichous, exstipulate, sessile, ligulate (absent in *Echinochloa*), leaf base forming tubular sheath, sheath open, surrounding internode incompletely, ligule is present at the junction of the lamina and sheath, entire, hairy or rough, linear, parallel venation.
B. Floral characters:
Inflorescence:
Compound spike which may be sessile or stalked. Each unit of inflorescence is spikelet. The spikelets are arranged in various ways on the main axis called rachilla. A compound inflorescence may be spike of spikelets (*Triticum*), panicle of spikelets (*Avena*).
The spikelet consists of a short axis called rachilla on which 1 to many sessile or short stalked flowers 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 placed 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. Above the glumes a series of florets are present. Each floret has an inferior palea or lemma and above it a superior palea. The lemma frequently bears a long, stiff hair called awn.
Flower:

Small, Inconspicuous, Bracteate and bracteolate, sessile, incomplete, hermaphrodite, or unisexual (*Zea mays*), irregular, zygomorphic, hypogynous, cyclic.

Perianth:

Represented by membranous scales called the lodicules. The lodicules are situated above and opposite the superior palea or may be absent, or many (*Ochlandra*), or 2 or 3.

Androecium:

Usually stamens 3, rarely 6 (*Bambusa*, *Oryza*) and one in various species of *Anrostis*, *Lepturus*; polyandrous, filaments long, anthers dithecous, basifixed or versatile, linear, introrse; pollen grains dry.

Gynoecium:

Monocarpellary, according to some authors carpels 3, of which 2 are abortive, ovary superior, unilocular with single ovule, basal placentation, style short or absent; stigmas two, feathery or papillate and branched.

Fruit:

Caryopsis (achene with pericarp completely united or adherent with the seed coat) or rarely nut (*Dendrocalamus*) or berry (*Bambusa*).

Seed:

Endospermic and containing a single cotyledon called scutellum, which is shield shaped and pressed against the endosperm.

Floral formula: Br $\circ|\circ\ \mathbb{\Psi}\ P_{0 \text{ or } 2 \text{ (Lodicules)}}\ A_{3 \text{ or } 6}\ \underline{G}_{1}$

Economic Importance of Poaceae:

The family stands first and foremost in respect of economic importance in whole of Angiosperms. The staple food grains of the population of world is derived from *Oryza sativa* (Rice) and *Triticum aestivum* (Wheat). They are cultivated from time immemorial.

The family has been divided on economic basis as follows:

Food: *Triticum aestivum* (Bread wheat), *Oryza sativa* (Rice), *Zea mays* (Maize), *Hordeum vulgare* (Barley), *Sorghum vulgare* (Jowar), *Avena sativa* (Oats), *Pennisetum typhoides* (Bajra) are cultivated for cereals, Millets and food grains.

Fodder: Many grasses as *Cynodon dactylon*, *Panicum*, *Cymbopogon*, *Agrostis*, *Poa* are grown for fodder.

Sugar: *Saccharum officinarum* (Sugarcane; H. Ganna) is cultivated for Jaggery and sugar. Molasses, a by product formed after sugar processing is used for Alcohol manufacturing.

Building material: Some species of *Bambusa* e.g. *B. tulda*, *B. vulgaris* are used for scaffolding, thatching huts etc.

Furniture: Species of *Dendrocalamus* (H. Bent), *Arundinaria*, *Melocalamus* are used in manufacture of furniture.

Aromatic grasses: Many grasses yield scented oils which are used in perfumery viz. *Vetiveria zizanioides* (H. Khus khus) yields vetiver oil from the roots. The roots are also woven into curtains. *Andropogon odoratus* (Ginger grass), *Cymbopogon citratus* (Lemon grass), *Cymbopogon martini* (Geranium grass), *Cymbopogon jawarancusa* etc. also yield oil.

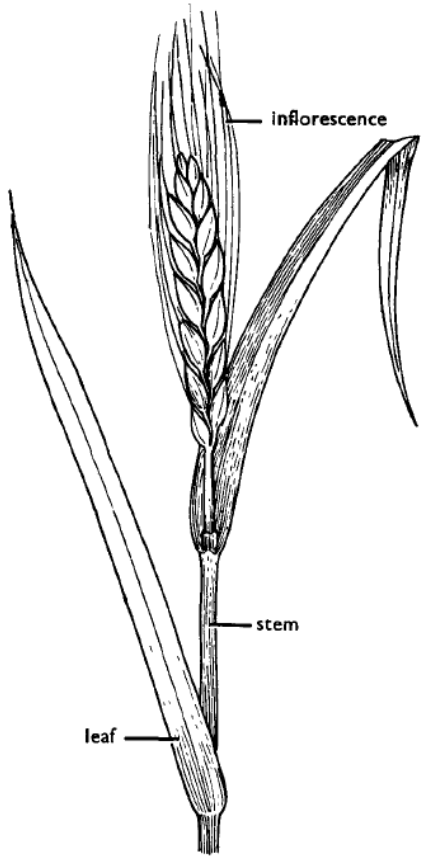
Medicinal: *Phragmites karka*, *Cymbopogon schoenanthus* etc. are medicinal. *Secale cereale* is cultivated for infection of its inflorescence by *Claviceps purpurea* for production of Ergot and for extraction of ergotine. Ergotine is an excellent remedy for uterine contraction.

Paper: It is manufactured from certain species of grasses and bamboos.

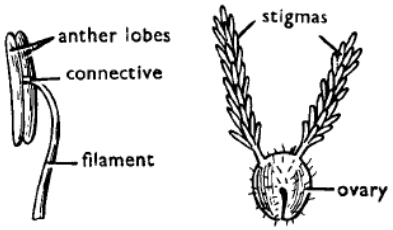
Fibres: Several grasses are source of hard fibres (Leaf fibres), e.g., Erianthus munja, Saccharum munja, S. spontaneum are used for making ropes or cordages.

Ornamental:

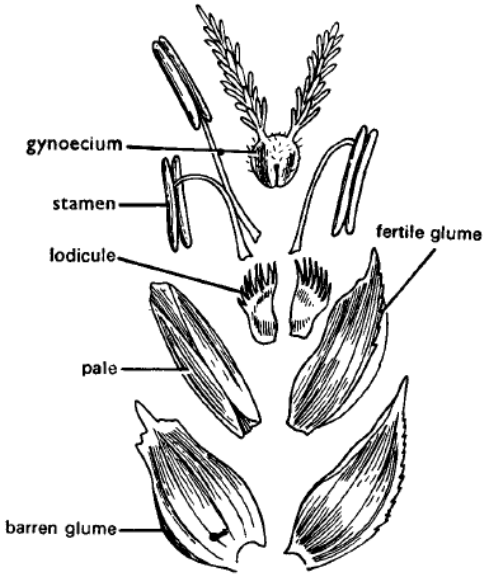
Rhynchelytrum repens, *Cortaderia selloana* and some species of the tribe Bambusoideae are ornamentals. Besides these a number of grasses are grown to form fine lawns, play grounds etc.



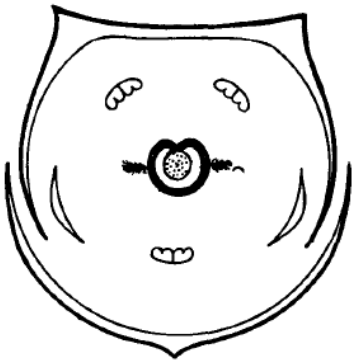
A FLOWERING TWIG



STAMEN GYNOECIUM



A DISSECTED SPIKELET



FLORAL DIAGRAM

Fig. 84. ***Triticum aestivum.***

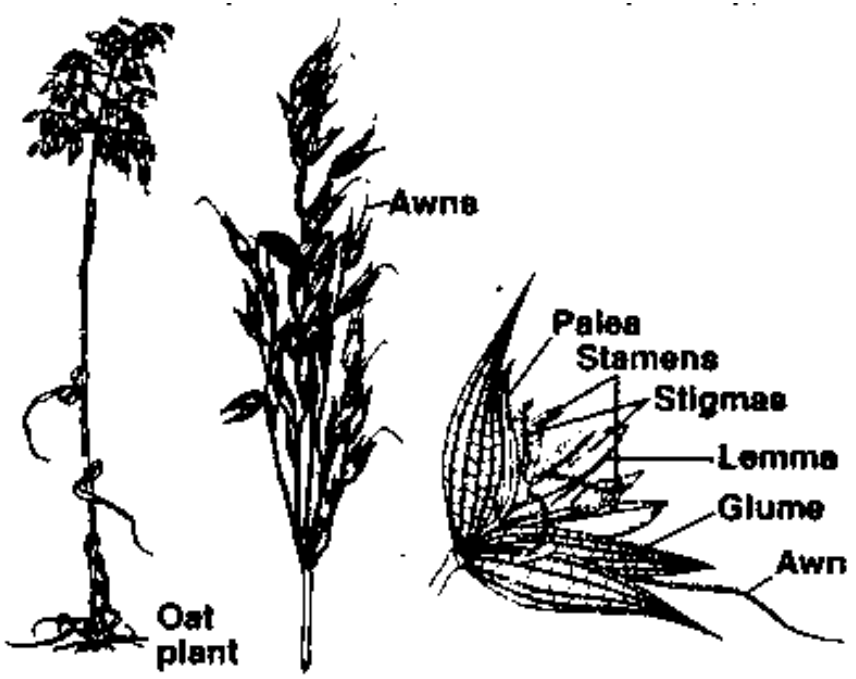


Fig: Oat plant

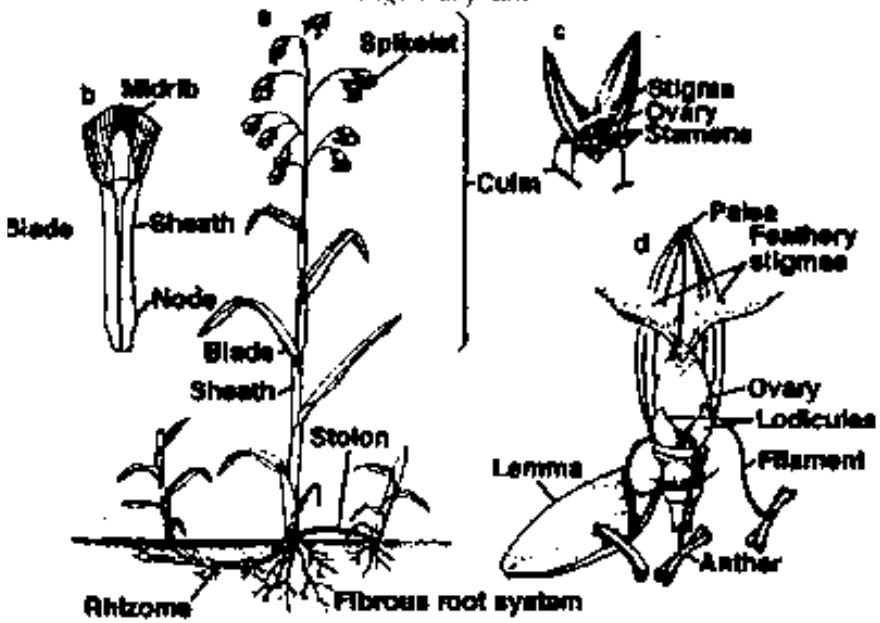


Fig: Generalized grass plant

Areceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Monocotyledonae
Order: Principes
Family: Poaceae
Characters of Arecaceae:
Mainly trees with stout unbranched stem ending in crown of leaves; leaves large, compound, alternate, young leaves are plicate, exstipulate with long petioles; inflorescence enclosed in a persistent spathe; flowers unisexual; perianth 6 in two whorls of 3 each; in male flower 6 stamens in two whorls, anthers versatile; in female flowers carpels three, apocarpous or syncarpous, superior, trilocular or rarely unilocular; fruit berry or drupe; seed endospermic.
Common Plants of this family: *Areca catechu, Cocos nucifera, Phoenix, Borassus*
Distribution of Arecaceae:
The family is commonly known as "Palm family". It includes 217 genera and 2500 species. The members are confined to tropics in both the hemispheres and extending in the warmer regions of the world. In India it is represented by 225 species belonging to 28 genera.
A. Vegetative characters:
Habit: Large unbranched trees (*Phoenix*, *Areca catechu*), shrubs or garden palms, trailing (*Calamus*), herbs (*Reinhardtia*).
Root: Adventitious roots arising from the base of bulbous stem. Thick aerial roots are also found in some species of *Manicaria*.
Stem: Aerial, woody, erect, unbranched, very rarely branched, (*Hyphaene*), in some short rhizome (*Nypa*), cylindrical, hairy, old stem protected by woody leaf bases, climbing (*Calamus*).
Leaves: Alternate crowded at the apex of stem giving palm like appearance to the plant; petiolate, leaf-base sheathing, broad and persistent; exstipulate, compound pinnately (*Phoenix*, *Areca*), palmately (*Borassus*), acute, thick, leathery, parallel venation. In some palms (*Copernica*) the petiole is prolonged into a ligule like structure called histula.
B. Floral characters:
Inflorescence: It is simple or compound, spike or branched panicle, usually a spadix with a woody spathe which opens by two valves; spadix may have sessile or pedicellate flowers, simple racemose (*Borassus*), or compound racemose (*Cocos*) or even profusely branched panicle (*Daemonorops*).
Flower: Sessile or shortly pedicellate, bracteate, mostly unisexual (*Phoenix*) or hermaphrodite (*Livingstonia*), actinomorphic, incomplete or complete, hypogynous trimerous, flowers are of small size and produced in large numbers. Plant may be monoecious or dioecious.
In monoecious flower the position of male and female flowers is variable i.e. male flowers at the base or at the apex and the female flowers at the upper part (*Ruffia*, *Raphis*) or male and female flowers are inter-mingled or female flowers in the centre, made on the either side as the *Cocos*, *Caryota*.
Perianth: Tepals 6, in two whorls of 3 each, polyphyllous or slightly connate at the base; perianth lobes tough, persistent, coriaceous, leathery or fleshy, valvate or imbricate aestivation, white or petaloid.
Androecium: In male or hermaphrodite flowers, stamens are 6 in number, two whorls of 3 each, polyandrous, staminodes may be present in the female flowers; anthers versatile, dithecous, basifixed or dorsifixed, introrse, filament short and distinct.
Gynoecium: In female or hermaphrodite flower-carpels 3 in number, apocarpous or syncarpous, ovary superior, trilocular, axile placentation, single ovule in each loculus; style short, stigma small or broad or 3 lobed.

Fruit: Usually a berry, fleshy or fibrous waxy coating on the fruit; the mature fruit contains a single seed (*Phoenix*); drupe (*Cocos nucifera*).

Seed: Endospermic.

Pollination: Anemophilous or entomophilous.

Floral formulae – Male flower : $\oplus\ \delta\ P_{3+3}\ A_{3+3}\ G_0$

Female flower : $\oplus\ ♀\ P_{3+3}\ A_0\ G_{\underline{(3)}\ or\ \underline{3}}$

Hermaphrodite flower : $\oplus\ ☿\ P_{3+3}\ A_{3+3}\ G_{\underline{(3)}\ or\ \underline{3}}$

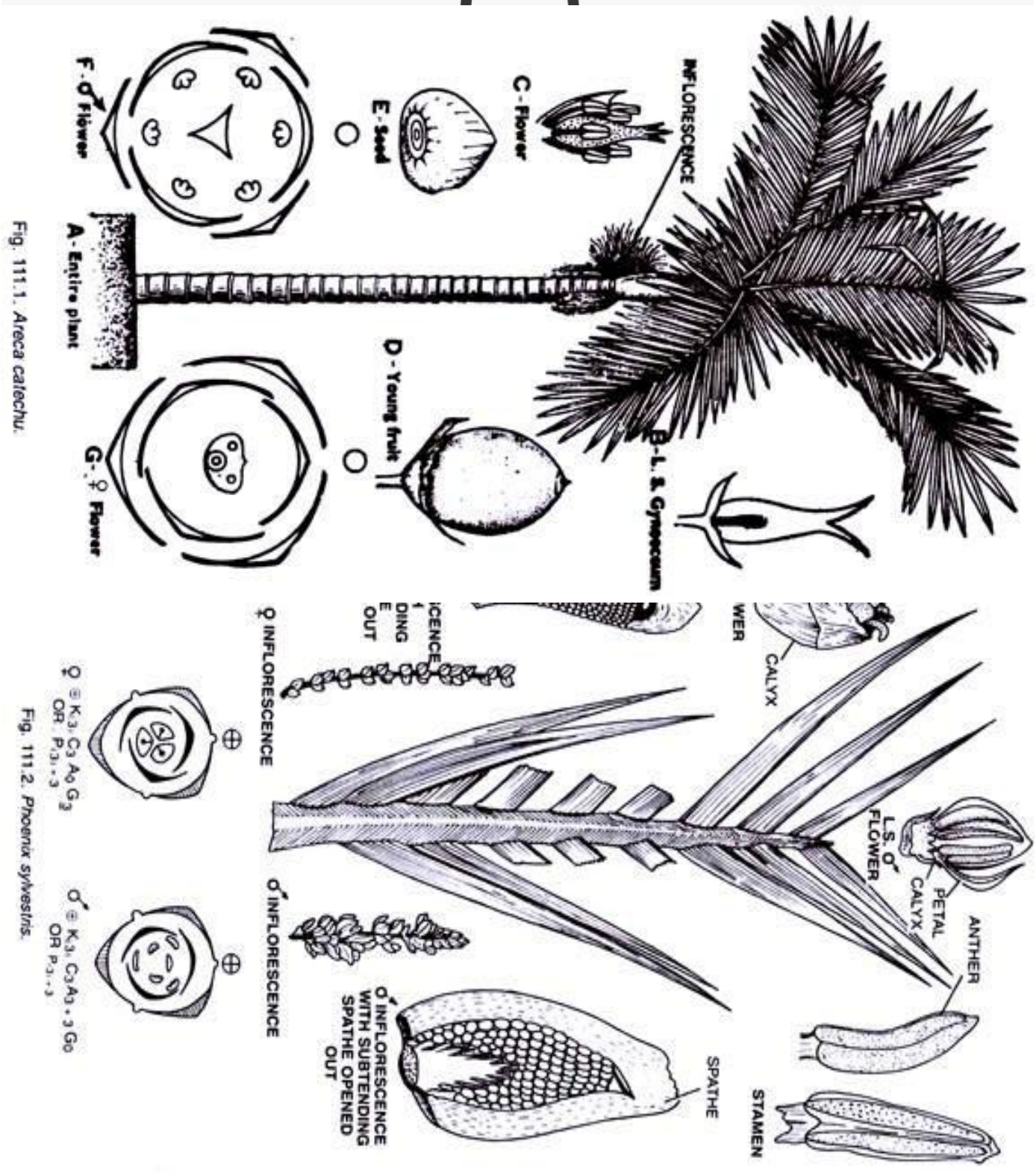


Fig. 111.1. *Areca catechu.*

Fig. 111.2. *Phoenix sylvestris.*

Economic Importance of Arecaceae:

1. Food: Pith of *Metroxylon rumphii* and *M. leave* (Sago palm) yield sago of commerce. The sap of *Borassus* yields a sugar, which on fermentation gives alcoholic drink "Toddy". Fruits of *Phoenix dactylifera* are very delicious and eaten throughout the Arab world. The nuts of Areca catechu serve as a asteringent and used with betel leaves. The milk of *Cocos nucifera* makes a refreshing drink, endosperm is eaten raw and stored when dry.

2. Medicinal: Tender leaves of *Calamus travancoricus* are given in bilousness, worms and dyspepsia.

3. Fibres: Mesocarps of the drupes of Coconut are extensively used for stuffing pillows and sofa sets. The cane of commerce is obtained from *Calamus tenuis* and *C. rotang* and are used for making mats, baskets and other furniture.

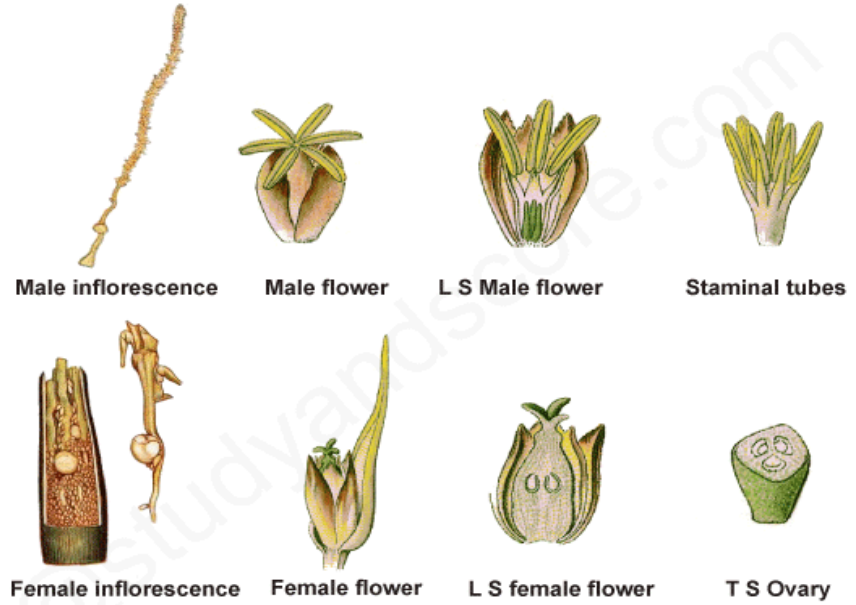
Borassus flabellifer – yields palmyra fibres which are used to prepare brushes and brooms. The leaves are used in the manufacture of hand fans, umbrellas, baskets and mats.

4. Wax and oil: Wax is obtained from the leaves of *Copernicia cerifera* and *Ceroxylon andicola*. The wax is used in making gramophone records, candles and models.

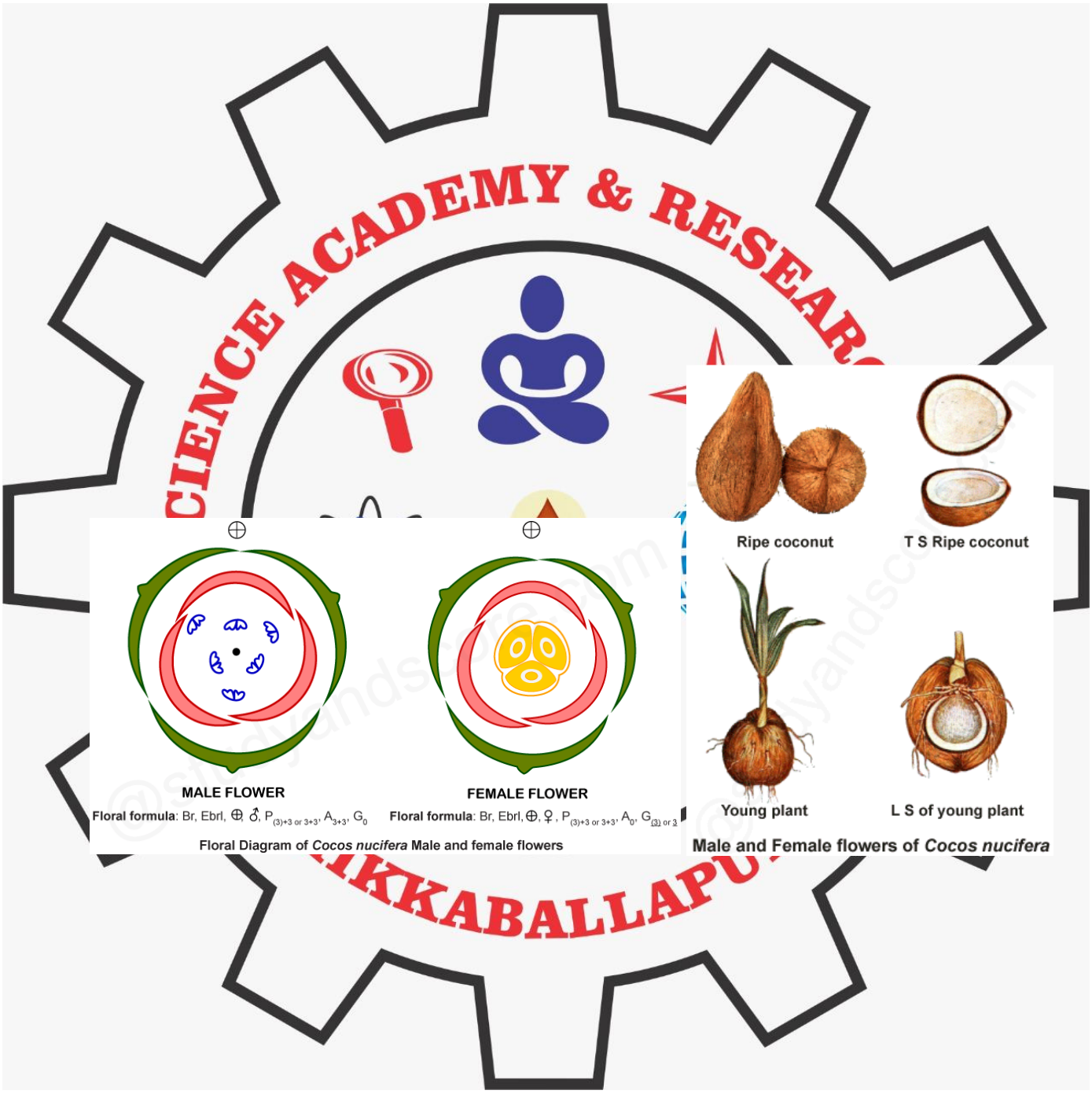
Coconut oil is obtained from the *Cocos nucifera* and is used as hair oil, in soap industry and also for cooking.

5. Ornamentals: *Roystonea regia* (Royal palm), *Corypha elata* (Talipot palm).

Vegetative characters of *Cocos nucifera*



Male and Female flowers of *Cocos nucifera*



RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

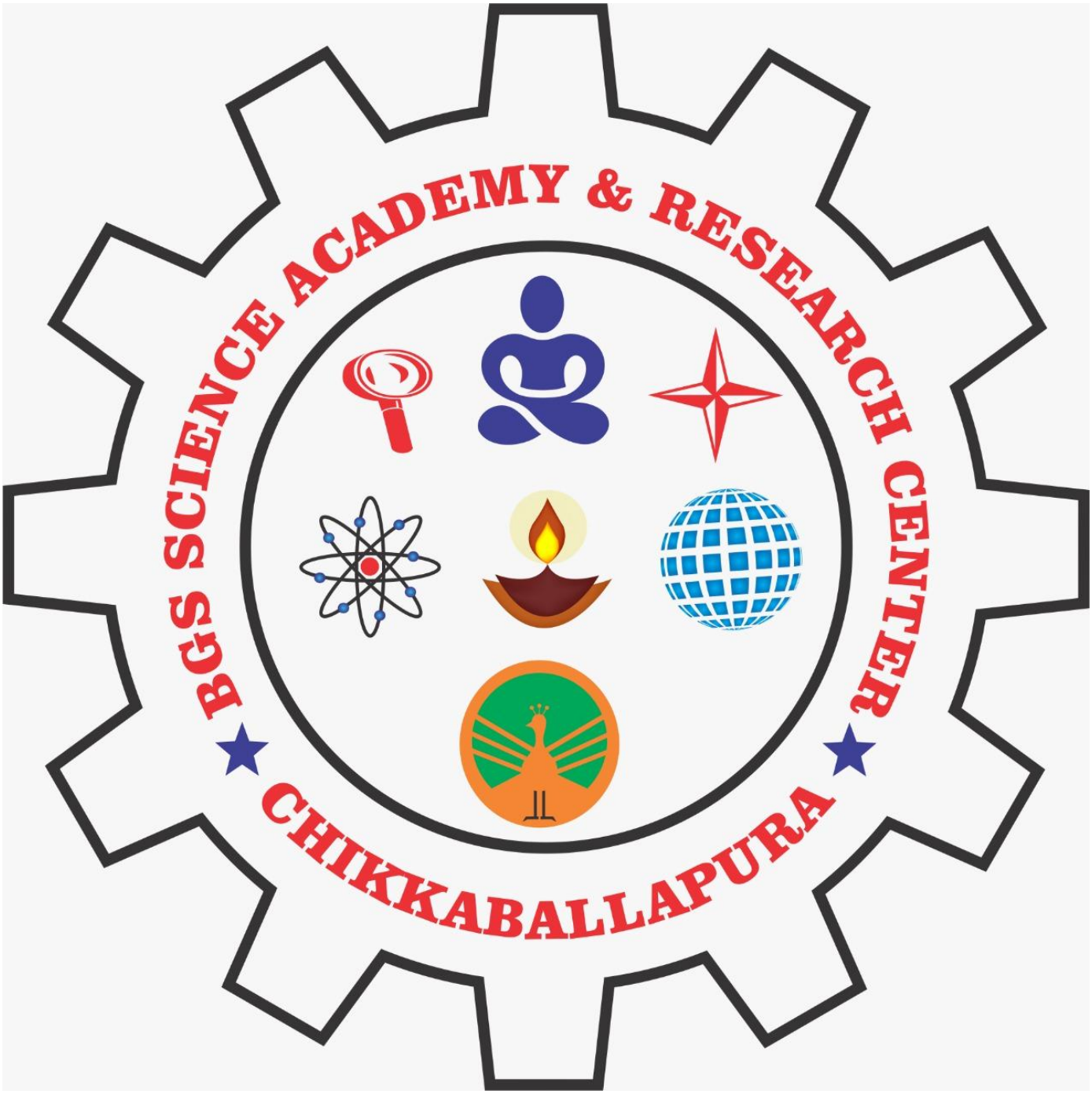
Musaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Monocotyledonae
Order: Scitaminae
Family: Musaceae
Characters of Musaceae
Plants are large herbs with false stem, or trees, leaves large, compound inflorescence with large often petaloid bracts; Flower zygomorphic, hermaphrodite or unisexual, perianth 3+3, petaloid, often united, stamens 3+2 and staminode, gynoecium tricarpellary, syncarpous, inferior, trilocular with 1 to indefinite ovules in each locule, fruit berry or capsule, seed endospermic, often with perisperm.
Common Plants of this family: *Musa paradisiaca*, *Ravenala*, *Heliconia*
Distribution of Musaceae:
The family is commonly known as Banana family. It is a small family comprising of 3 genera and 40 species. It is distributed in tropical Africa, Asia and Australia. In India the family is represented by a single genus Musa and 10 species and are found growing in Assam, Western Ghats, South India, and Himalayas. *Musa* has 33 species, *Ensete*- 6 species, and *Musella*-1 Species.
A. Vegetative characters:
Habit: Plants are gigantic herbs, perennial, may attain a height of 5 meters.
Root: Adventitious arising from rhizome and multiply by suckers.
Stem: Underground rhizome, perennating, branched, from which the many naked leaves spring. The sheaths of the leaves are rolled round one another below, and form, what looks like an aerial stem. The aerial pseudo stem is tall, stout and un-branched.
Ravenala has woody arboreal stem reaches nearly 30 metres in height.
Leaf: Large and oval, simple, stalk and sheath long and broad, blade oblong, end blunt; leaf blade when young is convolutely rolled up; midrib stout, parallel veins running from it to the edge, pinnate parallel venation.
B. Floral characters:
Inflorescence: The aerial stem terminates in an inflorescence. Simple or compound, spike or panicle, or panicle spadix with several woody or leathery bracts, large, sometimes coloured; each spathe enclosing clusters of flowers in two rows, which are arranged in uniparous cyme.
Flower: Large, brightly coloured, generally trimerous, unisexual or bisexual, when monoecious, male flowers usually at the upper end of the inflorescence and the female at the lower bracts; zygomorphic, epigynous, incomplete, plenty of honey present.
Perianth: Tepals 5, in two rows of three each, or coherent, petaloid, unequal in shape and size, superior. In *Musa* five tepals united into a tubular structure while the sixth posterior tepal is free and boat shaped.
Androecium: In hermaphrodite and male flowers stamens six, – all fertile (*Ravenala*), usually 5 fertile one posterior stamen is absent or staminode (*Musa*), filament filiform, free, stiff and attractive, anthers dithecous, linear, introrse, dehiscence by vertical slits.
Gynoecium: Tricarpellary, syncarpous, inferior, trilocular, ovule one and basal (*Heliconia*) or numerous with axile placentation; style single, filiform; stigma trilobed.
In male flower rudiments of ovary in the form of nectary is often present.
Fruit: Elongated berry (*Musa*), capsule (*Ravenala*), schizocarpic (*Heliconia*).
Seed: Hard, arillate, deeply coloured, endospermic or non-endospermic, yellowish perisperm. In cultivated varieties seeds are absent and propagation by rhizomes.
Pollination: Entomophilous due to coloured spathe and honey. Sometimes ornithophilous (by birds).

Floral formulae:

Male flower : Br o|o $\delta P_{(3+2)+1 \text{ or } 3+3 \text{ or } (3+2)+1} A_{3+2+1 \text{ stamnode}}$

Female flower : Br o|o $\varphi P_{(3+2)+1 \text{ or } 3+3 \text{ or } (3+3)} \underline{G_{(3)}}$



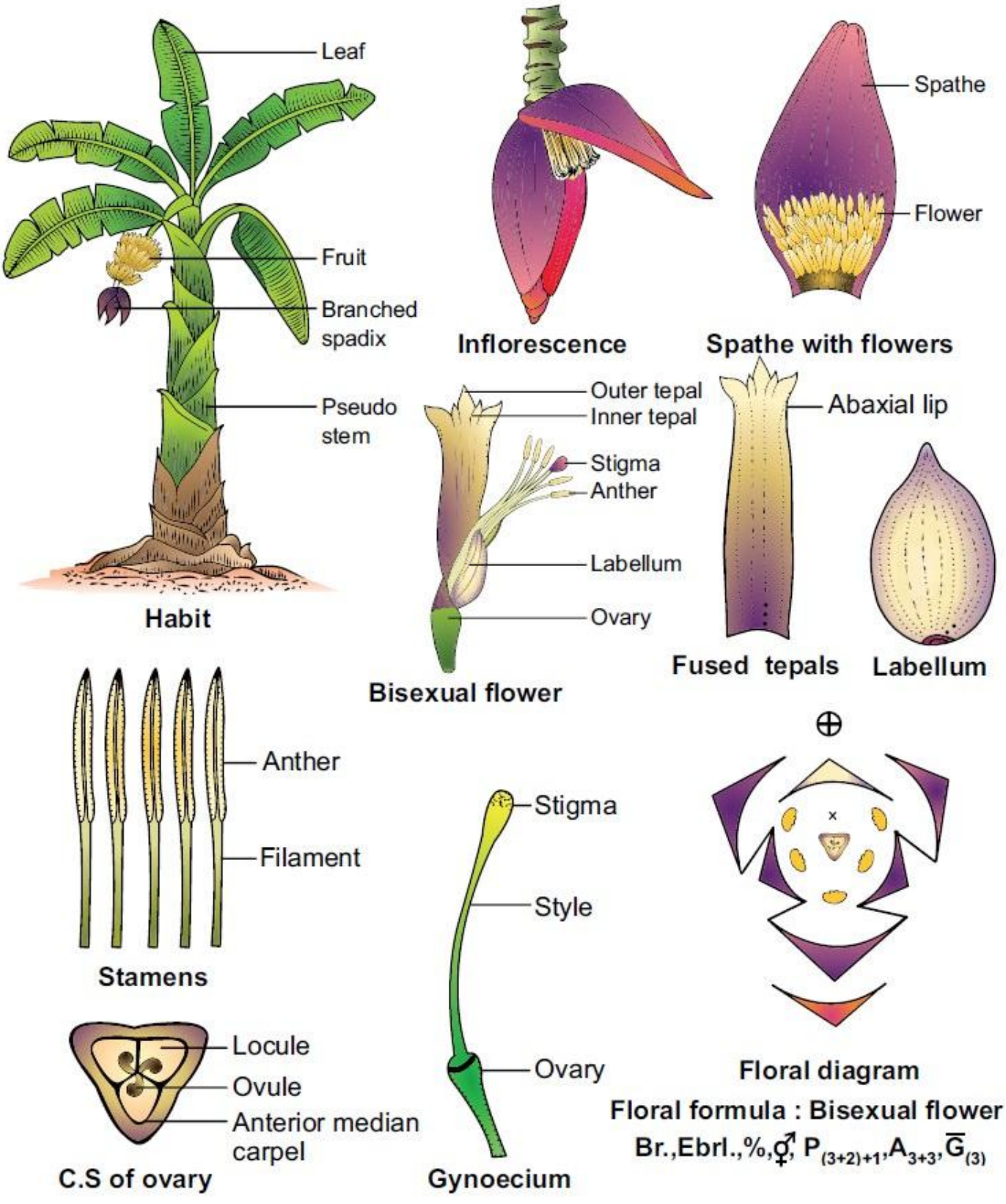


Figure 5.24: *Musa paradisiaca*

Economic Importance of Musaceae:

1. Food: The genus *Musa* is of great economic value and possesses several very important species and varieties. It is extensively cultivated in tropics and subtropics for its edible fruits.

The fruit of *Musa paradisiaca* subspecies *sapientum* (Banana H. Kela) when ripe is eaten as fruit.

The unripe fruits of banana are dried and ground to form plantain-meal. The green bananas are used as vegetables and are useful in Diarrhea and Dysentery.

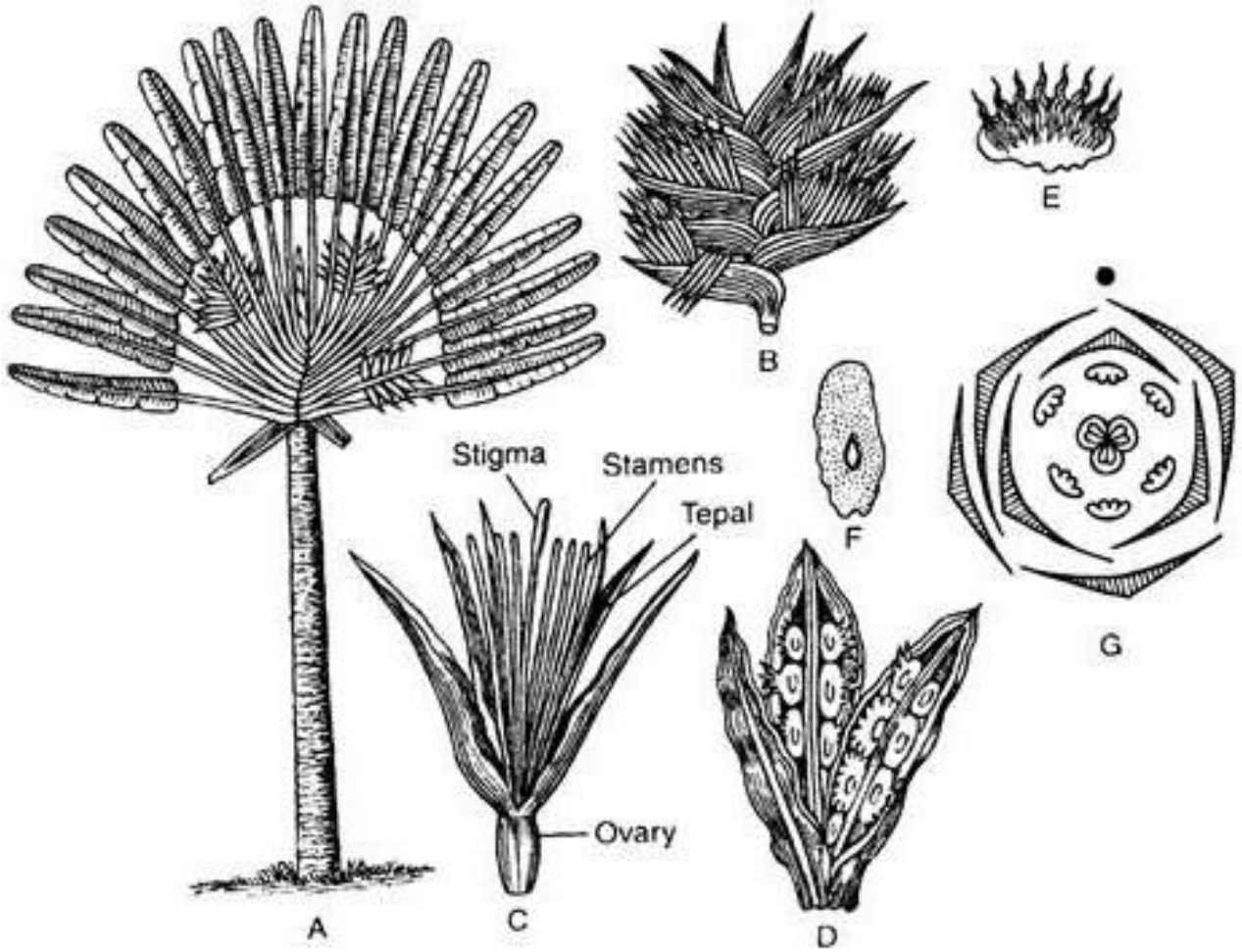
Banana is a good source of digestible starch. The ripe fruits are used as diet in diabetes, Uremia, Nephritis, Gout, hypertension, dysentery and cardiac diseases. It is also used in preparation of alcoholic drinks-banana wine. Fruits of *M. chinensis* are sweet and edible.

2. Medicinal: The roots and stems of *M. paradisiaca* are used as tonic in blood and venereal diseases. The juice of flowers mixed with curds is used in dysentery and menorrhagia. The sap of stem is used in nervous diseases like hysteria and epilepsy. The banana powder is used s baby food and manufacture of chocolates and biscuits.

3. Fiber: From the sheathing leaf bases of *Musa textilis*, a very useful fibers are extracted, which are woven into abaca cloth, used for making marine ropes, bags and wrapping papers. The fiber is called manila hemp or abaca.

4. Industrial: After distillation, the fruit pulp is used in dyeing of cotton, leather and even wood. After burning of dried fruit skin of *Musa sapientum* the ash or residue so obtained is very rich in potash and is largely used in soap industry.

5. Other: The leaves of *Musa* are used as plates in S. India.



157 : Musaceae (*Ravenala madagascariensis*), Travellers tree : A. Single plant showing woody stem, B. Portion of inflorescence, C. Flower, D. Fruit split open, E. Seed with comb-like aril, F. L.S. of seed, and G. Floral diagram

Orchidaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Monocotyledonae
Order: Microspermae
Family: Orchidaceae

Number and Distribution of Orchidaceae:

This family consists of about 450 genera and 10,000 – 15,000 species widely distributed in the tropical and temperate regions of the world. This is the largest family of Monocot and second largest in angiosperm (flowering plants). It is only in the Eastern Himalayas, Burma and Malaya Peninsula that the family predominates.

General Characters of Orchidaceae:

Plants—perennial herbs, terrestrial or epiphytic, a few saprophytic (e.g. *Didymoplexis*) deriving their nourishment from humus since their roots or rhizomes are associated with endotropic mycorrhiza rarely climbers (e.g. *Bulbophyllum*).

Roots—the main root is always absent, its place being taken by adventitious roots which arise especially from the nodes; they are generally of three kinds:

(1) Normal cylindrical earth-roots.
(2) Tuberous roots which serve for storage of reserve food materials and
(3) Aerial roots in which the epidermis is specially developed to form the velamen, special water-absorbing tissue, rarely absent.

Leaves—thick, usually alternate with closed sheaths. Inflorescence—raceme or spike. Flowers—bisexual, epigynous, medially zygomorphic, usually very showy. Perianth—free, 3 + 3, the outer consisting of 3 sepals, more or less similar, and the inner of 3 petals, more or less dissimilar; the two lateral petals are alike and resemble the sepals but the median petal is usually much larger and known as the labellum or lip; the labellum is provided with a spur, variously shaped and normally posterior in position but becomes anterior by the twisting of the ovary.

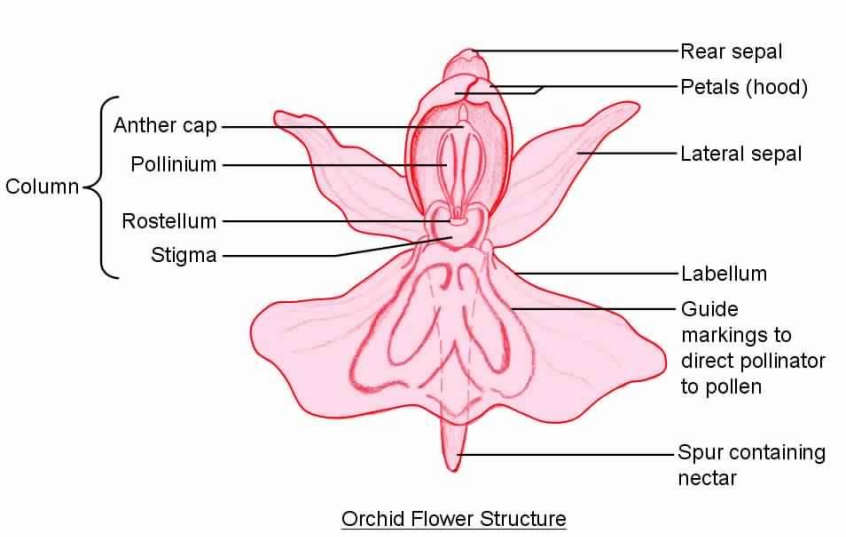
Stamen—1 (in Monandrae) or 2 (in Diandrae) in Monandrae the column bears an anther at the top and just under it there is a more less projecting beak, the rostellum and under this there lies two fertile stigmas which are more or less united into one; but in Diandrae the three stigmas are united into one, on which the two anthers are placed and there is no rostellum. (The rostellum is only the projecting portion of the stigma; it is itself functionless but bends over and conceals the receptive portion of the stigmatic surface.)

The filament is united with the style (gynandrous) forming a column or gynostegium; pollen grains granular, or powdery, more frequently united into masses called pollinia, 2-8 in number and each pollinium bears a cord, the caudicle, which ends in sticky discs or glands known as retinacula.

Carpels—(3); ovary inferior, usually twisted, 1-celled with three double parietal placentae bearing many ovules; stigmas 3, sticky, situated below the rostellum and facing the labellum. Fruit—capsule. Seed— very numerous, minute, exalbuminous. Embryo—undifferentiated.

Floral Formula of Orchidaceae:

$$\uparrow \ \delta \ P_{6(3+3)}, A_{1 \text{ or } 2}, \underline{G}_{(3)}$$



Orchid Flower Structure

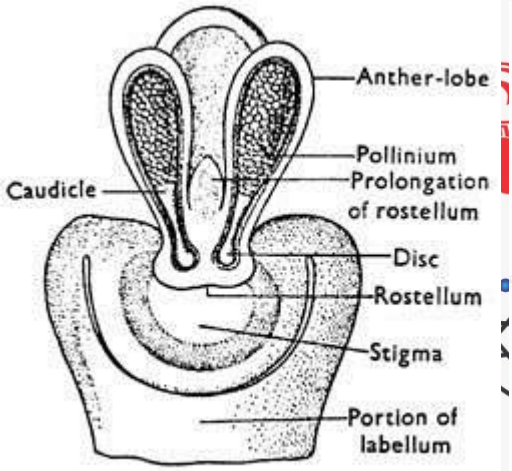


Fig. 4.152 : L.S. of an Orchid flower

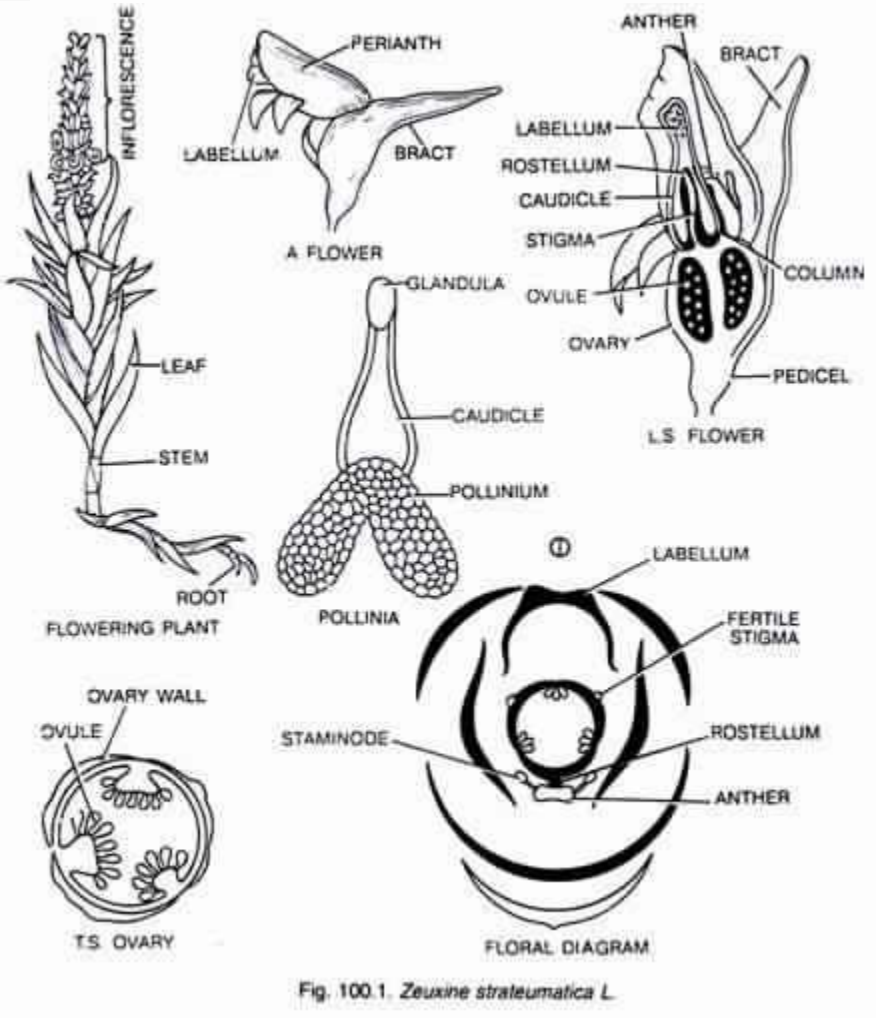


Fig. 100.1. *Zeuxine strateumatica* L.

Range of Floral Structures in Orchidaceae:

A wide variation occurs in the floral structures of this family.

The sepals and petals may be quite different in form or they seem to be almost alike. The sepals are generally minute and indistinct but sometimes become somewhat conspicuous and larger, as in *Masdevallia*. The sepals may be free or more or less united. The odd sepal becomes spurred in *Disa*, but in *Haemaria*, it joins with the lateral petals forming hood-like structure.

Variation in the form of petals is also noticeable. The lateral petal is obliterated in *Coryanthes*, but in *Epicranthes* the petals are usually filiform. The petals become usually smaller than the lip, but sometimes become larger, as in *Oncidium*. In *Cypripedium*, the petals look like narrow ribbon and occasionally they are one yard long.

In *Disa*, the labellum becomes sometimes minute and narrow or becomes large with spreading limbs, as in *Odontoglossum*, or they are curved, as in *Cattleya*. The labellum becomes slipper-like in *Cypripedium*, but in *Coryanthes* it assumes a bucket-like structure. The spurred petals may or may not be present. The origin of the spur is supposed to have been derived from the lip (labellum) or partly from the floral axis.

The incision of the lip may be various; it becomes either trifid or tripartite or the middle segment of the lip becomes 4-partite when re-divide or it may often represent the simplest type of lip which conform to the structure of the lateral petals, such as, in *Thelymitra*.

The odd member of the outer whorl of stamens, which is situated opposite the sepal, becomes generally fertile but a fleshy staminode is formed by that very stamen, as in Cypripedium and allied genera. In *Arundina pentandra*, they are found to be present and fertile, but in Diuris, they assume the form of leaf-like staminodes. In *Orchis*, they are represented by small auricles.

The lateral pair of the inner whorl of stamens becomes fertile, as in Cypripedium, but in others they form staminodes of different shapes, such as *Epipactis*, or are foliaceous, as in *Thelymitra*.

The anther may become erect and free on the top of the column, as in *Ophrys*, *Orchis* and others, but generally it becomes bent over the inner face of the latter. In *Coelogyne*, the anther seems to be hanged downwards vertically from the apex.

The union of column with anther may also vary. In the tribe Ophrydeae, it is provided with a broad, short filament from which it is quite inseparable. The anther remains strongly coherent with the column and it is not pulled off with the removal of pollen.

The anthers are either 2-, 4- or 6-chambered which correspond to the number of pollen masses. Pollen masses become either granular or powdery, as in *Cephalanthera*, or they are found to be united in packets by some sort of elastic net, as in *Orchis*, or waxy pollinia being united in a chamber are formed in *Cattleya*. A slender process is often formed by the drawing out of the lower part of the anther on each side and ultimately this process covers the lower sterile portion (caudicle) of the pollinium.

All three stigmas become functional in Cypripedeae and Apostasieae, but in some cases the lateral pair, the third being sterile and finally forms the rostellum. The stigmas originate as smooth, viscous, flat or cushion-like spots on the inner side, or sometimes on the end of the column, or often forms special processes that are carried up on the style-like projection, as in *Habenaria*.

The ovary manifests wide variations, but it is usually cylindrical or spindle-shaped. The ovary is often provided with longitudinal lines, ridges or wings which later on become more prominent with the ripening of the fruits.

The Orchids represent inferior and 1-locular ovary which bears numerous small ovules borne on three double parietal placentae.

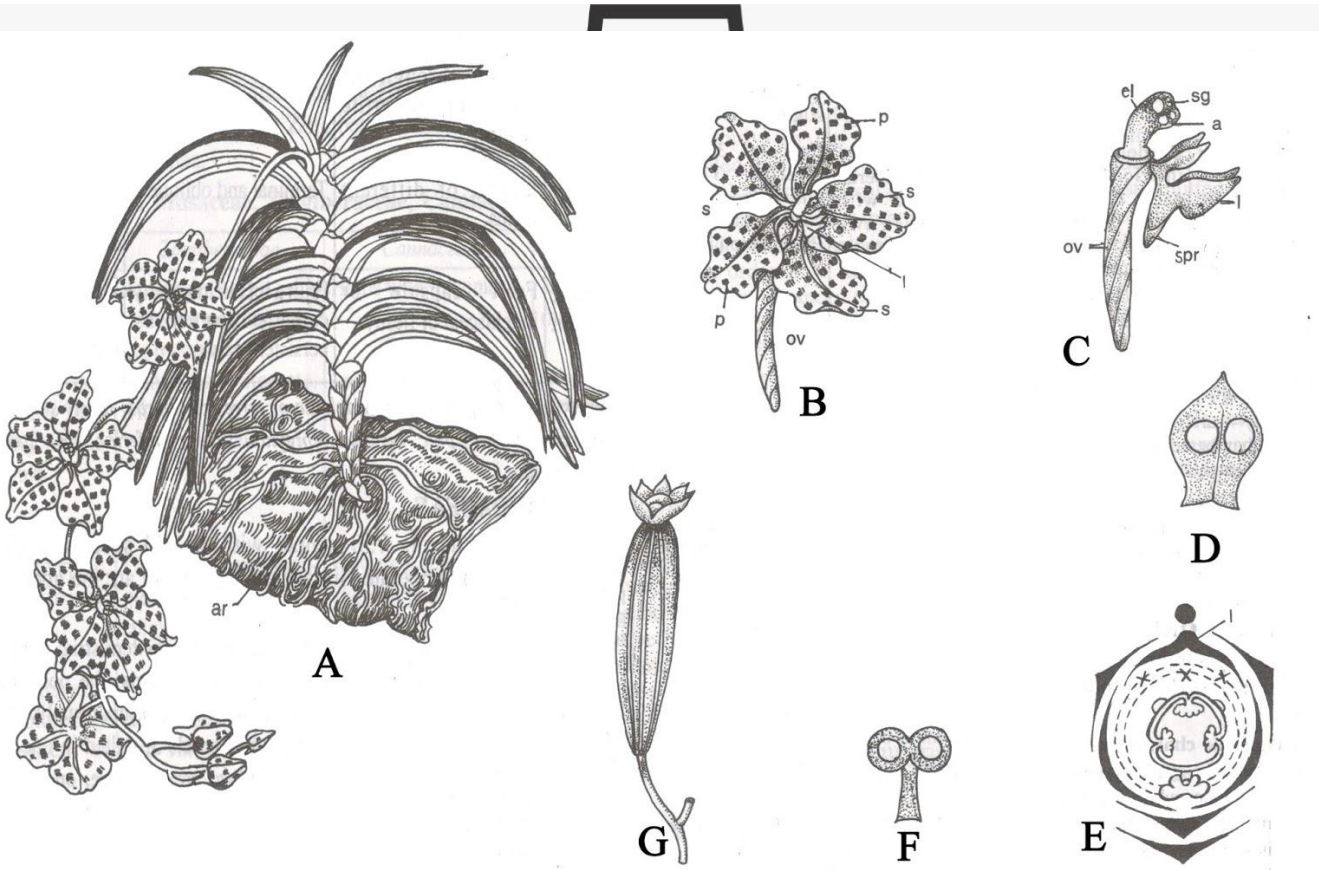


Fig: ***Vanda tessellate*** **(Orchidaceae).** (A) Plant showing habit, (B) Flower, (C) Flower with sepals and petals removed showing labellum,(D) Stamen, (E) Floral Diagram, (F) Part of ovary with column, (G) Fruit.

Magnoliaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Ranales
Family: Magnoliaceae

Characters of Magnoliaceae:

Trees and shrubs; two ranked stipulate leaves, stipules enclose young buds; flowers hermaphrodite, actinomorphic, large; perianth usually trimerous, whorled or spiral; stamens and carpels numerous; apocarpous, spirally arranged on elongated axis, fruit an etario of follicles or berries, sometimes samara.

Number and Distribution of Magnoliaceae:

Magnoliaceae or the *Magnolia* family embraces 10 genera and about 100 species. The members of this family belong to the temperate regions of northern hemisphere, with centres of distribution in eastern Asia, Malaysia, eastern North America, West Indies, Brazil and North-east and south east India.

Examples:- *Michelia*, *Magnolia*, *Illicium*, *Schisandra* etc.

A. Vegetative Characters:

Habit: Trees or shrubs sometimes climbing. Oil sacs present in stem and leaves.

Root: Taproot, branched.

Stem: Erect, aerial, woody, branched.

Leaves: Alternate, simple, entire, commonly ever-green, coriaceous, stipules large (*Magnolia*) covering young leaves.

B. Floral Characters:

Inflorescence: Solitary terminal or axillary.

Flower: Largest and sometimes, 25 cm in diameter (*Magnolia*, *Fraseri*), complete, regular, actinomorphic, unisexual (*Drimys*), usually bisexual, hypogynous, aromatic. Floral axis (torus) long to long convex.

Perianth: Nine to many, free, all alike and petaloid or the three outer ones green (*Liriodendron*), arranged in whorls of three, imbricate and cyclic (*Magnolia* and *Michelia*) or acyclic (spiral) arranged on an elongated or semi-elongated convex torus, free, inferior.

Androecium: Stamens many, free, often spirally arranged in a beautiful series, filaments short or absent, anther lobes linear, with a prolonged connective.

Gynoecium: Carpels numerous, free, superior, arranged spirally on a cone-shaped elongated thalamus (gynophore), rarely carpels are fused, e.g., *Zygogynum*, placentation marginal.

Fruit: An aggregate of berries or follicles, sometimes, a samara as in *Liriodendron*.

Seed: Large, with abundant oily endosperm, and bright or orange testa which makes them highly decorative.

Pollination: Entomophilous due to large and scented flowers.

Floral formula:

$\oplus\ \varphi\ \bar{\varphi}\ P_{3\ or\ \infty}\ A_{\infty}\ G_{\underline{\infty}}$

Economic Importance of Magnoliaceae:

1. Medicinal: The root bark and dried roots of *Michelia champaca* are used as purgative, while the flowers and fruits are used as carminative and in certain renal troubles and venerial diseases like gonorrhoea. The bark of *Drimys winteri* and *Illicium uerum* is useful in medicine.

2. Timber: The wood of *Michelia excelsa* is an excellent commercial timber known as "white wood". *M. acuminata*, *Manglietia hookeri*, *Michelia baillonii*, *M. dottsopa* and *Pachylarnax pleiocarpa* produce valuable timber used for mill work, furniture, musical instruments, toys etc.

3. Ornamentals: The species of *Magnolia* and *Michelia* are of surprising beauty because of their conspicuous white and yellow-tinted, fragrant flowers. Flowers of *Michelia champaca* are used by womens to ornament their hair and also offered in temples.

Michelia champaca yields 'champaca oil' from the flowers, camphor from the wood and scented water from the leaves.

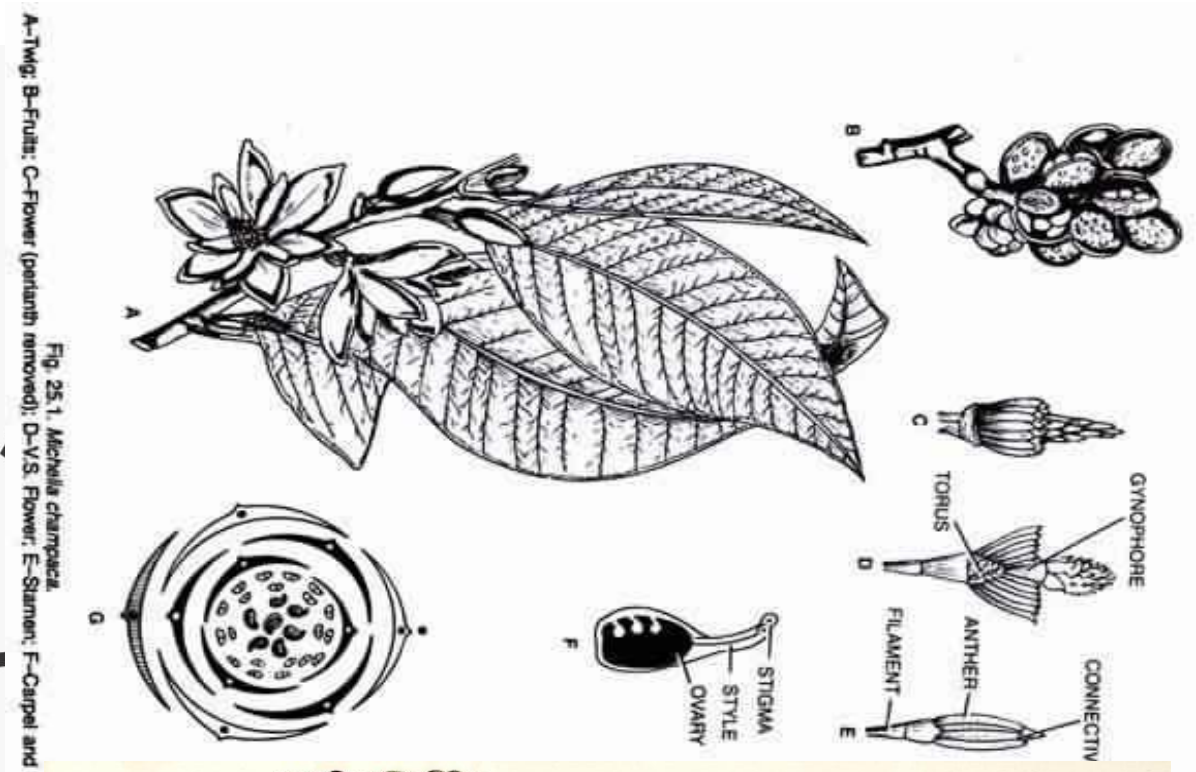


Fig. 25.1. *Michelia champaca*.
A–Twig; B–Fruits; C–Flower (perianth removed); D–V.S. Flower; E–Stamen; F–Carpel and G–Floral diagram.

Fig. 1. Stamens. 2. Pollen. 3. Gynoecium. 4. Carpel—*all magnified*. 5. Ripe fruit—*natural size*. 6, 7, 8. Seeds—*natural size*. 9, 10. Longitudinal sections of seeds. 11. Section of albumen. 12. Embryo.

Annonaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Ranales
Family: Annonaceae (Custard-apple family)

Characters of Annonaceae:
Wood aromatic, leaves exstipulate, floral parts usually numerous, free spirally arranged; stamens with distinctive enlarged and flat connective; gynoecium multipistillate, apocarpous.

Number and Distribution of Annonaceae:
The family comprises 128 genera and 2,300 species in this family. The family is widely distributed in the tropical regions of the world. Some genera are also found in the temperate climates. In India it is represented by 26 genera and 200 species. Examples: *Polyalthia*, *Annona*, *Artabotrys*, *Miliusa*, *Cananga* etc.

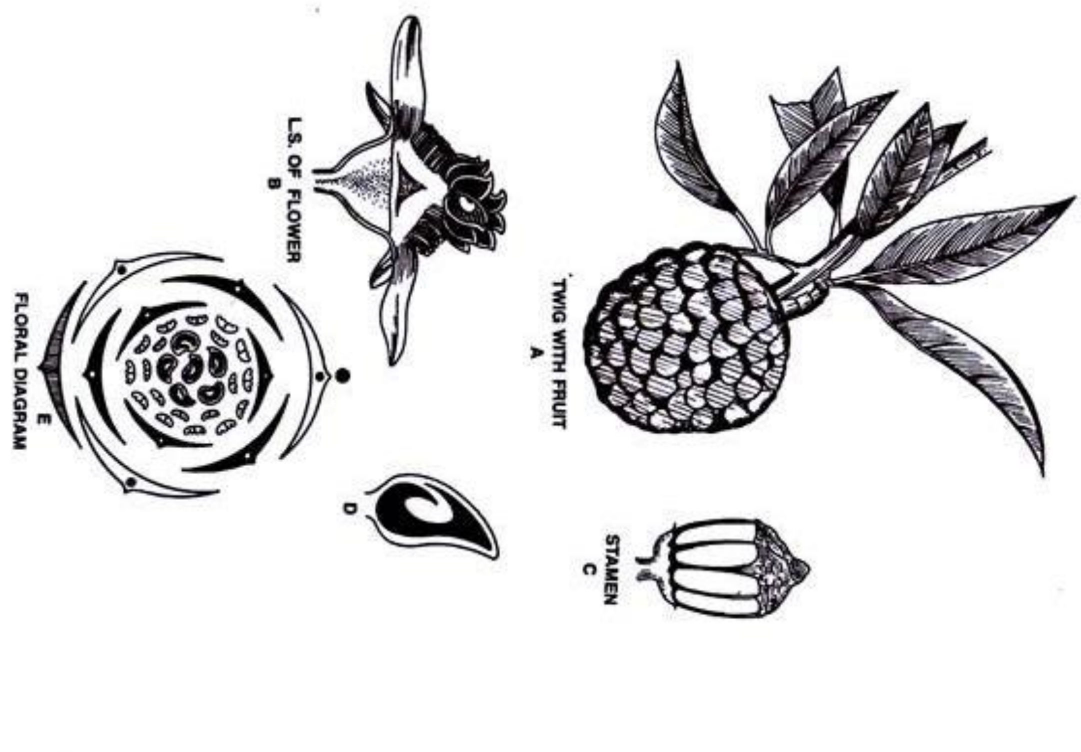
A. Vegetative characters:
Habit and habitat: Trees, shrubs or lianas. *Artabotrys* climbs by means of hooks. Oil ducts present in the bark, leaves and perianth leaves. Terrestrial and perennial. Evergreen, deciduous, cultivated as well as wild.
Root: Tap, deep and extensively branched.
Stem: Erect, branched, solid, woody, sometimes woody climbers.
Leaves: Simple, entire, alternate, exstipulate, distichous, gland dotted.

B. Floral characters:
Inflorescence: Often solitary, axillary, sometimes cauliflourous in groups.
Flower:
Actinomorphic but zygomorphic in *Monodora* due to difference in size of petals, hermaphrodite, unisexual in *Stelechocarpus*, complete, trimerous, hypogynous, perigynous (*Eupomatia*) spirocyclic, often aromatic.
Calyx: Sepals 3, sepaloid, polysepalous, connate at the base, valvate.
Corolla: Petals 6 in two whorls of 3 each, valvate or slightly imbricate. Sometimes no distinction into sepals and petals so perianth in 3 or more whorls of 3 each.
Androecium: Stamens numerous spirally arranged on the axis which forms a large convex receptacle, filament short and thick, anthers long, extrorse, truncate connective, dithecous.
Gynoecium: Carpels numerous or a few, usually free, spirally arranged on the raised receptacle, apocarpous, superior, unicarpellary, unilocular; ovules one to many, anatropous, style short or none, stigma small, *Monodora* (Africa) with syncarpous ovary and parietal placentation.
Fruit: An aggregate of berries, united to form a single compound fruit (*Annona squamosa*).
Seed: Large, numerous, often embedded in a copious, white fleshy pulp, endospermic.
Pollination: Entomophilous, due to gaudy and scented flowers.
Floral formula:

$\oplus\ \varnothing\ K_3\ C_{3+3}\ A_\infty\ G_{\underline{\infty}}$ or (∞)

Economic Importance of Annonaceae:
1. Food: The fleshy fruits of various *Annona* specifics are juicy and edible, and also used in preparation of soft drinks and jellies. Recent analysis shows that they contain about 18 per cent sugar.
Edible fruits are also obtained from various species of *Annona* and *Asimina*.
2. Timber: *Bocagea virgata, B. laurifolia*, *Cyathocalyx zeylanicus*, *Duguetia quitarensis*, *Oxandra lanceolata* and *Eupomatia laurina* yield useful timber.
3. Oil: The flowers of *Desmos chinensis* furnish 'Macassar oil' a perfume. The perfume is also obtained from *Mkilua fragrans* and specially liked by Arab women.

4. Fibre: The bark of *Goniothalamus wightii* produces strong fibres.
5. Ornamental: *Artabotrys odoratissimus* and *Annona discolor* are grown in garden for their scented flowers. *Desmes chinensis* is an ornamental tree.



Annona squamosa. A–Twig with fruit; B–L.S. of flower; C–Stamen; D–Carpel; E–Floral diagram.

Fig. 26.2. *Artabotrys uncinatus* (Lam.) Merr. (Syn. *A. odoratissiums* R. Br.). A. Twig with axillary solitary flower. B. single flower. C. Floral diagram. D. The flower after removal of the some of the floral members; s, sepal; pt, petal; t, torus with scars of removed floral members particularly those of stamens and carpels (in part); st, stamens; p, carpels. E. Petal and sepal. F. Single stamen; f, filament; a, anther consisting of 4 microsporangia (pollen sacs); c, protruded connective (note the primitive type of stamen). G. Single carpel in l.s., H. The aggregate fruit – Etaerio of berries.

Brassicaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Rhoedales
Family: Brassicaceae (Mustard family)

Characters of Brassicaceae:

Flowers actinomorphic rarely zygomorphic, hermaphrodite; sepals four in two whorls of two each, petals four, diagonally arranged-cruciform; stamens six, tetradynamous; gynoecium bicarpellary, syncarpous, parietal placentation, bilocular due to the formation of false septum (replum); fruit siliqua or silicula.

Number and Distribution of Brassicaceae:

The family includes 375 genera and 3200 species according to Willis. It is distributed all over the world but mainly confined to the Mediterranean region and north temperature regions.

Examples: *Brassica oleracea* var. *botrytis* (H. Phul gobhi), *B. oleracea* var. *capitata* (H. Band gobhi), *B. oleracea* var. *caulorapa* (H. Gand-gobhi), *Brassica campestris* var. *sarson* (white mustard), *Brassica rapa* (Turnip), *Raphanus sativus* (Radish), *B. campestris* (or white mustard) etc.

A. Vegetative characters:

Habit:

Generally herbs, annual (*Brassica*, *Capsella*) or biennial or shrubs. Common Indian herbs are *Eruca*, *Alyssum*, *Nasturtium*, *Lepidium*, *Coronopus* etc. Vegetative reproduction is by bulbils (*Dentaria bulbifera*) or by coral roots.

Roots:

Tap root, swollen on account of stored food materials. It may be conical (Radish), fusiform or napiform (Turnip).

Stem:

Herbaceous, erect, cylindrical (*Iberis*, *Brassica*) rarely woody or some times reduced (*Raphanus* & *Brassica* species), glabrous or hairy, solid and branched.

Leaves:

Alternate or sub-opposite, simple, exstipulate (*Brassica campestris*). May be cauline or radical (*Raphanus*), generally sessile, hairy. Lamina may be simple, entire, pinnatifid or pinnatisect or lyrate and with unicostate reticulate venation.

B. Floral characters:

Inflorescence:

Raceme (*Brassica campestris*) corymbose raceme (*Iberis*) or corymb.

Flower:

Pedicellate, hermaphrodite, actinomorphic rarely zygomorphic (*Iberis* and *Teesdalia*), hypogynous, complete or incomplete (*Lepidium*) and tetramerous.

Calyx:

Sepals 4 arranged in two whorls of two each, polysepalous (2 antero-posterior and 2 lateral), 2 lateral sepals may be saccate, imbricate aestivation, inferior.

Corolla:

Petals 4, alternate with sepals, polypetalous, petals arranged in the form of across known as cruciform. This arrangement is characteristic of the family Petals usually clawed, petals generally equal rarely unequal (*Iberis*, *Teesdalia*) or sometimes petals may be replaced by stamens (*Capsella bursa pastoris*).

Androecium:

Stamens 6, arranged in two whorls, outer two stamens short and inner four long (2+4), tetradynamous, polyandrous, anthers dithecous basifixed, introrse. Disc like nectaries, variable in number, present at the base of stamens. In some cases the number of stamens is variable – 16 (*Megacarpaea*), 4 (*Cardamine hirsuta*), 2 (*Coronopus*) etc.

Gynoecium:

Bicarpellary rarely tricarpellary (*Lepidium sativum*), syncarpous, ovary superior, unilocular, becomes bilocular due to the development of false septum called replum: parietal placentation, ovules many, style short, stigma simple or bifid. The crucifer carpel has been a puzzling subject for the morphologists and their attention attracted towards its for a long time. According to some there are only two carpels while others hold that there are four carpels.

Fruit:

Siliqua or silicula, sometimes lomentum (*Raphanus*); when the valves separate in a siliqua the seeds remain attached to the replum.

Seed:

Non endospermic. The germination of seed is epigeal.

Pollination:

Self or cross pollinated; flowers are visited by insects due to the presence of nectaries. Cleistogamy is found in *Cardamine chenopodifolia*. Anemophilous pollination is found in *Pringlea*.

Floral formula:

⊕ ☿ K2+2 C4x A2+4 G(2).

Economic Importance of Brassicaceae:

This family is of considerable economic importance.

1. Food:

The plants of this family which are cultivated as vegetable crops are:

Brassica oleracea var. *botrytis* (H. Phul gobhi), *B. oleracea* var. *capitata* (H. Band gobhi), *B. oleracea* var. *caulorapa* (H. Gand-gobhi), *Brassica campestris* var. *sarson* (white mustard), *Brassica rapa* (H. Shalgam), *Raphanus sativus* (H. Muli), are edible and cooked as vegetables.

2. Oil:

The seed of *B. campestris* (or white mustard) yield mustard oil or Karwa-tel which is widely used as a cooking medium. *B. nigra* (H. Kalirai) and *B. juncea* (H. rai) also produce oil.

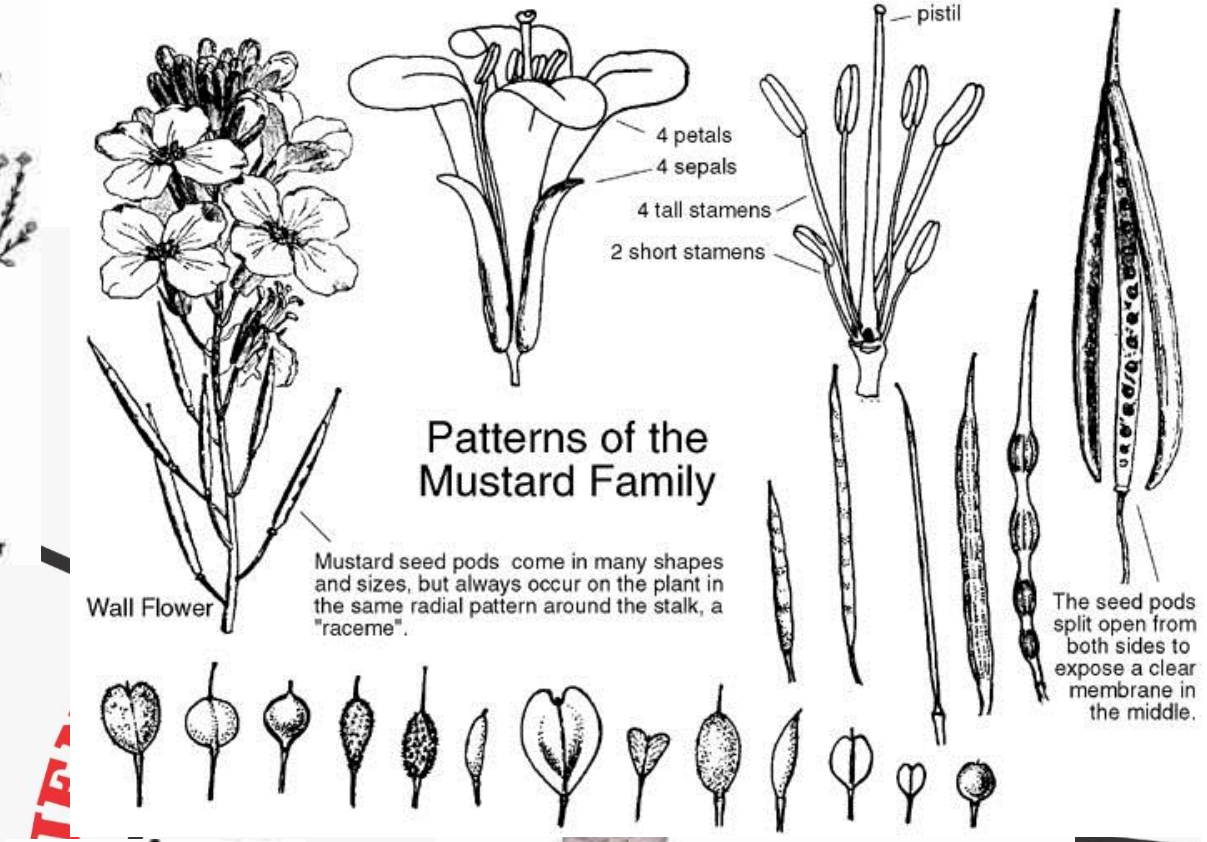
After extracting oil the cake is left behind which is highly nutritious as a cattle feed; the oil cake is also used as soil fertilizer. *Raphanus* seeds also produce a pungent oil which is often used in adulteration of sarson oil; this oil has digestive properties.

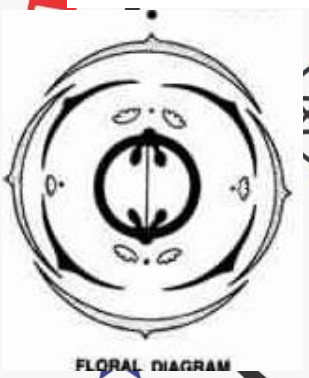
3. Medicines:

The leaves and tender shoots of *Lepidium sativum* are used in liver complaints, asthma, cough and bleeding piles. *Rorippa montana* is an appetizer and a stimulant. The seeds of *Cheiranthus cheiri* are used in bronchitis and fever. The flowers are used in paralysis and impotency. *Lobularia* is used for gonorrhoea. *Iberis amara* is used in rheumatism and gout.

4. Ornamentals:

Some plants are grown in gardens for their beautiful flowers viz. Cheiran thus cheiri (wall flower), *Iberis amara* (candituft) *Lobularia*, *Matthiola* (stock), *Hesperis* (rocket), *Alyssum*, *Lunaria* (honesty) etc.





RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

Rutaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Geraniales
Family: Rutaceae (Citrus family)

Characters of Rutaceae:
Leaves gland dotted, simple or compound; flower hermaphrodite, hypogynous, actinomorphic with a disc below the ovary; corolla polypetalous; stamens ten, obdiplostemonous; carpels 5 or many, ovary superior, multilocular; fruit capsule or berry; aromatic odour is present.

Number and Distribution of Rutaceae:
The family comprises 150 genera and 1300 species out of which India contributes 23 Genera with 71 species. The members of the family are distributed in tropical and temperate regions and they are predominant in South Africa and Australia.

Examples:
C. aurantifolia (Lemon), *C. maxima* (Pomello), *C. sinensis* (Musambi), *Aegle marmelos* (Bel), *Feronia limonia* (Bilva), *Murraya koenigii* (Curry leaves), *Ruta graveolous* (Nagadali) etc.

A. Vegetative characters:

Habit:
The plant are generally shrubs (*Murraya*, *Limonia*, *Zanthoxylum*), trees (*Aegle*, *Citrus*, *Feronia*), rarely herbs (*Ruta graveolens*) with strong fragrance Paramignya is a shrub but climbs by means of axillary thorns.

Root:
Tap root, branched often infected with fungus.

Stem:
Woody (*Citrus*, *Feronia*), erect, cylindrical, branched, solid often thorny (*Citrus*), gland dotted.

Leaves:
Alternate (*Citrus*, *Murraya*) or opposite (*Evodia*), petiolate, petiole may be winged (*Citrus aurantium*), simple or compound-pinnate (*Murraya*), palmate (*Aegle* and *Citrus*) smooth gland dotted, glands with essential oils, exstipulate, margin entire or serrate, unicostate reticulate venation. In *Citrus* petiole is winged.

B. Floral characters:

Inflorescence: Usually cyme or axillary or terminal corymb (*Murraya paniculata*) sometimes racemose or solitary.

Flower: Pedicellate, ebracteate, hermaphrodite, or unisexual (*Zanthoxylum*, *Evodia*, *Feronia*), actinomorphic rarely zygomorphic (*Dictamnus* and *Correa*), hypogynous, complete, pentamerous or tetramerous (*Acronychia* and lateral flowers of *Ruta*).

Calyx:
Sepals 5 or 4, free or fused; in zygomorphic flower it becomes gamosepalous and tubular; imbricate; sometimes deciduous.

Corolla:
Petals 5 or 4, polypetalous rarely gamopetalous (*Correa speciosa*) or absent (*Zanthoxylum*), variously coloured, imbricate.

Androecium:
In majority of cases the stamens are obdiplostemonous and 10 in number; in *Citrus* numerous stamens with polyadelphous condition; in *Zanthoxylum* 3 stamens and in *Skimmia* 5 stamens; anthers introrse, dithecous, basifixed or versatile.

Gynoecium:
Pentacarpellary and only slightly united at the base or the sides forming a deeply lobed ovary with fused styles originating from the centre. In *Citrus* and *Toddalia* the carpels are fully united. In *Feronia* the carpel is only one celled with many parietal placentae. In other genera the placentation is of the axile type. Ovary is superior with a prominent nectariferous disc below it. Ovule anatropous.

Fruit:
In Flindersioideae there is septicidal or loculicidal capsule; in Toddalioideae a drupaceous fruit; hesperidium in *Citrus*, berry in *Murraya*, Amphisarca in *Aegle.*

Seed:
Endospermic or exalbuminous.

Pollination:
Entomophilous; insects are attracted by the coloured petals, the nectar secreted by the disc is easily available. The flowers are protandrous. Thus in *Ruta* the stamens arise successively to the centre of the flower and after shedding the pollen grains wither away and fall back again.
The stigma now matures and if no insect visitor has come then the stamens rise again and the pollen grains that still remain are once again shed over the stigma. Thus self pollination is effected.

Floral formula:
⊕ ☿ K4–5 or (4–5) C4–5 A8 or 10 or α G (4–α).

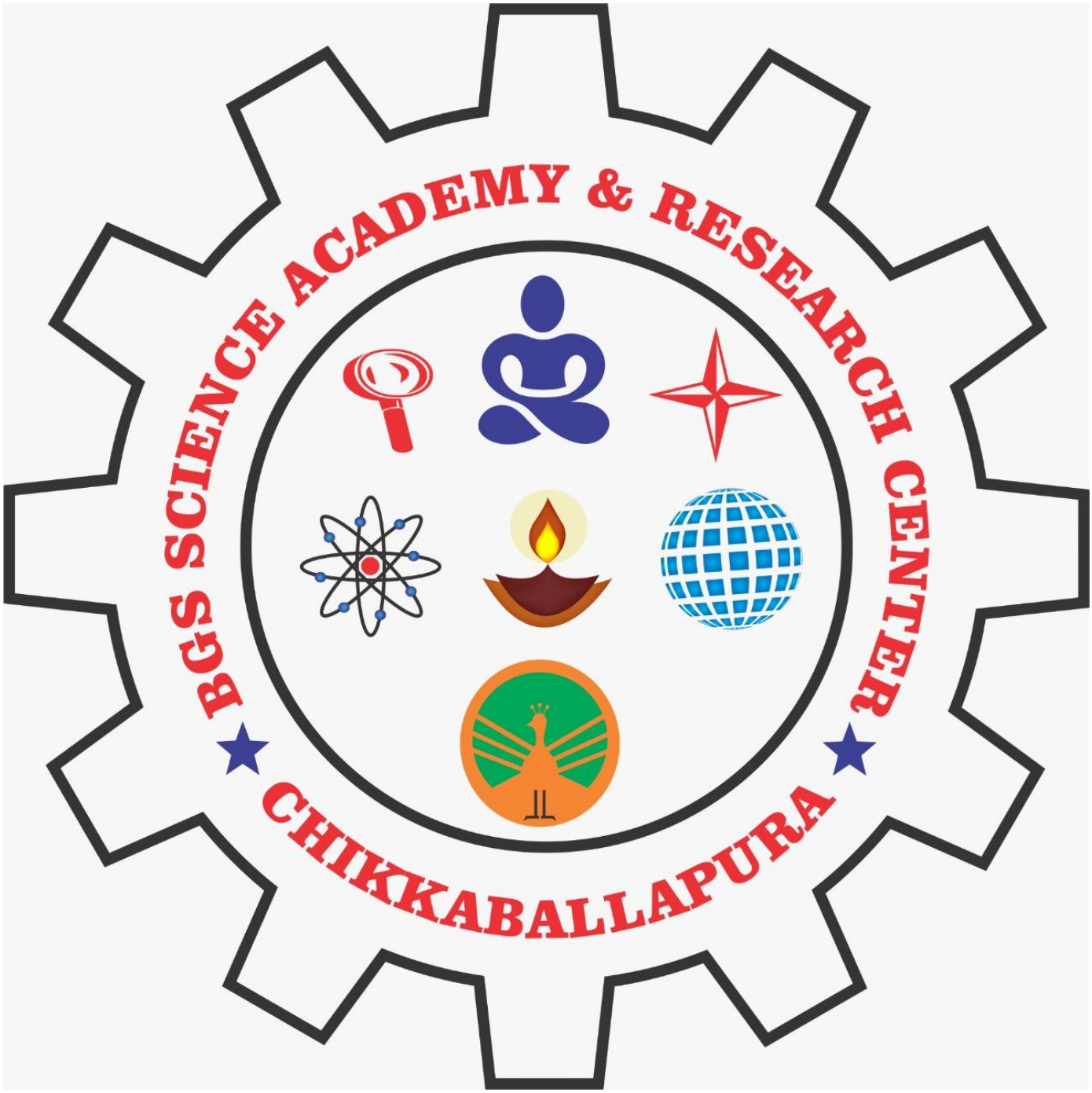
Economic Importance of Rutaceae:

1. Fruits:

The genus Citrus provides a number of fruits:
(a) *C. aurantifolia* (H-Kaghzi nimbu) has citric acid in its fruits and used in bilous vomiting. The fruit wall has essential oils.
(b) *C. aurantium* var. *bergamia* (H-Nimbu). The ripe fruit is digestive and a tonic, fruit wall gives oil of bergamot.
(c) *C. aurantium* var. *bigardia*. (H-Khatta). Rich in pro-vitamins A and vitamin B. Oil present in fruit wall.
(d) *C. maxima* (H-Chakotra) produces edible fruits.
(e) *C. sinensis* (H-Musumbi). The fruit is widely used during illness; it purifies blood, reduces thirst and improves appetite.
(f) *C. reticulata* (H-Santara or Narangi). The ripe fruit is highly nutritive and rich in assimilable calcium, the fruit wall also produces citrus oil.
(g) *C. limettioides* (H-Mitha Nimbu) is useful in fever and jaundice; oil also obtained from the wall.
(h) *C. limon* (H-Pahari Nimbu). The juice of ripe fruits is useful in rheumatism and dysentery.
(i) *Aegle marmelos* (H-Bel). This is normally edible. The fruit is particularly useful in stomach disorders. The plant is considered holy and its leaves used in worshipping the God Shiva.
(j) *Feronia limonia* (H-Kaith bel). The fruits edible; leaf and bark used medicinally.

2. Medicinal:
Citrus is not only edible but produces vitamins particularly vitamin C (ascorbic acid). *Barosma betulina* produces buchu from its leaves which is useful in urinary diseases.
Pilocarpus microphyllus: The active principle is pilocarpine which causes contraction of the pupil – it is just opposite to atropine. Jaborandi is prepared from the leaflets of this plant; this is useful in kidney diseases.
Murraya koenigii. (H-Katnim) has several medicinal properties. The green leaf is eaten raw in dysentery while bark and roots are useful in bites of poisonous animals when applied externally. The leaves are also used in curry powder particularly by S. Indians.

3. Ornamental and miscellaneous:
Plants like *Ruta*, *Luvunga scandens*, *Ptelea*, *Calodendrum*, *Limonia*, *Murraya* are cultivated in gardens for their fragrant flowers.
Zanthoxylum piperitum gives Japan pepper. *Ruta graveolous* gives French oil of Rue; *Galipea officinalis* yields cusparia bark.



RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

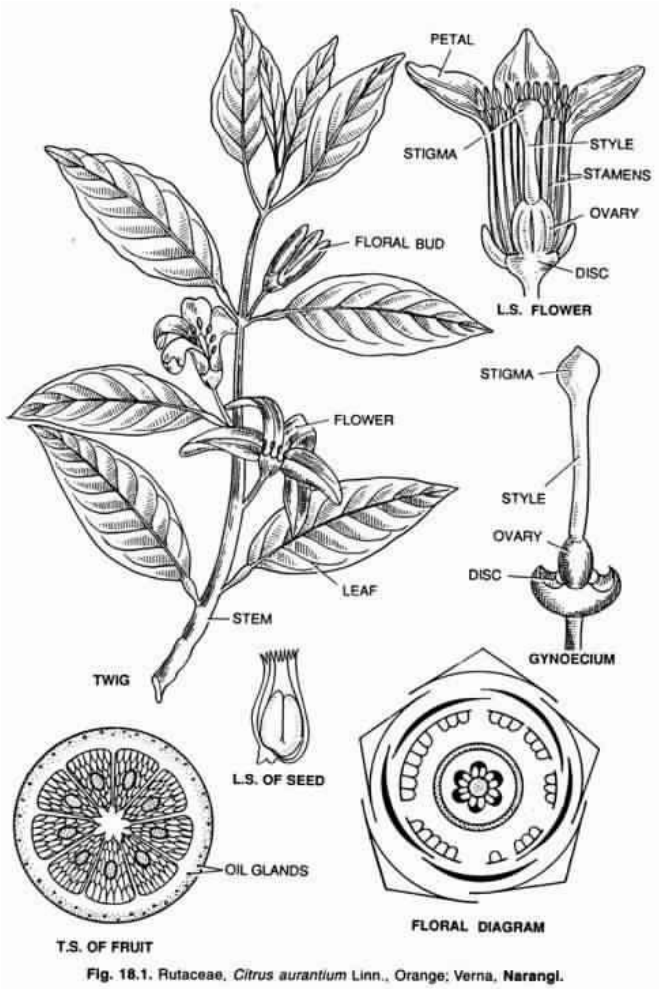


Fig. 18.1. Rutaceae, *Citrus aurantium* Linn., Orange; Verna, **Narangi.**

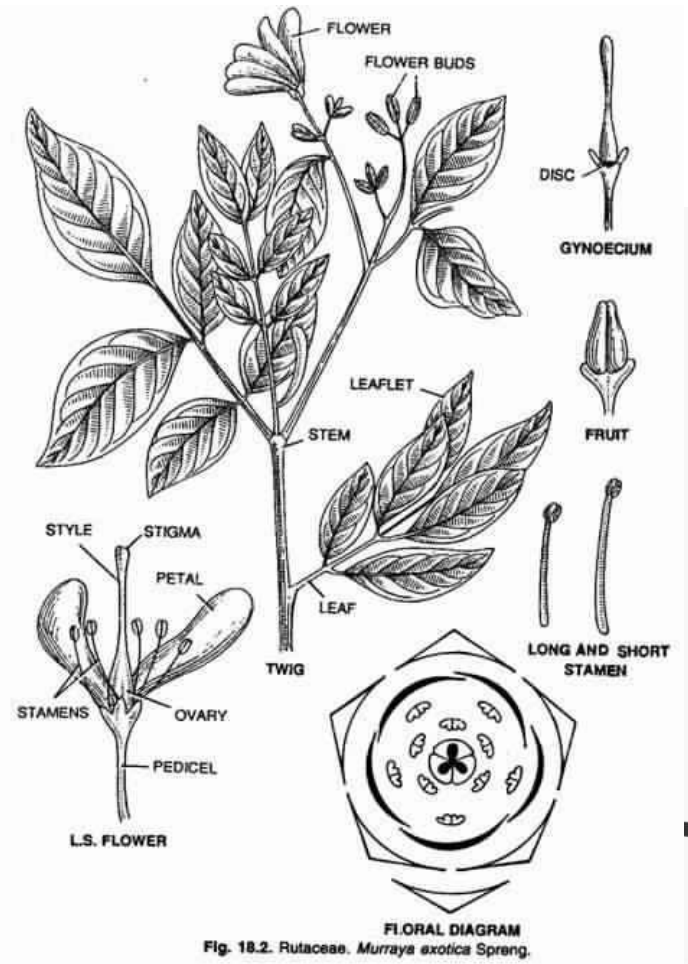


Fig. 18.2. Rutaceae. *Murraya exotica* Spreng.

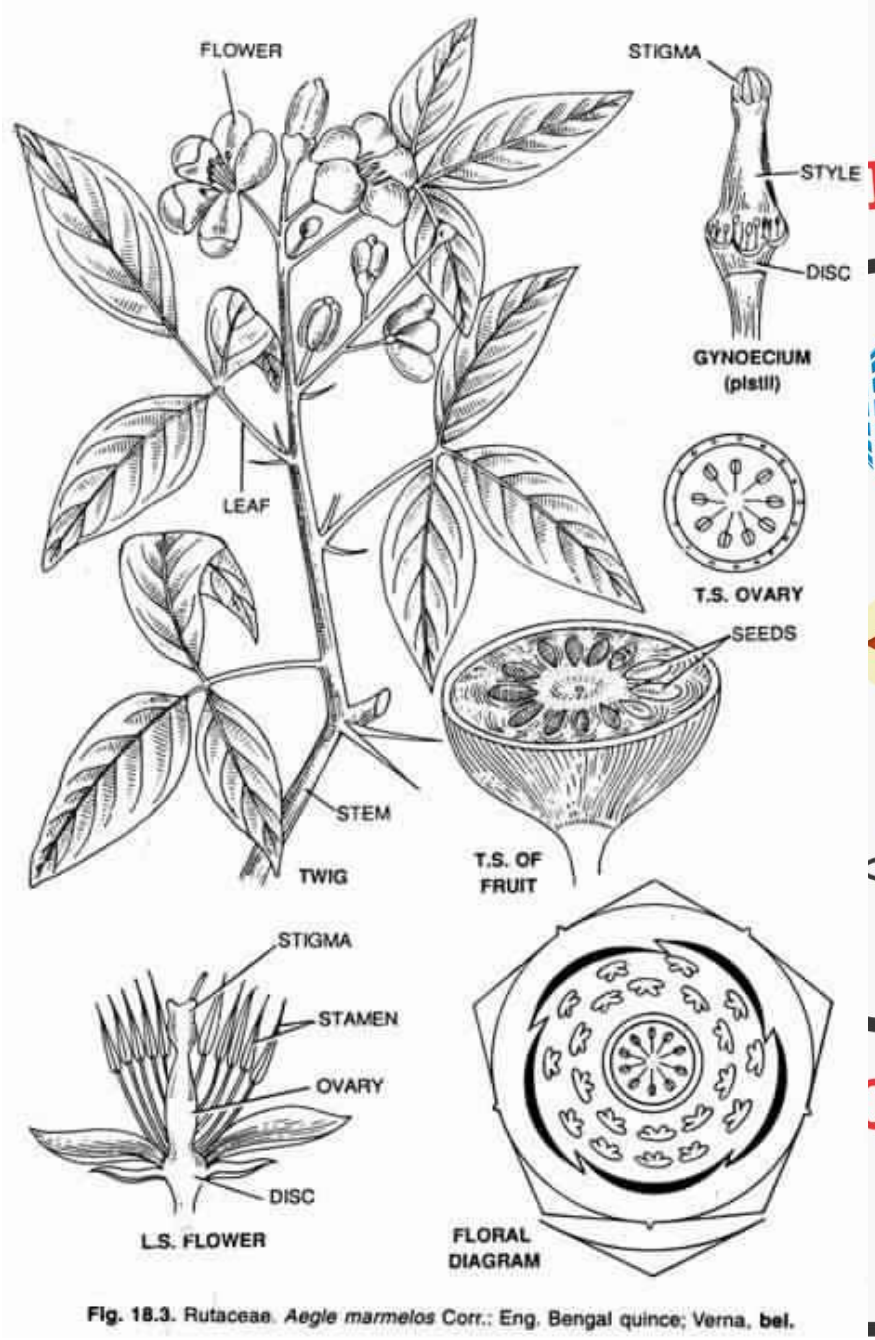


Fig. 18.3. Rutaceae. *Aegle marmelos* Corr.: Eng. Bengal quince; Verna, **bel.**

RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

Leguminosae : Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Rosales
Family: Leguminosae/ Fabaceae (Legumes family)

Leguminosae

It includes 600 genera and 13000 species. It is regarded as the second largest family of dicotyledons. In India the family is represented by 1100 species and 100 genera. This family is divided into 3 sub-families based upon the floral characters. The 3 sub-families are considered as 3 separate families e.g. Papilionaceae, Caesalpiniaceae and Mimosaceae by many botanists.

Sub-family 1. Papilionaceae or papilionoideae:
Flowers medianly zygomorphic; calyx gamosepalous, imbricate; corolla papilionaceous, vexillary; stamens 10, diadelphous or monadelphous.

Sub-family 2. Caesalpinioideae:
Flowers slightly irregular; calyx free or united, corolla free, imbricate; stamens 10 or few, free.

Sub-family 3. Mimosoideae:
Flowers actinomorphic; sepals and petals valvate; free or united, stamens 4 to many.

Papilionaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Rosales
Family: Leguminosae/ Fabaceae
Sub-Family: Papilionaceae (pea family)

Diagnostic features: Herbs, shrubs or trees, generally climbers; leaves alternate, stipulate, simple or compound; flower zygomorphic, hermaphrodite, corolla papilionaceous, stamens 10 or 9 diadelphous or monadelphous; carpel one, fruit legume.

Distribution of Fabaceae-Papilionaceae:
It includes 375 genera. The family is represented in India by 70 genera and 754 species. The members of this family are xerophytes, mesophytes, hydrophytes and halophytes (*Desmodium lattifolium*).

Examples: *Butea, Pisum, Dolichos, Vigna, Dalbergia.*

Characters of Fabaceae-Papilionaceae:

A. Vegetative Characters:

Habit: The plants show great variation in habit. The plants may be herbs (*Melilotus*, *Medicago*, *Trifolium*), shrub, (*Butea*, *Flemingia*), climbers (*Lathyrus*, *Pisum*, *Vicia*), twinners (.*Dolichos*, *Vigna*) and trees (*Dalbergia*, *Sesbania*, *Erythrina*). *Aeschynomene* is an aquatic plant.

Root: A much branched tap root system, bearing bacterial nodules.

Stem: Herbaceous or woody, erect or twinner, branched, angular or cylindrical, solid or fistular.
Leaves: Cauline or ramal; alternate, stipulate, compound mostly trifoliate sometimes simple as in *Alysicarpus*; modified partly or wholly into tendril (*Lathyrus*, *Pisum*, *Vicia*) leaf base may be pulvinate. In *Lathyrus aphaca* the entire leaf becomes modified into a tendril; in *Pisum* and *Lathyrus* the stipules are foliaceous and highly developed, in *Pisum* and *Vicia* the leaflets are modified into tendrils. In *Lupinus* and *Medicago* stipules are adnate. In *Desmodium gyrans* the two lateral leaflets perform autonomous movements. Sir J.C. Bose had done much work on the physiology of leaf movement in this species.

B. Floral characters:

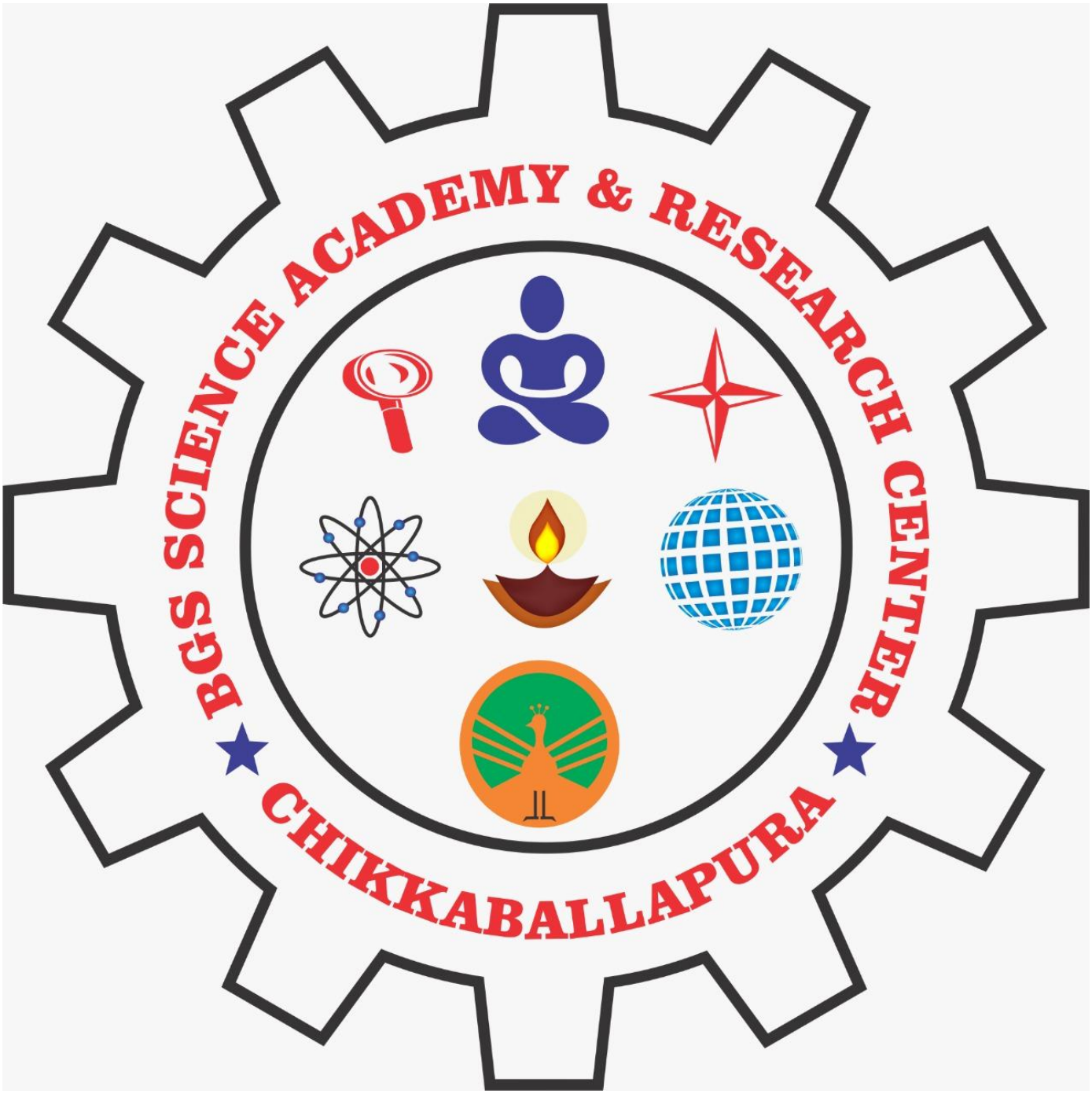
Inflorescence: Racemose raceme, rarely solitary axillary.
Flowers: Medianly zygomorphic, hermaphrodite, pedicellate, slightly perigynous, complete and pentamerous. The papilionaceous corolla is typical. The floral characters are rather uniform.
Calyx: Sepals 5, gamosepalous odd sepal anterior, sepaloid, ascending imbricate aestivation.
Corolla: Petals 5, polypetalous, papilionaceous, posterior petal outermost large – the vexillium or standard; next two lateral ones-the wings or alae; and the two anterior and innermost united to form a boat-shaped structure – the keel or carina; descending imbricate or vexillary aestivation.
Androecium: Stamens 10 or rarely nine (*Abrus*, *Dalbergia*), diadelphous or monadelphous (*Crotalaria*), posterior stamen is free and filaments of nine are fused to form a sheath around the ovary; in *Arachis* ten stamens are monadelphous and in *Sophora* all ten stamens are free.
Gynoecium: Monocarpellary; ovary superior, unilocular, marginal placentation, numerous ovules on the ventral suture; style long slightly bent at the apex, flattened, hairy or without hair (*Mucuna*): stigma simple or capitate (*Mucana*).
Fruit: Legume or pod, indehiscent (*Dalbergia*), lomentum (*Alysicarpus*).
Seed: Non-endospermic.
Pollination: Entomophilous.
Floral formula:

$$\oplus\ \varphi\ K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1\text{or }(10)}\ \underline{G1}.$$

Economic Importance of Fabaceae-Papilionaceae:

1. Food: The fruits and seeds of *Pisum sativum* (H. Matar), *Cicer arietinum*, (H. Chana), *Cajanus cajan* (H. Arhar), *Dolichos lablab* (H. Sem), *Vigna aconitifolius* (H. Moth), *Phaseolus radiatus* (H. Moong), *P. mungo* (H. Urd), *Lens esculenta* (H. Masur), *Glycine max* (Soyabean) are used as vegetable and pulse. Soya-bean is supposed to contain very high percentage *of* proteins comparable to meat.
2. Oil: The seeds of *Arachis hypogea* are pressed to obtain an oil. It is converted into vegetable ghee after hydrogenation and largely used as substitute for pure ghee. The oil cake is used for cattle feeding. Mungfali is also eaten after roasting.
3. Medicine: *Glycyrrhiza glabra* (H. Mulathi) is used in throat pain and cough. *Physostigma venenosum* has several alkaloids and sometimes used as an eye ointment. The fresh juice of the leaves of *Abrus precatorius* (H. Ratti) is said to remove spots of leucoderma. Its seeds have constant weight to an astonishing degree and traditionally used by goldsmiths.
Cyamopsis tetragonoloba (syn. *Psoralea tetragonolaea*) seeds are laxative, stimulant and produce a colourless essential oil. The juice of *Sesbania grandiflora* flowers is said to improve eye sight.
4. Fibre: *Crotalaria juncea* (Sunn Hemp or H-Swun) yields fibres, which are used for making rope, mat, coarse canvas, sacks, nets etc. It is a blast fibre.
5. Timber: *Dalbergia sissoo* (H. Shismam), *D. latifalia* (Indian rose wood) yield timber.
6. Dye:*Indigofera tinctoria* yields a dye – the indigo (H. Neel).
7. Ornamental and miscellaneous: Many plants viz., *Lathyrus odoratus*, *Clitoria*, *Sesbania*, *Lupinus*, *Genista*, *Robinia*, etc. are used as ornamental plants in gardens.
Erythrina – (Indian Coral tree) is bird pollinated and produces beautiful red flowers.

Peru balsam and Tolu balsam are obtained from Mysoxylon. Gum tragacinth is obtained from *Astragalus gummifer*. Gum is also obtained from *Butea monosperma* and *Pterocarpus*. Because of root nodules many plants of this family can enrich the soil with fixed nitrogen. Hence they are often used in crop rotation.



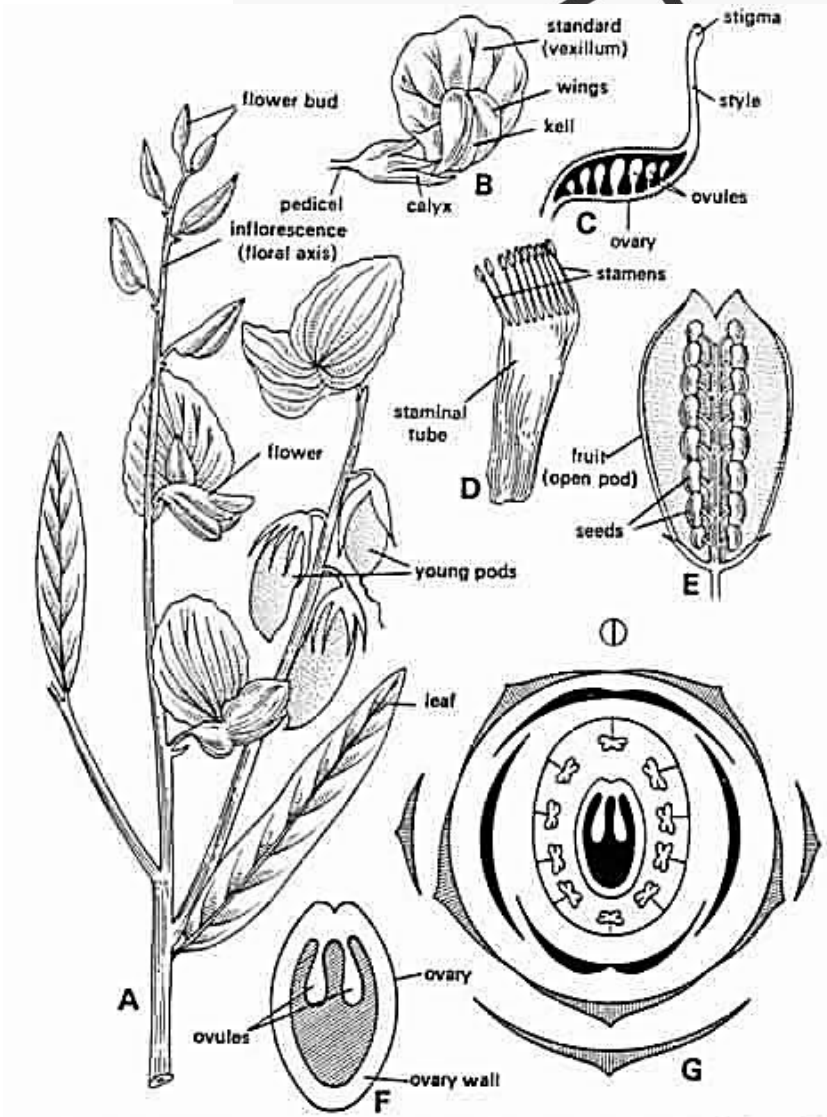


Fig. 15.9. Papilionaceae–*Crotalaria juncea*. A, flowering twig with young pods; B, flower; C, gynoecium; D, androecium; E, dehisced fruit; F, T.S. of ovary; G, floral diagram.

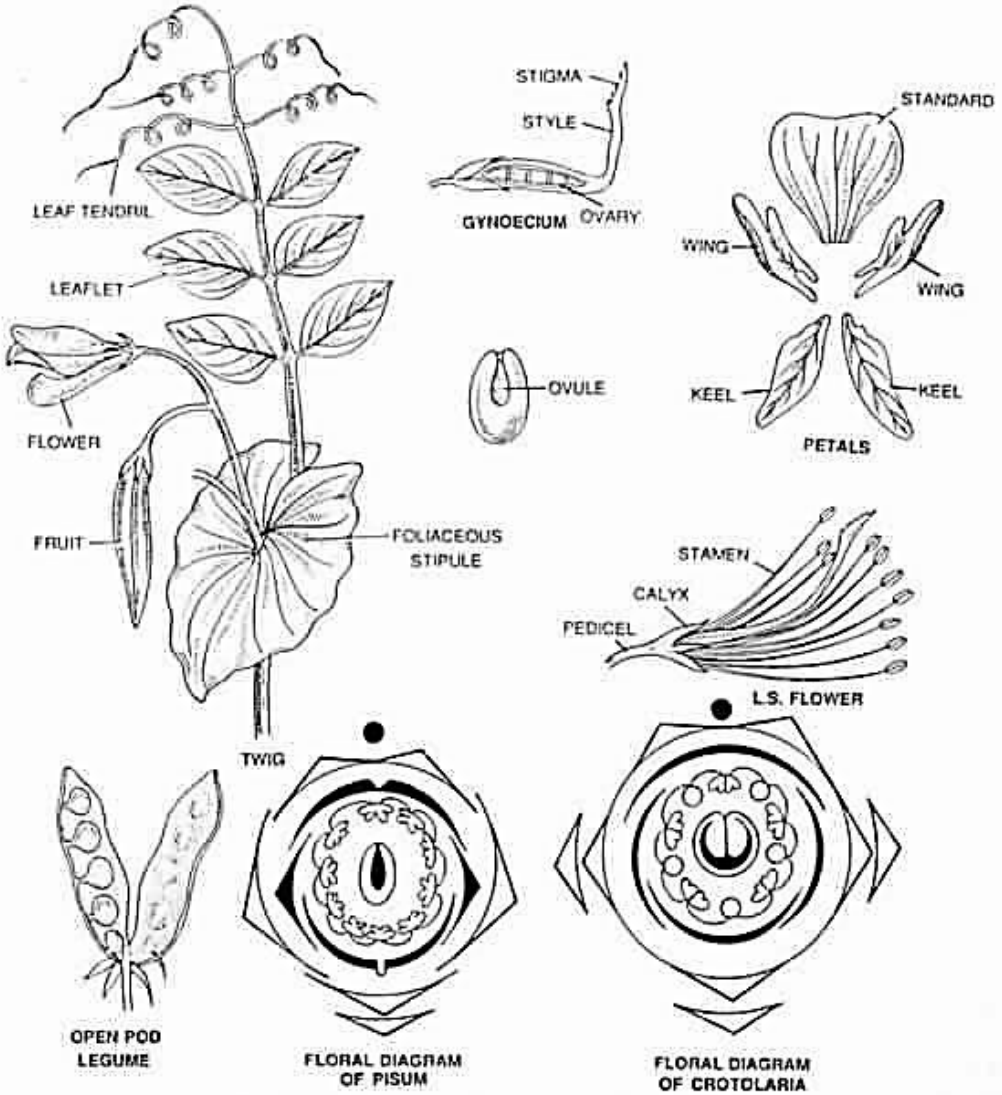


Fig. 15.7. Papilionaceae (Leguminosae)–*Pisum sativum* Linn.

Caesalpiniaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Rosales
Family: Leguminosae/ Fabaceae
Sub-Family: Caesalpiniaceae (Cassia family)
Characters of Caesalpiniaceae: Leaves paripinnate; flowers zygomorphic; calyx and corolla 5, ascending imbricate; stamens 10 or less, free, gynoecium monocarpellary with marginal placentation.
Distribution of Caesalpiniaceae: The sub-family contains 150 genera 2700 species which are cosmopolitan in distribution. In India it is represented by 110 species and more than 21 genera.
Examples: *Delonix regia, Tamarindus, Caesalpinia, Saraca indica, Cassia fistula, Bauhinia*
A. Vegetative characters:
Habit: It shows great variation in habit i.e. may be trees (*Delonix regia, Tamarindus, Caesalpinia, Saraca indica, Cassia fistula, Bauhinia* etc.), shrub, undershrubs or herbs. Besides this sometimes all types of plants occur in same genus e.g. *Cassia fistula* – tree; *C. sophera*-shrub; *C. occidentalis* – undershrub and *C. tora* – annual herb. *Bauhinia vahlii* is a woody climber.
Root: Tap and branched.
Stem: Erect, woody, herbaceous or climbing, branched, glabrous or covered with prickles and spines (*Parkinsonia*).
Leaf: Alternate, leaf base pulvinate, compound unipinnate (*Cassia, Tamarindus*), bipinnate (*Delonix, Caesalpinia*) or rarely simple; stipulate. In Bauhinia the leaf is deeply emarginate – perhaps due to the fusion of two leaflets.
B. Floral characters:
Inflorescence: Racemose.
Flower: Pedicellate, bracteate, zygomorphic, complete, hermaphrodite, slightly perigynous, pentamerous.
Calyx: Sepals 5, free, or connate, odd sepal anterior, imbricate aestivation. In Tamarindus the two posterior sepals are united.
Corolla: Petals 5, in *Tamarindus* there are only three posterior petals; in *Copaifera saraca* the petals are totally reduced; free, ascending imbricate aestivation, posterior petal is innermost.
Androecium: Stamens 10, free, reduction in number of stamens by the formation of staminodes. In *Cassia* there are 3 posterior staminodes; *Saraca* 3-8 stamens; in *Tamarindus* only 3 stamens and monadelphous; dithecous, introrse.
Gynoecium: Monocarpellary, ovary superior or slightly inferior, unilocular with marginal placentation, straight or curved, hairy; style long; stigma simple.
Fruit: Legume and never breaks up into one seeded parts.
Seed: Non-endospermic.
Pollination: Entomophilous.
Floral formula: Br, o|p ☿ K5 C5 A 10 or 7 + 3std, $\underline{G_1}$.
Economic Importance of Caesalpiniaceae:
1. Food: The flower buds of *Bauhinia variegata* (H. Kachnar) are used as vegetable. The fruits of *Tamarindus indica* (H. Imli) are spicy and used as condiment. The seeds of *Tamarindus indica* yield starch.
2. Medicine: The pulp of the pods of *Cassia fistula* (H. Amaltas) is utilised as a purgative. The bark-decoction of *Saraca indica* (H. Ashoka) is used as a remedy for menstrual disorders.

RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

3. Fibre: The bark of Bauhinia vahlli yields fibres which are used in rope making.

4. Dye: The wood of *Haematoxylon campechianum* yields a dye called haematoxylin. This is an anatomical stain.

5. Tanning: The pods of *Caesalpinia coriaria*, *C. sappan* and *C. digyna* are used in tanning leather.

6. Ornamentals: *Delonix regia* (syn. *Poinciana regia*) H – Gulmohar, *Bauhinia* sp., *Caesalpinia pulcherrima*, *Colvillea racemosa*, *Parkinsonia aculeata*, *Saraca indica* etc., are grown in gardens and along the road side. *Delonix* and *Saraca* are liked for their deep shade giving quality.

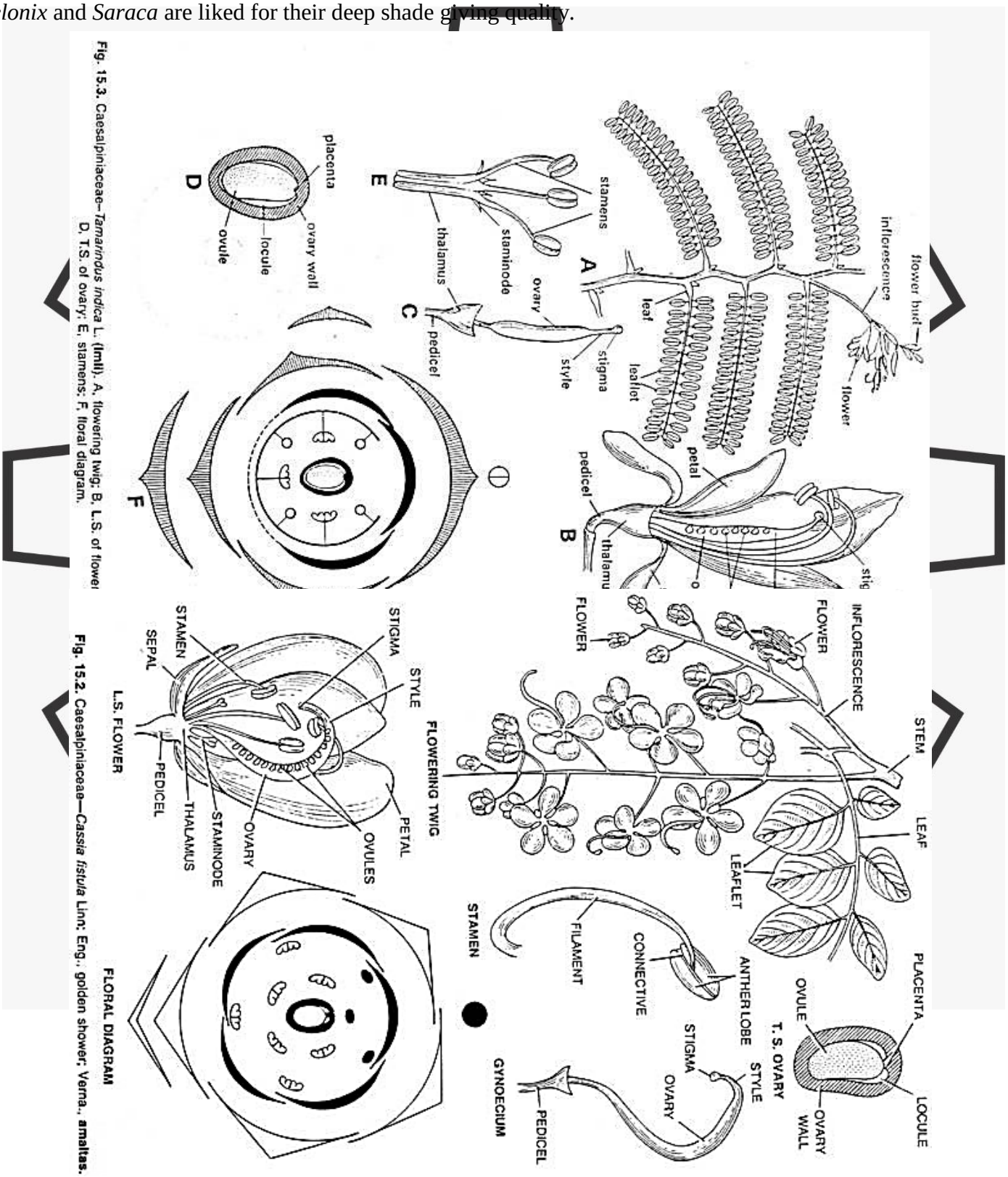


Fig. 15.3. Caesalpiniaceae–*Tamarindus indica* L. (Imli). A, flowering twig; B, L.S. of flower; D, T.S. of ovary; E, stamens; F, floral diagram.

Fig. 15.2. Caesalpiniaceae—*Cassia fistula* Linn; Eng., golden shower; Verna., **amaltas.**

Mimosaceae : Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Rosales
Family: Leguminosae/ Fabaceae
Sub-Family: Mimosaceae (Acacia family)
Characters of Mimosaceae: Trees or shrubs; leaves bipinnate and stipulate, stipule may be modified into spines; inflorescence cymose head or head; flowers actinomorphic, hermaphrodite, small, tetra or pentamerous; calyx and corolla valvate; petals connate below, stamens number varies from 4 (*Mimosa*) to many (*Acacia*, *Albizzia*); carpel one; fruit legume.
Distribution of Mimosaceae: It includes 40 genera and 2000 species. The members are mostly distributed in tropical and sub-tropical regions. In India it is represented by 12 genera and 90 species.
Examples: *Mimosa*, *Acacia*, *Albizzia*
A. Vegetative characters:
Habit: Herbs (*Mimosa*), climbers (*Entada*) and trees (*Acacia*, *Albizzia*) and hydrophytic (*Neptunia oleracea*). Many members are xerophytic (*Acacia*, *Prosopis*).
Root: Tap, much branched and deep.
Stem: Erect or climbing woody, branched angular or cylindrical, solid, covered with bark, some species yield gum, sometimes spiny.
Leaf: Cauline, ramal, alternate, pinnate or bipinnate compound, stipulate, stipules may be modified into spines, petiolate; in some species of Acacia the petiole becomes flattened into a phyllode and leaflets fall down; leaflets show movements (*Mimosa*, *Neptunia*).
B. Floral characters:
Inflorescence: Cymose head (*Acacia*), spike or racemose (*Dichrostachys* and *Prosopis*).
Flower: Pedicellate or sub-sessile (*Acacia*) or sessile (*Prosopis*), bracteate, actinomorphic, hermaphrodite, hypogynous, complete, tetra or pentamerous, small.
Calyx: Sepals 5, gamosepalous, valvate or imbricate (*Parkia*), green or petaloid (*Acacia nilotica*), inferior.
Corolla: Petals 5, polypetalous or gamopetalous (*Acacia*, *Albizzia*) valvate, inferior.
Androecium: 4 free in *Mimosa*, 10 free in *Prosopis*, indefinite and monadelphous in *Albizzia*, filaments long, anthers dithecous, pollen grains often in packets; often gland dotted to attract the insects.
Gynoecium: Monocarpellary, ovary superior, unilocular, marginal placentation, one or many ovules in a carpel; style long and filiform; stigma minute and simple.
Fruit: A legume or lomentum.
Seed: Non-endospermic.
Floral formula: $Br \oplus \varnothing K(4)$ or $(5)\ C_{4 \text{ or } 5}, A10$ or $\infty\ G_1$.
Economic Importance of Mimosaceae:
The sub-family is not of much economic importance. A few members are however useful.
1. *Acacia catechu* serves as a host for the lac insects. From this plant Katha is also obtained. Gum arabic is obtained from the barks of *A. nilotica* (syn. *A. arabica*) and *A. Senegal*. Saresh- a type of gum – is obtained from *Albizzia lebbek.*
The flowers of *A. decurrens* var. *dealbata* yield a perfume.
The bark of Acacia yields tannin which is used in leather tanning.
2. The wood of *Adenanthera pavonina* is powdered and yields a red dye.

3. *Prosopis spicigera* is grown as a hedge plant and also as a wind breaker in Rajasthan to check spreading desert, acts as water indicator.
4. Durable timber is obtained from *Acacia melanoxylon*, *Lysistoma sabicu*, *Xylia dolabriformis* (Iron wood).

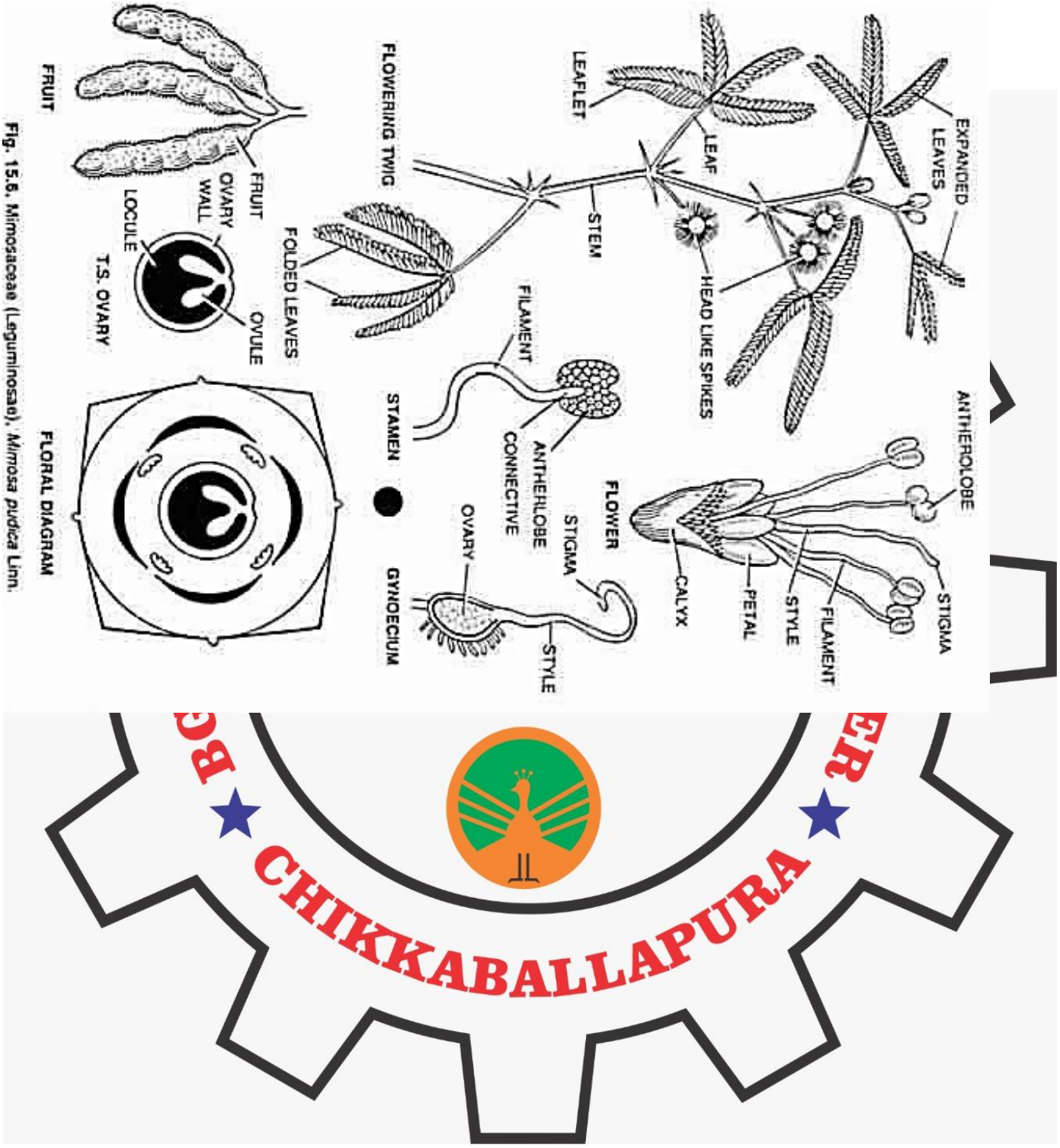


Fig. 15.6. Mimosaceae (Leguminosae), *Mimosa pudica* Linn.

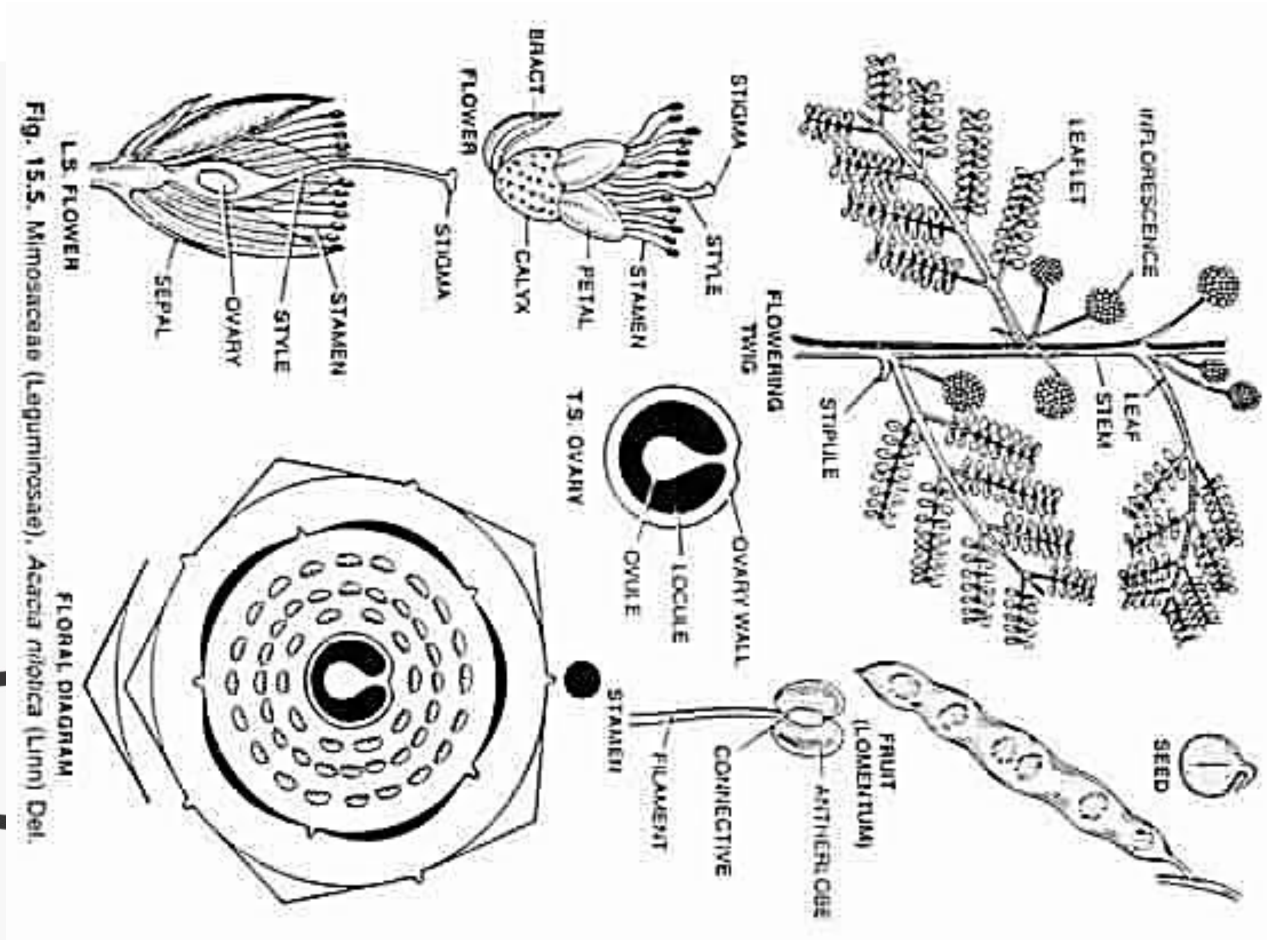


Fig. 15.5. Mimosaceae (Leguminosae). *Acacia nilotica* (Linn) Del.

Rosaceae : Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Subclass: Archichlamydeae
Order: Rosales
Family: Rosaceae
Characters of Rosaceae: Shrubs with prickles; leaves simple or compound, pinnate, alternate, stipulate; flowers actinomorphic very rarely zygomorphic hypo-, peri- or epigynous; calyx gamosepalous, 5; petals 5, polypetalous; stamens indefinite; carpels 1 to many, apo- or syncarpous, situated on swollen receptacle; fruit a collection of achenes, drupe or pome.
Distribution of Rosaceae: It is commonly known as rose family. The plants of the family are world wide in distribution and are abundant in Europe, N. America and Eastern Asia. It contains 115 genera and 3200 species out of which 257 species are found in India.
Examples: *Rosa* spp, *Pyrus malus* (H. seb), *Prunus amygdalus* (H. Badam), *Fragaria vesca* (strawberry)
A. Vegetative characters:
Habit: The plants show great variation in habit. The plants may be annual (*Neurada* spp.) or perennial prostrate herb, scandent or climbing or erect (*Rosa* spp.), shrubs or trees. Cydonia species are bushes. Trees are common and many of them are our popular fruit trees e.g. *Prunus amygdalus* (H. Badam); *Prunus persica* (H. Aru), *Pyrus communis* (H. Naspati); *Pyrus mains* (H. Seb) etc.
Root: Tap, branched sometimes adventitious arising from stem cuttings.
Stem: Erect, prostrate or climber, branched, hard and woody, runner or sucker. Vegetative propagation takes place by means of runner or sucker or cuttings, many shrubby species are with spines, in some prickles are present (*Rosa* spp.).
Leaves: Alternate rarely opposite (*Rhodotypos*), simple or compound sometimes pinnately compound, stipulate, stipule may be minute and caducous (*Spiraea*, *Pyrus*), adnate and persistent (*Rosa*, *Rubus*), leaf base conspicuous.
B. Floral characters:
Inflorescence: Solitary (*Potentilla*, *Rosa servica*) or grouped in racemose (*Agrimonia*). terminal corymbose (*Rosa moschata*), terminal cyme (*Geum*) or corymbose cyme (*Potentilla sibbaldi*).
Flower: Actinomorphic very rarely zygomorphic (*Chrysobalanoideae*), bisexual or rarely unisexual (Spiraea aruncus), pentamerous or tetramerous, hypogynous or epigynous (*Pyrus*) or perigynous (*Rosa*); stipules may be represented by epicalyx (*Fragaria*, *Potentilla*).
Calyx: Sepals 5, gamosepalous, adriate to the receptacle; sometimes epicalyx present; calyx tube remains free or adnate to the ovary, green, imbricate or valvate aestivation.
Corolla: Petals 5, or multiples of 5, polypetalous, rosaceous, inserted on the receptacle cup variously coloured; petals entirely absent (*Poterium*, *Alchemilla*, *Pygeum* gardneria*)*, or petals may be indefinite (*Rosa* spp.); sometimes stamens may be transformed into petal like structures; imbricate aestivation in bud.
Androecium: Stamens 2, 3 or 4 times the number of petals, may be indefinite, free, commonly borne on the rim of the torus; anthers small, dithecous, splitting longitudinally, introrse in bud; rarely stamens 1 to 4 (Alchemilla).
Gynoecium: Carpel 1 (*Prunus*, *Prinsepia*) or (*Agrimonia atorium*) or 5 (*Pyrus*) or indefinite (*Fragaria* and *Rosa*), apocarpous rarely syncarpous, ovary superior sometimes inferior (*Pyrus*), axile placentation, nectar secreting disc present between stamens and carpels; when syncarpous the placentation is axile, if apocarpous then basal.
Fruit: Variable; drupe (*Prunus*), etario of achenes (*Potentilla*) berry (*Eriobotrya japonica*), pome (*Pyrus*).

Seed: Non-endospermic.
Pollination: Entomophilous-insects are attracted by nectar, colour, aroma or protandrous nature.

Floral formula: ⊕ rarely ♂♀ ☿ K (5) C5 or α A α $G_{1-\alpha \text{ or } (2-5)}$

Economic Importance of Rosaceae:

1. Fruits: The fruits of *Pyrus malus* (H. seb), *Pyrus communis* (H. Nakh), *Prunus persica* (II. Aru), *Prunus amygdalus* (H. Badam), *Prunus domestica* (H. Alucha), *Prunus armeniaca* (H. Khuwani), *Eriobotrya japonica* (H. Loqat) are relished by all. *Fragaria vesca* is strawberry; black berries and raspberries belong to *Rubus*; *Cydonia oblonga* is Quince.

2. Medicinal: The petals of *Rosa* are used in making Gulkand, rose water and rose-scent.

The fruits of *Prunus domestica* are given in leucorrhoea and irregular menstruation. The roots of *Rubus fruticosus* are used in dysentery and whooping cough. *Crateagus ox*. is a very good homeopathic medicine for heart disease.

The fruits of *Eriobotrya japonica* are sedative and used in allaying vomiting and thirst.

3. Wood: The wood of *Cydonia indica*, *Crataegus oxyacantha* is used in making tool handles. The branches of *Cydonia indica* are excellent walking sticks.

4. Ornamental: *Rosa alba*, *Rosa moschata*, *Potentilla*, *Spiraea* are commonly grown in gardens. *Rosa* damascena (Damascus rose) and *R. centifolia* are cultivated for otto (itr) or roses. Oil is extracted from *Prunus amygdalus* (Badam oil).

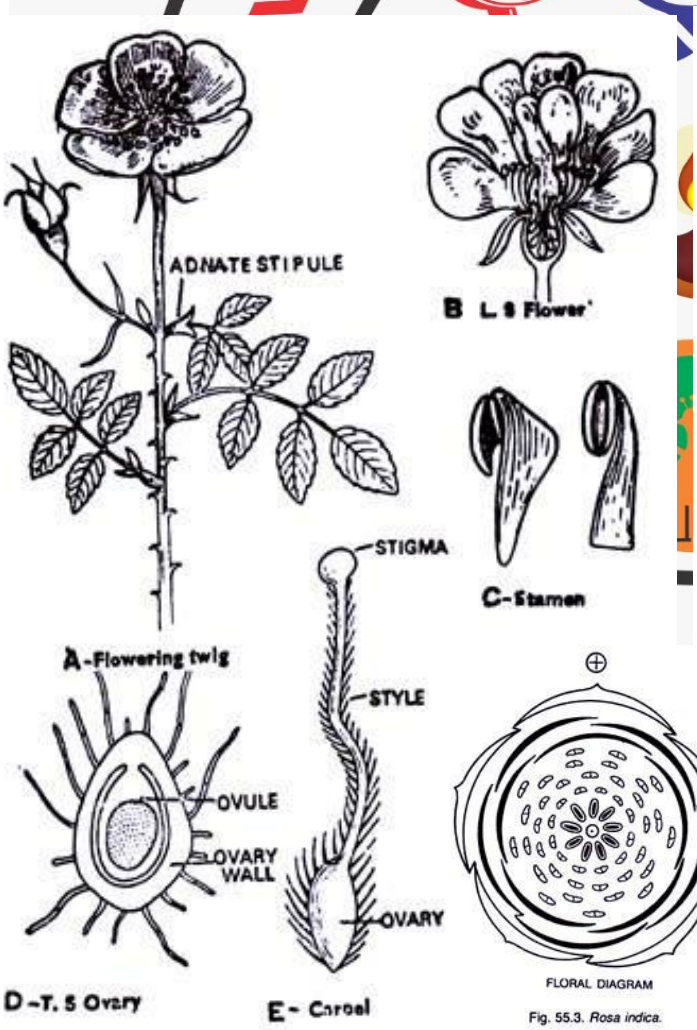


Fig. 55.2. *Rosa indica.*

Fig. 55.3. *Rosa indica.*

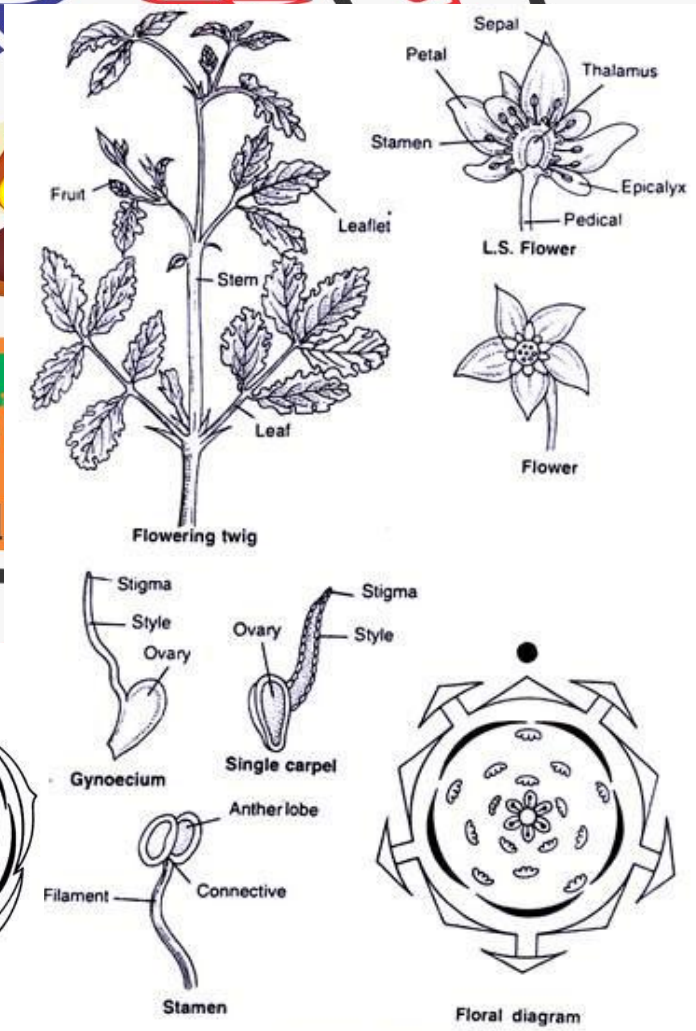


Fig. 55.1. *Potentilla.*

Family—Euphorbiaceae: Distribution, Characters and Economic importance

Classification:
Division: Angiospermae (Flowering Plants)
Class: Dicotyledonae
Sub-Class: Archichlamydae
Order: Geraniales
Family: Euphorbiaceae
Genus: 283 (W)
Species: 7,300 (W)

Distribution: Throughout the world but not in arctic regions. In India common genera are *Euphorbia*, *Ricinus*, *Phyllanthus*, *Croton*, *Pedilanthus*, etc. In the deserts of Africa and elsewhere the family is represented by cactus-like plants of different species of *Euphorbia*.

Habit: Great variation in their habit. The plants may be herbs, shrubs or trees. *Euphorbia hirta*, *Phyllanthus niruri*, *Croton sp.*, *Acalypha indica*, etc., are annual or perennial herbs. *Euphorbia pulcherrima* are beautiful shrubs. *Pedilanthus* sp., and *Jatropha* sp., are shrubby plants. *Euphorbia royleana*, *E. tirucalli* are cactus like shrubs. *Ricinus communis* is a tall annual and becomes small tree-like in habit. The tree habit of the family is represented by *Phyllanthus emblica* (Amla), *Bischofia javanica*, *Putranjiva roxburghii*, etc. *Hevea brasiliensis* (rubber tree) is a large tree 60 to 100 feet in height and 8-12 feet in girth. Species of the genus *Tragia* are tropical climbers. Majority of the members of the family possess large laticiferous vessels which contain latex.

Root: Tap and branched. Roots of *Manihot utilissima* and *M .palmata* are tuberous and rich in starch.

Stem: Herbaceous or woody, erect, very rarely climbing. The species of *Xylophylla* possess flat phylloclades. The stem is branched. It may be cylindrical, angular or flat. Usually solid but hollow in *Ricinus communis*. Many stems possess spines. In many *Euphorbia* sp., the stems become fleshy, green and cactus like in appearance.

Leaves: The form and position of leaves are variable. The arrangement is usually alternate but sometimes opposite, e.g., *Euphorbia hirta*. In *Pedilanthus* it is arranged alternately in the lower region whereas opposite in the floral region.

Usually leaves are simple but in some, deeply incised, e.g., *Ricinus*, *Manihot*, etc. In many *Euphorbias* the leaves are scaly and caducous. In many cases the leaves are reduced to spines. In few cases the leaves are replaced by cladodes. Usually the leaves are stipulate. In *Jatropha* sp., the stipules become branched and hair-like. In many *Euphorbia* sp., they are represented by glands or spines.

Inflorescence: it varies greatly, may be racemose or cymose or sometimes complex. In Euphorbia, the inflorescence is peculiar known as cyathium. In cyathium a large number of male flowers are stalked stamens found around a central stalked female flower. The female flower has gynoecium only.

The complete inflorescence looks like a single flower. The bracts are being arranged like a perianth. The bracts are united to form a cup-like structure.

In *Acalypha* the inflorescence is catkin. In *Croton* and *Ricinus* it is terminal racemes. In *Jatropha* it is of cymose type and the flowers are arranged in terminal cymes. In *Manihot* it is in racemes.

Flowers: they are always unisexual, much reduced, may be monoecious or dioecious. In *Euphorbia* sp., each male flower is represented by a single stalked stamen. The flowers are incomplete, regular, actinomorphic and hypogynous.

Perianth: Occasionally, both calyx and corolla are present, e.g., *Croton*. In majority either calyx or corolla or both are absent. In *Ricinus communis*, calyx is present but corolla absent. In *Euphorbia hirta* both are absent. In *Jatropha* sp., both are present.

In *Acalypha indica* the perianth has four minute sepaloid petals. In *Phyllanthus* only sepaloid perianth is present. In *Euphorbia* the perianth is absent or represented by tiny scaly structures.

The perianth consists of 4 to 5 petals. The calyx and corolla consists of 4 or 5 sepals or petals. The aestivation is valvate or imbricate.

Androecium: The number of stamens varies from one to many. Usually as many stamens are present as many perianth leaves. In *Euphorbia* a single stalked stamen, In *Ricinus* sp., usually five stamens, each stamen is profusely branched. In *Jatropha* they are in two whorls of five each.

In many the stamens are indefinite, e.g., *Croton*. The filaments may be free or united. The anthers are dithecous. They dehisce either by apical pores or by transverse or longitudinal slits.

Gynoecium: Three carpels (tricarpellary), syncarpous; the ovary is trilocular, superior. Each locule contains one or two pendulous, anatropous ovules. The placentaion is axile.

Fruit: Schizocarpic. The fruits break violently and dehisce into one seeded cocci. Such type of fruit is termed regma which is characteristic of *Ricinus* sp. The sp., of *Phyllanthus Emblica, Trewia* and *Bridelia* bear drupe.

Seeds: it is endospermic. In *Ricinus* caruncle develops from the micropyle. The cotyledons either lie flat or are folded within the endosperm.

Pollination: Usually entomophilous, i.e., through the agency of insects. Only cross- pollination takes place. In many species the leaves and bracts become coloured and showy to attract the insects. Sometimes anemophily is also found.

The floral formulae of different genera are as follows:

Euphorbia —	♂ K0, C0, A1
	♀ K0, C0, G(3).
Ricinus —	⊕ ♂ K5, C0, A5 (branched)
	⊕ ♀ K3, CO, G(3).
Croton —	⊕ ♂ K5, C5, A ∞
	⊕ ♀ K5, C5, G(3).

Economic Importance of the Family

- Ornamental- *Euphorbia milii, E. pulcherrima*
- Poison- roots of *Euphorbia tirucalli* are used for poisoning fish and birds.
- Medicinal value- *Euphorbia hirta* for treating many diseases of children and adults. *E. royleana* hedges, latex - used medicinally in several ways.
- *Euphorbia antiquorum* - decoction of stem- remedy of gout, juice of the plant-strong purgative, root bark is purgative.
- *Jatropha curcas*- seed oil- biodiesel, manufacturing candles, soaps and as a lubricant and for illumination- purgative, tender shoots are edible,
- *Jatropha gossypifolia, J. hastate, J. padagrica* – ornamental.
- *Manihot esculenta* (Tapioca) - tapioca tubers are exploited commercially to obtain starch, sago, semolina and flour.
- *Hevea brasiliensis* (Para rubber) - latex, obtained from the bark of the tree, is used for preparing rubber, which is used for tyres and inner tubes, waterproof clothing and various electrical goods.

- *Emblica officinalis* (Amla)- fruits are also used in diarrhoea and dysentery, bark, leaves, fruits, dyeing, tanning, wood yields excellent charcoal. The pickle or jam is prepared from the fruits. The fruit is very rich in vitamin C.
- *Emblica fischeri*- fruits are edible
- *Putranjiva roxburghii* (hedge plant)- nuts are made in rosaries, Hindus believe that if the hard stones of the fruits are made into rosaries and placed around the neck of the children, they keep them in good health. seeds also yield an oil which is used for burning purposes, leaves
- Fodder, leaves, fruits and stone of fruits, medicinally in colds and fevers.
- *Ricinus communis*- seeds are the source of castor-oil- lubricant, purgative, transparent soap, textile soap, typewriter-inks, perfume, aromatics, varnishes and paints.

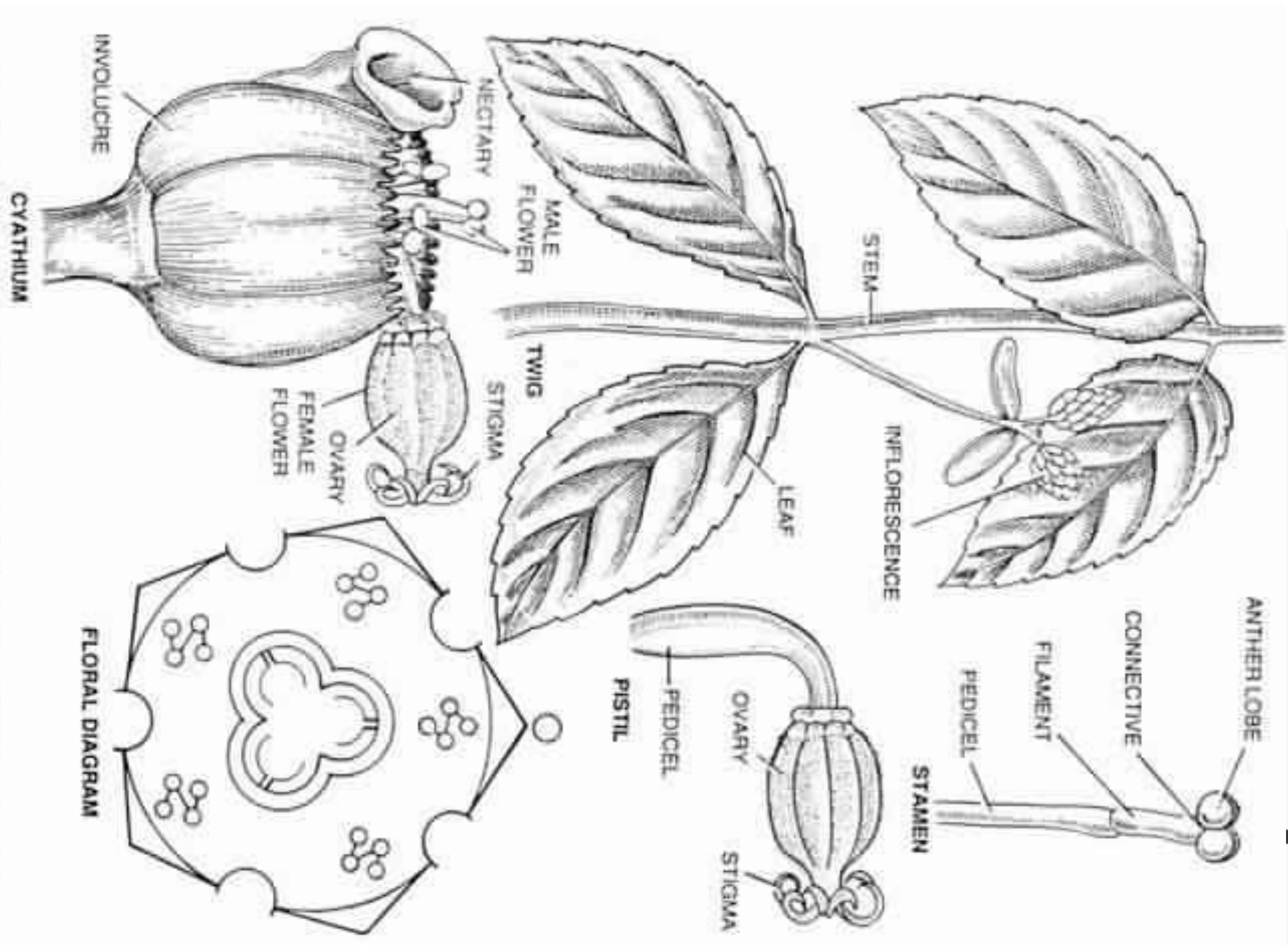


Fig.17.1. Euphorbiaceae. *Euphorbia* spp., plant with latex and cyathium inflorescence

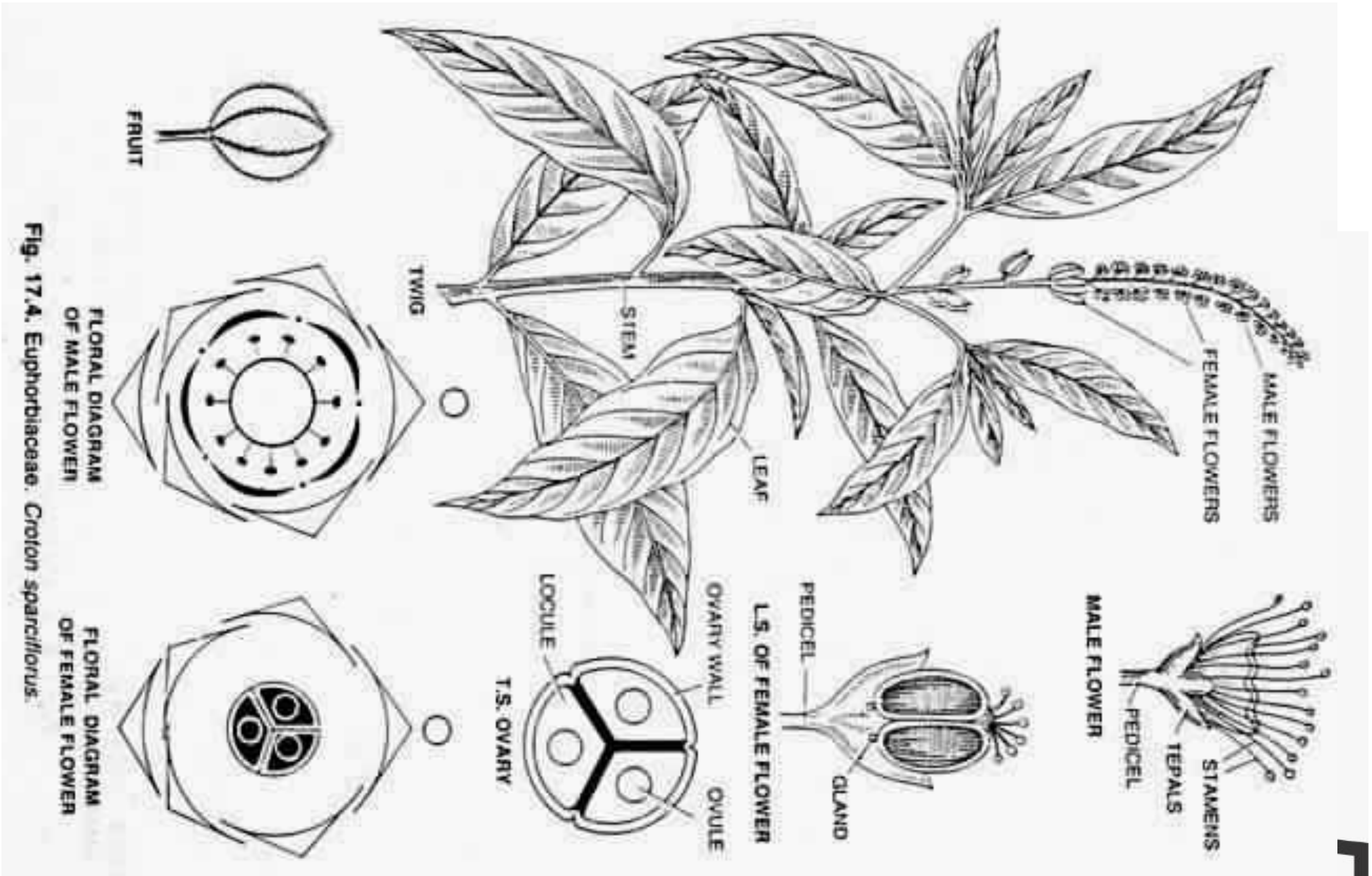


Fig. 17.4. Euphorbiaceae. *Croton sparciflorus.*

Family—Cucurbitaceae: Distribution, Characters and Economic importance

Systematic Position:

Class : Dicotyledonae
Subclass : Metachlamydeae
Order : Cucurbitales
Family : Cucurbitaceae
Genus : 110 (W) 37 (I)
Species : 850 (W) 90 (I)

Characters of Cucurbitaceae:

Prostrate herb bearing tendrils; leaves palmately lobed, surface hispid; flowers pentamerous, unisexual, monoecious or less commonly dioecious; stamens five, usually less, anthers free or connate, ovary inferior, trilocular, parietal placentation, fruit fleshy, pepo. Vascular bundles bicollateral and in two alternating rows.

Common plants of the family:

1. *Benincasa hispida* (White gourd)
2. *Citrullus vulgaris* (Water melon)
3. *Coccinia indica/cardifolia* (Donda kaya)
4. *Cucumis melo* (Cucumber)
5. *Cucumis melo mimordica* (Phut)
6. *Cucumis melo utilissimus* (Kakri)
7. *Cucumis sativus* (Cucumber)
8. *Cucurbita maxima* (Red Pumpkin)
9. *Cucurbita moschata* (Pumpkin)
10. *Cucurbita pepo* (Field Pumpkin)
11. *Langenaria siceraria* (bottle gourd; sorakaya)
12. *Luffa acutangula* (Ribbed gourd)
13. *Luffa cylindrica* (gourd; neti beerakaya)
14. *Mimordica charantia* (bitter gourd)
15. *Trichosanthes anguina* (Snake gourd)
16. *Trichosanthes dioica* (Pointed gourd)

Distribution : The members are chiefly inhabitants of tropical regions; a few in temperate regions. The members are wanting in the colder regions.

A. Vegetative characters:

Habit: Mostly annual or perennial herbs, rarely shrubs (Acanthosicyos) or small trees (Dendrosicyos), usually trailing, climbing by means of tendrils.

Root: Tap root, branched may be thickened due to storage of food and water.

Stem: Herbaceous, climbing, angular, fistular, branched.

Leaves: Alternate, petiolate- petiole long and hollow; simple, lobed, exstipulate, palmately veined; tendrils present in the axil of leaf or opposite to the leaf. In Acanthosicyos the leaves are absent but thorns are present.

B. Floral characters:

Inflorescence: There is great variation in the inflorescence. Flowers are solitary, or racemose or cymose panicles (*Actinostemma*).

Flower: Regular, mostly unisexual rarely bisexual (Schizopepon), incomplete, epigynous, small or large, mostly white or yellow, pentamerous.

Male flower: Produced in large numbers.

Calyx: Sepals 5, gamosepalous, sepals pointed, rarely petaloid, campanulate, aestivation imbricate.

Corolla: Petals 5, gamopetalous at base (*Momordica*) or through out (*Cucurbita*, *Coccinea*), polypetalous (*Luffa*, *Lagenaria*), may be campanulate, rotate, imbricate or valvate aestivation.
Androecium: Stamens 5, free or combined to form a central column, anthers dithecous extrorse, dehiscence longitudinal or in curves; androecium may be modified.
Gynoecium: Reduced or rudimentary or absent.

Female flower: They are fewer in number than the male flowers.
Calyx: Sepals 5, gamosepalous, calyx tube adnate to the ovary wall; imbricate aestivation, superior.
Corolla: Petals 5, gamopetalous, inserted on calyx tube; imbricate aestivation, superior.
Androecium: Staminodes 0, 3, 5.
Gynoecium: Tricarpellary, syncarpous, ovary inferior, unilocular with parietal placentation, the intruding placentae make the ovary to appear trilocular.
Style stout and columnar and bears a forked stigma for each carpel.
The stigmas are commissural i.e. stand above the dividing lines between the carpels. This is explained by assuming that each is a joint structure and composed of a branch of the stigmas of two adjacent carpels.
Fruit: Soft, fleshy, indehiscent and either a berry or pepo. Fruits sometimes very large in size (Citrullus sp. Benincasa sp., Cucurbita sp.). In Ecballium the fruit is highly turgid when ripe and dispersal is by explosion.
Seed: Exalbuminous, flattened, numerous, embryo straight, cotyledons large and oily.
Pollination: Entomophilous.
Floral formulae:

Male flower : ⊕ ♂ K(5) C5 or (5) A5 or (5) G0
Female flower : ⊕ ♀ K (5) C5 or (5) A O or 3–5 staminodes G (3)

Economic Importance of Cucurbitaceae:

This family is particularly important economically because its fruits are edible.
I. Vegetables and fruits:
1. *Cucumis melo*: The fruits are edible and a number of varieties are known. *C. melo var. momordica* is Phut and *C. melo var. utilissimus* is Kakri. Cucumis sativus is Khira.
2. *Citrullus vulgaris*: The fruits are large and ripen during summers; it is cultivated on the sandy beds of rivers. *C. vulgaris var. fistulosus* is Tinda which is used as vegetable.
3. *Cucurbita maxima*: *Cucurbita maxima* is Kaddu while *C. pepo* is Safed Kaddu; both are used as vegetable.
4. *Benincasa heipida*: It is used as vegetable;
5. *Lagenaria vulgaris*: the fruit is commonly used as a vegetable. From ripe fruit-shells sitar is made.
6. *Trichosanthes dioca*: whose fruits are also used in vegetable preparations. *T. anguina* is also used as vegetable.
7. *Luffa acutangula*: This is also a popular vegetable.
8. *Momordica charantia*: The fruits are bitter but used in vegetable preparations. It is said to be useful in gout and rheumatism.
II. Medicine:
There are a few plants also important medicinally.
9. ***Citrullus colocynthis*** – produces the alkaloid colocynthin from its fruits. The fruits and roots are used against snake bite. The alkaloid is also used in other diseases.
10. ***Ecballium elatarium*** fruits produce elaterium of medicine which has narcotic effect and useful in hydrophobia.
III. Ornamental: Some plants viz., *Ecballium*, *Sechium*, *Sicyos* are grown in gardens.

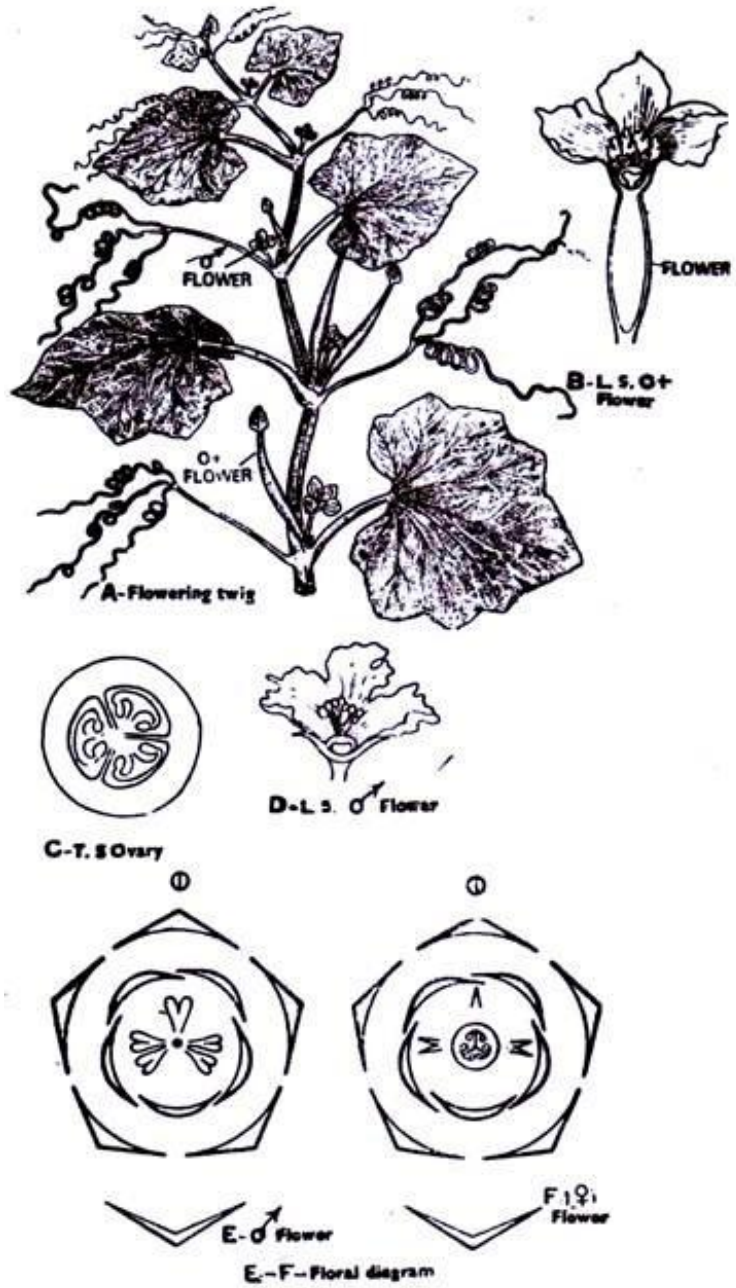
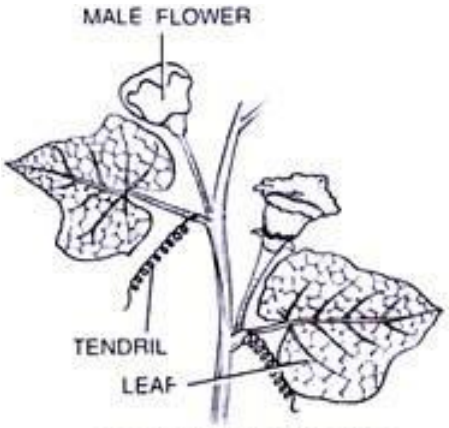
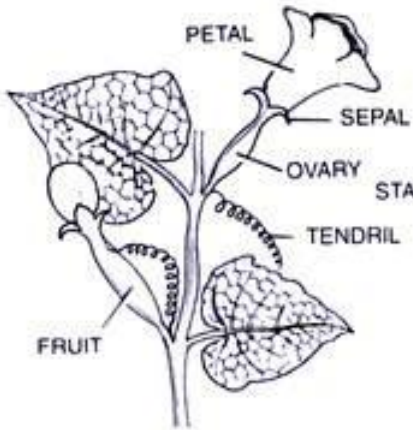


Fig. 64.2. *Cucurbita maxima.*

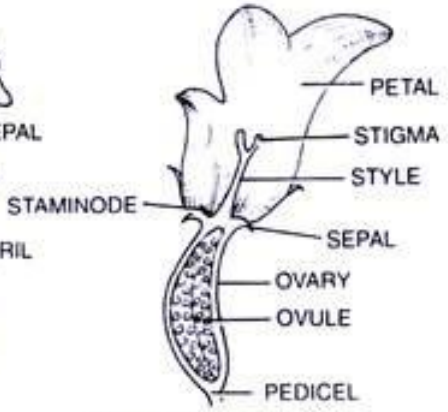


A MALE FLOWERING TWIG

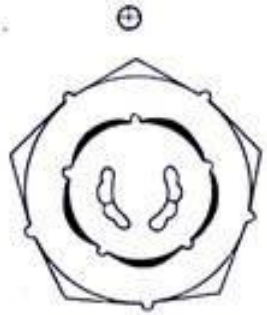
L.S. MALE FLOWER



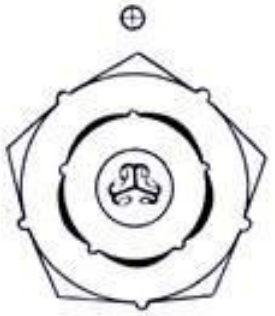
A FEMALE FLOWERING TWIG



L.S. FEMALE FLOWER



FLORAL DIAGRAM (MALE)



FLORAL DIAGRAM (FEMALE)

Fig. 64.3. *Coccinea grandis.*

Family—Apiaceae: Distribution, Characters and Economic importance

Systematic Position:

Class : Dicotyledonae
Subclass : Metachlamydeae
Order : Geraniales
Family : Apiaceae
Genus : 295 (W) 30 (I)
Species : 2850 (W) 180 (I)

Characters of Apiaceae:

Stem fistular, leaves alternate, much dissected mostly decompound, sheathing leaf base; inflorescence umbel or compound umbel occasionally simple; flowers epigynous, pentamerous, regular rarely zygomorphic, hermaphrodite; calyx superior, pentafid or 0; corolla five, polypetalous, often inflexed; stamens 5; carpels 2; syncarpous, bicarpellary with 2 pendulous ovules; honey-disc surrounding the stigmas – stylopodium is present; fruit cremocarp; seeds endospermic and oily.

Important plants of Apiaceae: *Anethum graveolens* (Dill), *Apium graveolens* (Celery seed), *Coriandrum sativum* (Coriander), *Cuminum cyminum* (cumin, Jeera), *Daucus carota* (Carrot), *Ferula asafoetids* (Asafoetida), *Foeniculum vulgare* (Somph) *Pastinaca sativa* (Parsnip), *Trachyspermum ammi* (Azwain, Vamu).

Distribution of Apiaceae: This family is commonly called carrot family. It was also named as Umbelliferae. The plants are distributed almost throughout the world except the arctic regions. The chief centres of the distribution are north temperate and sub-tropical regions.

A. Vegetative characters:

Habit: mostly herbs, annual, biennial or perennial, the herbs may be large (*Bupleurum*, *Heracleum*, *Agelica*) rarely shrubs with aromatic odour due to the presence of oil ducts. *Pseudocarum* climbs by its petioles which are very sensitive to contact.

Root: Tap, branched sometimes swollen for the storage of food material e.g., Carrot (*Daucus carota*).

Stem: Erect or prostrate; climbing in *Pseudocarum*; swollen nodes, sometimes ridged, usually fistular, glaucous or glabrous.

Leaf: Cauline and ramal; radical in young plants of *Daucus*, usually exstipulate, stipulate in *Centella*; alternate, opposite in some species or *Apiastrum*; simple or much dissected, often decompound; petiolate, petiole usually sheathing at the base, venation reticulate unicostate (*Centella*), multicostate (*Astrantia*), parallel in *Eryngium* and *Aciphylla*. Palmately lobed leaves in *Sanicula*.

B. Floral characters:

Inflorescence: Simple or compound umbel surrounded by thin leafy bracts called involucre; in some reduced to single flower e.g., in some species of *Centella* and *Azorella*; and to a compact head in *Eryngium*.

Flower: Pedicellate, bracteate (*Centella*) or ebracteate (*Foeniculum*), perfect, complete, actinomorphic and in some zygomorphic due to the enlargement of the outer petals of the marginal flowers of the umbel (*Coriandrum*); hermaphrodite, pentamerous, epigynous, disc is present.

In *Echinophora* each umbel has a central female flower surrounded by male flowers. In *Arctopus* and *Aciphylla* the flowers are fully dioecious. In *Astrantia* an intermediate condition is found.

Calyx: Sepals 5, gamosepalous, small teeth or scales or absent (*Foeniculum*), adnate to the ovary, valvate, green.

Corolla: Petals 5, polypetalous, epigynous often emarginate, tips inflexed, valvate (*Foeniculum*) imbricate, coloured.

Androecium: Stamens 5, polyandrous, inserted under the disc, anthers dithecous, versatile, introrse, filament long, equal in length, bent in the bud but ultimately spreading out.

Gynoecium: Bicarpellary, syncarpous, inferior, bilocular with a single pendulous ovule in each locule, antero-posteriorly placed, axile placentation, style two; stigmas two; on the top of the ovary an epigynous glandular-stylopodium is present.

Fruit: Schizocarpic cremocarp which splits into two one seeded mericarps, which remain attached to a slender often forked axis – the carpophore; mericarps are longitudinally ridged, in between the ridges are the furrows having oil ducts or vittae.

Seed: Endospermic, embryo small.

Pollination: Entomophilous due to nectar, scent and protandrous nature of flowers.

Floral formula:

⊕ or ♁ ☿ K (5) or 0 C5 A5 G (2).

Economic Importance of Apiaceae:

This family is of considerable importance from economic point of view chiefly because the plants have essential oil from which condiments or medicine are prepared.

Food: Carrot (*Daucus carota*), celery (*Apium graveolens*), parsnip (*Pastinaca sativa*) and sowa (*Peucedanum graveolens*) are chiefly used as pot herbs.

Condiments: Hing {*Ferula foetida*), Ajwain (*Carum copticum*), Zira (*Cuminum cyminum*), Saunf (*Foeniculum vulgare*), Dhania (*Coriandrum sativum*), are used as condiments or carminatives. Hing is a oleogum resin obtained from the roots. *Ferula sumbul* and *F. galbaniflua* also produce hing. Dorema also produces oleogum resin.

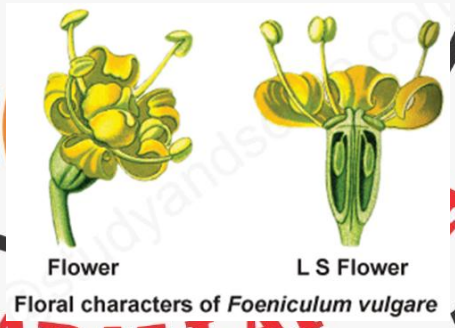
Fodder: Several members as carrot, Heracleum, Angelica provide fodder for cattle and horses.

Medicinal: Centella (H. Brahmi) is a very good tonic for brain. Hing, Saunf, Sowa, are used in digestive disorders. *Peucedanum, graveolens* (H. Sowa) is used as Dill water for children. *Conium maculatum* is the Hemlock plant. Its poison was given to Socrates; medicinally it is important in all spasmodic affections such as cholera, epilepsy, whooping cough, mania etc. *Conium* yields the alkaloid coniine.

Apium graveolens (H. Ajmud) produces aplin and used medicinally as cardiac tonic, or in asthma etc.

The fleshy roots of Cicuta and Aethusa are poisonous to all kinds of livestock.

Ornamental: Trachymene, Angelica, Eryngium, Heracleum are cultivated in gardens for their beautiful flowers.

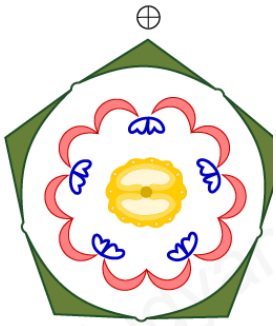


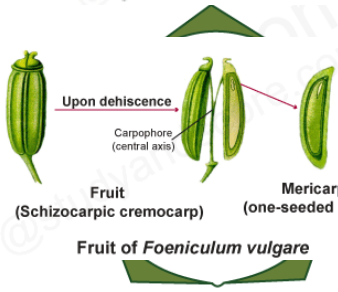
Floral characters of *Foeniculum vulgare*

Vegetative characters of *Foeniculum vulgare*

T S Ovary

Ovary of *Foeniculum vulgare*





Fruit of *Foeniculum vulgare*

CENTRAL FLOWER (Actinomorphic)

Floral formula: Br, Ebrl, ⊕, ♂, $K_{(5)}$, C_5, A_5, $G_{-(2)}$

PERIPHERAL FLOWER (Zygomorphic)

Floral formula: Br, Ebrl, %, ♂, $K_{(5)}$, C_5, A_5, $G_{-(2)}$

Floral Diagram of *Foeniculum vulgare*

RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

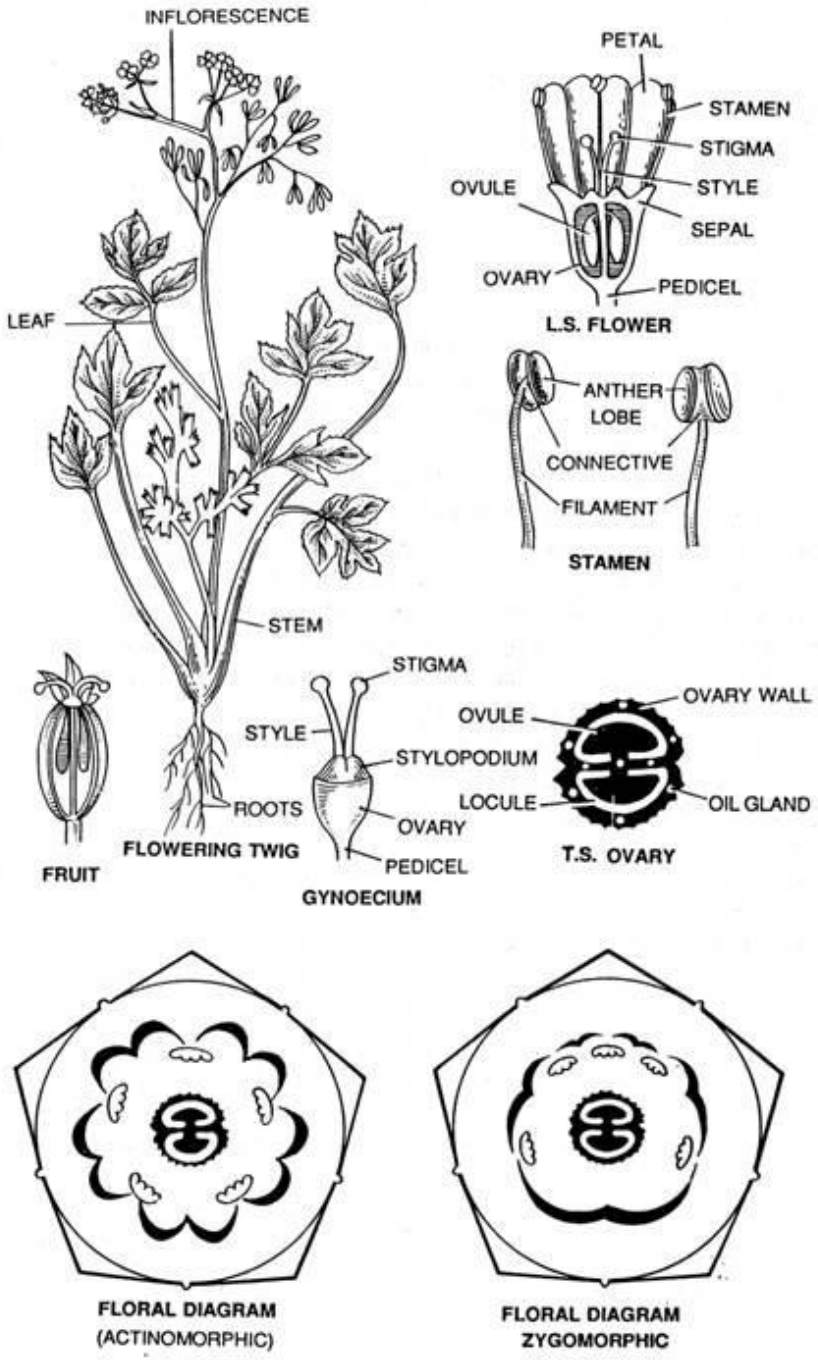


Fig. 25.3. Umbelliferae. *Coriandrum sativum* Linn., Eng. Coriander; Verna. **Dhaniya.**

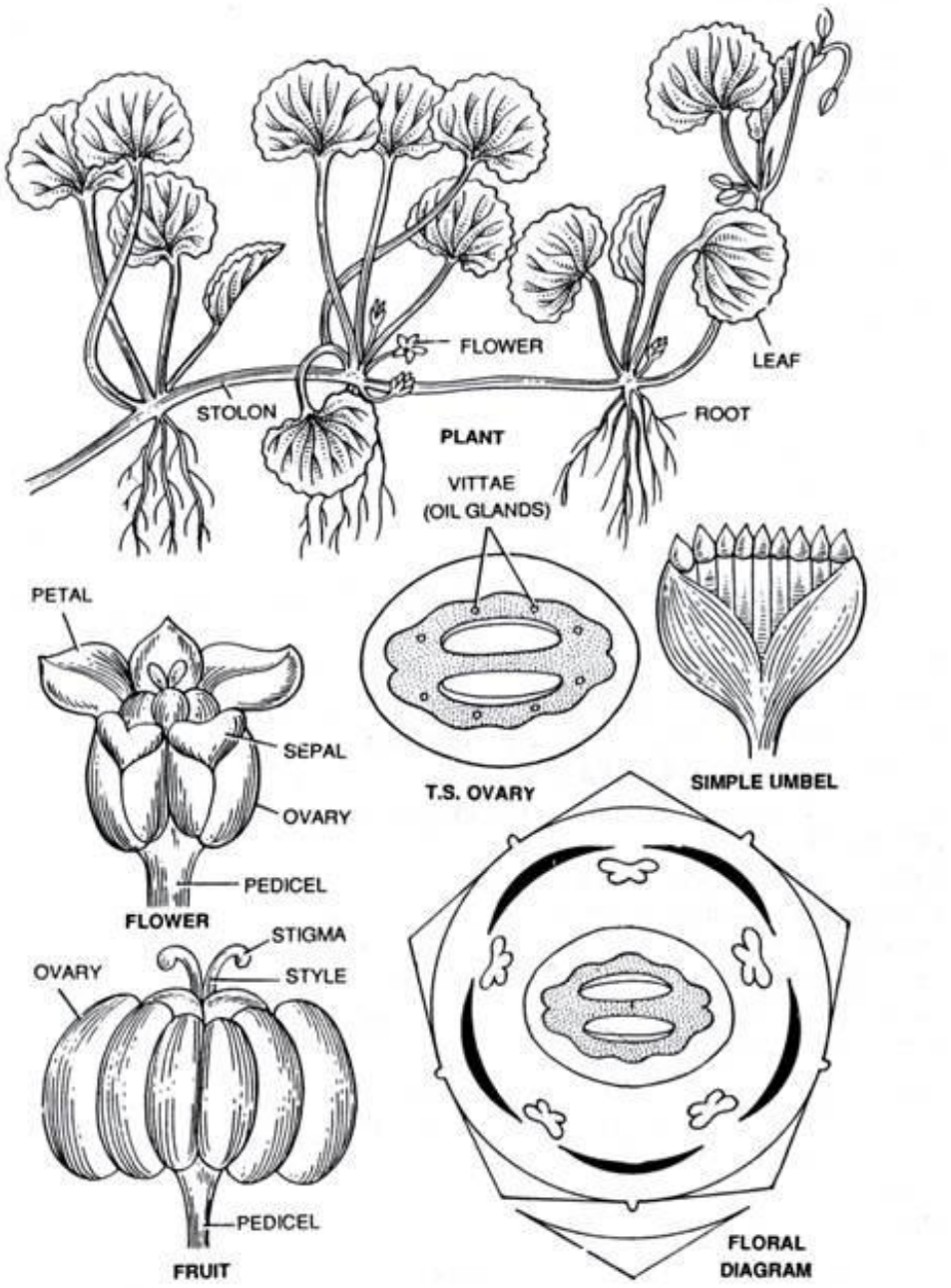


Fig. 25.2. Umbelliferae (Apiaceae). *Centella asiatica* (Linn). Urb. (Syn. *Hydrocotyle asiatica* L); Eng. Asiatic pennywort; Verna. **Brahmi.**

Family—Rubiaceae: Distribution, Characters and Economic importance

Systematic Position:
Class : Dicotyledonae
Subclass : Metachlamydeae
Order : Rubiales
Family : Rubiaceae
Genus : 500 (W) 76 (I)
Species : 6000 (W) 551 (I)

Characters of Rubiaceae: Trees or herbs; leaves alternate or opposite; stipules interpetiolar or intrapetiolar, inflorescence cymose; flowers tetra or pentamerous, hermaphrodite, actinomorphic, epigynous, corolla, gamopetalous; stamens 4-5; epipetalous, introrse, dithecous; ovary inferior, bilocular with one or many ovules in each loculus; fruit capsule or berry.

Common Plants of Rubiaceae: *Ixora coccinea*, *Oldenlandia corymbosa*, Cape jasemine (*Gardenia florida*), Coffee plant (*Coffea arabica* L.), Cinchona plant (*Cinchona succirubra*), Ipecac (*Psychotria ipecacuanha*), *Morinda citrifolia*, *Hamelia patens*, *Canthium angustifolium.*

Distribution of Rubiaceae: It is commonly known as Madder or Coffee family. The members of this family are distributed in tropics, sub-tropics and temperate regions.

A. Vegetative characters:

Habit: Mostly shrubs (*Gardenia*, *Ixora*, *Mussaenda*, *Hamelia*); trees (*Morinda*, *Adina*) and a few herbs (*Galium*, *Rubia*).

Root: Much branched tap root system.

Stem: Erect, herbaceous or woody or twinning (*Manettia*), climbing by hooks (*Uncaria*), branched, cylindrical or angular, hairy or smooth.

Leaves: Cauline, ramal, opposite or verticillate, simple, entire or toothed, stipulate, stipules bristle like (*Pentas*) and leafy (*Galium*, *Rubia*), stipules mostly interpetiolar or sometimes intrapetiolar; unicostate reticulate venation.

B. Floral characters:

Inflorescence: Solitary (*Gardenia*) usually cymose or globose head (*Adina*), or panicled cyme; may be axillary (*Coffea arabica*) or terminal cyme (*Mussaenda glabra*).

Flower: Actinomorphic, rarely zygomorphic (some what bilabiate as in *Henriquezia*), mostly hermaphrodite, rarely unisexual, epigynous, pedicellate or sessile (*Greenia*, *Randia*), bracteate or ebracteate, complete, tetra or pentamerous, cyclic, variously coloured.

Calyx: Sepals 4 or 5, gamosepalous, superior, sometimes one sepal modified into coloured bract like structure (*Mussaenda*), valvate.

Corolla: Petals 4 or 5, gamopetalous, lobed, generally funnel shaped (*Asperula*), tubular (Ixora), valvate to twisted or imbricate, superior.

Androecium: Stamens 4 or 5, rarely many (*Gardenia*), epipetalous, alternipetalous, inserted near the mouth of corolla tube, stamens dithecous, introrse, dehiscing longitudinally, superior.

Gynoecium: Bicarpellary, rarely polycarpellary, syncarpous, inferior rarely half inferior (*Synaptanthera*) or superior (*Paganea*), sometimes unilocular (Gardenia) with one to many anatropous ovules in each loculus, axile placentation (parietal placentation in Gardenia), style one sometimes bifid or multifid, stigma simple or bilobed.

Fruit: Capsular (*Anotis*), berry (*Mussaenda*, *Hamelia*, *Ixora*).

Seed: Endospermic, sometimes winged.

Pollination: Entomophilous; ant pollination is well known.

Floral formula: $\oplus$ or $\circ|\circ$ ☿ K (4–5) C (4–5) A4–5 $\underline{G\ (2–5)}$.

Economic Importance of Rubiaceae:

I. Medicinal plants: Bark of *Cinchona officinalis* yields an alkaloid called Quinine which is the best remedy for malarial fever. The roots of *Rubia cordifolia* are also used as medicine.

II. Beverage plants: The seeds of *Coffea arabica, C. liberica* and *C. robusta* are roasted and ground to give coffee powder.

III. Ornamental plants: *Rubia, Hamelia, Gardenia, Ixora, Mussaenda* are cultivated in gardens for their beautiful flowers.

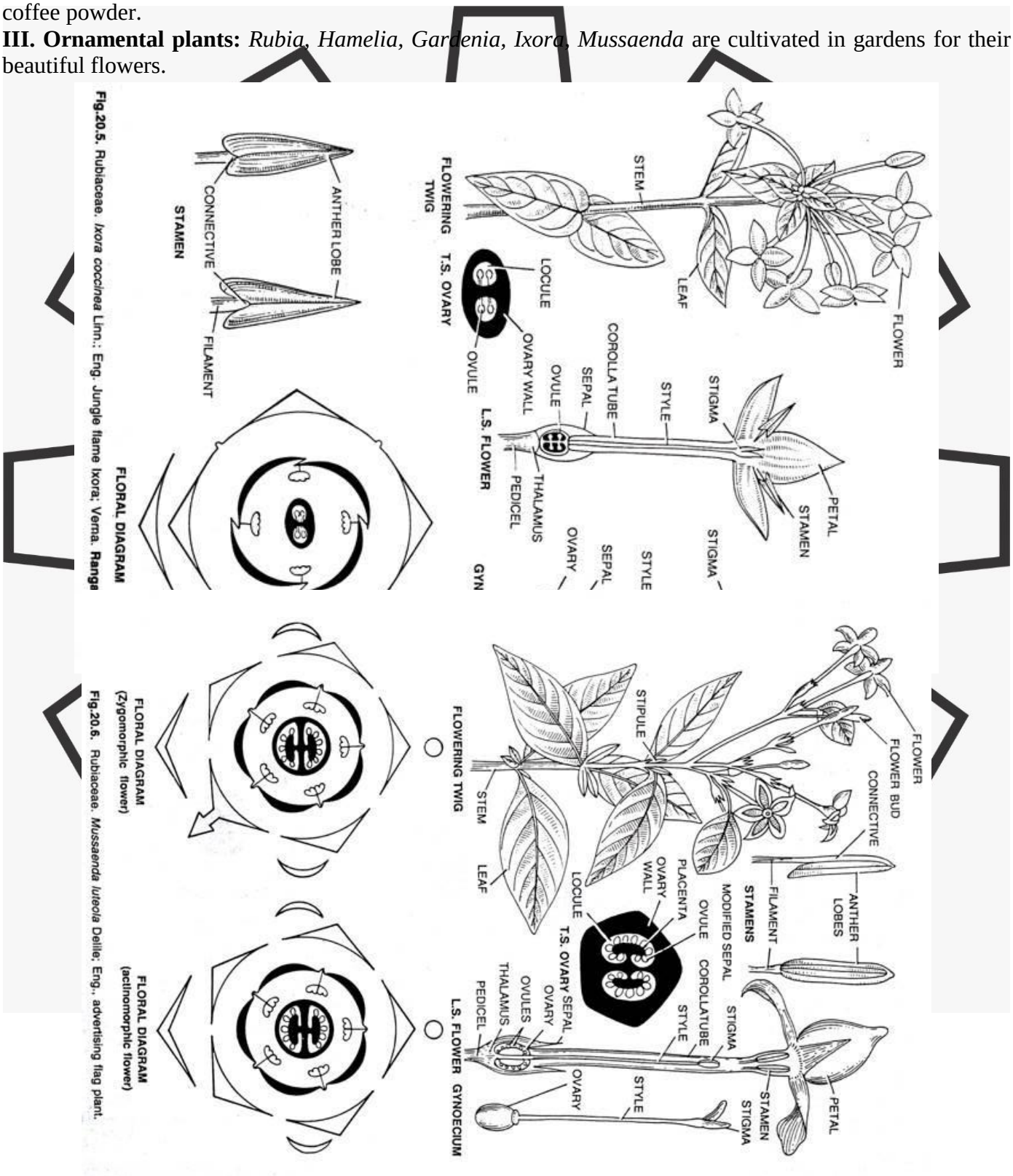
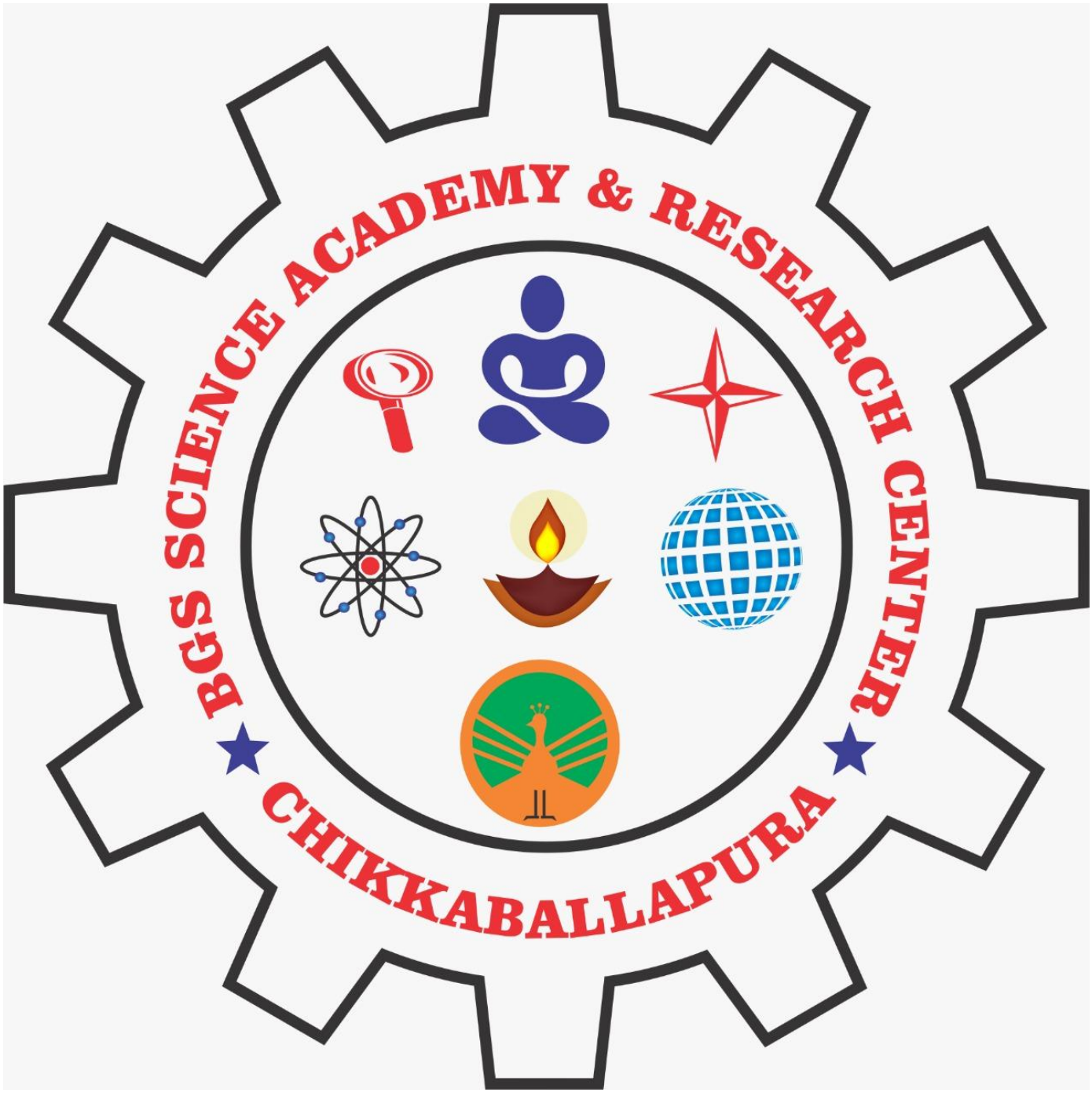


Fig.20.5. Rubiaceae. *Ixora coccinea* Linn.: Eng. Jungle flame Ixora; Verna. Ranga

Fig.20.6. Rubiaceae. *Mussaenda luteola* Delile; Eng., advertising flag plant.



RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

Family—Asteraceae: Distribution, Characters and Economic importance

Systematic Position:

Class : Dicotyledonae
Subclass : Metachlamydeae
Order : Companulales
Family : Asteraceae or Compositae (Sunflower family)
Genus : 1528 (W) 138 (I)
Species : 23,840 (W) 708 (I)

Characters of Asteraceae:

Mostly herbs or shrubs or rarely trees; leaves alternate rarely opposite, exstipulate rarely stipulate; inflorescence capitulum or head surrounded by involucre of bracts; ray and disc florets, flower tubular or ligulate, flowers bi- or unisexual or outer male or female, pentamerous, actinomorphic or zygomorphic, caryxpappus, corolla gamopetalous, petal lobes 5, stamens 5, epipetalous, usually dithecous, filament free and anthers united i.e. syngenesious, introrse, ovary unilocular, inferior, with basal placentation, style slender stigma bifid; fruit cypsela.

Important plants of Asteraceae: *Carthamus tinctorius* (Safflower), *Chrysanthemum cinerariaefolium*, *Chrysanthemum coccineum*, *Chrysanthemum marchallii*, *Cichorium intybus* (Chicory), *Helianthus annuus* (Sun flower), *Helianthus tuberosus* (Jerusalem Artichoke), *Lactuca saitva* (Garden lettuce), *Tagetes minuta* (Stinking roger), *Taraxacum officinale* (Common dandelion), *Tragopogon porrifolium* (Vegetable oyster), *Tussilago farfara* (Coughwort).

Distribution: It is the largest family of dicotyledons. They are worldwide in distribution and abundant in tropics and in cold arctic or alpines regions.

A. Vegetative characters:

Habit: Herbs (*Ageratum*, *Lactuca*, *Dahlia*, *Sonchus*), shrubs (*Inula*, *Senecio*) rarely trees (*Vernonia arborea* & *Leucomeris*). Many of the plants are xerophytes (*Proustia*), hydrophytes (*Cotula*) some are semiaquatic (*Caesulia axillaris*).

Root: Tap root, sometimes modified into tubers (*Dahlia*).

Stem: Erect, or prostrate, herbaceous or woody (*Artemisia*), hairy, sometimes with latex. Stem tubers are also present (*Helianthus*); tubers are edible (*H. tuberosus*); cylindrical; glabrous, solid or fistular, stem may be leaf-like (*Baccharis*).

Leaf: Alternate rarely opposite (*Zinnia*, *Dahlia*) or whorled; leaves may be radical, petiolate or sessile, exstipulate, mostly simple sometimes scale-like (*Senecio*), unicostate or multicostate reticulate venation.

B. Floral characters:

Inflorescence:

A head or capitulum, consisting of a few or large number of flowers or florets closely arranged on an axis surrounded by involucral bracts. The whole head or capitulum is apparently similar to a single flower because the involucral bracts perform the function of protection.

In Helianthus the outer or peripheral, ligulate and zygomorphic florets are called ray-florets; whereas inner or central, tubular and actinomorphic ones are called disc-florets.

In capitulum or head the form of flowers and distribution of sex also varies.

On the basis of form of flowers the heads are of three types:

1. Heterogamous or radiate heads. The outer or ray-florets are ligulate and zygomorphic and inner or disc-florets tubular and actinomorphic e.g. *Helianthus*.

2. Homogamous-rayed or ligulate heads. All the flowers in the head are ligulate, zygomorphic and alike; e.g. *Sonchus*.

3. Homogamous-non-rayed or discoid heads. All the flowers are tubular, actinomorphic and alike, e.g., *Ageratum*.

Distribution of sex: The flowers of a head may be all hermaphrodite (*Ageratum*), or ray-florets are female or neuter and inner ones hermaphrodite, or male; rarely the complete head bears unisexual flowers.

Flower: Bracteate, sessile, (*Sonchus*, *Ageratum*), complete or incomplete, hermaphrodite or unisexual, pentamerous, tubular (actinomorphic) or ligulate (zygomorphic), epigynous and inconspicious.

Ray-florets: Zygomorphic, ligulate, pistillate, or neuter or sometimes also bisexual, epigynous.

Calyx: Modified into pappus or absent or scale-like.

Corolla: Petals 5, gamopetalous, highly coloured, ligulate, strap-shaped, valvate.

Androecium: Absent.

Gynoecium: Either absent or if present then bicarpellary, syncarpous, inferior, unilocular with basal placentation, one anatropous ovule; style one; stigma bifid.

Fruit: Absent; if present cypsela.

Seed: Non-endospermic.

Floral formula:

Br. ob ♀ or neuter K pappus C (5) A0 G(2) or 0.

Disc florets:

Flower: Bracteate, sessile, complete, hermaphrodite, actinomorphic, pentamerous, epigynous and tubular.

Calyx: Modified into pappus or scale, persistent.

Corolla: Petals 5, gamopetalous, tubular, coloured.

Androecium: Stamens 5, epipetalous, syngenesious, dithecous, introrse, dehiscing longitudinally.

Gynoecium: Bicarpellary, syncarpous, inferior, unilocular with single anatropous ovule, basal placentation; style simple, long, stigma bifid.

Fruit: Cypsela.

Seed: Non-endospermic.

Pollination: Entomophilous.

Floral formula:

Br ⊕ ☿ K pappus $C_{(5)}$ $A_{(5)}$ $G_{\overline{(2)}}$

Economic Importance of Asteraceae:

1. Food: Leaves of *Lactuca sativa* are used as salad. The roots of *Helianthus tuberosus* are edible.

2. Oil: The seeds of *Helianthus* and *Artemisia* yield oil.

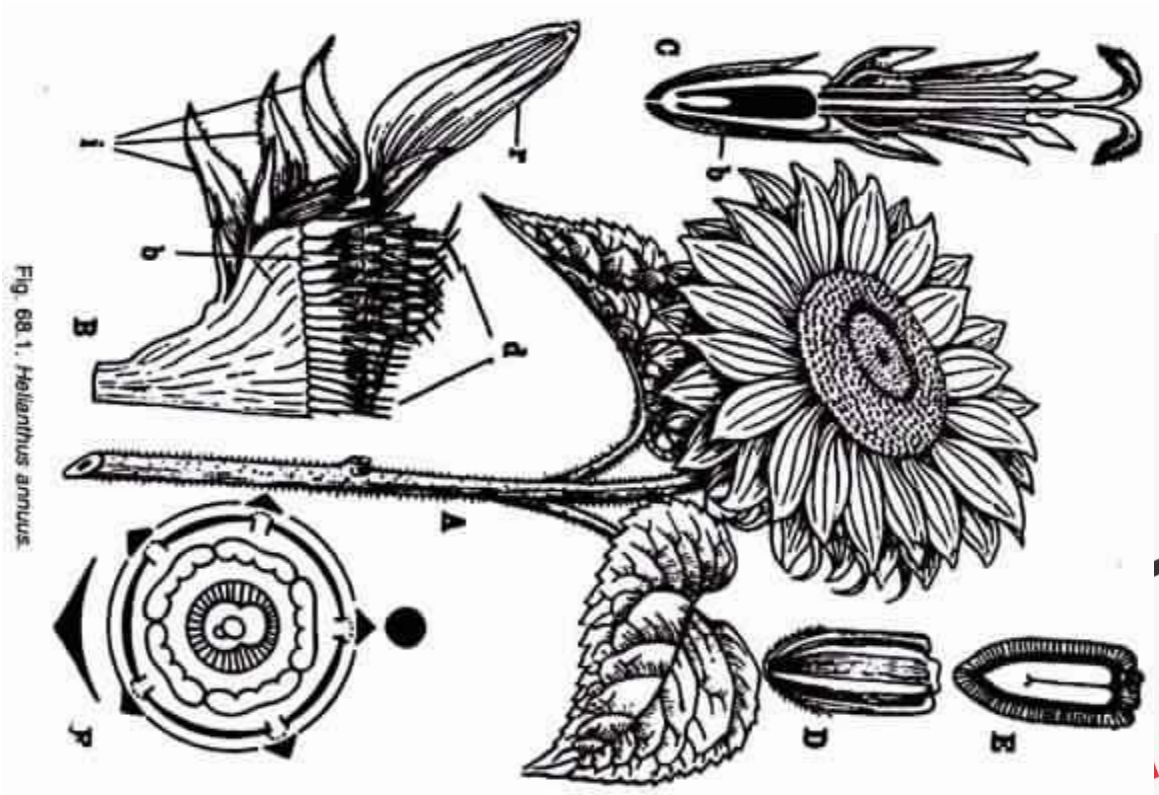
3. Medicinal: *Solidago* used in dropsy. *Artemisia* yields santonin which is used as vermifuge. The roots of *Taraxacum* used in bowel disorders. The juice of *Emillia sonchifolia* leaves has cooling effect and is used in eye inflammation and also for night blindness. *Eclipta alba* used as tonic in spleen enlargement. *Centipeda orbicularis* is used in cold and toothache.

4. Rubber: It is obtained from *Solidago laevenworthii* and *Taraxacum*.

5. Insecticide: The capitula of *Chrysanthemum roseum* and *C. cinerriefolium* are dried, powdered and used as insecticide.

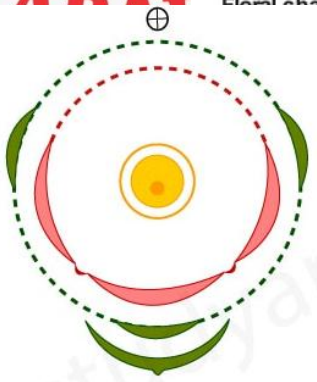
6. Ornamental: *Zinnia, Dahila, Cosmos, Chrysanthemum, Calendula, Helichrysium, Aster Helianthus* etc. are well known garden plants.

7. Weeds: *Xanthium, Blumea, Sonchus, Vernonia* are the common weeds.



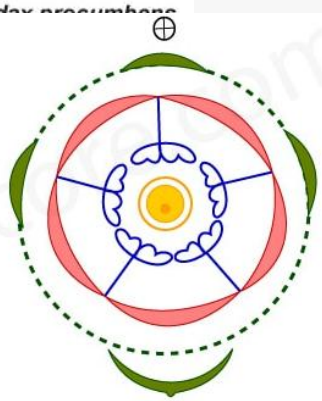
Vegetative characters of *Tridax procumbe*

Floral characters of *Tridax procumbens*



Floral Diagram of Ray floret

Floral formula: Br % ♀ $K_{(2-3)\,(pappus)}\ \overset{\frown}{C_{(3-5)}}\ A_0\ \overline{G}_{(2)}$



Floral Diagram of Disc floret

Floral formula: Br ⊕ ☿ $K_{2-3\,(pappus)}\ \overset{\frown}{C_{(5)}}\ A_5\ \overline{G}_{(2)}$

RANJITH KUMAR H T, ASSISTANT PROFESSOR, DEPARTMENT OF BOTANY

Family—Asclepiadaceae: Distribution, Characters and Economic importance

Classification:
Class: Dicotyledonae
Subclass : Metachlamydeae
Order : Contortae
Family : Asclepiadaceae
Genus : 320 (W) 53 (I)
Species : 2,000(W) 332 (I)

Characters of Asclepiadaceae: Plants herbs, shrubs, mostly twiners and rarely trees; leaves opposite, simple, entire margin rarely alternate; inflorescence cymose or racemose; flowers hermaphrodite, pentamerous; calyx of 5 sepals, imbricate; petals 5, gamopetalous, corona arising as outgrowth of petals or stamens; stamens 5, fused with stigmatic disc forming gynostegium; pollens forming pollinia; carpels bicarpellary, syncarpous, ovaries and style free, only stigma fused to form disc, marginal placentation, fruit follicles.

Important plants of Asclepiadaceae: *Asclepias curassivica* (Milk weed), *Asclepias tuberose* (butterfly weed), *Calotropis gigantean*, *Cryptostegia grandiflora* (rubber wine), *Gymnema sylvestre*, *Hemidesmus indicus* (Indian Sarsaparilla), *Tylophora indica* (Indian impecacuanha).

Distribution : It has worldwide distribution, but mostly confined to tropics and sub-tropics.

A. Vegetative characters:

Habit: Perennial herbs (*Asclepias*) or shrubs (*Calotropis*, *Leptadenia*), climbers (*Cryptostegia*, *Daemia*), succulent (*Stapelia*) with latex.

Root: A deep branched tap root.

Stem: Herbaceous, week and climbing or succulent, woody below (*Calotropis*), erect, twiner or climbers (*Cryptostegia*) cylindrical, rarely hairy and solid, latex present.

Leaves: Simple, petiolate, exstipulate, entire, opposite rarely whorled, waxy; in *Dischidia rafflesiana* leaves are modified into pitchers, reduced or absent (*Periploca*), succulent in *Hoya*.

B. Floral characters:

Inflorescence: Mostly umbellate cymes (*Calotropis*) or dichasial cyme ending in monochasial cyme.

Flower: Bracteate or ebracteate, pedicellate, complete, hermaphrodite, actinomorphic, rarely zygomorphic (*Ceropegia*), pentamerous, hypogynous.

Calyx: Sepals 5, polysepalous or gamosepalous-fused near the base, quincuncial aestivation, sometimes valvate.

Corolla: Petals 5, gamopetalous, 5 lobed, twisted aestivation or valvate, corona may be scaly or hairy out growth from petals – corolline corona in *Cryptostegia*, *Cryptolepis* or form staminal tube i.e. staminal corona in *Calotropis* and *Asclepias*.

Androecium: Stamens 5, synandrous, gynostegium (stamens fused with stigmatic disc to form gynostegium), anthers dithecous, epipetalous, coherent; the pollen grains of each half anther usually agglutinated into granular mass of tetrads or waxy pollen called pollinium (*Asclepias*, *Calotropis*). Thus each stamen has two pollinia.

The pollinia of two adjacent anther halves are connected together at the black, dot-like gland called corpusculum by appendages called – retinacula. The two pollinia (of adjacent anther halves), two retinacula and a corpusculum together form a single translator. So in all there are 5 translators.

Gynoecium: Bicarpellary, syncarpous, ovaries free, superior, enclosed in staminal tube, ovules many on marginal placentation, each carpel is unilocular; style 2, free, distinct; stigmas united to form a pentangular disc with which anthers are fused to form gynostegium.

Fruit: An etaerio of two, often widely divergent follicles; in some one follicle is abortive.

Seed: Many small, compressed with long silky hairs.

Pollination: Entomophilous, translator mechanism.

Floral formula: $\oplus\ \varnothing\ \ K_{5\text{ or }(5)}\ C_{(5)}\ A_{(5)}\ \underline{G_{(2)}}$

Economic Importance of Asclepiadaceae:

1. Food: *Gymnema lactiferum* yields latex which is used as food in Ceylon.

2. Fibres: Some plants like *Daemia extensa*, *Calotropis procera*, *C. gigantea*, *Marsdenia* and *Leptadenia* etc. yield silky fibres which axe used for making ropes, mat, stuffing pillows etc.

3. Medicinal: The source of medicine in the family is latex from which alkaloids are extracted. The roots of *Oxystelma esculentum* are specific for jaundice. This roots of *Pentatropis* are used in gonorrhoea. *Hemidesmus indicus* is used in leucorrhoea, rheumatism and in snake bites. *Daemia extensa* is used in cough; asthma and diarrhoea.

4. Rubber: *Cryptostegia grandiflora* is a natural source of rubber in India.

5. Poison: Some species of *Asclepias* are important as live-stock poison. The sap of *Matelea* has been used as an arrow poison.

6. Ornamental: *Asclepias*, *Cryptostegia*, *Hoya*, *Huernia*, *Ceropegia*, *Periploca* etc. are cultivated for ornamental purposes.

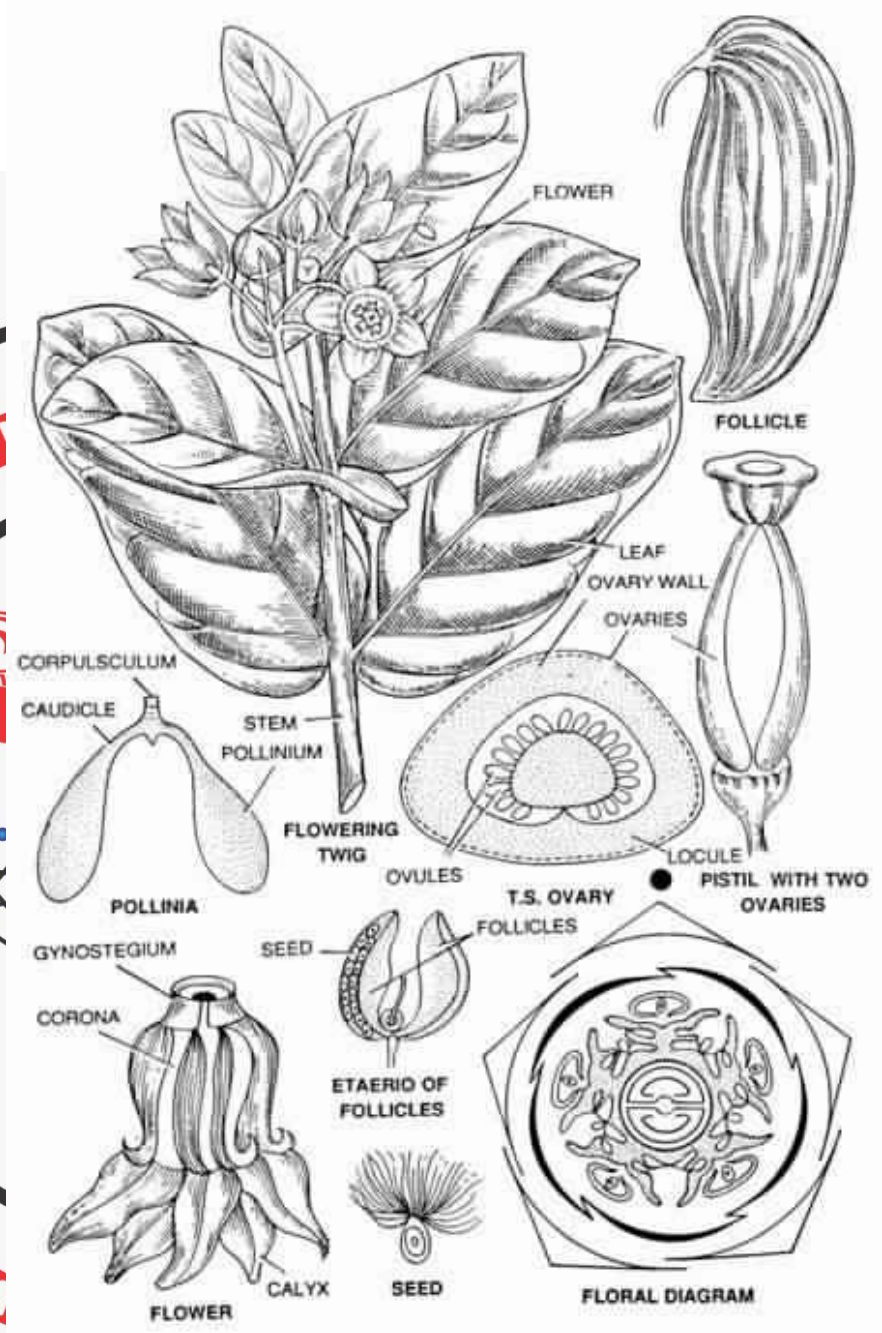
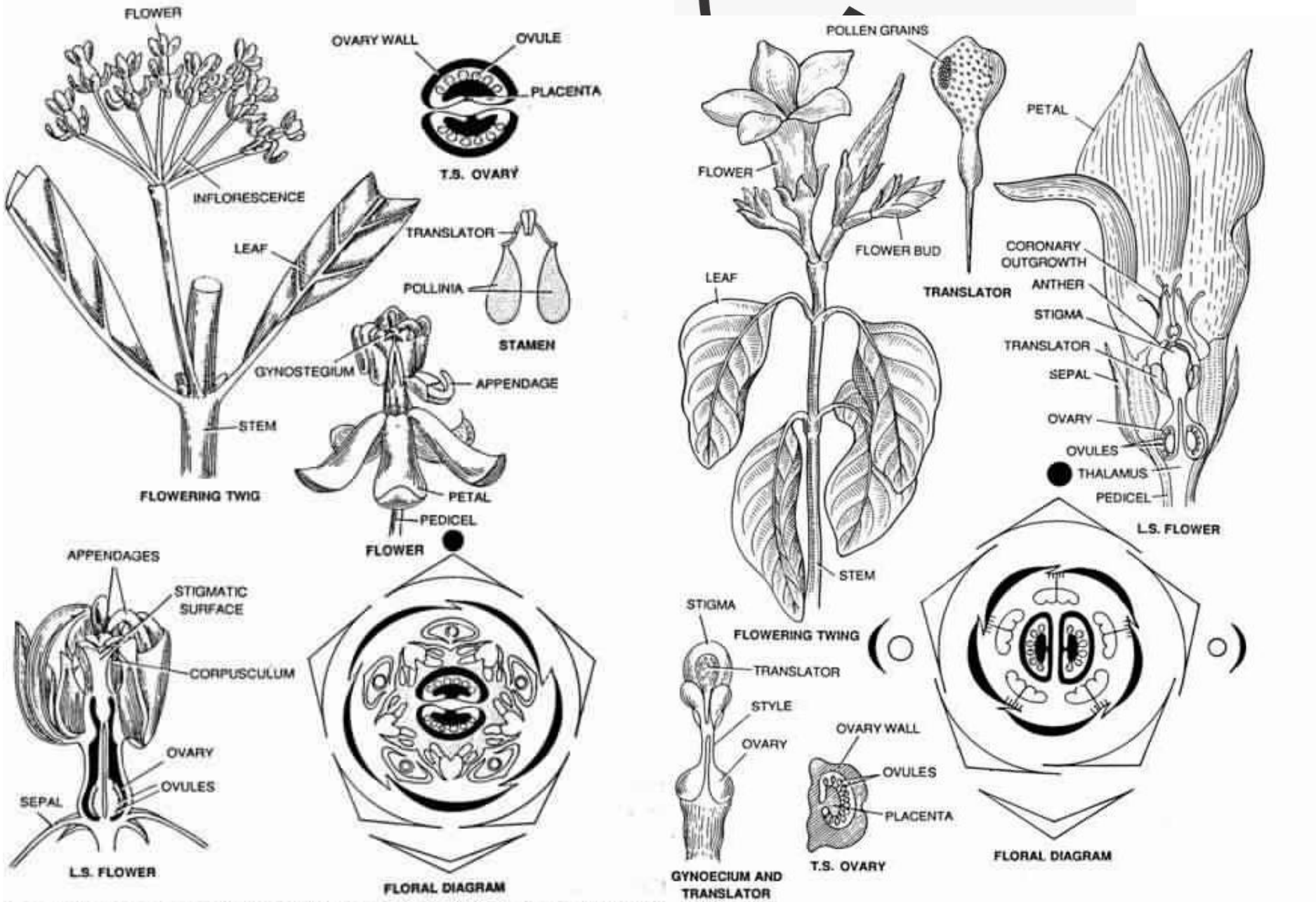


Fig. 19.6. Asclepiadaceae. *Calotropis procera* (Ak.)



19.7. Asclepiadaceae. *Asclepias curassavica* Linn. Eng. Blood flower; Verna. **Kukatundi.** **19.8.** Asclepiadaceae. *Cryptostegia grandiflora* R. Br., rubber vine; Verna. **vilayati vakhandi.**

Family—Acanthaceae: Distribution, Characters and Economic importance

Classification:

Class	**:** Dicotyledonae
Subclass	**:** Metachlamydeae
Order	**:** Tubiflorae
Family	**:** Acanthaceae
Genus	**:** 250 (W) 53 (I)
Species	**:** 2500 (W) 508 (I)

Characters of Acanthaceae:

Mostly herbs, shrubs; leaves opposite decussate, exstipulate, inflorescence cymose, flowers bracteate, bracteolate, zygomorphic, hermaphrodite, hypogynous; calyx five or 4 gamosepalous, corolla pentapartite, gamopetalous, often bilipped; stamens 4 to 2 didynamous, polyandrous, epipetalous; carpels two, syncarpous, ovary superior, axile placentation, style simple, stigma bilobed; fruit loculicidal capsule, seeds non-endospermic with jaculators.

Common Plants of Acanthaceae: *Crossandra, Barleria, Justicia adhatoda (*syn. *Adhatoda vesica), Ruellia, Thunbergia.*

Distribution: The family is chiefly distributed in tropics and sub-tropics.

A. Vegetative characters:

Habit: Plants are mostly herbs, shrubs or a few climbers (*Thunbergia*)-, some xerophytes (*Barleria*, *Blepharis*, *Acanthus*), aquatic (*Asteracantha longifolia*).

Root: Branched tap root system.

Stem: Aerial, erect, underground (*Ruellia tuberosa*), herbaceous or woody, branched cylindrical, node swollen, climbing or twining (*Thunbergia*), spinous (*Barleria*).

Leaves: Opposite decussate, simple, exstipulate, petiolate, usually entire, acute apex, hairy, cystoliths are present in the epidermal cells of stem and leaves.

B. Floral characters:

Inflorescence: Solitary axillary (*Thunbergia*), spike (*Blepharis*) racemes, dichasial or monochasial cymes.

Flower: Bracteate, bracteolate, bracts and bracteolates conspicuous, pedicellate or sessile, and brightly coloured, hermaphrodite, complete, zygomorphic, pentamerous, or tetramerous, hypogynous, nectariferous disc present below the ovary wall.

Calyx: Sepals 4 or 5 gamosepalous, mostly bilabiate, hairy, imbricate, inferior.

Corolla: Petals 2 to 5, bilipped, gamopetalous, variously coloured, imbricate or twisted, inferior.

Androecium: Generally 4, rarely 5 (*Penstemon*), in some 2 fertile stamens and 2 staminodes, epipetalous, filaments free, dithecous, dorsifixed, alternate with the corolla lobes, one anther lobe may be smaller than the other and unequally placed, anthers sometimes spurred.

Gynoecium: Bicarpellary, syncarpous, superior, bilocular, axile placentation, carpels median, one or more ovules per loculus, style simple, stigma bilobed, disc present below the ovary.

Fruit: Loculicidal capsule or rarely drupe.

Seed: Non-endospermic with hooks (jaculators).

Pollination: Entomophilous.

Floral formula: Br, Brl ♁ ♀ $K_{(4-5)}$ $C_{(5) \text{ or } (2+3)}$ $A_{2+2 \text{ or } 2 \text{ or } 5}$ $G_{(2)}$.

Economic Importance:

1. Medicinal: Many plants of the family are medicinal. *Adhatoda vasika* and *Barleria cristata* are used in cough. Roots of *Rhinanthus*, *Ruellia* are also used in medicine. Roots of *Ecbolium* are used in jaundice. *Andrographis paniculata* is used for liver diseases. Fruits and leaves of *Phlogacanthus thyrsiflorus* are used for fever. Leaves of *Phlogacanthus tubiflorus* when rubbed in water yields lather which is used like soap for washing purposes.

2. Ornamental: Many plants are cultivated for ornamental purposes viz., *Acanthus*, *Barleria*, *Justicia*, *Thunbergia*, *Jacobinia*, *Ruellia*, are often used as hedge.

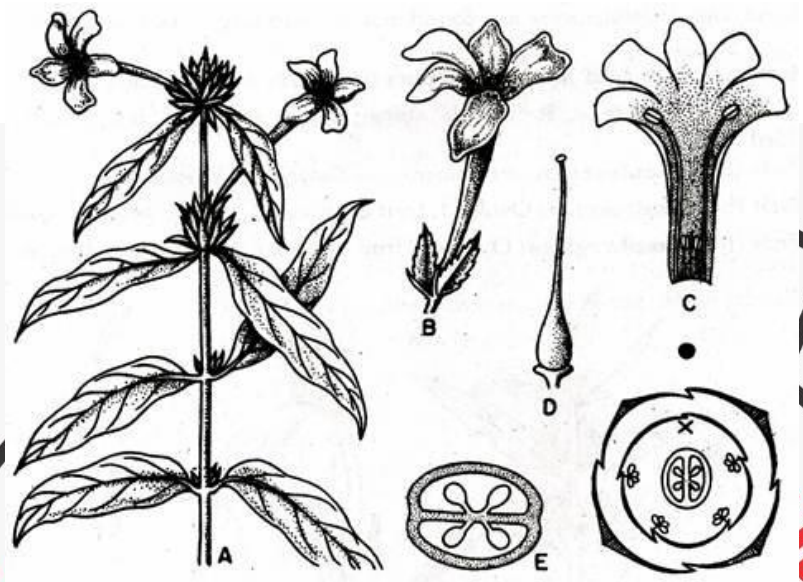


Fig. 144. Barleria cristata Linn. A. Leafy shoot with flower clusters ($\times\frac{1}{2}$); B. One flower with bracts ($\times 1$); C. Corolla split open to show the stamens; D. Ovary; E. T.s. of ovary.

Fig. 4.123 : Acanthaceae (*Adhatoda vasica*) : A. Portion of a plant with flowers; B. Single flower; C. Stamen; D. Pistil, and F. T.S. of ovary

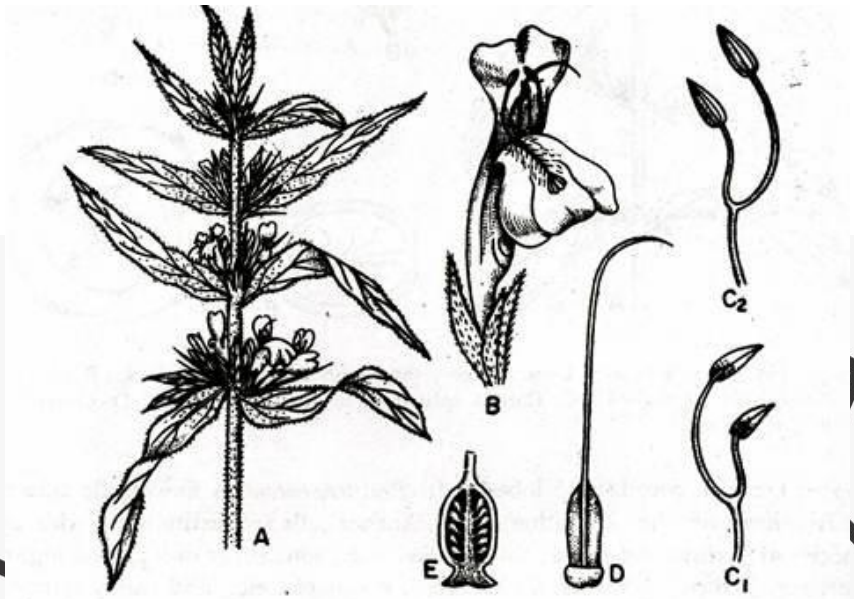


Fig. 145.—Hygrophila auriculata Heine. A. Leafy shoot with flowers ($\times\frac{1}{8}$); B. One flower ($\times 2$); C_1 & C_2. Stamens; D. Ovary; E. L.s. of same.

Family— Lamiaceae: Distribution, Characters and Economic importance

Systematic Position

- **Class** : Dicotyledonae
- **Subclass** : Metachlamydeae
- **Order** : Tubiflorae
- **Family**: Labiatae or lamiaceae
- **Genus :** 264 (W) 64 (I)
- **Species :** 6990 (W) 200 (I)

Characters of Lamiaceae: Sweet aromatic smell due to essential oils present in sessile glandular hairs; stem rectangular in cross section, leaves opposite decussate rarely alternate, simple, exstipulate with hairs; inflorescence verticellaster; flowers zygomorphic, hermaphrodite, hypogynous, bracteate; calyx gamosepalous, persistent; corolla bilabiate; stamens 4 epipetalous, didynamous; gynoecium 2 four celled by false septum, syncarpous, axile placentation, gynobasic style, seated on lobed disc; fruit schizocarpic carcerulus.

Common plants of the family: *Coleus aromaticus* (H. Ajwain), *Leucas lantana*, *Lavandula vera*, *Mentha piperata* (H. Pudina), *Ocimum sanctum* (H. Tulasi).

Distribution: world wide distribution

A. Vegetative characters:

Habit: Plants are mostly aromatic herbs or shrubs (*Leonotis*, *Pogostemon*). Tree habit is found in the Brazilian genus *Hyptis* and climbing habit in American species of *Scutellaria*.

Root: Tap, branched, rarely adventitious (*Mentha*).

Stem: Aerial, herbaceous, rarely woody, erect or prostrate, quadrangular, hairy, branched, solid or hollow, sometimes underground suckers (*Mentha*).

Leaves: Opposite decussate, rarely whorled, simple, petiolate or sessile, exstipulate, hairy with aromatic smell, entire, pinnatifid (*Perovskia*), unicostate reticulate venation.

B. Floral characters:

Inflorescence: Very commonly verticillaster consisting of a pair of condensed dichasial cymes at each node; often the verticillasters are grouped together in a thyrsus form; rarely solitary (*Scutellaria*).

Flower: Pedicellate or sessile, bracteate, complete, zygomorphic rarely actinomorphic (*Mentha*, *Elsholtzia*), hermaphrodite, rarely unisexual (*Nepeta*, *Thymus*), pentamerous hypogynous.

Calyx: Sepals 5, gamosepalous, bilabiate (*Salvia*, *Thymus*) campanulate (*Teucrium*), persistent, valvate or imbricate aestivation. When a bilabiate calyx is present the arrangement of the sepals may be (1/4) as in *Ocimum* or (2/3) as in *Calamintha*.

Corolla: The corolla possesses a tubular base which widens towards the mouth. Petals 5, gamopetalous & the five teeth are sub-equal and mostly bilabiate. In *Mentha* a four lobed corolla arises due to the fusion of two upper teeth. When a distinct bilabiate condition is found the arrangement of the petals may be gamopetalous 2/3 i.e. two petals in the posterior upper lip and three in the anterior lower lip (*Salvia*, *Nepeta*, *Leucas* etc.).

In *Ocimum*, *Coleus*, *Plectranthus* etc. the petals arrangement is gamopetalous 4/1 i.e. four petals in the posterior upper lip and only one petal in the anterior lower lip. In extreme cases the arrangement may be gamopetalous 0/5 i.e. all the five petals forming the lower lip so that the corolla becomes one lipped. Aestivation in the petals is valvate or imbricate.

Androecium: Typically only 4 stamens, didynamous (2+2) and posterior stamen is reduced or represented by a staminode; in *Calamintha* only two perfect stamens are found, two are imperfect and the fifth reduced. In Salvia only two stamens on the anterior side are found; they are characterised by peculiarly long connectives which help in insect pollination stamens generally introrse and dithecous.

Gynoecium: Bicarpellary, syncarpous, superior, situated on hypogynous honey secreting disc; bilocular becomes tetralocular by the formation of false septum; axile placentation, one ovule in each loculus; style gynobasic (arising from the base of the ovary), stigma bilobed. The gynoecium character is thus uniform without any variation.

Fruit: Usually schizocarpic carcerulus or achenes or nutlets rarely drupaceous.

Seed: Non-endospermic.

Floral- formula:

$$\text{Br } \bar{o}\underline{b}\ \ \varnothing\ \ K_{(3/2) \text{ or } 5}\ C_{(2/3) \text{ or } (4/1) \text{ or } (0/5)}\ A_{2+2\ (\text{std})}\ \underline{G}_{(2)}$$

Economic Importance:

1. Food: Tubers of *Stachys sieboldi* are edible. Leaves of *Mentha viridis*, *Ocimum basilicum*, *Melissa officinalis* etc. are used as condiments.

2. Medicinal: Many plants of this family are used in medicines. *Ajuga bracteosa*, *Leucas cephalotes* are used in fever. *Mentha piperata* and *Thymus serphyllum* give Menthol and Thymol respectively, which are extensively used in medicines. Leaves of *Ocimum kilimandus charicum* give camphor.

Ocimum sanctum and other species of Ocimum are used in various ailments.

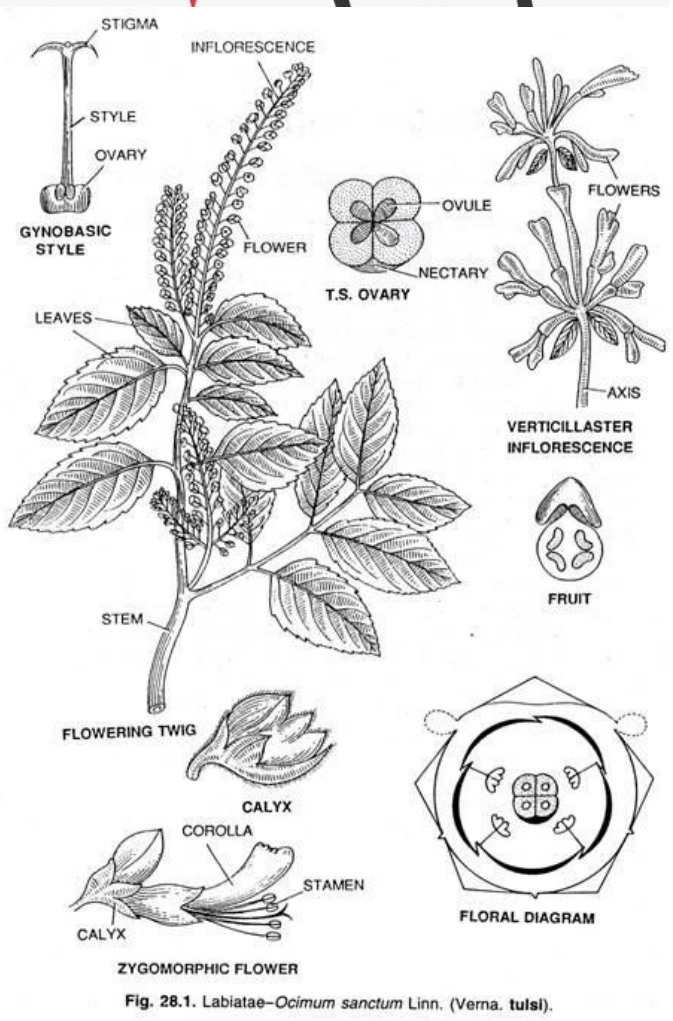


Fig. 28.1. Labiatae–*Ocimum sanctum* Linn. (Verna. **tulsi**).

3. Ornamental: Several species of *Salvia*, *Coleus*, *Ajuga*, *Leonotis*, *Dracocephalum*, *Thymus*, *Lavandula* etc. are cultivated in gardens for ornamental purposes.

4. Perfumes: Aromatic oil is extracted from *Thymus*, *Lavandula* (Lavender oil), *Rosmarinus* (Rosemary oil), *Calamintha*, *Pogostemon* etc.

5. Dye: Fruits of *Lycopus europaeus* yield red dye.

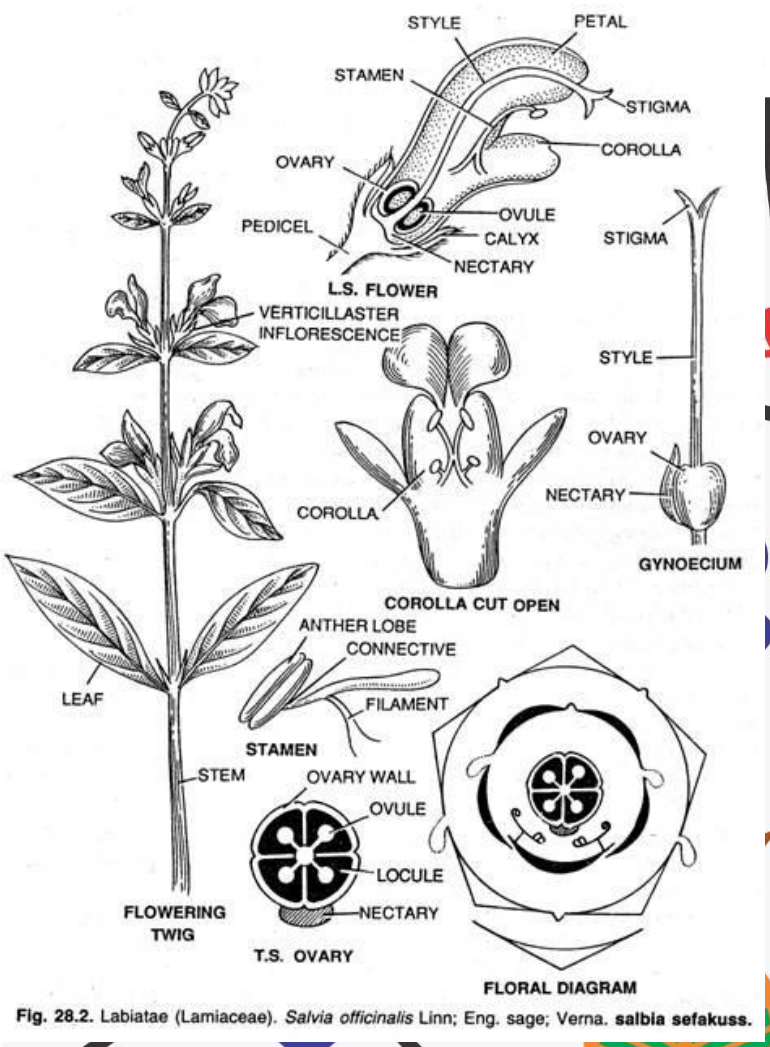


Fig. 28.2. Labiatae (Lamiaceae). *Salvia officinalis* Linn; Eng. sage; Verna. **salbia sefakuss.**

ETHNOBOTANY: A GENERAL ACCOUNT

Ethnobotany is the scientific study of the relationships that exist between people and plants. Ethnobotanists aim to document, describe and explain complex relationships between cultures and (uses of) plants: focusing, primarily, on how plants are used, managed and perceived across human societies (e.g., as foods; as medicines; in divination; in cosmetics; in dyeing; as textiles; in construction; as tools; as currency; as clothing; in literature; in rituals; and in social life.)

Ethnobotany has its roots in botany, the study of plants. Botany, in turn, originated in part from an interest in finding plants to help fight illness. In fact, medicine and botany have always had close ties. Many of today's drugs have been derived from plant sources.

Pharmacognosy is the study of medicinal and toxic products from natural plant sources. At one time, pharmacologists researching drugs were required to understand the natural plant world, and physicians were schooled in plant- derived remedies. However, as modern medicine and drug research advanced, chemically-synthesized drugs replaced plants as the source of most medicinal agents in industrialized countries.

Although research in plant sources continued and plants were still used as the basis for some drug development, the dominant interest (and resultirtg research funding) shifted to the laboratory.

The 1990's have seen a growing shift in interest once more; plants are reemerging as a significant source of new pharmaceuticals. Industries are now interested in exploring parts of the world where plant medicine remains the predominant form of dealing with illness.

South America, for example, has an extraordinary diversity of plant species and has been regarded as a treasure grove of medicinal plants. The jungles and rain forests of South America contain an incredibly diverse number of plant species, many still unexplored, many unique and potentially useful as medicinal sources.

Scientists have also realized the study of the native cultures which inhabit these regions can provide enormously valuable clues in the search for improved health. To uncover the secrets of the rain forest, specialists are needed, well-trained and willing to spend long, hard time in the field. This is where the ethnobotanist comes in.

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

By necessity, ethnobotany is multidisciplinary. This multidisciplinary approach gives ethnobotanists more insight into the management of tropical forest reserves in a period of tremendous environmental stress. Unfortunately, due to human factors which have influenced the ecological balance of these delicate ecosystems, we are presently faced with the possibility of losing our rain forests.

ECONOMIC BOTANY

STUDY OF THE FOLLOWING PLANTS WITH BOTANICAL NAMES, FAMILY, PART USED AND ECONOMIC USES

SL. NO	BOTANICAL NAME	COMMON NAME	FAMILY	PART USED	USES
I.			**EDIBLE OILS**		
	Arachis hypogea	Ground nut	Fabaceae	Seed	Used to extract groundnut oil used in domestic food preparations and cake used as cattle fodder.
	Cocos nucifera	Coconut	Aracaceae	Seed	Used to extract coconut oil, used as edible oil in food preparations.
	Sesamum indicum	Sesamum	Pedaliaceae	Seed	The seeds of this herb yield an edible oil used in confectionery and for several medicines.
II.			**SUGAR AND STARCH**		
	Saccharum officinarum	Sugarcane	Poaceae	Stem juice	Used in manufacture of sugar and also extract alcohol
	Beta vulgaris	Beet root	Chenopodiaceae	Tap root	Used as vegetables and also as a source of starch
	Solanum tuberosum	Potato	Solanaceae	Stem tuber	Used as vegetables and also as a source of starch
	Manihot esculenta	Tapioca	Euphorbiaceae	Tuberous roots	Used as vegetables and also as source of starch.
III.			**FIBERS**		
	Gossipium hirsutum	Cotton	Malvaceae	Seed hairs	Used in textile industries to manufacture cloths, bandages and also used in bedding industries to prepare cushions, sofa etc.
	Corchorus capsularis	Jute	Tiliaceae	Phloem fibres	Used in manufacture of rough cloths, gunny bags, sacks, mats, ropes, threads etc.
	Cocos nucifers	Coir	Aracaceae	Fruit wall fibres	Used to manufacture ropes, mats and also used in bedding industries.
IV.			**PAPER AND PULP**		
	Dendrocalamus sps Bambusa sps	Bamboo	Poaceae	Stem	Stem pulp used in paper industries, paper used as stationary goods, tissue paper, napkins, newspapers, card boards etc.
	Eucalyptus sps	Eucalyptus	Myrtaceae	Stem	Stem pulp used in paper and textile
V.			**BEVERAGES**		
	Coffea Arabica	Coffee	Rubiaceae	Dried cotyledons	Used to prepare non alcoholic beverage
	Thea sinensis or Camellia sinensis	Tea	Theaceae	Young dried leaves	Used to prepare non alcoholic beverage

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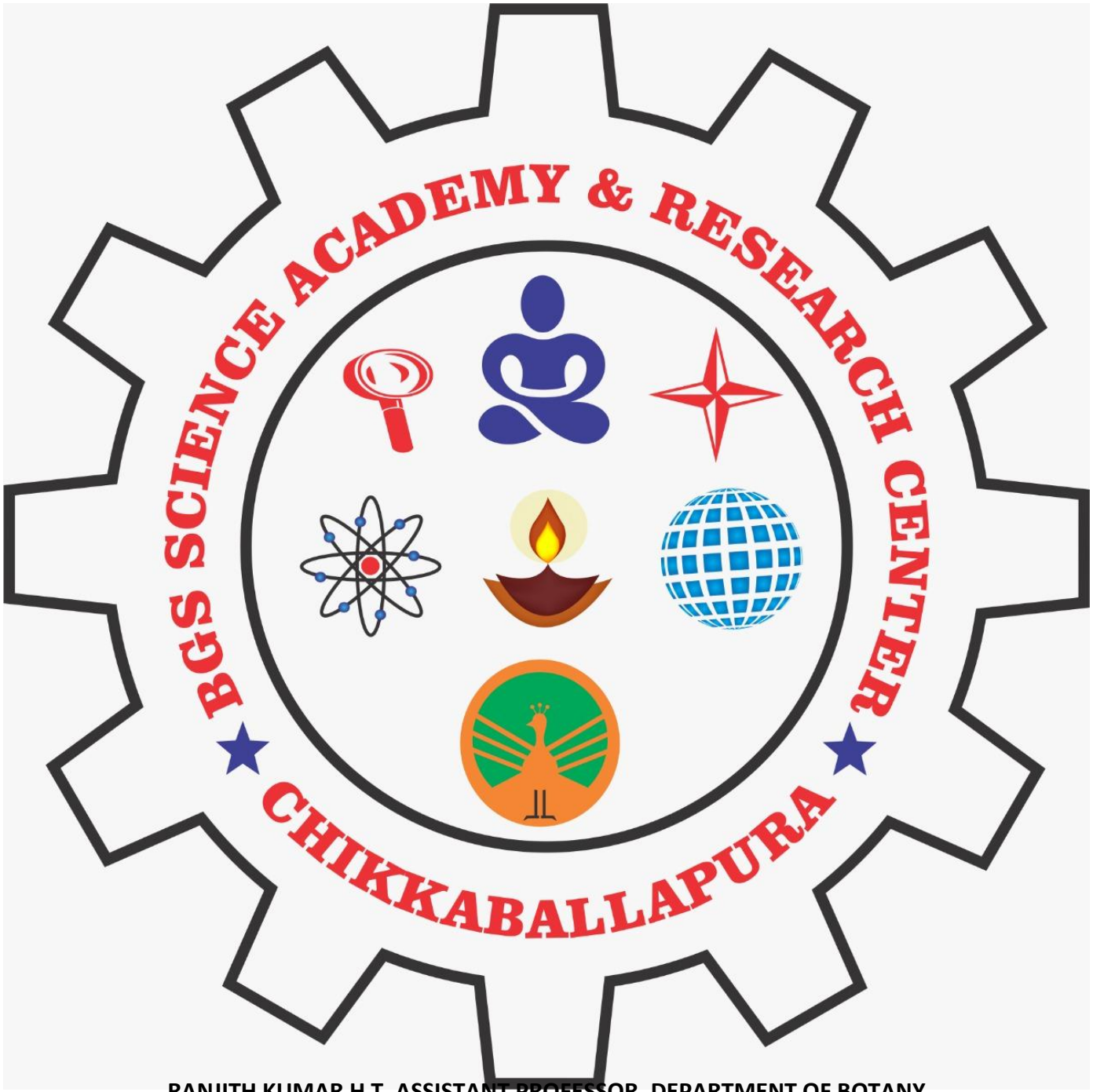
	Theobroma cacao	Cocoa	Sterculaceae	seeds	The seeds on grinding yield cocoa and chocolate.
VI.			**SPICES**		
	Zingiber officinale	Ginger	Zingiberaceae	Rhizome	Ginger is stimulant, carminative and diaphoretic. It is used to flavour food stuff, beer and other drinks. It is used as a condiment in curries.
	Elettaria cordamomum	Cardamom	Zingiberaceae	Seed	Used as spices in domestic food preparations and in condiments to increase the flavor.
	Syzygium aromaticum	Clove	Myrtaceae	Flower bud	Used to extract clove oil and in preparation of condiments.
	Cinnamomum zeylanicum	Cinnamon	Lauraceae	Stem bark	Used as spices in domestic food preparations.
	Ferula assafoetida and *F. narthex*	Asafoetida	Umbelliferae or Apiaceae	Gum Resin	It is widely used in vegetable curries, sauces, and other foodstuffs. It helps in digestion and metabolism of food.
	Curcuma longa	Turmeric	Zingiberaceae	Rhizome	Food, flavourent and adjunct. Also used as stimulant, Carminative, expectorant etc.
	Crocus sativas	Saffron	Iridaceae	Dried Stigma	Apart from flavouring and colouring properties it has extraordinary medicinal value also. Mostly used in exotic dishes like sweets, Biryani etc.
	Myristica fragrans	Nutmeg	Myristicaceae	Dry seeds	Nutmeg are condiment.
VII.				**TIMBER**	
	Tectona grandis	Teak	Verbenaceae	Stem heart wood	Used in cabinet works house building, furniture, ship and boat building etc.
	Dalbergia latifolia	Rosewood	Fabaceae	Stem wood	Used in manufacturing furniture, door, ship, boat and cabinet making etc.
VIII.			**MEDICINAL PLANTS**		
	Withania somnifera	Ashwagandha	Solanaceae	Roots	Used as a tonic in geriatrics promote strength and vigour aphrodisiac and rejuvenator. It is used for the treatment of rheumatic pain, inflammation of joints and certain paralytic conditions, used for all types of nervous disorders and as sedatives in the treatment of insanity and in hypertension. Roots have long been in use for hiccup, cough, dropsy, rheumatism, and female disorders.
	Aloe barbedensis	Indian Aloe	Liliaceae	Leaves	After removing the skin of leaves they are given in fevers, enlargement of the liver, spleen and other glands, skin diseases, gonorrhoea, constipation, menstrual suppression, piles, jaundice and rheumatic affections. The juice of

					roasted leaf is being given with honey for cough and cold. The pulp of one leaf is being given daily in abdominal tumors, dropsy, carbuncles, piles, sciatica, rheumatism and retention of urine in fevers. A salad of leaves is eaten in indigestion, constipation and flatulence. The leaf juice is given as a remedy for intestinal worms in children. A poultice of the leaves is applied to tumours, cysts, inflamed parts and scalds.
	Centella asiatica	Indian Pennywort	Umbelliferae (Apiaceae)	Leaves	The weed is alterative, tonic, diuretic, antiphlogistic, blood purifier and local stimulant. It is a remedy for skin diseases, like chronic eczema, chronic ulcers etc., enlargement of glands, chronic rheumatism, chronic nervous diseases, madness, cholera, amenorrhoea and piles. The leaves are a household remedy in early stages of dysentery of children. The powder of leaves is given with milk in small doses in mental weakness and to improve memory. The fresh juice of leaves mixed with milk is given as an alternative in gonorrhoea, jaundice and fevers; this is also useful for children in skin diseases and for improving the blood and nervous system. An ointment made of leaf juice and lanoline is of great value in elephantiasis.
	Ocimum sanctum	Holy Basil	Labiatae	Leaves	The leaves are expectorant, stomachic, anticatarrhal, diaphoretic and aromatic; their decoction or infusion is given in malaria, gastric diseases of children and liver disorders; as a prophylactic against malaria fresh leaves are taken with black pepper in the morning. The leaf juice is given in chronic fever, haemorrhage dysentery and dyspepsia; it is also used to check vomiting and as an anthelmintic.
	Emblica officinalis	Amla	Euphorbiaceae	Fruit	The fruit is one of the richest sources of vitamin C. The fresh fruit is refrigerant, tonic, antiscorbutic, diuretic and laxative. It is used in fevers, vomiting, indigestion, habitual constipation and other digestion troubles. The dried fruit is a good astringent, refrigerant, stomachic, antiscorbutic and blood purifier. It is given in diarrhoea, dysentery and

					haemorrhage. The infusion of seeds is a useful eye-wash in ophthalmic diseases.
	Vinca rosea or Catharanthus rosea	Catharanthus vinca	Apocyanaceae	Root bark	Used in depressions of nervous systems against wasp stings. Relaxation of muscle pains, antibacterial agent.
	Azadirachta indica	Neem (Margosa tree)	Meliaceae	All parts of plant body	Used in tooth paste, soaps, shampoos, skin disorders. Seed cake used in fertilizer industries etc. seed oil is used in medicines.
	Pogostemon perilloides Pogostemon benghalense and *P. cabin*	Patchouli	Labiatae or Lamiaceae	Leaves	The leaves yield an essential oil, which is used for making soaps and perfumes. The dried leaves are used for scenting clothes to keep off insects. The leaf extract of repel leeches. In modern scented industrial products such as paper towels, laundry detergents, and air fresheners. It is used to make an herbal tea and leaves are eaten as a vegetable or used as a seasoning.
	Mentha piperita	Peppermint	Labiatae or Lamiaceae	Leaves	The oil obtained from the leaves is widely used in perfumes and various types of soaps. The oil is used as carminative, stimulant and for treating nausea and vomiting. Oil is also used in rheumatic pains, cough syrups, mouth washes and inhalations. Several headache ointments are also prepared from peppermint. Its leaves are also used for flavouring purposes.
	Lavendula latifolia, L. hybrida and *L. angustifolia*	Lavender	Labiatae or Lamiaceae	Flowers	Plants are the great source of lavender oil used in soaps, cosmetics and in perfumery. The oil also used as insect repellent and curminative.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