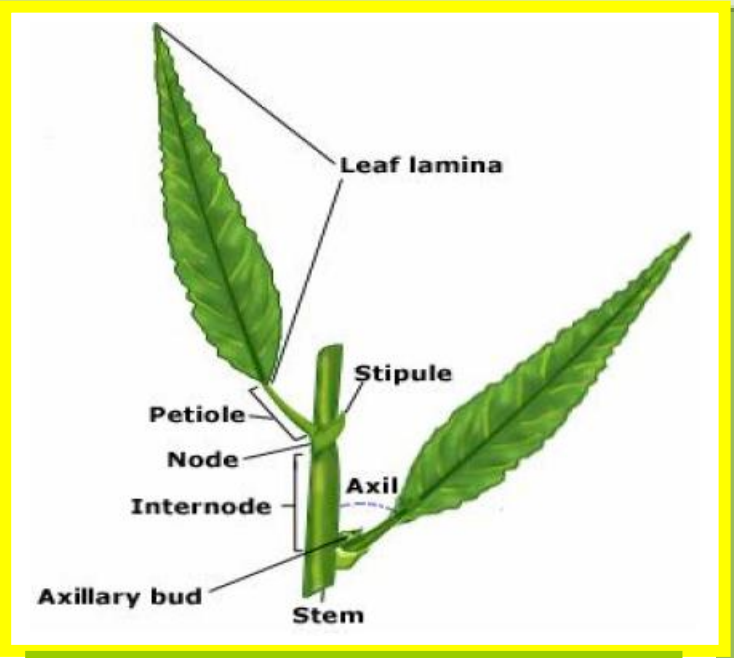
Kurdistan Region - Iraq
Ministry of Higher Education and Scientific Research
Salahaddin University - Erbil
College of Agricultural Engineering Sciences
Field Crops and Medicinal Plants Dept.

2023-2024

BSc. Students, Second year

PLANT TAXONOMY

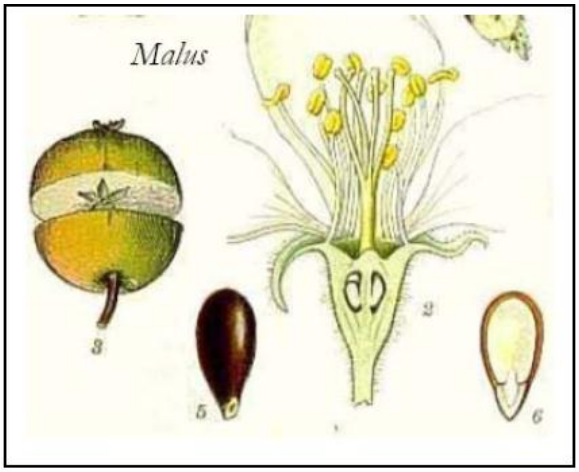


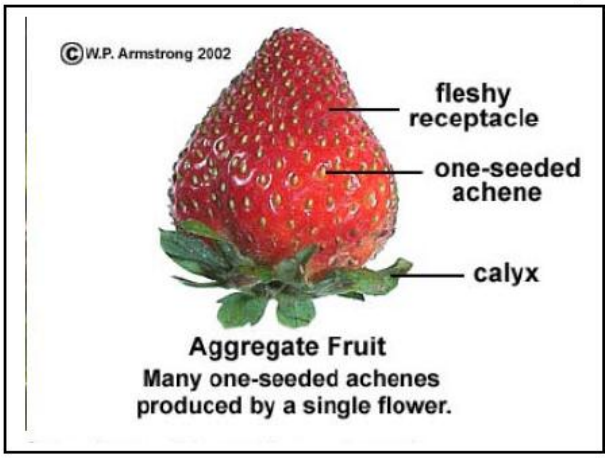
Serwan T. Al-Dabbagh

Theoretical Lectures

2023-2024

Departments: Plant protection, Field crops &Medicinal Plants, Horticulture and Forestry





Fundamental Components of Taxonomy

For scientific study of an organism, it is necessary to identify it, have a name for its communication and assign it to a group to which it fits well-the three main functions of taxonomy. The literal meaning of **taxonomy** (Greek, **taxus** = arrangement; **nomos** = law or rule) is the "*lawful arrangement*" or "*arrangement by rules*" of things. Plant taxonomy refers to classification of plants following certain rules of principles, after to introduce the term plant taxonomy which has its synonymous names as systematic botany and plant systematic in general.

Basic Botany Areas

1. **Plant Taxonomy.**
   Identification, Naming and Classification.
2. **Plant Morphology.**
   Plant Form and Anatomy.
3. **Plant Physiology.**
   Functions and Reaction.

What is Systematics?

Systematics is defined as a science that includes and encompasses traditional taxonomy, the description, identification, nomenclature, and classification of organisms and that has as its primary goal the reconstruction of phylogeny, or evolutionary history of life. Systematics is founded in the principles of evolution, its major premise being that there is one phylogeny of life. The goal of systematists is, to discover that phylogeny.

TAXONOMY

Taxonomy is a major part of systematics that includes four components: **D**escription, **I**dentification, **N**omenclature, and **C**lassification (**DINC**). The general subjects of study are **taxa** (singular, **taxon**), which are defined as groups of organisms. Ideally, taxa should have a property known as **monophyly** and are traditionally treated at a particular rank. It should be pointed out that the four components of taxonomy are not limited to formal systematic studies but are the foundation of all intellectual endeavors of all fields, in which conceptual entities are described, identified, named, and classified.

1. **Description** is the assignment of features or attributes to a taxon. The features are called **characters**. Two or more forms of a character are **character states**. One example of a character is petal color, for which two-character states are yellow and blue. Another character is leaf shape, for which possible character states are elliptic, lanceolate, and ovate. Numerous character and character state terms are

used in plant systematics, both for general plant morphology. The purpose of these descriptive character and character state terms is to use them as tools of communication, for concisely categorizing and delimiting the attributes of a taxon, an organism, or some part of the organism. An accurate and complete listing of these features is one of the major objectives and contributions of taxonomy.

2. **Identification** is the process of associating an unknown taxon with a known one, or recognizing that the unknown is new to science and warrants formal description and naming. One generally identifies an unknown by first noting its characteristics, that is, by describing it. Then, these features are compared with those of other taxa to see if they conform. Plant taxa can be identified in many ways. A taxonomic key is perhaps the most utilized of identification devices. Of the different types of taxonomic keys, the most common, used in all Floras, is a dichotomous key. A **dichotomous key** consists of a series of two contrasting statements. Each statement is a **lead**; the pair of leads constitutes a **couplet**.

3. **Nomenclature** is the formal naming of taxa according to some standardized system. For plants, algae, and fungi, the rules and regulations for the naming of taxa are provided by the International Code of Botanical Nomenclature. These formal names are known as **scientific names**, which by convention are translated into the Latin language. The fundamental principle of nomenclature is that all taxa may bear *only one scientific name*. Although they may seem difficult to learn at first, scientific names are much preferable to common (vernacular) names. The scientific name of a species traditionally consists of two parts (which are underlined or italicized): the genus name, which is always capitalized, e.g., *Quercus*, plus the specific pithet, which by recent consensus is not capitalized, e.g. *agrifolia*. Thus, the species name for what is commonly called California live oak is *Quercus agrifolia*. Species names are known as **binomials** (literally meaning two names) and this type of nomenclature is called binomial nomenclature, first formalized in the mid-18th century by Carolus Linnaeus.

4. **Classification:** is the arrangement of entities (in this case, taxa) into some type of order. The purpose of classification is to provide a system for cataloguing and expressing relationships between these entities. Taxonomists have traditionally agreed upon a method for classifying organisms that utilizes categories called **ranks**. These taxonomic ranks are hierarchical, meaning that each rank is inclusive of all other ranks beneath it. As defined earlier, a **taxon** is a group of organisms typically treated at a given rank.

Magnoliophyta is a taxon placed at the rank of phylum; Liliopsida is a taxon placed at the rank of class; Arecaceae is a taxon placed at the rank of family; etc. Note / that taxa of a particular rank generally end in a particular suffix.

There are two major means of arriving at a classification of life: phenetic and phylogenetic. **Phenetic** classification is that based on overall similarities. Most of our everyday classifications are phenetic. For efficiency of organization (e.g., storing and retrieving objects, like nuts and bolts in a hardware store) we group similar objects together and dissimilar objects apart. Many traditional classifications in plant systematics are phenetic, based on noted similarities between and among taxa. **Phylogenetic** classification is that which is based on evolutionary history, or pattern of descent, which may or may not correspond to overall similarity.

The primary taxonomic ranks accepted by the International Code of Botanical Nomenclature.

Major Taxonomic Ranks	**Taxa .**
Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Liliopsida (Monocots)
Order:	Arecales
Family:	Arecaceae
Genus: (plural: genera)	*Cocos*
Species: (plural: species)	*Cocos nucifera*

International Code of Botanical Nomenclature. (I.C.B.N.):

The publication of Cod is based on the realization that botany requires a precise and simple system of nomenclature used by botanists in all countries and aims at providing a stable method of naming plants and taxonomic groups, avoiding and rejecting the use of names which may cause error or ambiguity or throw science into confusion.

Rules and Recommendation of ICBN:

Some important ones are discussed below;

A- The rank of taxa:

The term **taxon** (pl. **taxa**), a taxonomic group of any rank, has been introduced for the first time in 1956 edition of the Code. The system of nomenclature provides a hierarchical arrangement of ranks and every plant is treated as belonging to number of successively higher taxa, each assigned a particular rank with species as a basic unit. The seven principal-obligatory ranks in descending sequence are: Kingdom (regnum), Division (divisio or phylum), Class (klass, classis), Order (ordo), Family (familia), Genus (genus) and Species (species).

The ending of the names:

The ending of the name indicates its rank, as below:

- **Kingdom, ---- (various) e.g. Plantae**
- **Division, ---- phyta e.g. Magnoliophyta (Tracheophyta)**
- **Subdivision, ---- phytina e.g. Magnoliophytina (Spermatophytina)**
- **Class, ---- opsida e.g. Magnoliopsida (Angiospermopsida)**
- **Subclass, ---- idae e.g. Magnoliidae (Monocotyledonidae)**
- **Order, ---- ales e.g. Liliales**
- **Suborder, ---- ineae e.g. Lilineae**
- **Family, ---- aceae e.g. Liliaceae**
- **Genus, ---- (various) us, as, a, um, es, on, ii… *Lilium* L.**
- **Species, ---- (various) *Lilium candidum***

The rank of species is basic, on or more species make up a genus, one or more genera make up a family and so on.

B- Special exception is made for the following eight families. These names because of long usage are treated as validly published. For these families alternative names are also permitted ending in-*aceae*.

Old name	New name
i. Palmae	**(Arecaceae)**
ii. Gramineae	**(Poaceae)**
iii. Cruciferae	**(Brassicaceae)**
iv. Leguminosae	**(Fabaceae)**
v. Guttiferae	**(Clusiaceae)**
vi. Umbelliferae	**(Apiaceae)**
vii. Labiatae	**(Lamiaceae)**
viii. Compositae	**(Asteraceae)**

Historical Retrospect (Periods of Plant Taxonomy)

History of plant taxonomy witnessed various phases (periods) from early history to modern approaches.

- - - - - - Early History of Plant Taxonomy - - - - - -

Period I, Classification Based on Habit: Man, soon he set his foot on this planet, felt the need to have knowledge about plants. His first priority was to know what plants he should make use as food, utilize for shelter, use us care for ailments and avoid others. Initially, this information was accumulated and sorted in his brain and passed on to generations orally, and remained restricted to small communities. With the man's gate knowledge of black and white. It could become possible to facilitate others to share and improve knowledge about this treasure of information and bring the mankind to reach a stage whereby this can easily be stored and utilized for far-reaching conclusions in plant taxonomy.

Theophrastus: Father of Botany (Appendages -1)

Theophrastus (372 – 287 BC), the successor of Aristotle (*Father of Botany*) in the peripheral school (those following the philosophy propagated by Aristotle), his original name was Tytamus, but the later became known by nickname "Theophrastus". He described about 500 kinds of plants, and classified plants into four major groups:

1. Tree 2. Shrubs 3. Undershrubs 4. Herbs

And also made distinction between flowering and non-flowering plants, superior and inferior ovary, free and fused petals and fruit types. Were used by him in his ***De Historia Plantarum*.** Thus, the knowledge of botany flourished at the Athens during this truly **golden age of learning.**

- - - - - - Later Progress in Plant Taxonomy - - - - - -

By the end of 16th century, the science of botany developed as an independent discipline which caused the need to study more and more plants and large number of characters in order to arrive at a satisfactory classification. The period from the 17th century onwards witnessed a great revolution in constructing suitable systems of classification of plants. Various systems of classification were suggested by different taxonomists during this period, naming and classifying plants and giving various systems include:

Period II - Artificial or Sexual Systems:

Caesalpino (Andrea Caesalpino)

Caesalpinus, (1519-1603 A.D.) an Italian physician philosopher, was the author of ***De Plantis,*** which carries the description of over 1500 species of plants. Following Aristotelian classification, he divided the plants into two major groups based on **woody** and **herbaceous** habit. He recognized the characters of **fruit, seed** and **embryo** in further grouping of plants.

John Ray (App 2)

Jon Ray, (1628-1705 A.D.) was a British botanist and he produced a three-volume work, ***Historia Plantarum***, which contains an improved version of his system of classification originally. His classification represented a notable advancement on that of his predecessors and was approach towards the natural system. He was the first to divide these groups into **Dicotyledons** and **Monocotyledons** on the basis of presence of two and one cotyledon respectively.

1- Herbae: (herbs)

A- Imperfectae: Algae, Fungi, Bryopsida, Pteridophyta

B- Perfectae:

a– Monocotyledonae b- Dicotyledonae

2- Arborae:(trees and shrubs)

a –Monocotyledonae b- Dicotyledonae

Linnaeus (Carolus Linnaeus) (App 3)

Linnaeus (1707-1778 A.D.) a great Swedish naturalist, is rightly known as the "**father of modern botany**". He became interested in the study of natural history science his childhood. His ***Species Plantarum*** was published in 1753, a work where some 7300 species are described and arranged according to his sexual system of classification. In his book Linnaeus introduced the consistent use of the binomial system of plant names.

Linnaeus system of classification is thought artificial, he was the first ho recognize the significance of flower and fruit structure. He recognized 24 classes determined on the basis of number, size and union of stamens. The classes were subdivided into orders based, note on character, but on his idea of their relationships.

"Twenty four classes of Linnaeus are as follows"

The system of Linnaeus which largely depended on the number of stamens and carpels in the flower was very simple and convenient and became very popular. It remained dominate for over 75 years until it was replaced by the system of *de Jussieu* and *de Candolle*.

(1) Monandria (Stamen one)
(2) Diandria (Stamens two)
(3) Triandria (Stamens three)
(4) Tetrandria (Stamens four)
(5) Pentandria (Stamens five)
(6) Hexandria (Stamens six)
(7) Heptandria (Stamens seven)
(8) Octandria (Stamens eight)
(9) Eneandria (Stamens nine)
(10) Decandria (Stamens ten)
(11) Dodecandria(Stamens eleven to ninteen)
(12) Icosandria (Stamens twenty or more, attached to the calyx)
(13) Polyandria (Stamens twenty or more, attached to the receptacle)
(14) Didynamia (Stamens didynamous)
(15) Tetradynamia (Stamens tetradynamous)
(16) Monadelphia (Stamens monadelphous)
(17) Diadelphia (Stamens diadelphous)
(18) Polydelphia (Stamens polydelphous)
(19) Syngenesia (Stamens syngenesious)
(20) Gynandria (Stamens adnate to gynoecium)
(21) Monoecia (Plants monoecious)
(22) Dioecia (Plants dioecious)
(23) Polygamia (Plants polygamous)
(24) Cryptogamia (Flowers concealed i.e. Algae, Fungi, Mosses and Ferns)

Period III - Natural Systems:

De Jussieu (Antoine Laurent de Jussieu) (App 4)

De Jussieu, (1686 – 1758 D.C.) a French botanist, published his system in final form in his ***Genera Plantarum***. He particularly taken into consideration the position of the stamens with respect to the ovary and divided the plants into 15 classes.

The main groups recognized are:

Divisions, Classes and Orders (Ordo**)**

Division I. Acotyledones

Class 1: with as families: Fungi, Algae, Hepaticae, Musci, Filices, Najades

Division II. Monocotyledones

Classes: 2-4

2: Stamina hypogyna

3: Stamina epigyna

4: Stamina perigyna

Division III. Dicotyledones

Classes: 5-7

b) Monopetalae

Classes: 8-11

c) Polypetalae

Classes: 12-14

B. Diclinae

Class: 15

De Candolle (Augustin Pyrame Laurent de Candolle) (App 5)

De Candolle, (1778 – 1841 D.C.) a French botanist, published his views on classification in his classic work, ***Theorie elementaire de la botanique***, the system of de Candolle was similar to that the de Jussieu in many respects but it was certainly an improvement over that of the latter particularly in the treatment of the Dicotyledons. He divided the **Dicotyledons** into two groups on the basis of presence or absence of petals, the one with petals was subdivided on the basis of free or fused petals and the former was further divided on the basis of the position of ovary.

Bentham and Hooker's system of Classification (App 6)

George Bentham (1800-1884) and Joseph Dalton Hooker (1817-1911), the two British botanists who were associated with the Royal Botanic Garden, Kew, England joined their forces to bring out a ***Genera Plantarum*** system of Classification. The first part of ***Genera Plantarum*** appeared in July 1862 and the last part in April 1883. They have provided first rate descriptions of the families and genera of seed plants then known.

- - - - - - Modern Approaches in Plant Taxonomy- - - - - -

Period IV - Phylogenetic Systems:

The outlook of taxonomy was changed with the publication of ***Origen of Species*** by Darwin in 1859. The systems of this period are based on the course of evolutionary descent and they tried to reflect the genetic and phylogenetical relationships. The most widely known phylogenetic systems are:

Engler and Prantl (App 7)

Adolph Engler (1844-1930) and Karl A.E. Prantl (1849-1893), the two German botanists published a twenty-volume work, ***Die natiirlichen pflanzenfamilien*** wherein they classified the plants of the world, from algae to angiosperms, according to their system of classification. This system has gone under some changes in ***Syllabus der pflanzenfamilien***, a one volume work which was published in several editions.

The significant feature of their system is that they placed Monocotyledons before Dicotyledons, considered the Orchids to be more highly evolved than the

grasses, the apetalous and catkin bearing Dicotyledons (Amentiferae) as primitive to the flowers which bear petals and simple unisexual flowers. These views are, however, not acceptable to most of the recent phylogenetists. The amalgamation of the Polypetalae and Apetalae (of Bentham and Hooker) was certainly a forward step.

The following is the outline of the Engler and Prantl's system of classification:

Class 1. Monocotyledoneae (6 Orders).
Class 2. Dicotyledoneae
Subclass Archichlamydeae (29 Orders).
Subclass Metachlamydeae (Sympetalae) (10 Orders).

Rendle

Alfred Barton Rendle (1865-1938), keeper of the Department of Botany, British Museum of Natural History, London, is known for his two-volume work, ***Classification of Flowering Plants***. Rendle's system patterned directly on that of Engler's system and differs from the later only in a few minor features.

Bessey (App 8)

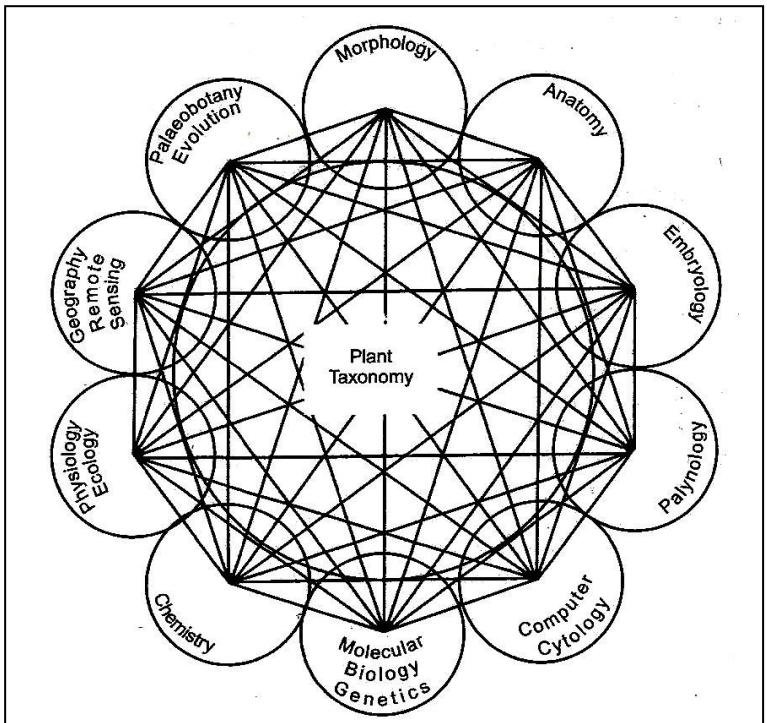
Charles Edwin Bessey (1845-1915), an American botanist, developed phyloginitic system of classification which appeared in final form in 1915 in the Annals of the Missouri Botanical Garden under the (***The Phylogenetic Taxonomy of Flowering Plants***). His system was based on number of dicat (guiding principles).

- - - - - - Recent Systems of Classification: (App 9) - - - - - -

The recent system was published in 1942 by **Armen Takhtajan**, as an appendix to ***The Origin of Angiospermous Plants*** which was first published in Russian in 1954. After 1966 the system of classification is undergoing some modification. It was published in English in 1969 in ***Flowering Plants: Origin and Dispersal***. The recent systems were followed by **Cronquist** he presented the comprehensive version of his concepts of classification in The Evolution and Classification of Flowering Plants (1968). The latest version of his system has appeared in great detail in 1981 in ***An Integrated System of Classification of Flowering Plants***. His system parallels Takhtajan's system to considerable extent.

Modern Trends or Scope of Plant Taxonomy

The scope of plant taxonomy is diverse. It's benefiting not only to botanists but also to those who are working in other fields where plants are used as tool. Plant taxonomy being multidisciplinary in nature, has close link with morphology, anatomy, embryology, palynology, palaeobotany, cytology, genetics, evolution, physiology, molecular biology, chemistry, geography, ecology, remote sensing and computer science.



Interrelation with allied sciences

Plant taxonomy has played a significant role in agriculture, horticulture and forestry in developing high yielding varieties. Other branches of botany in plant taxonomy are:

1. Anatomy:

Anatomical characters of the vegetative organs of flowering plants have been employed with great success to the solution of taxonomic problems and to the elucidation of phylogenetic relationships. They have also proved very helpful in the identification of fragmentary material (of economic importance) and herbarium specimens which are not accompanied by flowers and fruits. Some important anatomical characters of well-established taxonomic value are as:

1. Epidermis
2. Leaf anatomy and venation
3. Petiole and nodal anatomy
4. Sclereids
5. Cellular contents
6. Wood anatomy

2. Palynology:

In addition to the size and general shape, other pollen characteristics such as number and position of furrows and apertures, and the details of sculpturing of the exine are of taxonomic value.

These characters have been helpful in differentiation of various taxa. They have also proved useful in the classification of newly discovered taxa and in phylogenetic considerations.

3. Embryology:

Embryology has also played a significant role in systematic considerations. A large amount of work has subsequently been done in this direction where embryological characters are of value in classification.

There are certain families, which are specially marked out by their embryological features. For example, the families of Ranunculaceae, Cyperaceae and Podostemonaceae.

4. Cytology:

Cytology has made an outstanding contribution to taxonomy during the past few decades. Cytology characters such as chromosome number and morphology and their behavior and structure at meiosis are of considerable taxonomic value. Since the cytological data are directly derived from nucleus the seat of hereditary material, they may be used for understanding the evolution and relationship of population. The chromosome number is usually constant in a species and this makes it an important character.For example, the genera ***Agave*** and ***Yucca*** placed in two separate families, **Amarylidaceae** and **Liliaceae**, respectively by some earlier works, have 5 long and 25 short chromosomes.

5. Chemotaxonomy:

The application of chemistry to systematics is called chemotaxonomy or chemical taxonomy**.** Chemical characters of plants have long been of practical value. For example, the smell of crushed foliage (due to the presence of characteristic essential oils) of the Apiaceae and Lamiaceae are quicker means of identifying their members. Chemical characters of plants can often find as wide application in classification as do characters from gross morphology. Chemical data are also a reliable guide to phylogenetic relationship of various taxa. However, all kinds of chemical substances do not reveal information useful to the taxonomist. Distribution of secondary compounds of low molecular weight such as, **Non-protein amino acids, Phenolic compounds, Flavinoids, Alkaloids, Terpenoids** and **Steroids** provide valuable clues to the systematist.

6. Numerical Taxonomy:

The classification of taxonomic units into various groups by numerical method is known as numerical taxonomy. Although attempts to use some kind of quantitative

methods in taxonomy date back to the end of nineteenth century, the last three decades have witnessed marked change in outlook and methodology in the field of biological systematics with the application of high-speed computers.

Plant Morphology

Plant morphology is a field of study dealing with the external and gross internal structure of plant organs. Morphology intergrades somewhat with plant anatomy, which is the study of tissue and cell structure of plant organs. Morphology forms the basis of taxonomic descriptions and generally constitutes the most important data in determination taxa.

Plant Structure (Plant organs)

The basic structural components, or organs, of plants are delimited by and strongly correlated with their specific functions. The major organs of vascular plants are sporophytic roots and shoots. **Roots** are present in almost all vascular plants and typically function in absorption of water and minerals. Roots consist of an apical meristem that gives rise to a protective root cap, a central endodermis-bounded vascular system, absorptive epidermal root hairs, and endogenously developed lateral roots.

The sporophytic **shoots** of vascular plants consist of stem plus leaves. Shoots contain an apical meristem of actively dividing cells that, through continued differentiation, result in the elongation of the stem and formation of leaves and buds. The **stem** is a generally cylindrical organ that bears the photosynthetic leaves. Stems typically function in conduction of water and minerals from the roots and in support and elevation of both leaves and reproductive structures, although some stems are highly modified for other functions.

The **leaf** is that organ of the shoot that is generally dorsiventrally flattened and that usually functions in photosynthesis and transpiration. Leaves are derived from **leaf primordial** within the shoot apex and are often variously modified. In vascular plants, leaves contain one to many vascular bundles, the **veins**, in some mosses, the gametophytic leaves may contain a vein like **costa**, consisting of specialized (although not truly vascular) conductive tissue. **Buds** are immature shoot systems, typically located in the axils of leaves. Buds may grow to form lateral vegetative branches or reproductive structures.

Among reproductive plant organs, the **sporangium** is the basic spore-producing part of all land plants. In heterosporous plants (including all of the seed plants) sporangia are of two types: male (microsporangium) or female (megasporangium). The sporangium of liverworts, hornworts, and mosses is known as a **capsule** and typically makes up most of the sporophyte. A **cone**, also called a

strobilus, is a modified, determinate, reproductive shoot system of many non-flowering vascular plants, consisting of a stem axis bearing sporophylls. An **ovule** is a megasporangium enveloped by one or more protective integuments. A **seed** is the mature ovule of the seed plants, consisting of an internal embryo surrounded by nutritive tissue (endosperm) and enveloped by a protective seed coat. The reproductive organ of angiosperms is the **flower**, a modified, determinate shoot bearing sporophylls called stamens and carpels, with or without outer modified leaves (the perianth). An **inflorescence** is an aggregate of one or more flowers, the boundaries of which generally occur with the presence of vegetative leaves. A **fruit** is the mature ovary of flowering plants, consisting of the pericarp (mature ovary wall), seeds, and (if present) accessory parts.

Plant habit

Plant habit refers to the general form of a plant, encompassing a variety of components such as stem duration and branching pattern, development, or texture. Most plants can be clearly designated as an herb, vine, liana, shrub, or tree. An **herb** is a plant in which any aboveground shoots, whether vegetative or reproductive, die back at the end of an annual growth season. Although the aboveground shoots are annual, the herb itself may be annual, biennial, or perennial, the last by means of long-lived underground rootstocks. Such perennial herbs, having a bulb, corm, rhizome, or tuber as the underground stem, are termed **geophytes**.

A **Vine** plant with elongate, weak stems that are generally supported by means of scrambling, twining, tendrils, or roots; vines may be annual or perennial, herbaceous or woody. A **liana (**also spelled liane) is a vine that is perennial and woody, large; lianas are major components in the tree canopy layer of some tropical forests. A **shrub** is a perennial, woody plant with several main stems arising at ground level. Finally, a **tree** is defined as a generally tall, perennial, woody plant having one main stem (the trunk) arising at ground level.

Plant habitat and Duration:

A- Plant habitat:

Plant habitat refers to the general environment where the plant is growing. General habitat terms include whether the plant is **terrestrial**, growing on land; **aquatic**, growing in water; or **epiphytic**, growing on another plant. If aquatic, a plant can be **immersed**, occurring under water; **floating**, occurring at the water surface; or **emergent**, having roots or stems anchored to the substrate under water and aerial shoots growing above water. Other aspects of the habitat include the type of substrate that the plant is growing in (e.g., whether on sandy, loam, clay, gravelly, or rocky soil, the slope, elevation, moisture, and surrounding vegetation, community, or ecosystem).

B- Plant duration:

According to duration, the flowering plants classified to:

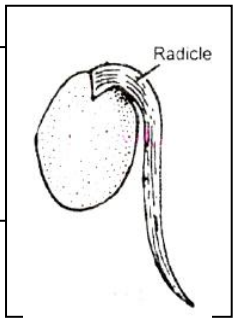
1. **Annual:** A plant completing its life cycle in a single season, from seed to germination, reproduction and death, e.g. ***Anagallis*** (AIN ALJAMAL).
2. **Ephemeral:** A plant which completes its life cycle in a very short time say within some weeks single season, e.g. ***Chenopodium*** (RIGHELA).
3. **Biennial:** A plant which completes its life cycle in two seasons e.g. ***Raphanus sativus*** (AL-FIJIL تور).
4. **Perennial:** A plant which grows for several years, e.g. most trees, shrubs, and some herbs.

ROOTS

The root is the underground organ of the plant. Its primary function includes uptake of water and minerals and anchorage of the above-ground (aerial) portions of the plant.

Origin of roots;

The first root to develop in a vascular plant is the radicle of the embryo.

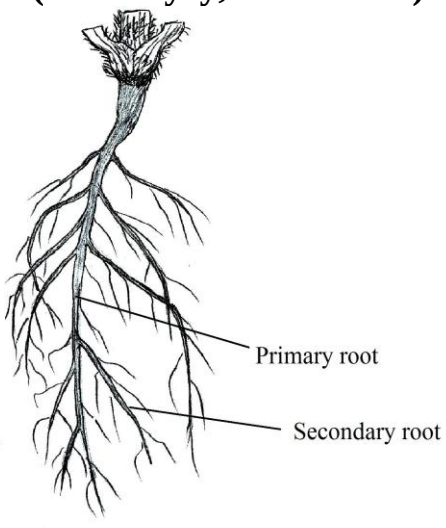


1. Primary root & **Lateral roots**: Formed by radicle, as in most Dicots. Taproot system.

2. Adventitious roots: Formed by any other part of a plant except radicle, as in Monocots.

Root system;

1. Normal roots Taproot system (Allorrhyzy, Dicot roots)



Tap root (Allorrhyzy)

2. Fibrous root system (Homorrhyzy, Monocot roots)

Fibrous root (Homorrhyzy)

Modified Roots;

Some roots are modified to carry out specialized functions of mechanical and physiological nature.

A. Some taproots are modified for food storage as fleshy or succulent taproots.
B. Some adventitious roots are modified for other functions also.

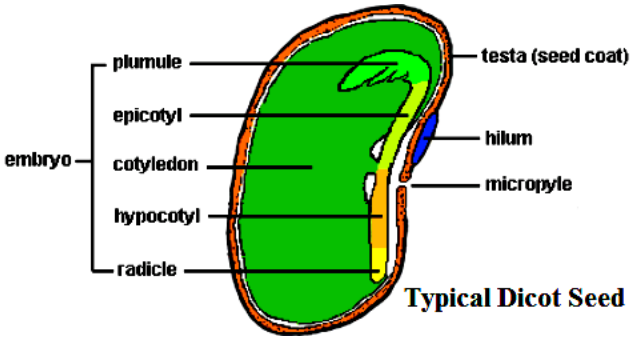
STEMS (Shoot System)

Stems function both as supportive organs (supporting and usually elevating leaves and reproductive organs) and as conductive organs (conducting both water/minerals and sugars through the vascular tissue between leaves, roots, and reproductive organs). As mentioned earlier, a **shoot** is a stem plus it's associated leaves. Sporophytic shoots that are branched and bear leaves are an apomorphy for all vascular plants; the leafy shoot like structures of mosses and some liverworts are gametophytic and not directly homologous with shoots of vascular plants.

Stem is the axis of a plant bearing leaves with buds in their axils. It is formed by the plumule of the seed.

Origin of stem;

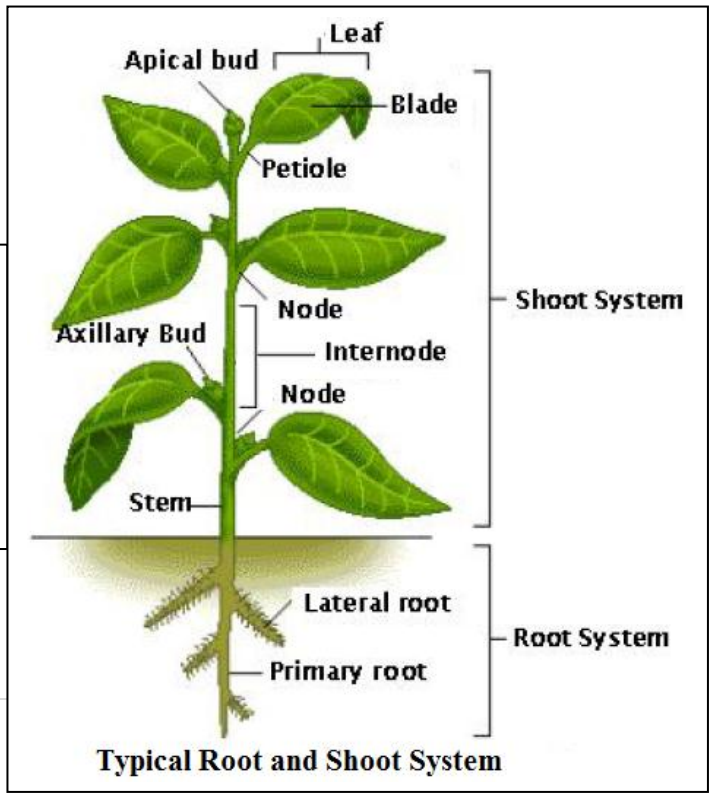
The first shoot of a seed plant develops from the epicotyl of the embryo. The epicotyl elongates after embryo growth into an axis (the stem) that bears leaves from its tip, which contains the actively dividing cells of the shoot **apical meristem**. Further cell divisions and growth results in the formation of a mass of tissue that develops into the immature leaf, called a **leaf primordium**.



Typical Dicot Seed

Part of a stem;

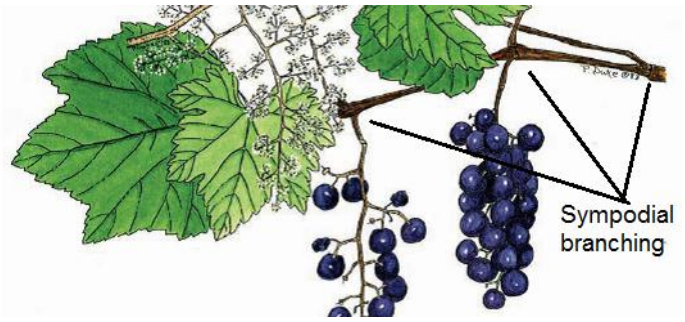
1. **Shoot tip;**
2. **Node;**
3. **Inter node;**
4. **Bud, A terminal bud;**



Typical Root and Shoot System

Monopodial and Sympodial system of branching;

1. **Monopodial; indeterminate**
   A branching pattern in which a given axis is derived from a single apical meristem, as fined in ***Prunus*** and ***Pinus.***
2. **Sympodial; determinate,**
   A branching pattern in which a given axis is made up of several unites, each of which derived from a separate apical meristem, the units themselves determinate or indeterminate, as fined in ***Vitis***.



Stem habit types;

Aerial (Terrestrial) stem:

Stems function both as supportive organs (supporting and usually elevating leaves and reproductive organs) and as conductive organs (conducting both water/minerals and sugars through the vascular tissue between leaves, roots, and reproductive organs).

Modified stems;

1- **Arial modifications;** Many modified types of stems that are aerial (aboveground) also have specific functions. For example, a **cladode** is a flattened, photosynthetic stem that may resemble and function as a leaf, found, e.g., in prickly-pear cacti, *Asparagus*, and *Ruscus*.

2- **Underground modifications (Subterranean stems) ;** Rootstocks function as storage and protective organs, remaining alive underground during harsh conditions of cold or drought. When environmental conditions improve, rootstocks serve as the site of new shoot growth, sending out new adventitious roots and new aerial shoots from the apical meristem or from previously dormant buds.

BUDS

Buds are immature shoot systems that develop from meristematic regions. In deciduous woody plants the leaves fall off at the end of the growing season and the outermost leaves of the buds may develop into protective **bracts** (modified leaves) known as **bud scales**. The bud of a twig that contains the original apical meristem of the shoot (which by later growth may result in further extension of the shoot) is called

the **terminal** or **apical** bud. Buds formed in the axils of leaves are called **axillary** or **lateral** buds.

A given bud may be **vegetative**, if it develops into a vegetative shoot bearing leaves; **floral** or **inflorescence**, if it develops into a flower or inflorescence; or **mixed**, if it develops into both flower(s) and leaves. In some species more than one axillary bud forms per node. If the original terminal apical meristem of a shoot aborts (e.g., by ceasing growth or maturing into a flower), then an axillary bud near the shoot apex may continue extension growth; because this axillary bud assumes the function of a terminal bud, it is called a **pseudoterminal bud**.

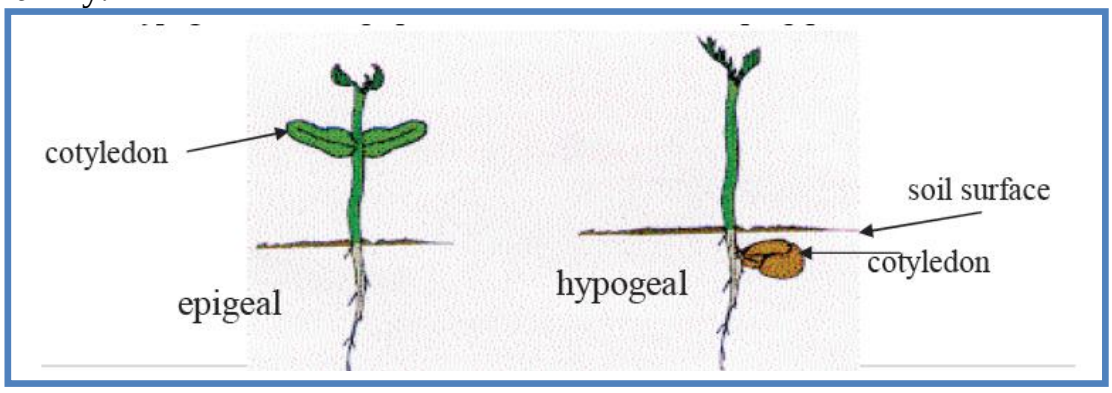
LEAVES

Leaf is a lateral appendage of the stem born at the node and bears an axillary bud in its axil. It is usually expanded and concerned with the manufacture of food (photosynthesis).

Origin of leaf;

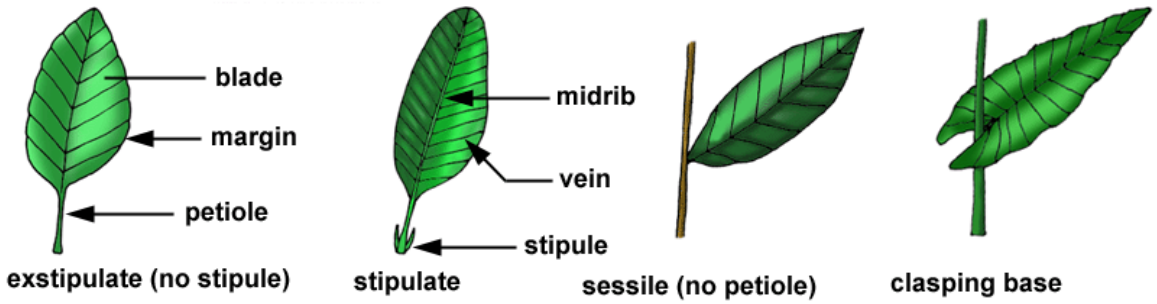
The leaf primordia arise exogenously at the growing point as lateral protuberances or transverse ridges, initially undifferentiated.

1. **The cotyledons;** The cotyledons, the life of which is usually only short, are almost always less complex in form than the normal leaves. In the Germination of the seed they may remain enclosed within the testa and concealed beneath the surface of the soil (**hypogeal germination**), e.g. *Quercus*, *Pisum*, and *Vicia faba*. In (**epigeal germination**), the cotyledons burst through the testa and appear above the surface of the earth, e.g *Phaseolus vulgaris* and most genus of the Poacea family.



2. **The foliage leaves;**

The foliage leaf usually consists of number of parts. Thus, we can recognize the flat, green, frequently very thin, expanse or lamina of the leaf, the stem-like petiole (petiolule for leaflet stalks), and the leaf base. This may be differentiated as a leaf sheath, or may bear stipules.



Phyllotaxy or Leaf arrangement (number of leaves at a node);

It is a mode of arrangement of leaves on the stem includes;

1) **Alternate;** leaves are produced alternately or spirally on the long axis or stem. As in *Eucalyptus* and most Poaceae.
2) **Opposite;** Leaves occurring in pairs at the node, they may be –

a. Decussate : Leaves that stands at right angle to next upper or lower pair eg. *Silene* and *Dianthus*.

b.Superposed : Successive pairs of leaves stand directly over a pair in the same plane, in some Onagraceae, and some Labiatae.

3) **Whorled** or **verticillate;** in which 3 – 5 leaves form a whorl in each node as 3 leaves in *Nerium oleander* and 5 in *Galium.*

Leaf incision (simple & compound leaves);

Indentation of the lamina margin is called leaf incision. Accordingly two main categories are recognized; Simple leaf & Compound leaf.

1) Simple leaf;

A leaf having entire margin (not divided), as in *Vinca* and *Punica*.

2) Compound leaf;

The leaf has incised margin, and the incision goes so deep, touching the midrib, so that lamina breaks up into lobes or segments called leaflets. A compound leaf may be pinnate or palmate.

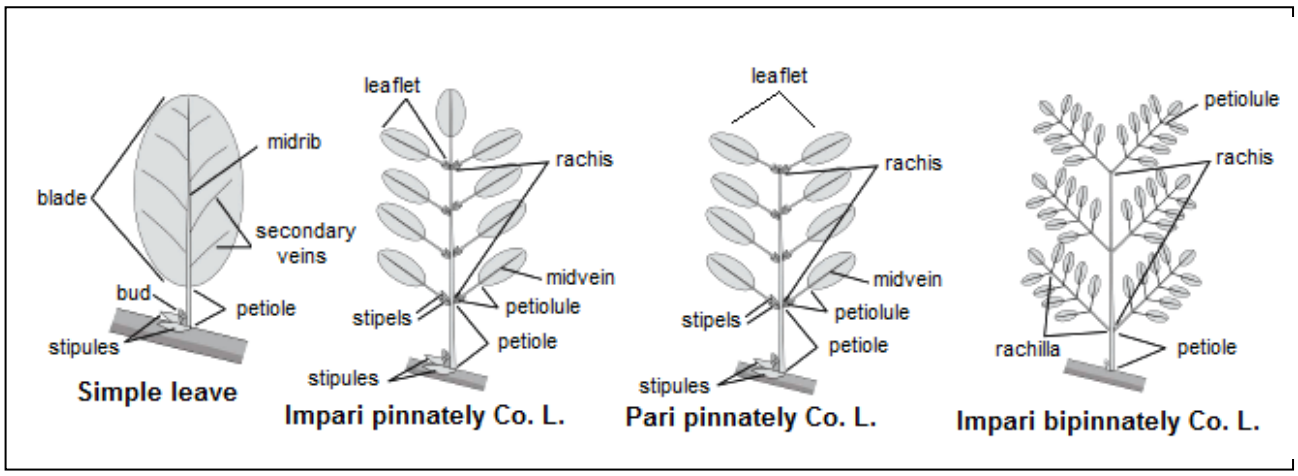
A. Pinnate compound;

The midrib (or rachis) directly bears the leaflets or pinnae along both the sides. It may be simple pinnate, bi-pinnate, tri-pinnate and decompounds.

i. **Simple pinnate** or **uni-pinnate —** leaflets born directly on rachis, and may be **paripinaate-** leaflets present in pairs as in *Tamarindus indica* and *Acacia*. Or may be **Imparipinnate** – rachis is terminated by an odd leaflets as in *Rosa* and *Melia azadirachta*.

ii. **Bi-pinnate —** a compound leaf with main segments again pinnately divided into pinnules i.e., leaflets born on the rachis but on its branches as in *Acacia arabica* and *Mimosa punica*.

iii. **Tri-pinnate —** incision goes to the 3rd order so that leaflets are found on secondary branches of the rachis, as in *Prosopis*.



B. Palmate compound;

In such leaves, rachis does not differentiate and the lamina appears articulated or attached to a point on the top of the petiole. Such compound leaves may be of following types;

i. **Uni-foliate —** single leaflet attached to the top of the petiole, as in *Citrus*.
ii. **Bi-foliate —** only two leaflets articulated to the rachis, as in *Bignonia grandiflora*.
iii. **Tri-foliate —** three leaflets articulated at the top of the rachis, as in *Oxalis*.
iv. **Quadri-foliate —** (it is a rare type) four leaflets articulated at the top of the rachis, as in *Paris quadrifolia* and *Marsilea quadrifoliata*.
v. **Multi-foliate —** more than four leaflets attached at the top of the rachis, as in *Acanthopanax*.

Leaf parts (of foliage leaves);

(A) Leaf base attachment; The point of attachment of the leaf to the stem. In general, leaves may be **petiolate**, with a petiole, or **sessile**, without a petiole. Leaflets of a compound leaf are, correspondingly, either **petiolulate** or **sessile**.

(B) Stipules;

A pair of lateral outgrowth present at the base of the leaf. Leaves possessing stipules are called **stipulate** and lacking are **exstipulate** as in *Melia azadirachta* .

(C) Petiole; Stalk of the leaf, a leaf having a petiole is called **petiolate,** and without petiole is called sessile. The petiole shows, sometime modifications, as it is **winged** (*Citrus*), **spongy** (*Eichhornia*), **flattened** (*Acacia*), **spinous** (*Quisqualis*).

(D) Lamina (Blade);

The most important part of the leaf and a seat of gaseous exchange for photosynthesis, respiration, transpiration . . . etc.

Several features of leaf are considered regarding appearance of lamina, such as shape, base, margin, apex, surface, texture, venation, incision and simple or compound . . . etc.

Leaf Venation:

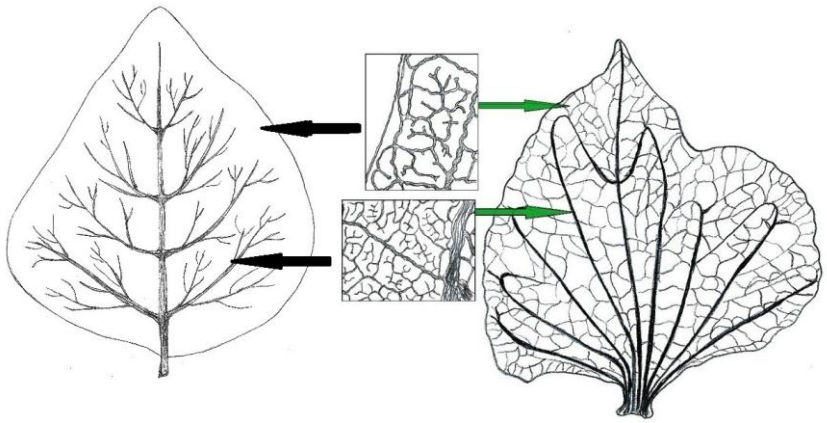
The pattern of arrangement of vascular system in the lamina is called venation. It is mainly of two types:

Ψ **Reticulate venation;**

Netted or **reticulate,** in which the ultimate vein-lets form an interconnecting netlike pattern, e.g., most dicot flowering plants.

Reticulate leaves can be;

1) **Pinnately veined (pinnate netted)**, with secondary veins arising along length of a single primary vein (the midrib or, in a compound leaf, mid-vein); as in *Lactuca* and *Myrtus*.
2) **Palmately veined (palmate-netted),** with four or more primary veins arising from a common basal point; as in *Vitis* and *Ricinus*.
3) **Ternately veined (ternate-netted)**, with three primary veins arising from a common basal point, As in *Cinnamomum*.

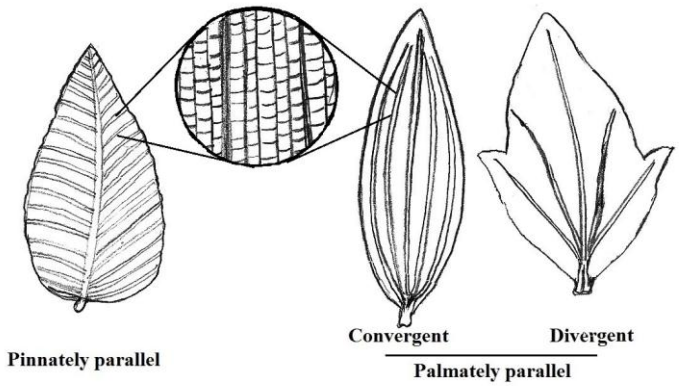


Pinnately reticulate Palmately reticulate

Ψ Parallel venation;

Similar to parallel venation in having transverse ultimate veinlets are

1) **penni-parallel** (also called **pinnate-parallel)**, with secondary veins arising from a single primary vein region, the former essentially parallel to one another (e.g., *Phoenix reclinata*);
2) **palmate-parallel,** with several primary veins (of leaflets or leaf lobes) arising from one point, the adjacent secondary veins parallel to these (e.g., *Washingtonia filifera* ; fan palms).



Pinnately parallel Convergent Divergent Palmately parallel

BRACTS and BRACTEOLES

Axillary floral buds are usually born in the axils of the specialized leaves called **bracts.** Such flower is called **bracteat,** as in most members of Acanthaceae. In some cases, bracts are absent where flowers are called **ebracteat**, as in Brassicaceae and Boraginaceae. Sometimes additional bract-like small and thin structures are born on the pedicel (or peduncle) between the flower and bracts. These are called **bracteoles** and such flowers are called **bracteolate** as in most members of Umbelliferae.

Bract and bracteoles may be variously modified, such as: **Foliaceous or leafy bract** in *Capparis* and *Antirrhinum*. **Petalloid bract** in *Boungainvillea* and *Euphorbia pulcherrium*. **Epicalyx** e.g. *Hibiscus*, other Malvaceae (as in *Malva* and *Alcea*). **Scaly bract** in *Ornithogalum* and *Aloe*. **Glumes** in Poacea (Gramineae), also called **empty glumes**. **Spathy bract** in *Arum* and *Narcissus* sp; **Cymba-** a woody, durable spath valve that encloses the inflorescence as in *Phoenix*. **Cupule** in *Quercus*. Finally, **Involucral bract –** These form involucres' as in Asteraceae (Compositae). Involucre of bracts is also found in Umbelliferae (Apiaceae) as in *Daucus carota*. In addition to bracts, there may be smaller involucres round the base of each branch of the inflorescence as in *Daucus* and these are called **involucels.**

FLOWER

A major diagnostic feature of angiosperms is the flower. A **flower** is a modified reproductive shoot, basically a stem with an apical meristem that gives rise to leaf primordia. Unlike a typical vegetative shoot, however, the flower shoot is determinate, such that the apical meristem stops growing after the floral parts have formed.

Flower parts;

The basic parts of a flower, from the base to the apex, are as follows. The **pedicel** is the flower stalk. (If a pedicel is absent, the flower attachment is sessile.) Flowers may be subtended by a **bract**, a modified, generally reduced leaf; a smaller or secondary bract, often borne on the side of a pedicel, is termed a **bracteole** or **bractlet**.

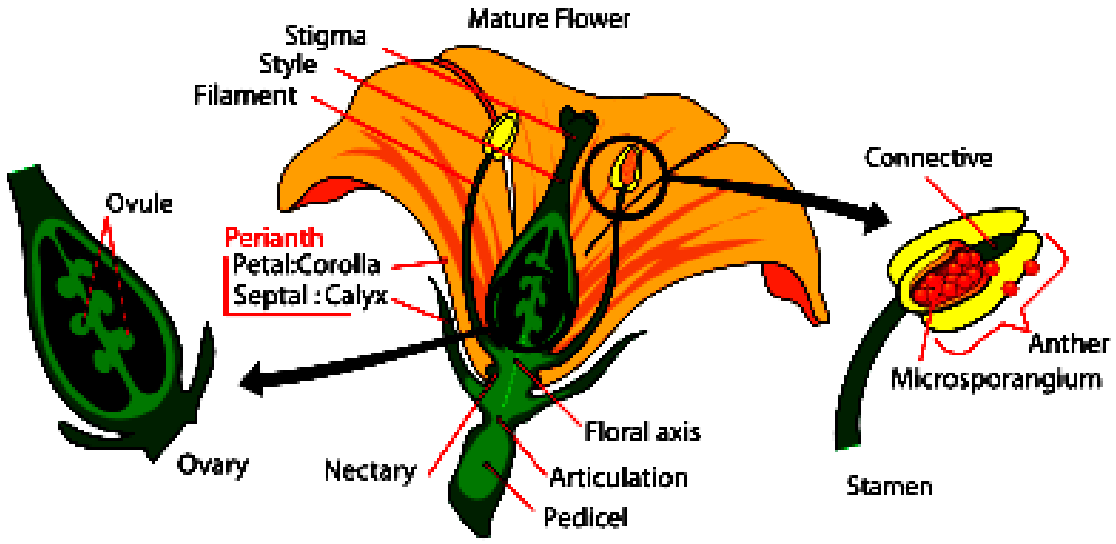
[In some taxa, a series of bracts, known as the **epicalyx**, immediately subtends the calyx (see previous discussion), as in *Hibiscus* and other members of the Malvaceae.] The **receptacle** is the tissue or region of a flower to which the other floral parts are attached. The receptacle is typically a small, obscure region. In some taxa the receptacle can grow significantly and assume an additional function. From the receptacle arise the basic floral parts. The **perianth** (also termed the **perigonium**) is the outermost, non-reproductive group of modified leaves of a flower. If the perianth is relatively undifferentiated, or if its components intergrades' in form, the individual leaf-like called **sepaloid**, as in *Beta vulgaris* and *Phoenix*. And the petal-

like called **petaloid**, as in *Muscary, Allium, Tulipa, Anemon* and *Ornithogalum*, and the parts are termed **tepals,** in most flowers the perianth is differentiated into two groups. The **calyx** is the outermost series or whorl of modified leaves. Individual units of the calyx are **sepals**, which are typically green, leaf-like, and function to protect the young flower. The **corolla** is the innermost series or whorl of modified leaves in the perianth. Individual units of the corolla are **petals**, which are typically colored (non-green) and function as an attractant for pollination.

Many flowers have a **nectary**, a specialized structure that secretes nectar. Nectaries may develop on the perianth parts, within the receptacle, on or within the androecium or gynoecium (below), or as a separate structure altogether.

The **androecium** refers to all of the male organs of a flower, collectively all the stamens. A **stamen** is a microsporophyll, which characteristically bears two thecae (each theca comprising a pair of microsporangia; Stamens can be leaf-like (laminar), but typically develop as a stalk-like **filament**, bearing the pollen-bearing **anther**, the latter generally equivalent to two fused thecae.

The **gynoecium** refers to all of the female organs of a flower, collectively all the carpals. A **carpel** is the unit of the gynoecium, consisting of a modified megasporophyll that encloses one or more ovules. Carpals typically develop in a conduplicate manner. A **pistil** is that part of the gynoecium composed of an **ovary**, one or more **styles** (which may be absent), and one or more **stigmas**.



Flower Cycly;

Flower cycly refers to the number of cycles (series or whorls) or floral parts. The two basic terms used are **complete**, for a flower having all four major series of parts (sepals, petals, stamens, and carpels), e.g. *Rosa* spp. and **incomplete**, for a flowering lacking one or more of the four major whorls of parts (e.g., any unisexual flower, or a bisexual flower lacking a corolla).

Terms for absence of parts include **achlamydeous**, lacking a perianth altogether, e.g. *Euphorbia*, **apetalous**, having no petals or corolla, and **asepalous**, having no sepals or calyx. e.g. *Salix*, *Juglans* and *Quercus*.

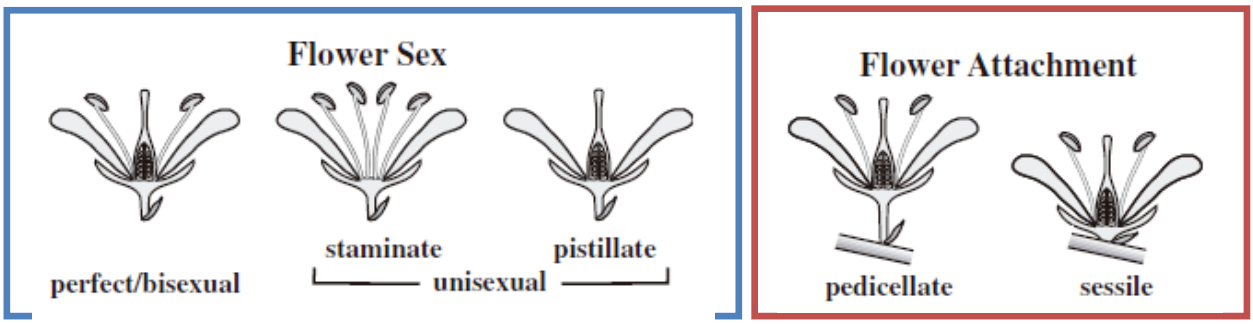
Flower Sex and Plant Sex;

Flower sex refers to the presence or absence of male and female parts within a flower. Most flowers are **perfect** or **bisexual**, having both stamens and carpels. Bisexual flower sex is likely the ancestral condition in angiosperms.

Many angiosperm taxa, however, have **imperfect** or **unisexual** flower sex. In this case, flowers are either **pistillate** / **female**, in which only carpels develop, or **staminate**/ **male**, in which only stamens develop.

Plant sex refers to the presence and distribution of perfect or imperfect flowers on individuals of a species.

1. **Hermaphroditic;** plant is one with only bisexual flowers.
2. **Monoecious;** (*mono*, one + *oikos*, house) plant is one with only unisexual flowers, both staminate and pistillate on the same individual plant; e.g. *Quercus* spp. and *Zea mays*.
3. **Dioecious**;(*di*, two + *oikos*, house) plant is one with unisexual flowers, but with staminate and pistillate on separate individual plants (i.e., having separate male and female individuals; e.g., *Salix* spp. Plant sex can vary within individuals of a species, and there may also be a combination of perfect and imperfect flowers in different individuals.
4. **Polygamous;**is a general term for a plant with both bisexual and unisexual flowers.



NOTE/ Androecium+Gynoecium = Reproductiv organs (Essential organs).
Perianth = Sepals +Petals + Other parts (Accessory organs)

Appendages;

Hypanthium or **floral cup**, a generally tubular or cup-shaped structure at the top rim of which are attached the corolla.

Aestivation:

Arrangement of sepals and petals in the bud which may be of following types:

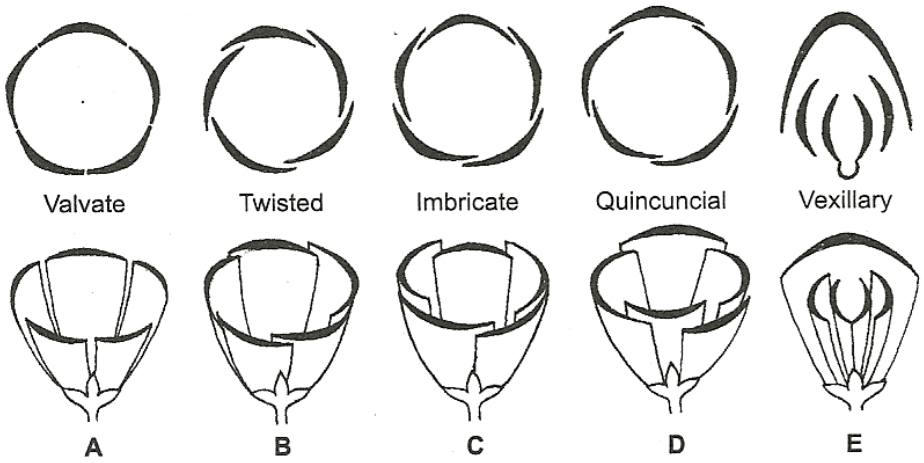
A. Valvate; Petals (Sepals) are closely arranged in a circle without overlapping to each other as in *Mimosa* sp.

B. Twisted; With parts rolled up in such a way that the outer part of each covers the inner part of the one in front of it, while in turn its inner part is covered by the one behind it.

C. Imbricate; Both ends of one petal (sepal) are outer and of another petal (sepal) are inner while other three petals (sepals) have one end outer and another one inner.

D. Quincuncial; Two petals (sepals) are outer end two petals (sepals) are inner while one petal (sepal) has one overlapped and one exposed margin.

E. Vexillary; With one large posterior petal, two lateral and two inner most fused. As in Fabaceae members e.g. *Vicia faba*.

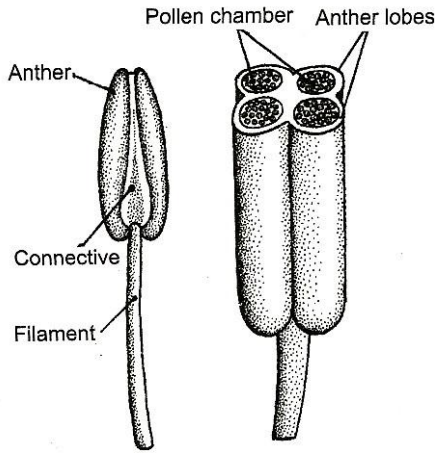


Aestivation of corolla; in two different views:
A- valvate, B- twisted C- imbricate, D- quincuncial E- vexillary

Androecium;

The androecium consists of all the floral male (pollen producing) reproductive organs, the units of which are stamens. Stamens initiate as primordia from the flower apical meristem, but at maturity are attached to the receptacle, corolla (having an epipetalous stamen fusion; see below), hypanthium rim, or **staminal disk**, a fleshy, elevated, often nectariferous cushion of tissue.

Stamens are far more common, having a stalk-like, generally terete **filament** with a discrete pollen-bearing part, the **anther**.



POLLEN GRAINS

Palynology: is the study of spores and pollen grains. Spores and pollen grains have a number of morphological and ultrastructural features.

Pollen unit;

Pollen unit refers to the number of pollen grains united together at the time of release. Such single, infused pollen grains are called **monads**, found in the great majority of angiosperms. Rarely, pollen grains will fuse in pairs, each pair known as a **dyad**. More commonly, the four haploid products of meiosis remain fused together, comprising a **tetrad**.

Pollen polarity;

Pollen polarity refers to the position of one or more apertures relative to a spatial reference. This spatial reference defines a **polar axis** as the extended pollen grain diameter that passes through the center of the original pollen tetrad. a right angle to the pole and passing through the center of the grain defines the pollen **equatorial axis**, the surrounding area being the equatorial region.

Polar view: observing a pollen grain from the direction of either pole is known as a polar view.

Equatorial view: observing from the equatorial direction is an equatorial view**.**

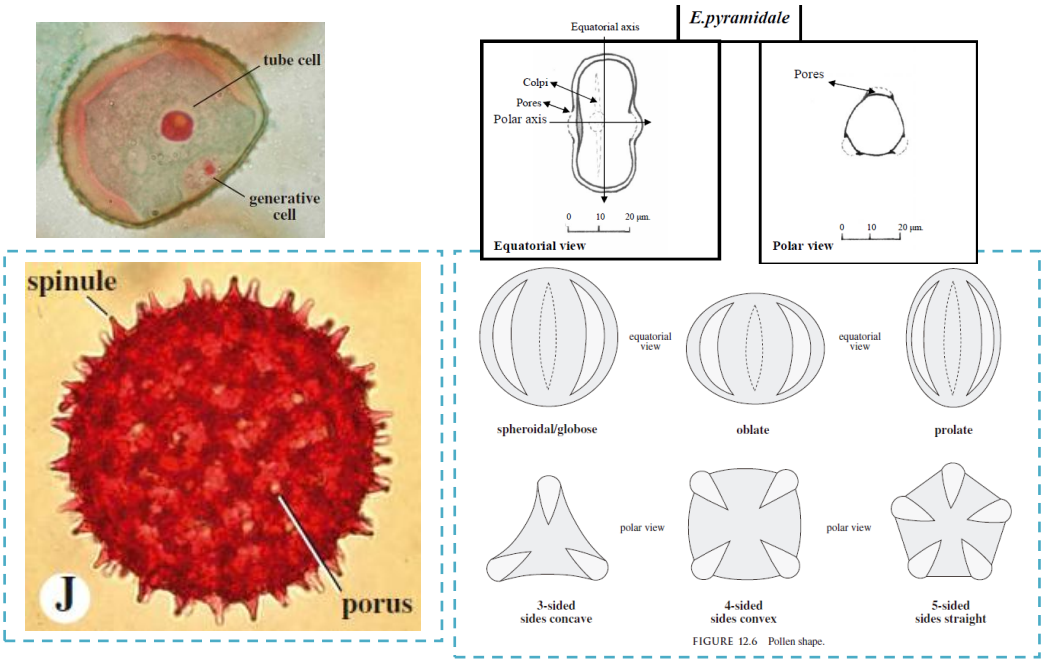


FIGURE 12.6 Pollen shape.

Gynoecium, (carpel, and pistil);

A **locule** is an ovary cavity, enclosed by the ovary walls and septa. Locule number may be an important systematic character; the term unilocular may be used for an ovary with one locule, pleurilocular for an ovary with two or more (typically many) locules.

Placenta;

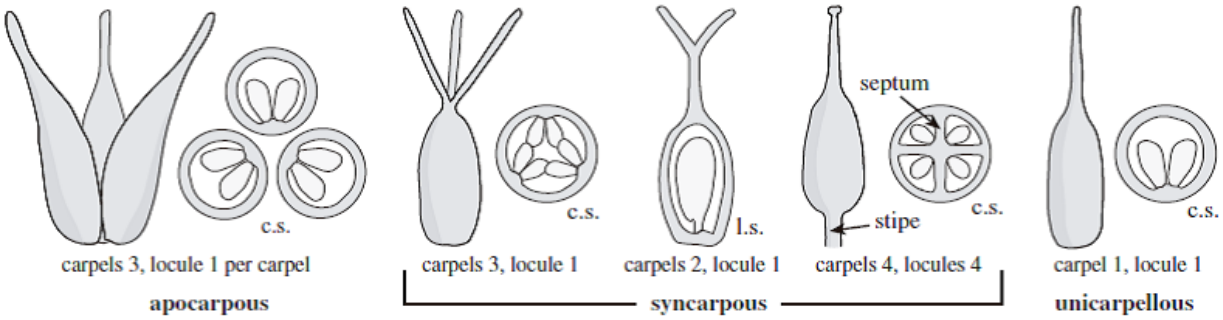
Placenta are the tissues of the ovary that bear the ovules, the immature seeds. A **funiculus** is a stalk that may lead from the placenta to the ovule.

Carpel / locule number;

Carpel number is often critical in classification and identification of flowering plants. A line or mark of carpels union or fusion is called a **suture;** there are **dorsal suture** and **ventral suture** (which consider the carpels fusion line). Carpel number is determined as follows:

If the gynoecium is **apocarpous**, the number of carpels is equal to the number of pistils, as in *Ranunculus*; this is because each pistil is equivalent to a single carpel in any apocarpous gynoecium. (For example, pistils of *Delphinium* have one stile and stigma, is a **monocarpous**, pistils of all members of the Asteraceae have two styles and stigmas, and thus carpel number is interpreted as 2).

Syncarpous, gynoecial fusion is one in which carpels are connate (the pistil compound) and is the most common type in flowering plants, as fined in Malvaceae and Cucurbitaceae.



Ovary position;

Ovary position: assesses the position or placement of the ovary relative to the other floral parts: hypanthium, calyx, corolla, and androecium.

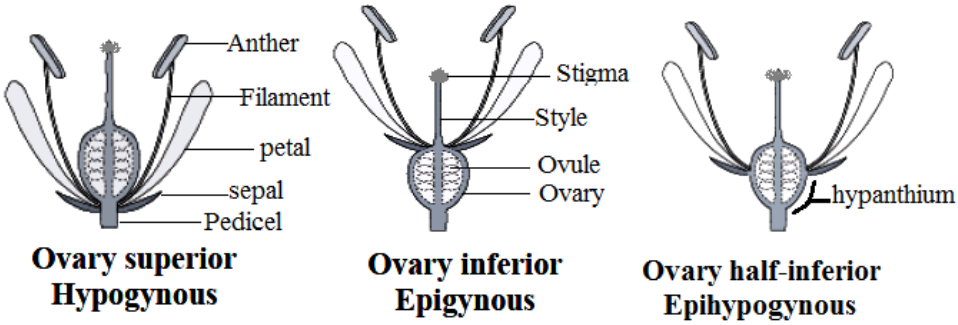
1. **Superior ovary,** is one with sepals, petals, and stamens, and/or hypanthium attached at the base of the ovary, as in *Antirrhinum*, *Solanum* sp., and *Petonia*.
2. **Inferior ovary**, position has sepals, petals, stamens, and/or hypanthium attached at the ovary apex, as in *Cucumis* sp., *Helianthus annuus* and *Myrtus communis*.

3. **Semi** or **half-inferior ovary,** is used for sepals, petals, stamens and/or hypanthium attached at the middle of the ovary, as in *Rosa* and *Pyrus malus*.

Perianth/Androecial position;

Perianth/androecial position describes placement of the perianth and androecium relative both to the ovary and to a hypanthium, if present.

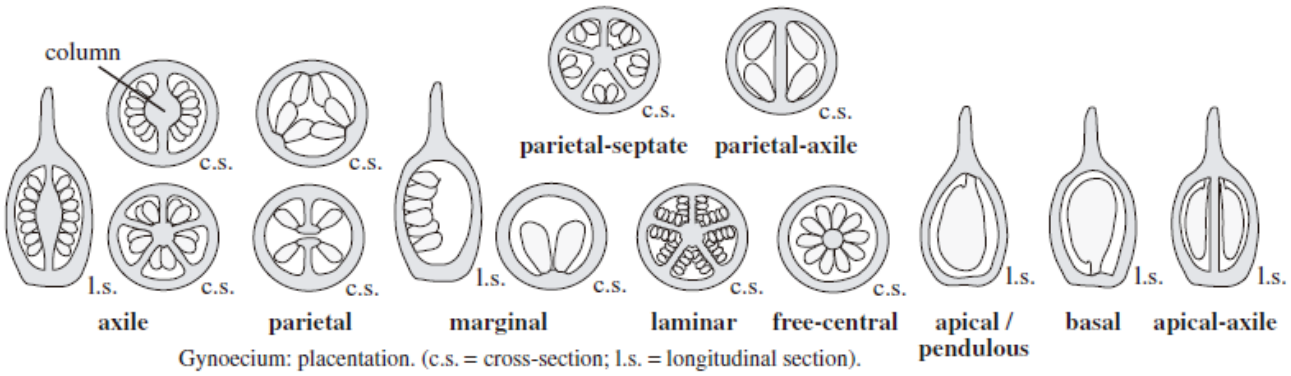
1. **Hypogynous** is used for sepals, petals, and stamens attached at base of a superior ovary.
2. **Epigynous** refers to the sepals, petals, and stamens attached at apex of an inferior ovary.
3. **Perigynous** or **Epihypogynous** is used for sepals, petals, and stamens attached at middle of the ovary, the ovary being half-inferior.



Placentation;

Placentation refers to the positioning of the ovules and takes into account the number and position of placentae, septa, and locules. Placentation types are:

1. **Axile**, with the placentae arising from the column in a compound ovary, common in many flowering plants such as the Liliaceae, Malvaceae (e.g. *Hibiscus esculentus*), and Solanaceae.
2. **Apical** or **pendulous**, with a placenta at the top of the ovary, as in Apiaceae and Moraceae.
3. **Basal**, a single ovule with a placenta borne at the base of a unilocular ovary as occurs in the Asteraceae and Poaceae.
4. **Free-central**, with the placentae along the column in a compound ovary without septa, such as in the Caryophyllaceae, *Dianthus caryophyllus*.
5. **Laminar** or **Lamellate**, with ovules arising from the surface of the septae, as *in Papaver* sp.
6. **Marginal**, with the placentae along the margin of a unicarpellate (simple) ovary, as in the Fabaceae, *Vicia faba*.
7. **Parietal**, with the placentae on the ovary walls or upon intruding partitions of a unilocular, compound ovary, such as in the Violaceae, Brassicaceae, and Cucarbitaceae (e.g. *Cucumis melo* and *Cucumis sativus*).



Gynoecium: placentation. (c.s. = cross-section; l.s. = longitudinal section).

NECTARIES

Nectaries are specialized nectar-producing structures of the flower. Nectar is a solution of one or more sugars and various other compounds and functions as an attractant (a reward) to promote animal pollination.

Commonly, a floral **disk**, consisting of a disk-like or doughnut-shaped mass of tissue surrounding the ovary base or top, functions as a nectary.

INFLORESCENCES;

An inflorescence is a collection or aggregation of flowers on an individual plant. Inflorescences often function to enchance reproduction.

Inflorescence parts:

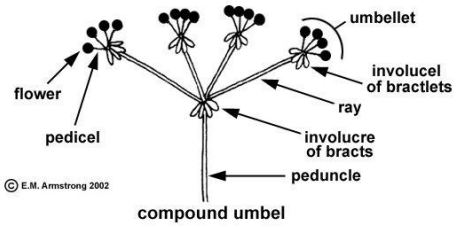
Several terms deal with leaf-like structures found in the inflorescence. An **inflorescence bract** is one that subtends not an individual flower but an inflorescence axis or a group of flowers. (Bracts that subtend an individual flower should be termed floral bracts; however, some sources do not make the distinction or will use inflorescence bract to refer to either.) A group or cluster of bracts subtending an entire inflorescence is termed an **involucre** (adjective involucrate); a similar group of bracts subtending a unit of the inflorescence is an **involucel**.

Other terms deal with various (stem) axes in an inflorescence.

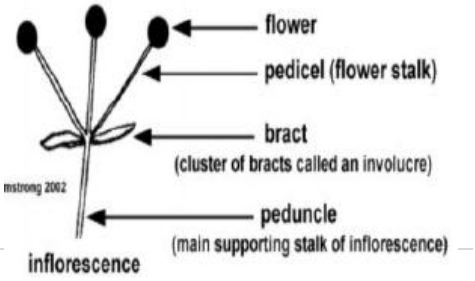
A **peduncle** (adjective pedunculate) is the stalk of an entire inflorescence.

A **compound receptacle** (also called a torus) is a mass of tissue at the apex of a peduncle that bears more than one flower. A peduncle that lacks well-developed leaves, arising from a basal rosette of vegetative leaves is termed a **scape** (adjective scapose, as in *Allium* and *Narcissus*), the plant habit in such a case being acaulescent.

A **rachis** is a major, central axis within an inflorescence. However, the central axis of a grass or sedge spikelet is a **rachilla**. Finally, a **ray** is a secondary axis of a compound umbel.



Typical inflorescence of the carrot family (Apiaceae = Umbelliferae)



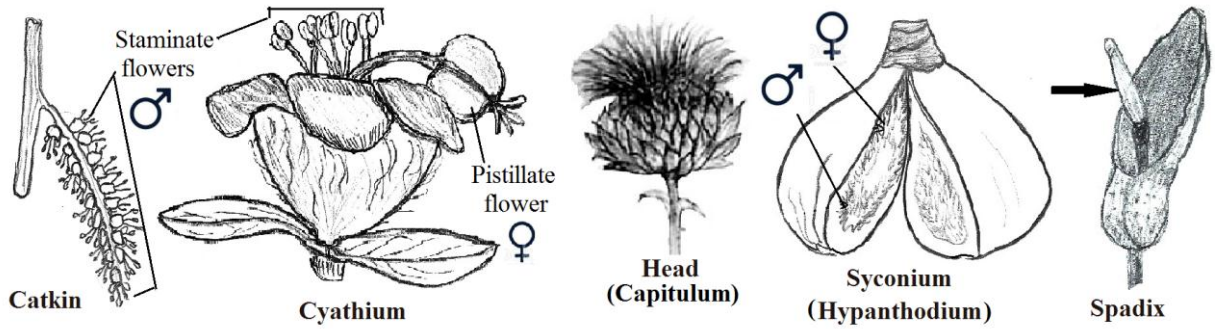
Inflorescence development:

1. A **determinate** inflorescence is one in which the apical meristem of the primary inflorescence axis terminates in a flower; typically, the terminal flower matures first, with subsequent maturation occurring from apex to base. Determinate inflorescences are characteristic of **cymes** "**Cymose"**.

2. An **indeterminate** inflorescence is one in which the apical meristem of the primary inflorescence axis does not develop into a flower; typically, the basal flower matures first, with maturation occurring from base to apex. Indeterminate inflorescences **"Racemose'**, include a number of types, such as spikes, racemes, and panicles.

Specialized inflorescences;

Some inflorescences are quite specialized and often restricted to certain taxonomic groups as: **Catkin** (also called an ament) in *Quercus* and *Salix*. **Cyathium** as in *Euphorbia helioscopia Euphorbia pilulifera*. **Head** or **capitulum** are typical of the Asteraceae and Dipsacaceae (and some other groups. **Syconium** or **Hypanthodium** in *Ficus*. And **Spadix** is a spike with a thickened or fleshy central axis, typically in the Araceae, e.g. *Arum* sp.



Specialized inflorescence types