جامعة الملك سعود
King Saud University

PRINCIPLES OF PLANT TAXONOMY

BOT 222

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What is Taxonomy / Systematics ?

Q: Why we keep the stuffs of our home at the fixed place or arrange into some kinds of system?

Animal group	No. of species
Amphibians	6,199
Birds	9,956
Fish	30,000
Mammals	5,416
Reptiles	8,240
Subtotal	59,811
Insects	950,000
Molluscs	81,000
Crustaceans	40,000
Corals	2,175
Others	130,200
Total	1,203,375

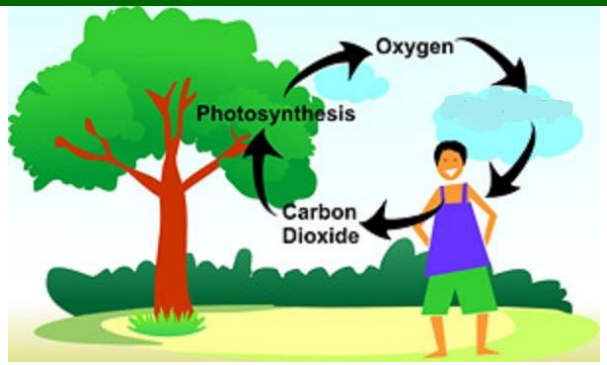
- Every Human being is a Taxonomist

Plants	No. of species
Mosses	15,000
Ferns and allies	13,025
Gymnosperms	980
Dicotyledons	199,350
Monocotyledons	59,300
Green Algae	3,715
Red Algae	5,956
Lichens	10,000
Mushrooms	16,000
Brown Algae	2,849
Subtotal	28,849
Total	1,589,361

- We have millions of different kind of plants, animals and microorganism. We need to scientifically identify, name and classify all the living organism.
- Taxonomy / Systematics is the branch of science deals with classification of organism.
- Q. What is Plant Taxonomy / Plant systematics

We study plants because:

❑ Plants produce oxygen. We breathe oxygen. We cannot live without oxygen.



❑ Plants convert Carbon dioxide gas into sugars through the process of photosynthesis.

❑ Every things we eat comes directly or indirectly from plants.

❑ Plants provide fibres for paper or fabric.

❑ Many chemicals produced by the plants used as medicine.

❑ Study of plants science helps to conserve endangered plants.

❑ Study of plants science helps to learn more about the natural world

❑ Plants can be a source of biofuels. Sugars, starches and cellulose can be fermented into ethanol. Ethanol is used as fuel.

❖ **We have millions of different kind of plants, animals and microorganism. We need to scientifically identify, name and classify all the living organism**

Taxonomic Hierarchy

Carrolus Linnaeus first adopted the hierarchic system of taxonomy classification in 1753. The succession groups are as follow:

Species:

- **Organisms sharing a set of biological traits and reproducing only their exact kind.**
- **The lowest major group, representing plants and animals referred to as Species.**
- **Species is the fundamental unit in taxonomy**

Genus: Genus are the closely related species

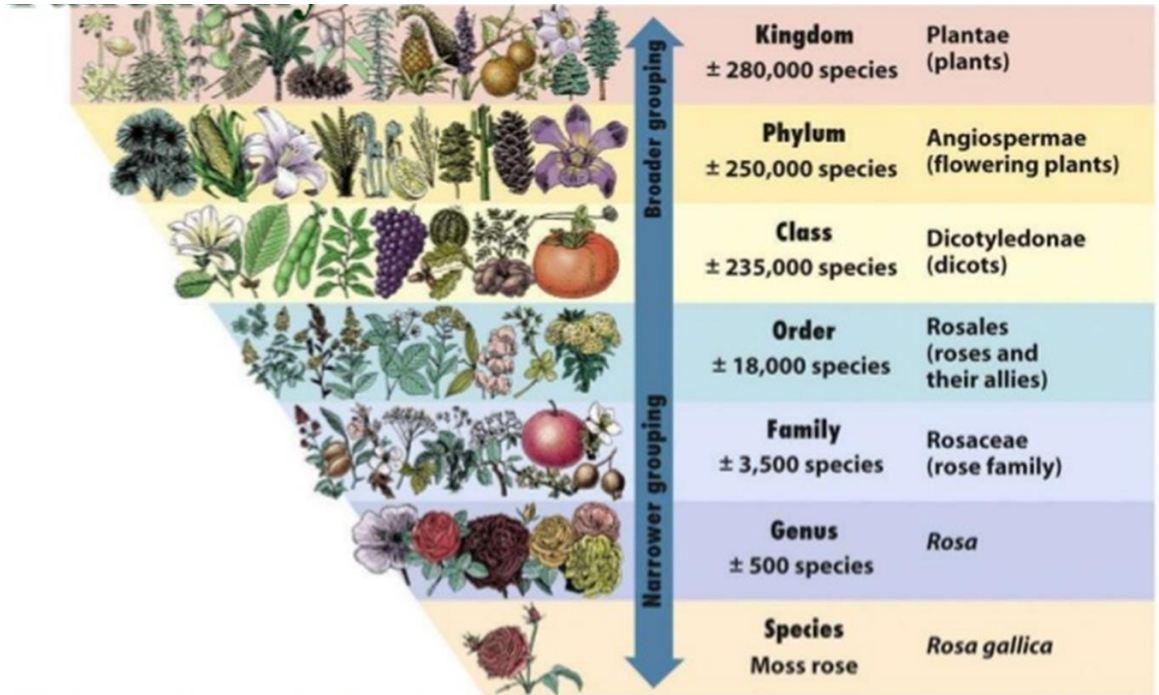
Family : Family is the closely related genera

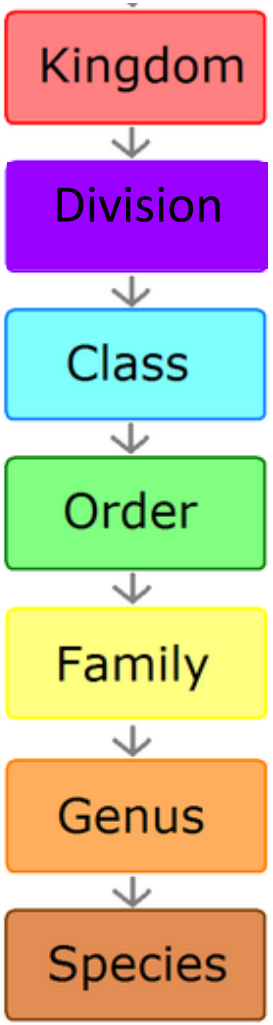
Order : Order is the closely related families

Class : Class are the closely related order

Division / Phylum: Division or Phylum is the related classes

Kingdom: Kingdom is the related Division / Phylum





Objective / Goals / Aims of Plant Taxonomy

- To provide an inventory of plant taxa for local, regional or continental needs.
- To establish suitable method for identification, nomenclature and description of plant taxa.
- Classification of organism into classes, Order, Families, Genera, and species
- To provide significantly valuable information concerning wild and medicinal species, endangered species, unique plants, genetic and ecological diversity

Scope of Taxonomy

- Taxonomy is one of the oldest sciences.
- It provides thorough knowledge of living species and their various forms.
- All the branches of biology are dependent on taxonomy for proper identification the species.
- It has been proceeded further incorporating data from phytochemistry, cyto-genetics supported by proper computation.

Basic components (Principles) of Plant Taxonomy / Plant Systematics

1) Plant collection, Preservation and Documentation

2) Plant Structure (Taxonomic Terminology, Taxonomic description of external and internal morphology)

3) Taxonomic Identification

4) Scientific Nomenclature / Botanical nomenclate : Nomenclature deals with the application of a correct name to a plant or a taxonomic group. Scientific names are necessary because the same common name is used for different plants in different areas of the world.

5) Taxonomic Classification (History and Systems of Plant Classification)

6) Taxonomic evidences / Source of data (Morphology, Anatomy, Embryology, palynology, Micromorphology, Chemistry, DNA etc.) in plant taxonomy

Basic components of Plant Taxonomy

***Phoenix dactylifera* L**

Taxonomic Identification

Stems solitary or clustered and then with few shoots, to 30 m tall, to 50 cm in diam., rough with persistent, diamond-shaped leaf bases. Leaves 3–5 m; sheath and petiole to 1 m; rachis 1–2 m; acanthophylls many per side of rachis; pinnae to 200 per side of rachis, linear, irregularly arranged and spreading in different planes; middle pinnae to 40 × 2 cm. Male inflorescences erect, to 1 m, with many rachillae, these ca. 30 cm; female inflorescences erect, becoming pendulous, to 2 m, with to 150 rachillae, these to 40 cm. Fruits variable in shape, usually oblong, to 7 × 3 cm, brown or black; endosperm homogeneous.

Taxonomic description (Plant Morphology)

Plant Classification

Kingdom: Plantae
Class: Angiosperms
Order: Arecales
Family: Arecaceae
Genus: *Phoenix*
Species: *Phoenix dactylifera*

Scientific name / Botanical Nomenclature

Types of Taxonomy / Taxonomic Studies / Plant Taxonomic Classification

From the various stages of classification, the types of taxonomy are defined: -

❖ **Alpha (α) Taxonomy / classical taxonomy:-**

It involves description and naming of organisms. It is the parent of other types of taxonomy.

❖ **Beta (β) Taxonomy: -**

In addition to morphological description, it also involves consideration of affinities and their inter-relationship between separate group of species.

❖ **Gama (ɣ) Taxonomy: -**

It is concerned with description, inter-relationship and evolution of one species from the other.

❖ **Omega (Ω) Taxonomy: -**

It is the modern experimental taxonomy in which the taxonomic activities have been enriched with data from ecology, phyto-chemistry, phyto-geography, cyto-genetics and physiology coupled with adequate computation.

Alpha (α) Taxonomy / classical taxonomy:

Plant collection, Preservation and Documentation

Herbarium: Plant collecting, Preservation and Documentation

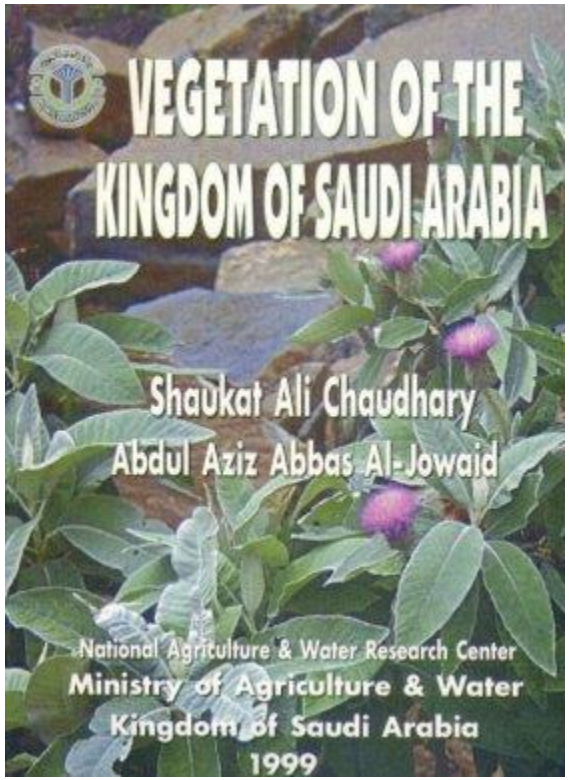
- **A HERBARIUM is a collection of dried plants systematically named and arranged for ready reference and study.**
- **To make a herbarium specimen, the plant is collected, and notes are made about it. The plant is then pressed until dry between blotters that absorb moisture and mounted onto a herbarium sheet with a suitable label, and stored in steel cabinet arranged into some system of classification.**
- **Herbarium techniques involve : (i) Collection, (ii) Drying, (iii) Poisoning, (iv) Mounting, (v) Stitching, (vi) Labelling, and (vii) Deposition.**



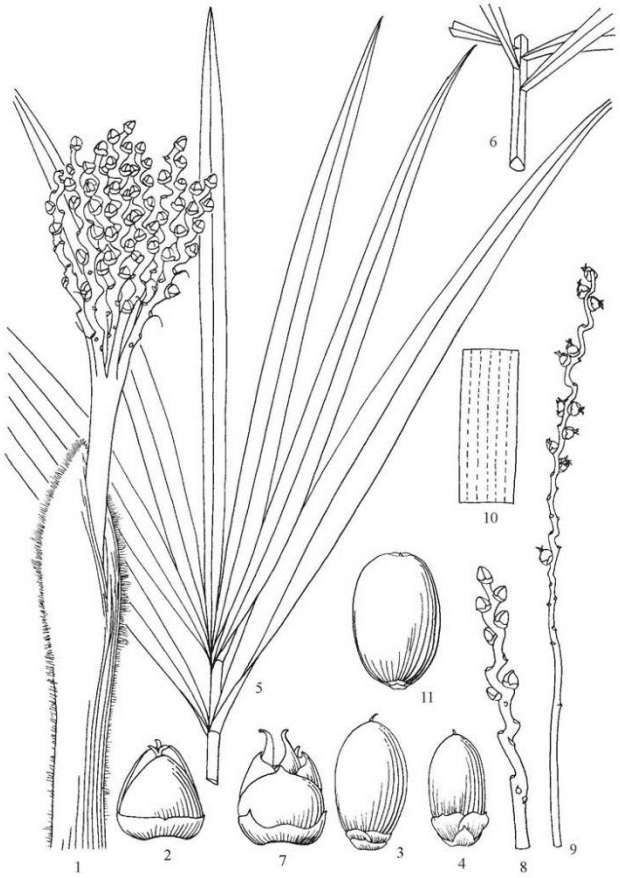




The FLORA is the main Resources of Taxonomic Information



Flora = it is the documentation of plants occurring in a particular region.



Description of plant need taxonomic terminology

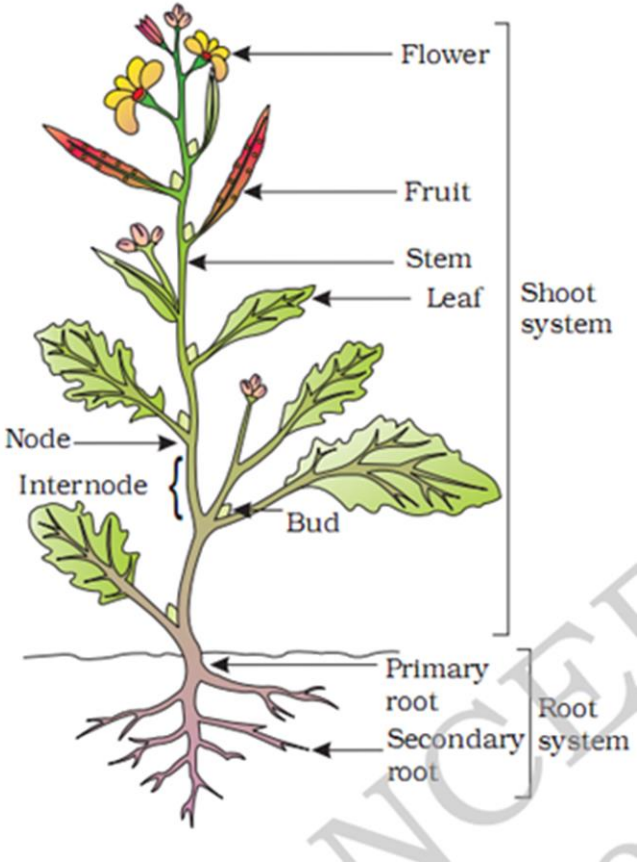
Phoenix dactylifera Linnaeus, Sp. Pl. 2: 1188. 1753.

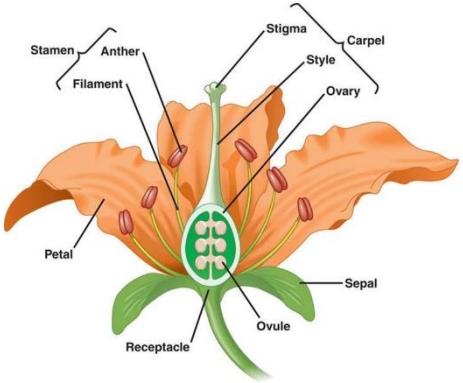
Stems solitary or clustered and then with few shoots, to 30 m tall, to 50 cm in diam., rough with persistent, diamond-shaped leaf bases. Leaves 3-5 m; sheath and petiole to 1 m; rachis 1-2 m; acanthophylls many per side of rachis; pinnae to 200 per side of rachis, linear, irregularly arranged and spreading in different planes; middle pinnae to 40 × 2 cm. Male inflorescences erect, to 1 m, with many rachillae, these ca. 30 cm; female inflorescences erect, becoming pendulous, to 2 m, with to 150 rachillae, these to 40 cm. Fruits variable in shape, usually oblong, to 7 × 3 cm, brown or black; endosperm homogeneous.

PLANT STRUCTURE
(MORPHOLOGY AND ANATOMY)

- Plant Morphology: Study of external structure of a plant
- Plant Anatomy: Study of Internal structure of a plant
- Flowering plants possess three kinds of vegetative (non-reproductive) organs: Roots, Stems, and Leaves
- The flower is the reproductive organ of the Angiosperms / Flowering plants.

Vegetative and Reproductive Parts of Plants





- **Root:**

In vascular plants, the root is the organ of a plant that typically lies below the surface of the soil. Root is meant for absorption of water and minerals from soil, and provide anchorage to plants.

- **Nodes :**

The nodes hold one or more leaves, as well as buds which can grow into branches (with leaves or inflorescences (flowers). Adventitious roots may also be produced from the nodes.

- **Internodes :**

The internodes distance one node from another.

- **Stem:**

The main body or stalk of a plant or shrub, typically rising above ground.

- **Leaf:**

A leaf is an organ of a vascular plant ,and is the principal lateral appendage of the stem,

- **Flower:**

The seed-bearing part of a plant consisting of reproductive organs (stamens and carpels) that are typically surrounded by a brightly coloured corolla (petals) and a green calyx (sepals).

- **Fruit:**

A fruit is the seed-bearing structure in flowering plants formed from the ovary after flowering

Habit of Plants

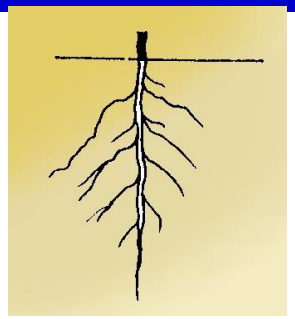
Herb. A usually low, soft or coarse plant with annual aboveground stems.
Shrub. A much-branched woody perennial plant usually without a single trunk.
Tree. A tall, woody perennial plant usually with a single trunk.
Vine *or* Liana. An elongate, weak-stemmed, often climbing annual or perennial plant, with herbaceous or woody texture.

shrubs

Tree

Vines

Different Types of Roots



Tap Root:
A straight tapering root growing vertically downwards and forming the centre from which subsidiary rootlets spring.

Adventitious Roots

- Some roots, called adventitious roots, arise from an organ other than the root—usually a stem, sometimes a leaf.

Fibrous Root

- A fibrous root system is the opposite of a taproot system.
- The fibrous root is usually formed by thin, moderately branching roots growing from the stem.
- A fibrous root system is universal in monocotyledonous plants and ferns

- **Prop roots**

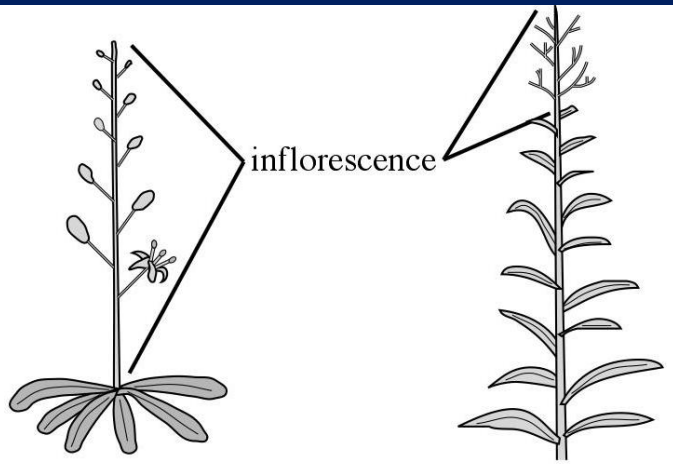
The adventitious root when modified for aerial support, are called prop roots

Respiratory Roots:

- An erect root that protrudes some distance above soil level.
- Pneumatophores are formed in large numbers by certain plants, e.g. *Sonneratia* and some mangrove species, growing in areas with waterlogged badly aerated soils.

Parasitic Root:
A parasitic plant is a plant that derives some or all of its nutritional requirements from another living plant.
All parasitic plants have modified roots, named haustoria, which penetrate the host plants, connecting them to the conductive system – either the xylem, the phloem, or both

Stem Habit = Relative position of stem (+ growth, structure)



Acaulescent

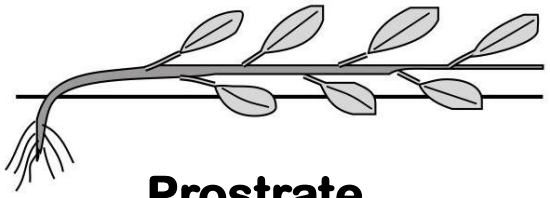
- Apparently a stemless plant having very inconspicuous reduced stem

Caulescent

- With a distinct stem

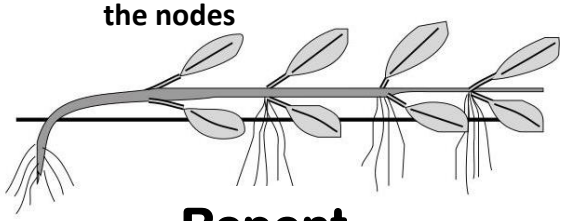
Cespitose

- Short, much-branched, plant forming a cushion



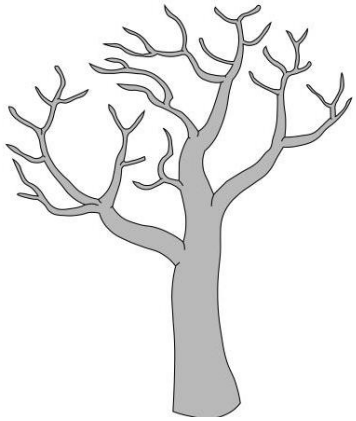
Prostrate

- Trailing or lying flat, not rooting at the nodes



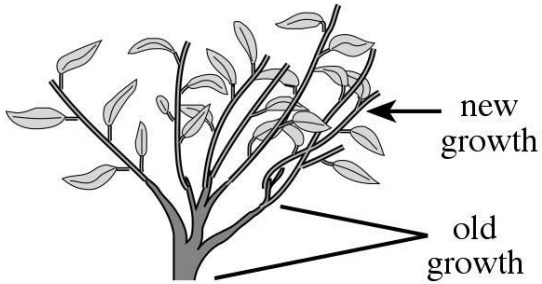
Repent

- Creeping or lying flat and rooting at the nodes



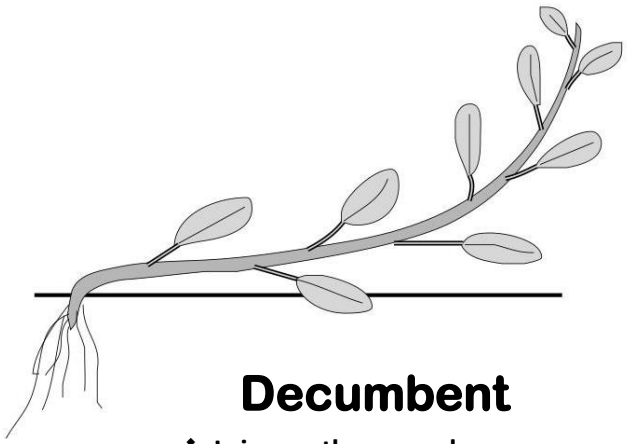
Arborescent

- Tree-like in appearance and size



Suffrutescent

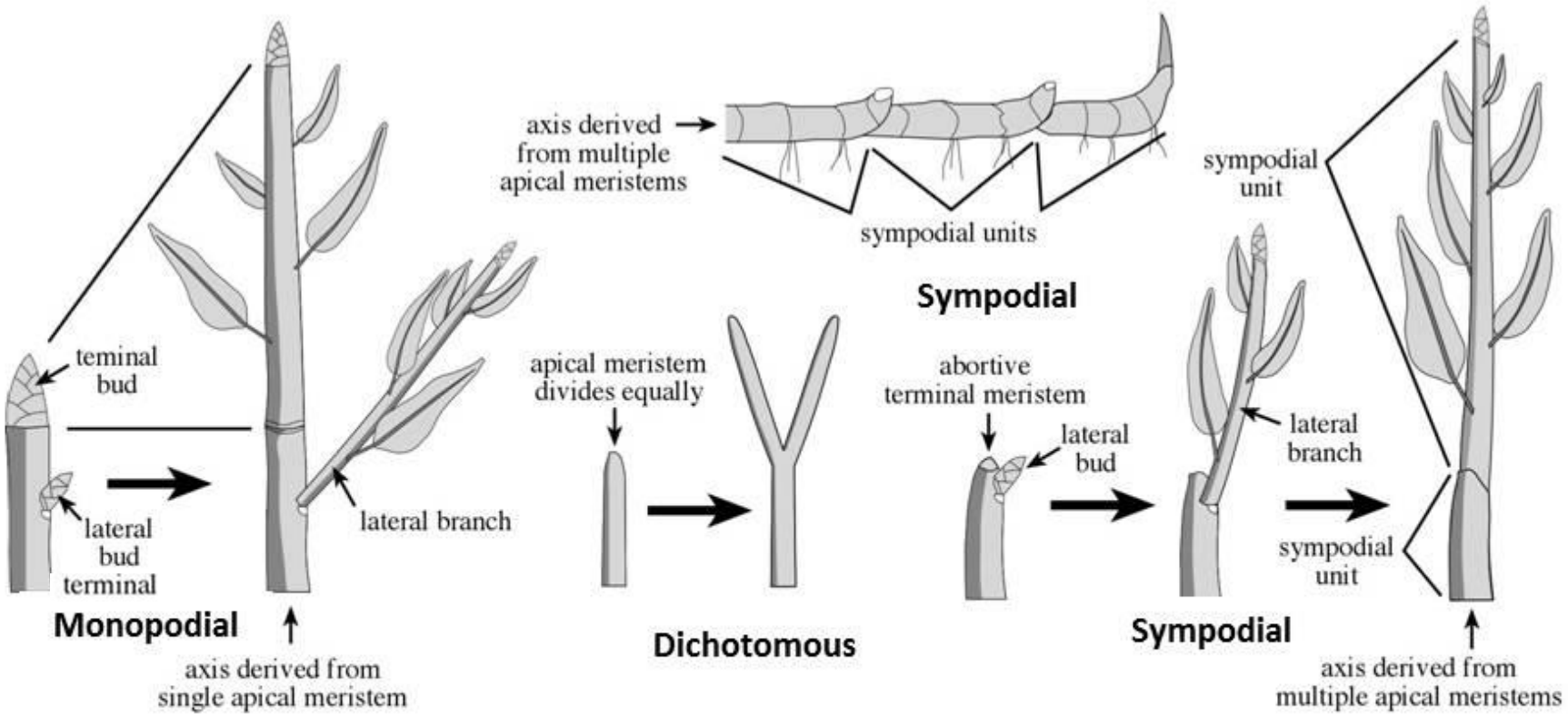
- Woody basally, herbaceous apically



Decumbent

- Lying on the ground with the tips ascending

Stem Branching



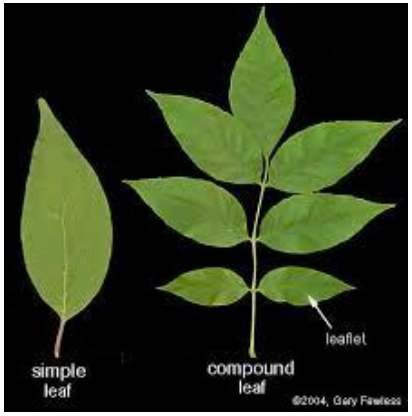
- **Monopodial:** Branching with a main axis and reduced or missing

- **Dichotomous:** Branching into two equal parts

- **Sympodial:** Branching without a main axis but with many, more or less, equal laterals

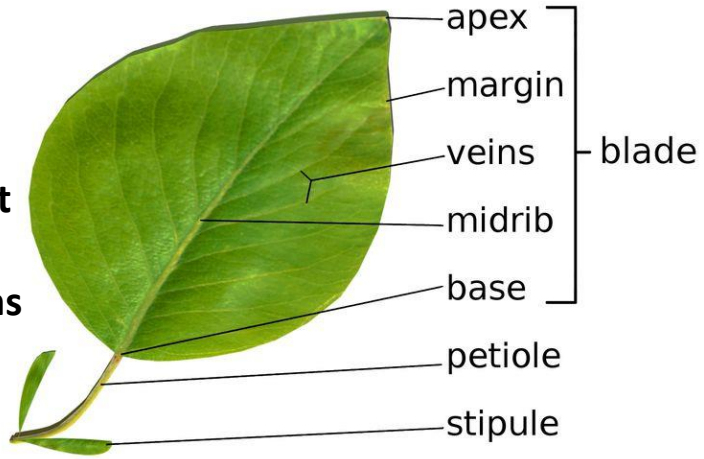
LEAVES

- The leaf is the main photosynthetic organ of most vascular plants.
- Leaves generally consist of a flattened blade and a petiole, which joins the leaf to a node of the stem.
- Some plant species have evolved modified leaves that serve various functions. For example: climbing, pollinator attraction, storage, digestion, prevention of water loss, etc.

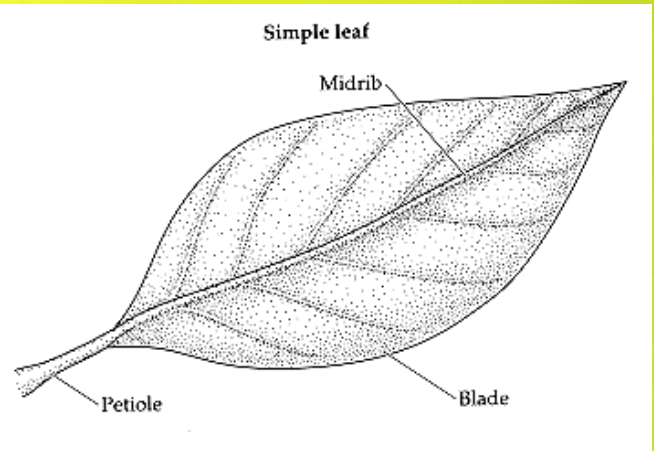


There are large number of terminology leaf based on:

- Margin
- Apex
- Base
- Venation
- Arrangement
- Petiole
- Modifications



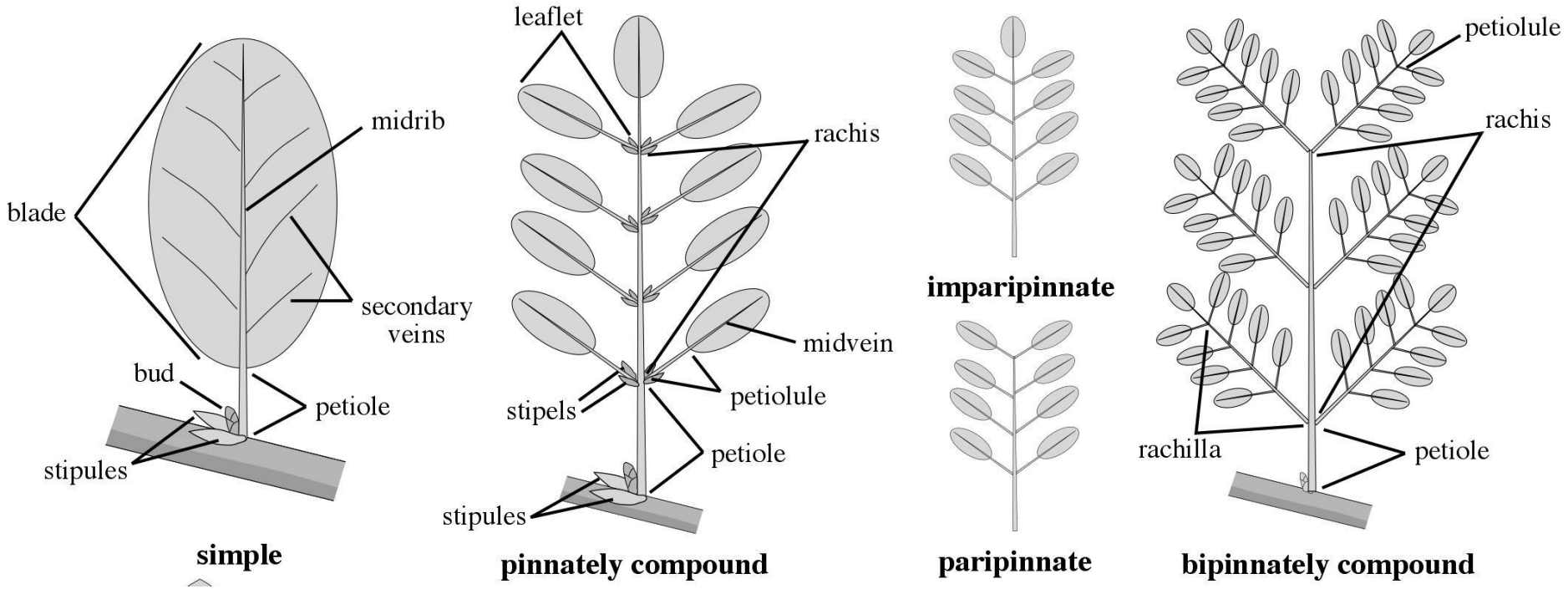
Leaves



External Parts of the Leaf:

- **Petiole** عنق
  - Leaf stalk or part that connects the leaf to the stem.
- **Blade** نصل
  - The large, flat part of a leaf.
- **Midrib** عرق وسطي
  - The large center vein.

Leaf Types

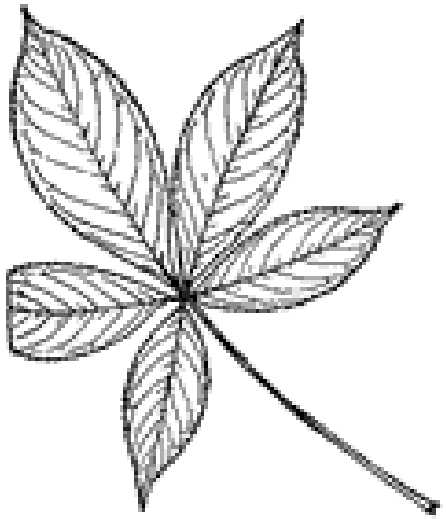


(a) **Simple leaf.** ورقة بسيطة A simple leaf is a single, undivided blade.

(b) **Compound leaf (Pinnate).** مركبة ريشية In a compound leaf, the blade consists of multiple leaflets. Note that a leaflet has no axillary bud at its base.

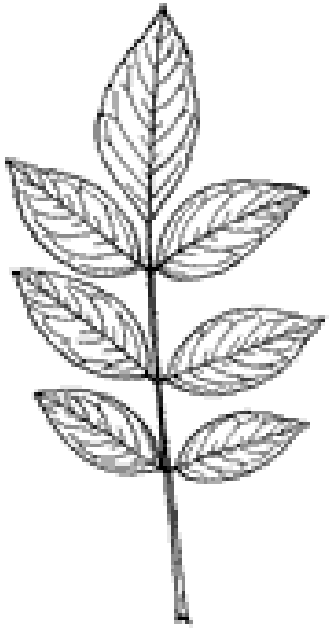
(c) **Doubly compound leaf (Bipinnate).** مركبة ريشية مزدوجة In a doubly compound leaf, each leaflet is divided into smaller leaflets.

Compound Leaves



palmately compound

- With leaflets from one point at end of petiole



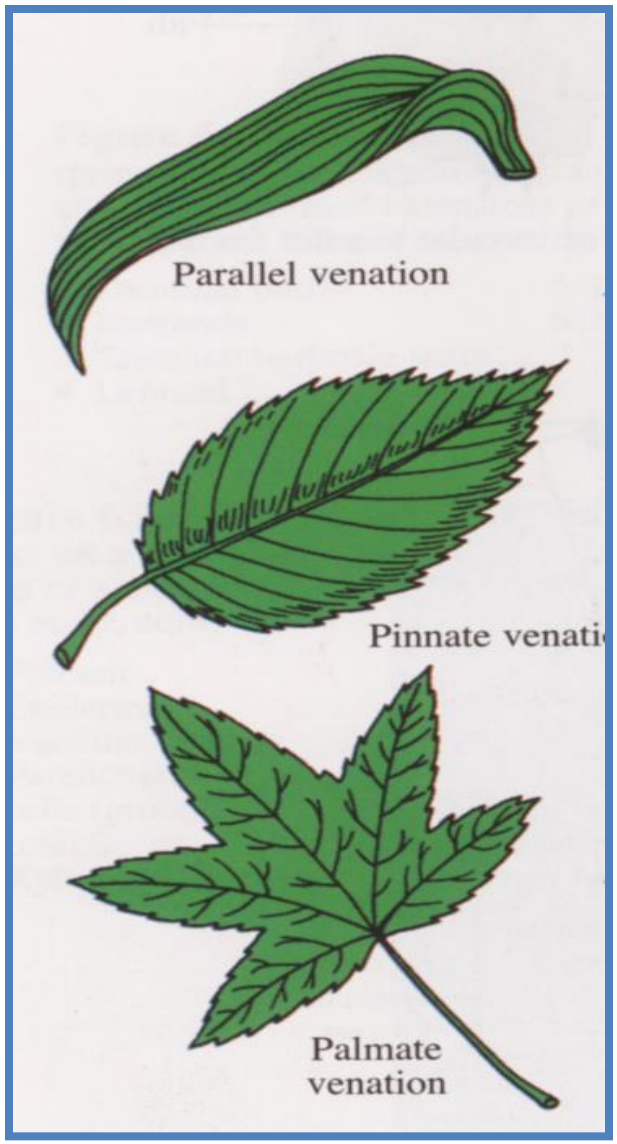
pinnately compound

- With leaflets arranged oppositely or alternately along a common axis

Bi-Pinnately Compound Leaf

- With two orders of leaflets, each pinnately compound

Leaf Venation



- **Parallel-** متوازي **veins extend the entire length of the leaf with little or no cross-linking**
- **Pinnate-** ريشي **leaves have one major vein from which others branch**
- **Palmate-** راحي **leaves have several veins which branch**

Dicot and Monocot Leaves

Reticulate
شبكي

Parallel
متوازي

Leaf Adaptations/ Modifications

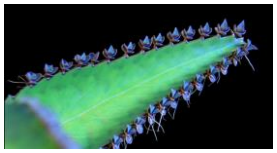
Some plant species have evolved modified leaves to serve various functions.

Tendrils: Usually a coiled rachis or twining leaflet modification.

Thorns, Spines, and Prickles : The thorns, spines and prickles, and in general spinose structures are hard, rigid extensions or modifications of leaves, roots, stems or buds with sharp, stiff ends

Storage leaves: Most succulents, such as ice plant, have leaves modified for storing water.

Bracts: a modified leaf or scale, typically small, with a flower or flower cluster in its axil. Bracts are sometimes larger and more brightly colored than the true flower, as in *Poinsettia*



Reproductive leaves: The leaves of some succulents, such as *Kalanchoe daigremontiana* produce adventitious plantlets, which fall off the leaf and take root in the soil.

Tentacular Leaf

A leaf bearing numerous, sticky, glandular hairs or bristles that function in capturing and digesting small animals, e.g. *Drosera*

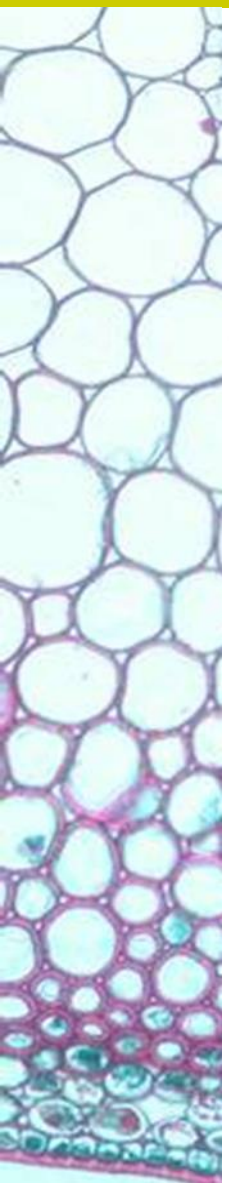
Carnivorous plants

- Insect-Trapping Leaves in areas with low soil Nitrogen.
- Insect digested by enzymes to release Nitrogen from proteins.
- Example: Trap Leaf of *Dionaea muscipula* capturing fly

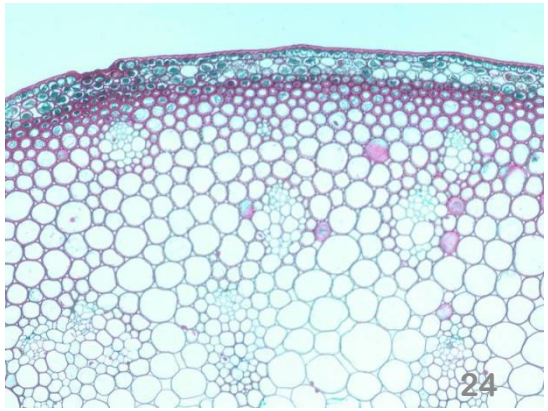
Pitcher plant:

Pitcher plants are several different carnivorous plants which have modified leaves known as pitfall traps—a prey-trapping mechanism featuring a deep cavity filled with digestive fluid liquid

PLANT ANATOMY
(Study of internal structure of plant)

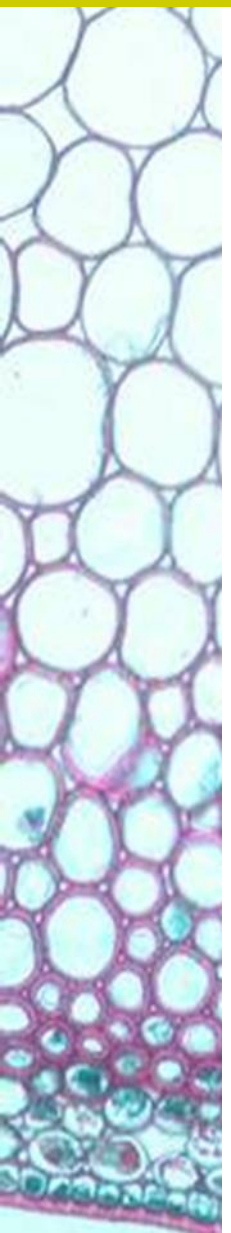


L.S ----Longitudinal section .
T.S ------ Transverse section .



Plant Tissue

(Group of cells having similar structure and function is called as tissue)



Tissue Systems

There are four plant tissue systems:

1. Ground tissue system :

- **-Parenchyma tissue**
- **-Collenchyma tissue**
- **-Sclerenchyma tissue**

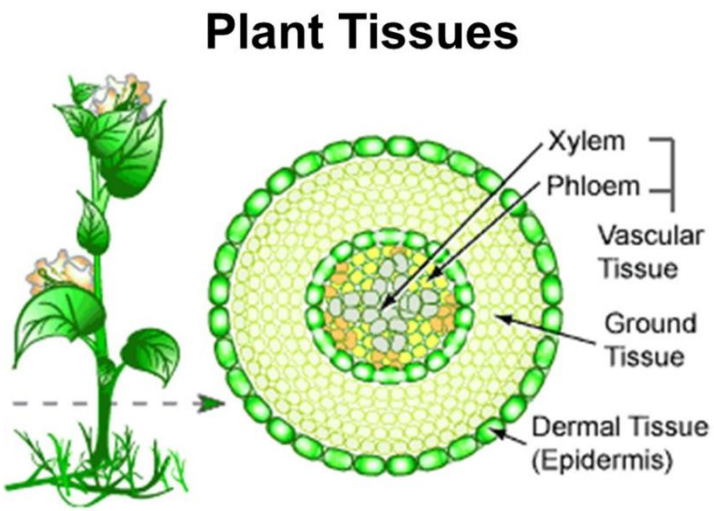
2. Vascular tissue includes:

- **-Xylem tissue**
- **-Phloem tissue**

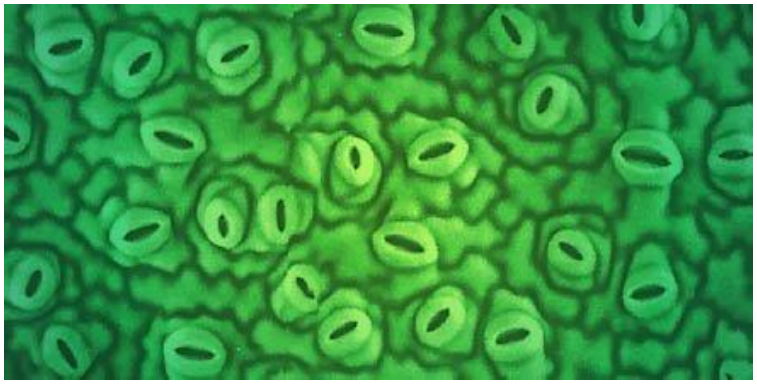
3. Dermal tissue:

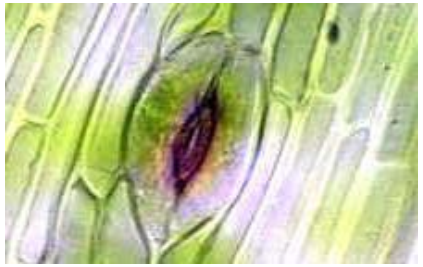
- **-Epidermis**

4. Meristematic tissue: (dividing tissue)

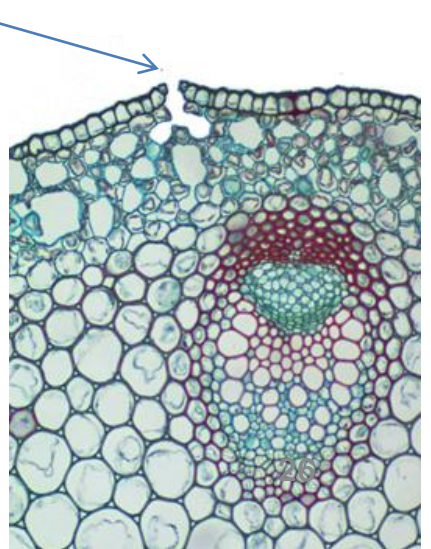


Dermal Tissue - Stomata



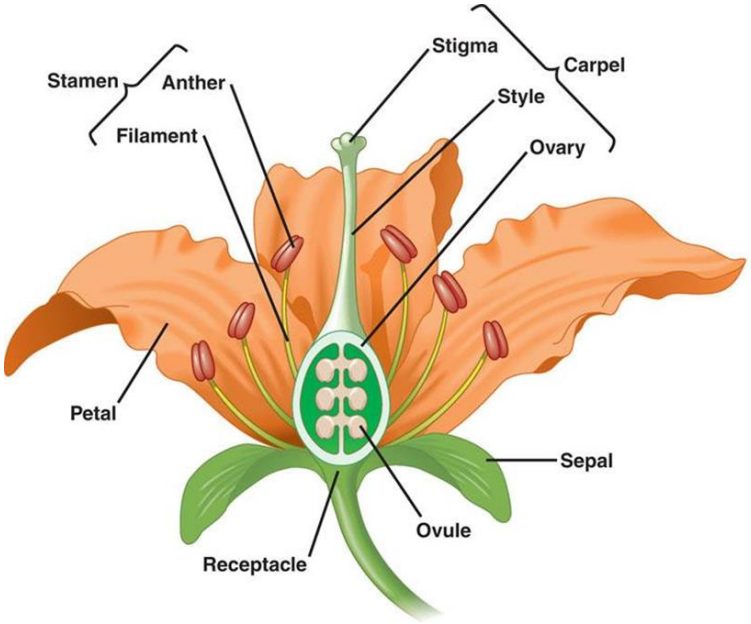


- **Openings in the epidermis on the underside of a leaf where gases are exchanged are called stomata.**



Angiospermae
(Anthophyta – Flowering Plants)

- All Angiosperms produce flowers containing the sexual reproduction structures.
- The angiosperms (*angios*=covered, *sperm* = seed) produce fruits and seeds.
- There are presently 235,000 known living flowering plants species.



Parts of Angiospermic flowers

Peduncle: The stalk of a flower.

Receptacle: The part of a flower stalk where the parts of the flower are attached.

Sepal: The outer parts of the flower (often green and leaf-like) that enclose a developing bud.

Petal: The parts of a flower that are often conspicuously colored.

Stamen: The pollen producing part of a flower, usually with a slender filament supporting the anther.

Anther: The part of the stamen where pollen is produced.

Pistil: The ovule producing part of a flower. The ovary often supports a long style, topped by a stigma. The mature ovary is a fruit, and the mature ovule is a seed.

Stigma: The part of the pistil where pollen germinates.

Ovary: The enlarged basal portion of the pistil where ovules are produced.

Unisexual and Bisexual Flower

Bisexual or Hermaphrodite flower:

- **A bisexual flower is that, which contains both the male and female reproductive whorls, i.e., androecium and gynoecium.**
- **Examples: Hibiscus (Chinarose), Brassica (Mustard).**

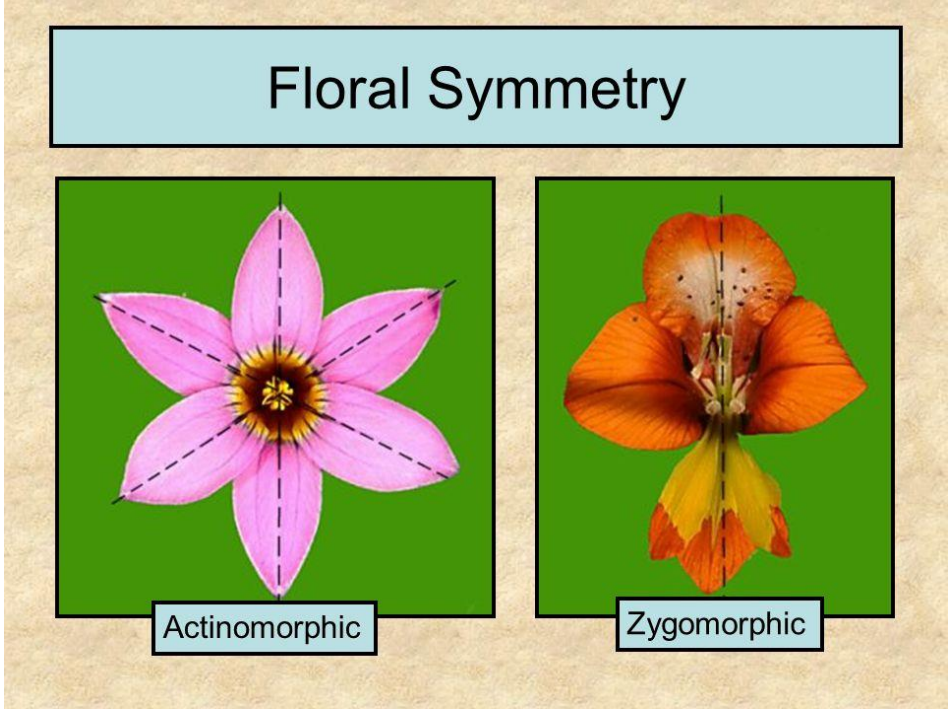
Unisexual flower:

- **A flower is unisexual, when either of the male or the female reproductive organ is absent.**
- **Examples of these types of flowers are staminate and pistillate flower of *Cucurbita* (gourd).**

Floral Symmetry

Regular or Actinomorphic flower:

A flower is said to be regular types of flowers, when all the floral members of the respective whorls (viz., sepals, petals, stamens, carpels) are having equal size and shape and are more or less equidistant from each other, hence the flower can be dissected into two equal halves at any plane, e.g., *Hibiscus* (Chinarose); *Datura*.



Irregular or Zygomorphic flower:

A flower is said to be irregular, when the floral members vary in their size and shape, and hence the flower can be cut into two equal halves through one plane only ; example *Pisum sativum* (Pea).

Cyclic and Acyclic Flower

Cyclic Flower:

Types of flowers are said to be cyclic, when all the four whorls (viz., sepals, petals, stamens and pistils) are arranged in whorled or verticellate manner.

Example, *Hibiscus* (Chinarose).

Acyclic Flowers:

Types of flowers are said to be acyclic, when the floral members are arranged spirally on the thalamus.

Example: *Paoenia*.

Spirocyclic, Nude and Neuter Flower

❖ **Spirocyclic flower:**

The floral members of a spirocyclic flower are both arranged spiral as well as in whorled manner example, *Nymphaea*, *Magnolia*.

❖ **Nude flower:**

The types of flowers are said to be naked, because neither calyx nor corolla is present, example Male flower within the cyathium of *Pedilanthus*.

❖ **Neuter flower:**

A flower is said to be neuter, when it is devoid of both male androecium and female gynoecium, as an example the Ray florets of sunflower.

Monochlamydous and Dichlamydous Flower

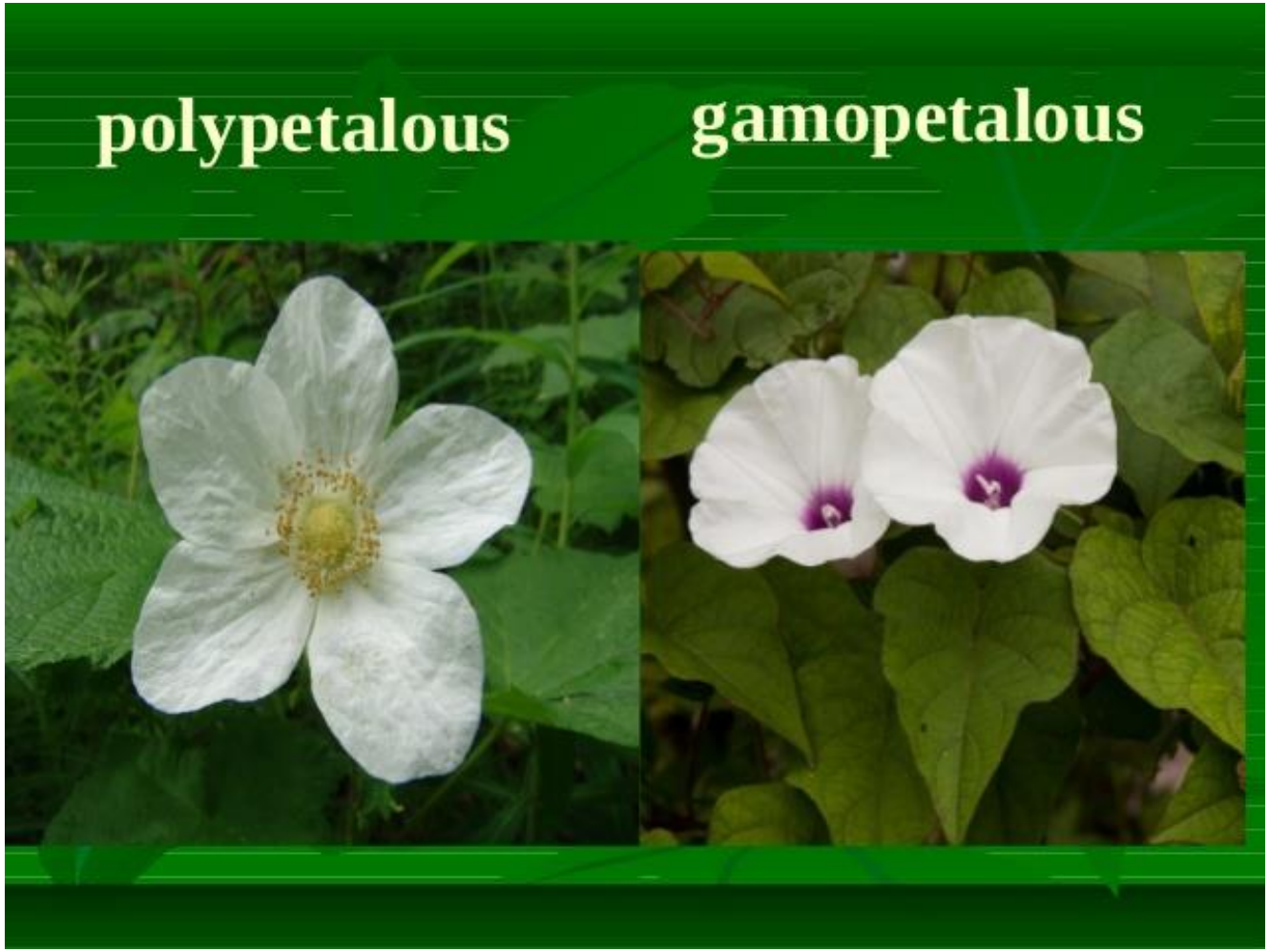
Monochlamydous flower:

The types of flowers are said to be monochlamydous, when either calyx or corolla is present, e.g., *Polyanthes* (tuberose).

Dichlamydous flower:

A normal flower with both the accessory whorls, i.e., calyx and corolla is called dichlamydous. Example, *Hibiscus* (chinarose).

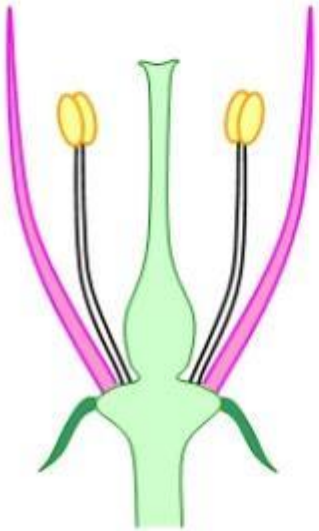
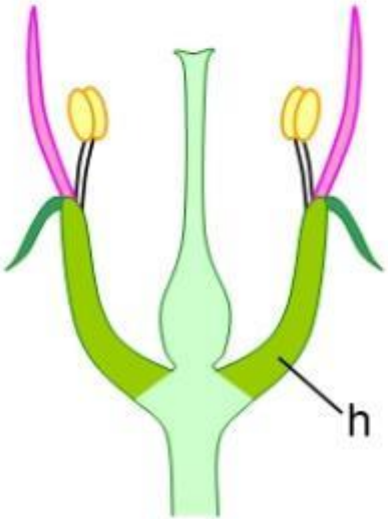
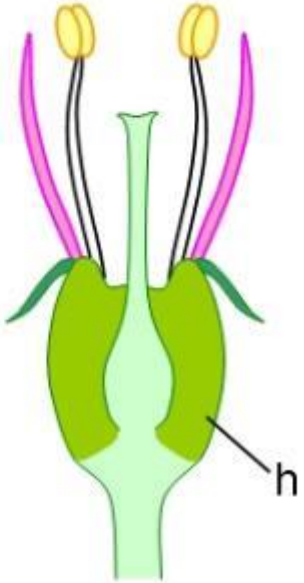
Polypetalous and Gamopetalous Flower



Polypetalous is having a corolla composed of distinct, separable petals.

Gamopetalous having petals wholly or partially fused such that the corolla takes the form of a tube

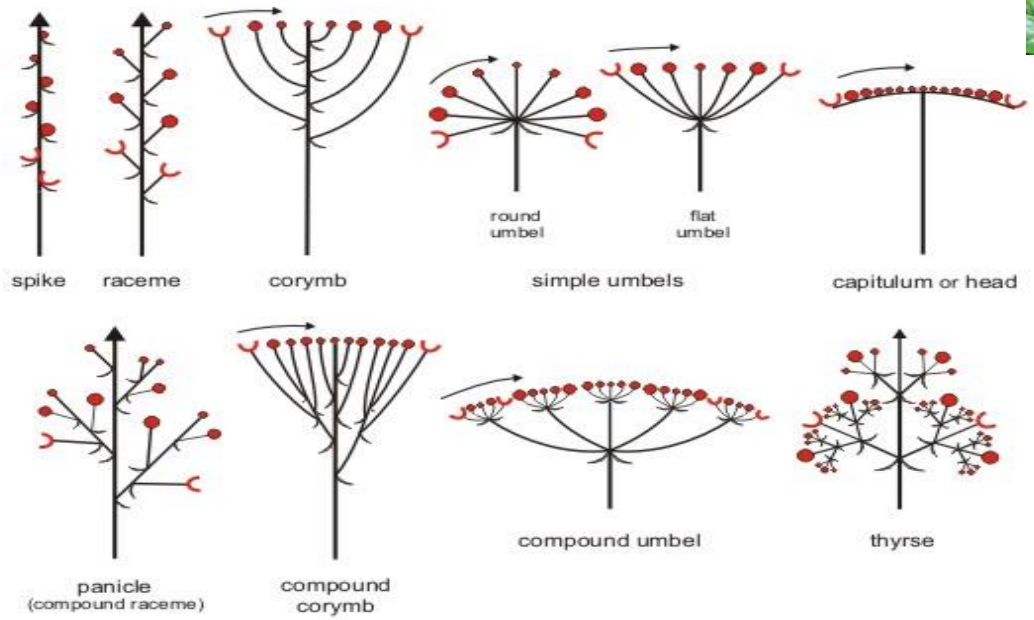
Relative Positions of Floral Appendages

Relative Positions of Floral Appendages		
		
Hypogynous flower Superior ovary (ovary above stamens which are above perianth). Stamens and perianth hypogynous.	Perigynous flower Superior ovary. Stamens and perianth perigynous – i.e. their bases are united into a hypanthium (h) which holds them level with ovary.	Epigynous flower Inferior ovary. Stamens and perianth epigynous – i.e. positioned above the ovary on a hypanthium (h).

Inflorescence

(An inflorescence is an arrangement of one or more flowers on a floral axis)

- **Inflorescence type determined by:**
  - **Number of flowers**
  - **Positional relationships**
  - **Degree of the development of their pedicels**
  - **Nature of their branching pattern**



Simple Inflorescences

- **Terminal: flower at the tip of a stem.**
- **Example: *Hibiscus coccineus***

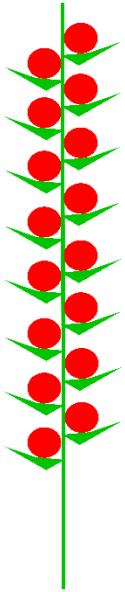
Scarlet rose-mallow (*Hibiscus coccineus*)

Compound Inflorescences

- Two or more flowers in every inflorescence
- Example: Sunflower

Compound Inflorescences

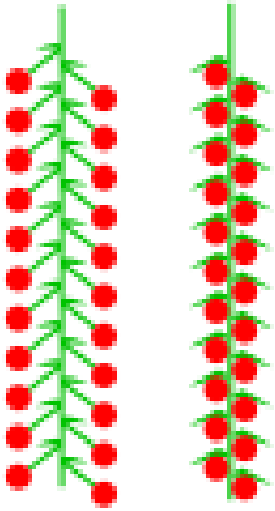
- **Spike**: elongate inflorescence; flowers are sessile, dense, or remote from one another



Spiked blazing star (*Liatris spicata*)

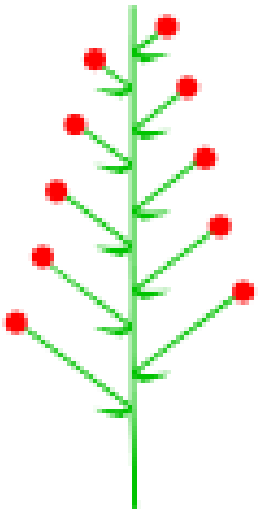
Compound Inflorescences

- **Catkin**: A spike like inflorescence of unisexual flowers; found only in woody plants.



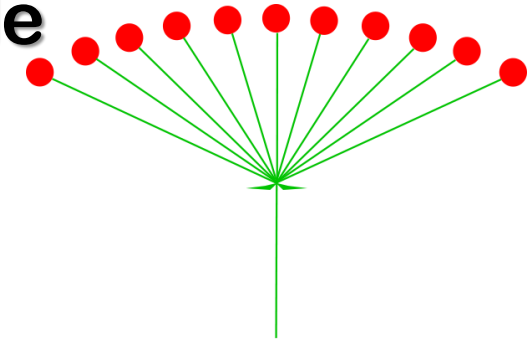
Compound Inflorescences

- **Raceme**: an elongate inflorescence of pedicellate flowers on an unbranched rachis



Compound Inflorescences

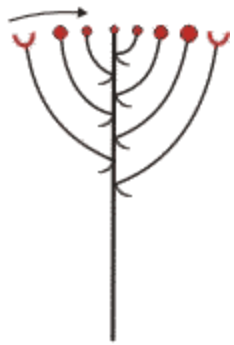
- **Umbel**: a flat-topped or somewhat rounded inflorescence in which all of the pedicels arise from a common point at the tip of the peduncle



Butterfly weed (*Asclepias* sp.)

Compound Inflorescences

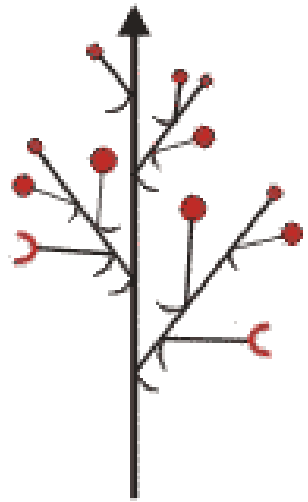
- **Corymb**: a flat-topped or somewhat rounded inflorescence in which the pedicels of varying length are inserted along the rachis



corymb

Compound Inflorescences

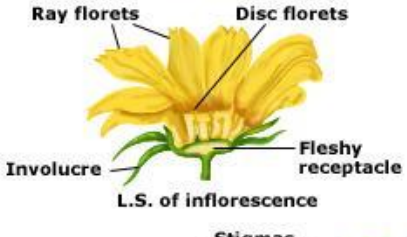
- **Panicle**: a much-branched inflorescence with a central rachis which bears branches which are themselves branched

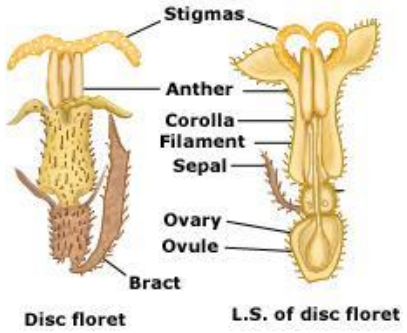


panicle
(compound raceme)

Compound Inflorescences

- **Head, (Capitulum) : is a short dense spike in which the flowers are borne directly on a broad, flat peduncle, giving the inflorescence the appearance of a single flower.**

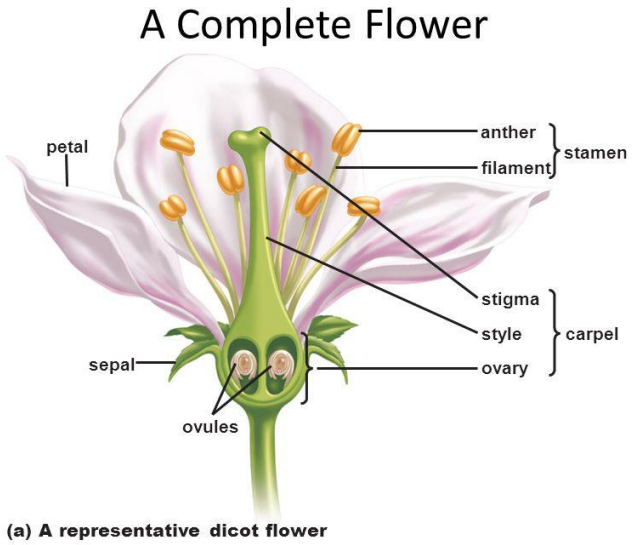




Complete and incomplete flower

Complete flower:

- **A flower is said to be complete, when it has all the four whorls (calyx, corolla, androecium and gynoecium).**
- **Example: Hibiscus (Chinarose), Brassica (mustard) and Datura.**



Incomplete flower:

- **A flower is incomplete, when any one of the four whorl (calyx, corolla, androecium and gynoecium) is absent.**
- **Examples of these types of flowers are *Polyanthes* (calyx absent), *Beta* (corolla absent), *Cucurbita* male flower (gynoecium absent), female flower (androecium absent).**

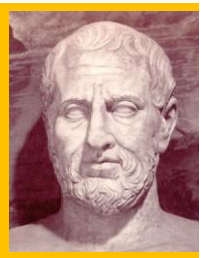
PLANT CLASSIFICATION

History and Systems of Classification of Plants

Preliterate Mankind / Folk taxonomies:

- Classification of plants by preliterate early mankind to know:
  - what he should eat
  - what he should avoid
  - what he should use as cures for disease
  - what he should utilize for his shelter
- The information was accumulated and stored in the human brain and passed on one generations to the other generation through words of mouth

Theophrastus (372 BC to 287 BC):



- ❑*Father of Botany*
- ❑The Greek philosopher
- ❑Wrote more than 200 manuscripts
- ❑Theophrastus work translated in to English :

Enquiry into plants (1916)
The Causes of plants (1927)

- ❑Theophrastus described about 500 kinds of plants
- ❑Theophrastus classified into four major groups: the trees, shrubs, subshrubs and herbs
- ❑Theophrastus recognized the differences between flowering plants and non-flowering plants
- ❑ Theophrastus recognized superior ovary and inferior ovary, free and fused petals and also fruit types

Medieval Botany:

- During the Middle Ages (5 to 15 century AD), little or no progress was made in botanical investigation.
- During this period in the history, Europe and Asia witnessed wars etc.

Islamic Botany:

- 610-1100 AD saw the revival of literacy.
- Greek manuscripts were translated.

Ibual- Awwan described nearly 600 plants

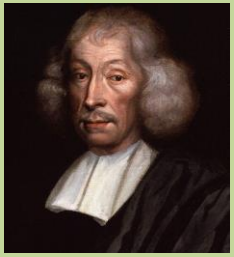
- ❖Described sexuality as well as the role of insects in fig pollination
- ❖But not develop any significant scheme of classification

Page from 15th century Arabic edition of Dioscorides herbal

Andrea Cesalpino (1519-1603)

- Andrea Cesalpino Italian botanist
- Director of the Botanical Garden, and later Professor of Botany and Medicine at Bologna
- *De Plantis libri in 16* volumes appeared in 1583 and contained descriptions of 1520 species of plants grouped as herbs and trees and further differentiated on fruit and seed characters

John Ray (1627-1705)



- John Ray was an British Botanist
- Published
- *Methodus plantarum nova (1682)*
- *Historia plantarum (1686-1704)*
- *Methodus (*1703) included 18000 species

J. P. de Tournefort (1656-1708)

- J. P. de Tournefort (1656-1708)—*Father of genus concept*
- A French botanist published *Elements de botanique in 1694*
- Published 698 genera and 10,146 species
- First to give names and description of genera
- Recognized petaliferous and apetalous flowers, free and fused petals, and regular and irregular flowers

Binomial Nomenclature and Carolus Linneaus System of Plant Classification

- ❖ **Taxonomic Systems of Classification: Ideally our systems of classification should allow us to place similar species of plants together in the same category.**

- ❖ **There are two types of Classification Schemes:**

- ❑ **<u>Artificial</u> taxonomy was a system of grouping unrelated plant species by a common criteria (i.e. a flowers sexual organs)**
- ❑ **<u>Natural</u> classification reflects relationships among taxon**

- ➢ **Carolus Linneaus was a Swedish botanist.**

- ➢ **Carolus Linneaus traveled to Lapland (Blue Lake, CA) and collected large number of plants.**

- ➢ **Carolus Linneaus introduced Binomial Nomenclature.**

Binomial nomenclature = Uses two Latin words to indicate the genus and the species. The first word is the genus and the second word is the species. Example- the botanical name of dates is *Phoenix dactylifera*

- ➢ **Carolus Linneaus published the book '<u>Species Plantarum</u>' in 1753.**

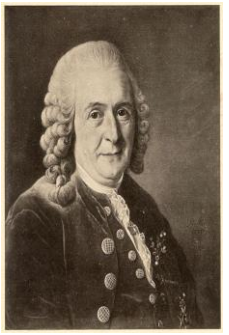
- ➢ **Carolus Linneaus classified the plants based on the plant's method of reproduction and structure of reproductive parts.**

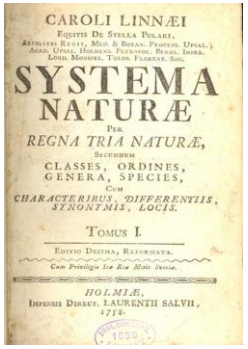
- ➢ **Produced his sexual system of classification (Artificial classification)**

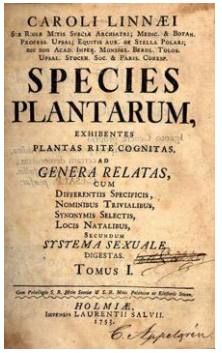
- ➢ **Carolus Linneaus divided plants into 24 classes. The Classes in the Linneaus is based largely on the amount, union and length of stamens**

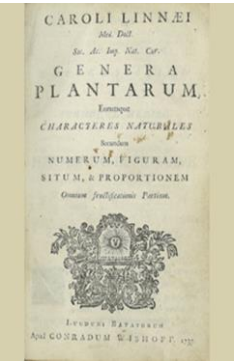
Classes

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. Ennandria- stamens nine
10. Decandria- stamens ten
11. Dodecandria- stamens 11-19
12. Icosandria- stamens 20 or more, on the calyx
13. Polyandria- stamens 20 or more, on the receptacle
14. Didynamia- stamens didynamous; 2 short, 2 long
15. Tetradynamia- stamens tetradynamous; 4 long, 2 short
16. Monadelphia- stamens monadelphous; united in 1 group
17. Diadephia- stamens diadelphous; united in 2 groups
18. Polyadelphia- stamens polyadelphous; united in 3 or more groups
19. Syngenesia- stamens syngenesious; united by anthers only
20. Gynandria- stamens united with the gynoecium
21. Monoecia- plants monoecious
22. Dioecia- plants dioecious
23. Polygamia- plants polygamous
24. Cryptogamia- flowerless plants

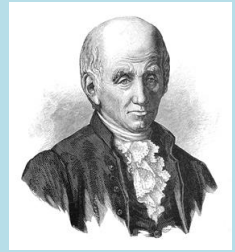








Michel Adanson (1727-1806)

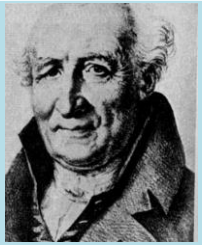


- A French botanist
- *Published Familles des plantes (1763)*
- Recognized 58 natural orders

Jean B.P. Lamarck (1744-1829)

- A French naturalist
- Published *Flore Francaise (1778)*
- Proposed key for identification of plants
- Proposed principles concerning the natural grouping of species, orders and families

Antoine Laurent de Jussieu (1748-1836)



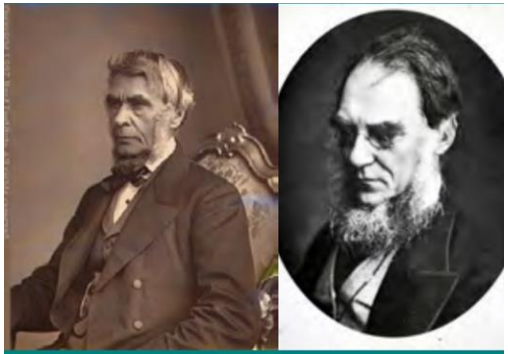
- 15 classes and 100 orders
- The author of *Genera plantarum (1789)*

de Candolle (1778–1841)

- de Candolle was Professor of Botany at Montpellier
- de Candolle Published *Theorie elementaire de la botanique, Prodromus systematis naturalis and regni vegetabilis*
- de Candolle for the first time introduced the term ‘taxonomy’ in his *Theorie elementaire de la botanique (1813)*
- de Candolle considered 161-213 natural orders
- de Candolle grouped the plants primarily on the basis of the presence or absence of vascular structures
- Ferns were with monocots and Gymnosperms with among dicots in the de Candolle system of classification.
- de Candolle highlighted importance of anatomical data

Bentham and Hooker System of Plant Classification

- Bentham and Hooker, two English botanists, represented the most well developed natural system of plant classification. The classification was published in a three-volume work Genera plantarum (1862-83).
- Hooker supervised the publication of Index Kewensis (2 volumes, 1893), listing the names of all known species and their synonyms.
- Many important herbaria of the world have specimens arranged according to Bentham and Hooker system of plant classification.
- Bentham and Hooker recognized three class:



Class DICOTYLEDONES:

Subclass POLYPETALE with three series Series 1. THALAMIFLORÆ, Series 2. DISCIFLORÆ, Series 3. CALYCIFLORÆ;
Subclass DICOTYLEDONES (GAMOPETALÆ) with three series that is Series 1. INFERÆ, Series 2. HETEROMERÆ, Series 3. BICARPELLATÆ, and
Subclass DICOTYLEDONES MONOCHLAMIDEÆ.

Class GYMNOSPERMEÆ (Gymnosperms are placed between Dicotyledons and Monocotyledons)

Class MONOCOTYLEDONES

PLANT CLASSIFICATION
Beta (β), Gama (ɣ) and Omega (Ω) Taxonomy:

Beta (β) Taxonomy: -
In addition to morphological description, it also involves consideration of affinities and their inter-relationship between separate group of species.

Gama (ɣ) Taxonomy: -
It is concerned with description, inter-relationship and evolution of one species from the other.

Omega (Ω) Taxonomy: -
It is the modern experimental taxonomy in which the taxonomic activities have been enriched with data from ecology, phyto-chemistry, phyto-geography, cyto-genetics and physiology coupled with adequate computation.

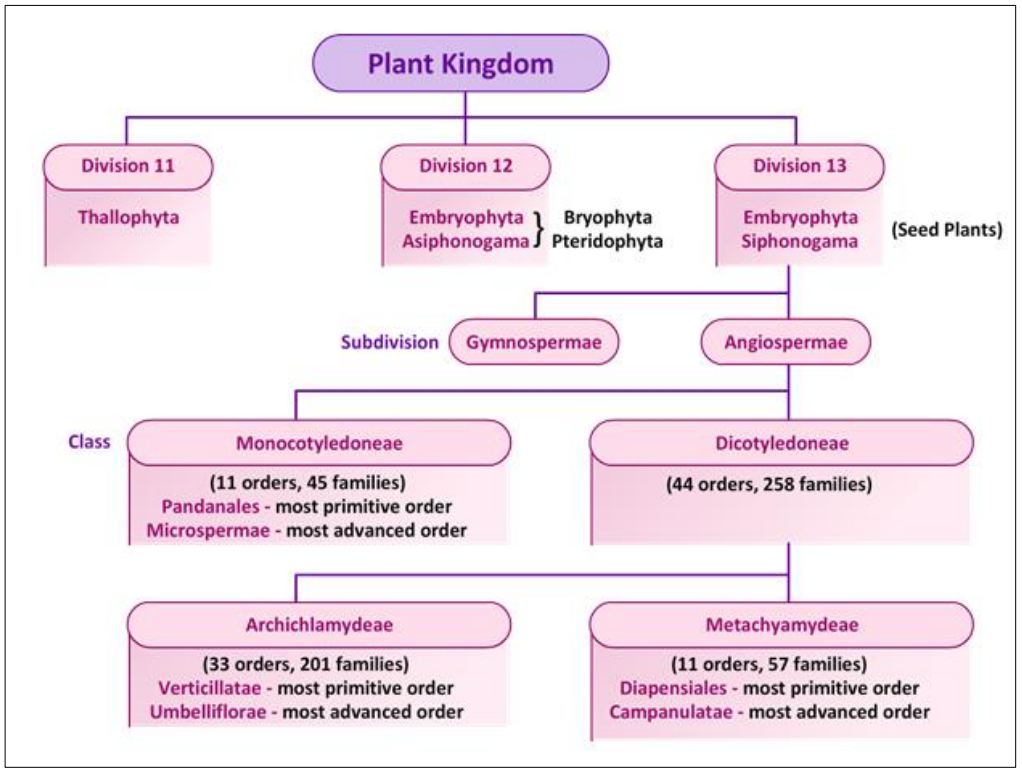
Engler and Prantl System of Classification

- Engler and Prantl were German botanists published *naturlichen Pflanzenfamilien* (= The Natural Plant Families)
- The classification covered the entire plant kingdom from Algae to Angiosperms which has been divided into 13 divisions.
- The first 11 divisions in the Engler and Prantl System of Classification are Thallophytes
- The 12th division in the Engler and Prantl System of Classification is *Embryophyta Asiphonogama* (plants with embryos but no pollen tubes; Bryophytes and Pteridophytes).
- The 13th division in the Engler and Prantl System of Classification is *Embryophyta Siphonogama* (plants with embryos and pollen tubes) which includes seed plants. This is divided into 2 subdivisions:

1. Gymnospermae,
2. Angiospermae

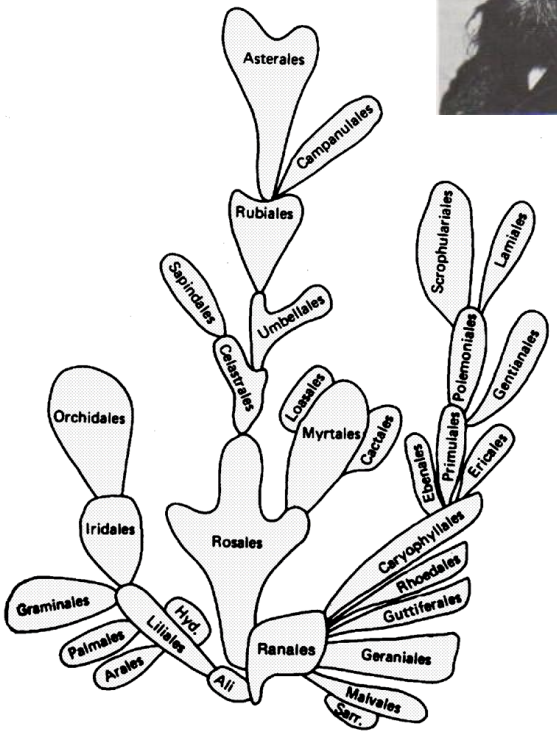
- The subdivision Angiospermae is further divided into 2 classes:

Class 1. Monocotyledoneae
Class 2. Dicotyledoneae



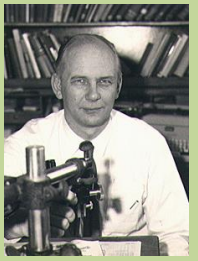
Bessey System of Plant Classification

- Charles E. Bessey (1845-1915) proposed a modified system of classification of Bentham and Hooker.
- Bessey separated the gymnosperms from angiosperms.
- Bessey reorganized the orders of angiosperms.
- Bessey system of plant classification is popularly known as Besseyan system.
- Bessey published the system of classification in the book “The phylogenetic Taxonomy of Flowering plants”.
- Bessey’s system was based on primitiveness and evolutionary advancement of plant groups.



Modified Bessian Classification Schemes: Modern phylogenetic Systems of Plant Classification

Cronquist System of Plant classification:



- Auther Cronquist 1968 was from NY Botanuical Gardens.
- Cronquist published book:

-The Evolution and Classification of Flowering Plants
- An Integrated System of Classification of Flowering Plants
-The Evolution and Classification of Flowering Plants

Classification-

Division. Magnoliophyta- 2 classes, 11 subclasses, 83 orders and 386 families; 219,300 species
Class 1. Magnoliopsida (Dicotyledons)- 6 subclasses, 64 orders, 320 families; 169,400 species
Class 2. Liliopsida (Monocotyledons)- 5 subclasses, 19 orders, 66 families; 49,900 species

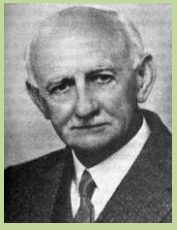
Takhtajan system of plant classification:

- Armen Takhtajan 1969 was a Russian plant taxonomist
- Takhtajan published the books

-Origin of Angiospermous Plants
-Die Evolution der Angiospermen
-Systema et Phylogenia Magnoliophytorum
-Flowering Plants—Origin and dispersal
-Diversity and Classification of Flowering Plants 1997

Class 1. Magnoliopsida (Dicotyledons)- 11 subclasses, 55 superorders, 175 orders, 458 families (8 subclasses, 37 superorders, 128 orders, 429 families, estimated genera- 10,000, species- 1,90,000
Class 2. Liliopsida (Monocotyledons)-6 subclasses, 16 superorders, 57 orders and 131 families (4 subclasses, 16 superorders, 38 orders, 104 families, estimated genera-3,000, species- 60,000

John Hutchinson (1884-1972)



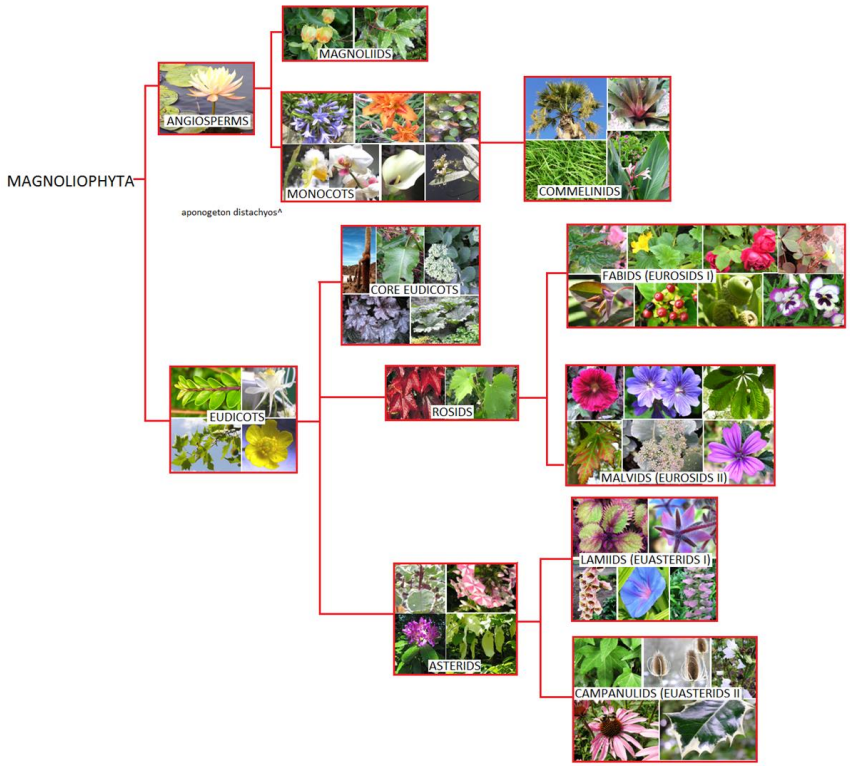
- John Hutchinson was a British botanist associated with the Royal Botanic Gardens, Kew, England.
- Published classification of plants in the book *The Families of Flowering Plants*

Rolf Dahlgren (1932-87)

Rolf Dahlgren (1932-87) Danish botanist working in Botanical Museum of the University of Kopenhagen

Angiosperm Phylogeny Group (APG)

- The APG system of flowering plant classification is the modern, mostly molecular-based, system of plant taxonomy for flowering plants (angiosperms) being developed by the Angiosperm Phylogeny Group (APG).
- The APG was first published in 2008.
- Currently the APG IV system recognizes a total of 64 angiosperm orders and 416 families.
- The families in APG classification have been grouped into 40 putative monophyletic orders under a small number of informal monophyletic higher groups: monocots, commelinoids, eudicots, core eudicots, rosids, eurosids I, eurosids II, asterids, euasterids I and euasterids II



Botanical Nomenclature

Species Concept

- **Species is the basic unit of classification**
- **Plants in the same species consistently produce plants of the same types**

TAXONOMIC RANKS OF LAND PLANTS	ENDING	EXAMPLE TAXON
Kingdom	(various)	**Plantae**
Phylum [Division]	**-phyta**	**Magnoliophyta**
Subphylum [Subdivision]	-phytina	Magnoliophytina
Class	**-opsida**	**Asteropsida**
Subclass	-idae	Asteridae
Order	**-ales**	**Asterales**
Suborder	-ineae	Asterineae
Family	**-aceae**	**Asteraceae**
Subfamily	-oideae	Asteroideae
Tribe	-eae	Heliantheae
Subtribe	-inae	Helianthinae
Genus	(various)	***Helianthus***
Subgenus	(various)	*Helianthus*
Section	(various)	*Helianthus*
Series	(various)	*Helianthus*
Species [abbr. sp. (sing.), spp. (pl.)]	(various)	***Helianthus annuus***
Subspecies [abbr. subsp. or ssp. (sing.), subspp. or sspp. (pl.)]	(various)	*Helianthus annuus* ssp. *annuus*
Variety [abbr. var. (sing.), vars. (pl.)]	(various)	*Helianthus annuus* var. *annuus*
Form [abbr. f.]	(various)	*Helianthus annuus* f. *annuus*

The name of the plants must should be written in italics. For example *Phoenix dactylifera*

SCIENTIFIC NOMENCLATURE / BOTANICAL NOMENCLATE :

Nomenclature deals with the application of a correct name to a plant or a taxonomic group.

- **We have millions of species distributed in different geographical regions of the world.**

- **The Scientific names (Botanical name and Zoological name)of the living organism (Plants and Animals) are necessary because the same common name is used for different plants / Animals in different areas of the world.**

- **Swedish Botanist Carolus Linnaeus introduced Binomial Nomenclature.**

- **The Binomial nomenclature uses two Latin words to indicate the genus and the species. The first word is the genus and the second word is the species. Example- the botanical name of Dates is *Phoenix dactylifera***

International Code of Botanical Nomenclature (ICBN)

The current activity of botanical nomenclature is governed by the International Code of Botanical Nomenclature (ICBN) published by the International Association of Plant Taxonomy (IAPT).

The Code is divided into 3 divisions:

I. Principles
II. Rules and recommendations
III. Provisions for the governance of the Code

Principles of ICBN

1. Botanical Nomenclature is independent of Zoological Nomenclature. The Code applies equally to the names of taxonomic groups treated as plants whether or not these groups were originally so treated.

2. The application of names of taxonomic groups is determined by means of nomenclatural types / TYPIFICATION.

3. Nomenclature of a taxonomic group is based upon Priority Of Publication.

4. Each taxonomic group with a particular circumscription, position and rank can bear Only One Correct Name, the earliest that is in accordance with the rules.

5. Scientific names of taxonomic groups are treated as LATIN, regardless of derivation.

6. The rules of nomenclature are Retroactive, unless expressly limited.

Names of Taxa

Rank	*Ending*	*Example*
Kingdom	-bionta	Chlorobionta
Division	-phyta	Magnoliophyta
	-mycota (Fungi)	Eumycota
Subdivision	-phytina	Pterophytina
	-mycotina (Fungi)	Eumycotina
Class	-opsida	Magnoliopsida
	-phyceae (Algae)	Chlorophyceae
	-mycetes (Fungi)	Basidiomycetes
Subclass	-opsidae	Pteropsidae
	-idae (Seed plants)	Rosidae
	-physidae (Algae)	Cyanophysidae
	-mycetidae (Fungi)	Basidiomycetidae
Order	-ales	Rosales
Suborder	-ineae	Rosineae
Family	-aceae	Rosaceae
Subfamily	-oideae	Rosoideae
Tribe	-eae	Roseae
Subtribe	-inae	Rosinae
Genus	*-us, -um, -is, -a, -on*	*Pyrus, Allium, Arabis, Rosa, Polypogon*
Subgenus		*Cuscuta* subgenus *Eucuscuta*
Section		*Scrophularia* section *Anastomosanthes*
Subsection		*Scrophularia* subsection *Vernales*
Series		*Scrophularia* series *Lateriflorae*
Species		*Rosa canina*
Subspecies		*Crepis sancta* subsp. *bifida*
Varietas		*Lantana camara* var. *varia*
Forma		*Tectona grandis* f. *punctata*

❖ **Generic Name:**

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

❖ **Specific Epithet:**

The specific epithet is often an adjective and it is written with a small initial letter.

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

TYPIFICATION

Type Specimen is the one representative of the taxon.

- **Holotype:**

A specimen designated by the author in the original publication (nomenclatural type).

- **Isotype:**

A duplicate specimen of the holotype collected at the same time and place (may be in other herbarium).

- **Lectotype:**

A specimen chosen from the author's original material when no holotype has been designated.

- **Neotype:**

A specimen selected when all original specimens have been destroyed

Author Citation, Effective Publication and Principle of Priority

Author Citation

- **For a name to be complete, it should be accompanied by the name of the author or authors who first published the name validly. The names of the authors are commonly abbreviated, Example L. for Carolus Linnaeus**
- ***Aizoon canariense* L.**
- ***Tribulus macropterus* var. *arabicus* (Hosni) Al-Hemaid & J. Thomas**

Basic structure of a taxonomic Research papers / Recent publication of a new species in taxonomic journal

Ann. Bot. Fennici 53: 37–39 ISSN 0003-3847 (print) ISSN 1797-2442 (online)
Helsinki 4 January 2016 © Finnish Zoological and Botanical Publishing Board 2016

Silene langshanensis (Caryophyllaceae), a new species from Inner Mongolia, China

Li-Qing Zhao[1,*], Zhi-Ming Xin[2] & Yi-Zhi Zhao[1]

[1] College of Life Science, Inner Mongolia University, Hohhot 010021, China (*corresponding author's e-mail: zhaolieniu@126.com)
[2] Experimental Center for Desert Forestry, Chinese Academy of Forestry, Dengkou, Inner Mongolia 015200, China

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Zhao L.Q., Xin Z.M. & Zhao Y.Z. 2016: *Silene langshanensis* (Caryophyllaceae), a new species from Inner Mongolia, China. — *Ann. Bot. Fennici* 53: 37–39.

Silene langshanensis L.Q. Zhao, Y.Z. Zhao & Z.M. Xin *sp. nova* (Caryophyllaceae), is described and illustrated from Inner Mongolia, China. It appears to be most closely related to *S. scabrifolia* of *Silene* sect. *Holopetalae*. *Silene langshanensis* can be distinguished by the basally pubescent carpophore, petals with obtuse auricles, stems and leaves with dense, short hairs, and by the glabrous calyx.

In total, there are about 600 species of *Silene s. lato* (Caryophyllaceae) (Zhou *et al.* 2001). They are distributed mainly in the northern temperate regions, but occur also in Africa and South America (Zhou *et al.* 2001). Among these species, 110 are known from China, of which 67 are endemic. Twenty of the endemics (nine species of *Silene s. stricto*, nine of *Melandrium*, one of *Cucubalus* and one of *Lychnis*) are found in Inner Mongolia.

In September 2008 and later, in 2014, the authors Zhao and Xin collected specimens of *Silene* from Langshan in Bayannaoer (Inner Mongolia) from desert steppe communities on mountain slopes at 1150–1400 m a.s.l. After careful study, we concluded that the specimens represented an undescribed species of *Silene*.

Silene langshanensis L.Q. Zhao, Y.Z. Zhao & Z.M. Xin, *sp. nova* (Fig. 1)

HOLOTYPE: China. Inner Mongolia, Bayannaoer, Dengkou, Mt. Langshan, 40°43′58.4″N, 106°22′28.5″E, on stony mountain slopes, 1371 m a.s.l., 9 June 2014 *Li-Qing Zhao, Zhi-Ming Xin, Shuai Qin & Long Chen N14-001* (HIMC). — PARATYPES (all HIMC!): Same location as holotype, 9 June 2014 *Li-Qing Zhao, Zhi-Ming Xin, Shuai Qin & Long Chen N14-002, N14-003, N14-004*; Mt. Langshan, 40°39′27.7″N, 106°23′14.1″E, on stony mountain slopes, alt. 1185 m a.s.l., 10 September 2008 *Li-Qing Zhao & Zhi-Ming Xin N08-001*.

Herbs perennial, 20–50 cm tall. Roots robust, lignified. Plants cespitose with erect stems, multi-branched or sparsely branched, pubescent, upper parts glabrescent. Basal leaves oblanceolate, 20–60 × 2–6 mm, both surfaces pubescent, margins ciliate, base attenuate into a long petiole, apex acute; cauline leaves 3–7 pairs, linear-oblanceolate or linear-lanceolate, with short, axillary sterile branches or sometimes elongated flowering axillary branches. Flowers in a racemiform-like thyrse; cymes alternating (resulting from suppression of opposite cyme at same node) or opposite, 1-flowered (rarely 2), peduncles nearly equal or shorter than pedicels. Pedicel 2–6 cm, glabrescent; bracts ovate-lanceolate, ciliate, base connate, apex acuminate. Calyx tubular, green, sometimes violet, narrowly campanulate, slightly inflated in fruit, 10–13 × 4–5 mm, glabrous; calyx teeth broadly triangular-ovate, apex obtuse or acute, margin membranous, ciliate. Carpophore 2–3 mm, basally pubescent. Petals ca. 15 mm, claws cuneate, glabrous, auricles obtuse; limbs yellowish green, narrowly obovate, margin entire or emarginate, coronal scales absent. Stamens and styles prominently exserted; filaments glabrous. Styles 3. Ovary ovate-elliptic, ca. 5 mm long. Capsule 6-valved. Flowering and fruiting in June–September.

Silene langshanensis is placed in the section *Holopetalae*, of which five species are now known from China (Zhou *et al.* 2001). It resembles *S. scabrifolia* (*see* Shishkin 1936: 677) but can be distinguished by several characters (Table 1). The following key should be useful when identifying species of sect. *Holopetalae* in China.

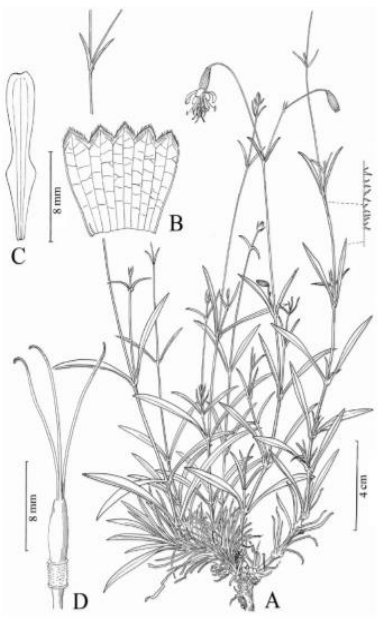

Fig. 1. *Silene langshanensis* (from the holotype, drawn by Ping Ma). — **A**: Habit. — **B**: Calyx. — **C**: Petal. — **D**: Pistil and carpophore.

Table 1. Main morphological differences between *Silene langshanensis* and *S. scabrifolia*.

Character	*S. langshanensis*	*S. scabrifolia* (= *S. komarovii*)
Stem	densely pubescent, upper part glabrescent when flowering	pubescent in lower part, glabrous and viscid above
Basal leaves	oblanceolate, 20–60 × 2–6 mm	spatulate or lanceolate, 60–80 × 5–10 mm
Cyme	1-flowered (rarely 2)	multiflowered
Pedicel	20–60 mm long, glabrescent	5–10 mm long, sparsely pubescent
Calyx	narrowly campanulate, 10–13 × 4–5 mm, glabrous	tubular-clavate, 8–12 × 2–3 mm, glabrous or sparsely villous
Carpophore	shortly pubescent	glabrous
Petal	with obtuse auricles	without distinct auricles
Limbs	yellowish green	yellowish white

1. Leaves ovate-lanceolate, 15–30 mm wide ..... *S. kungessana*
1. Leaves lanceolate or linear, 1.5–10 mm wide 2
2. Leaves linear, 10–30 × 1.5–3 mm ..... *S. holopetala*
2. Leaves oblanceolate or lanceolate, 30–80 mm long, usually more than 4 mm wide 3
3. Stems usually not branched; calyx 6–9 mm; petals pinkish abaxially ..... *S. pseudotenuis*
3. Stems branched; calyx 8–13 mm; petals yellowish green or yellowish white 4
4. Stem pubescent in lower part, glabrous and viscid above; cymes multiflowered; petals yellowish white, without obvious auricles; carpophore glabrous ..... *S. scabrifolia*
4. Stem with dense short hairs, upper part glabrescent when flowering; cymes 1-flowered (rarely 2); petals yellowish green, with obtuse auricles; carpophore basally pubescent ..... *S. langshanensis*

Acknowledgements

We are grateful to Ping Ma for the drawing. This study was financially supported by Natural Science Foundation of Inner Mongolia Autonomous Region (2014ZD02), National Key Basic Research Program of China (2014CB138802) and the Central Public-interest Scientific Institution Basal Research Fund (CAFYBB2014MA016).

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Effective publication in the journal, available to Botanist

Date of valid publication (principles of priority): If the same species will be published by some one else after this date then the publication will be not valid. (/Principles of Priority).

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Helsinki 4 January 2016

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[1] *College of Life Science, Inner Mongolia University, Hohhot 010021, China (*corresponding author's e-mail: zhaotieniu@126.com)*
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Abstract / Summary / Synopsis.

Previously it was required to write in Latin.

In total, there are about 600 species of *Silene s. lato* (Caryophyllaceae) (Zhou *et al.* 2001). They are distributed mainly in the northern temperate regions, but occur also in Africa and South America (Zhou *et al.* 2001). Among these species, 110 are known from China, of which 67 are endemic. Twenty of the endemics (nine species of *Silene s. stricto*, nine of *Melandrium*, one of *Cucubalus* and one of *Lychnis*) are found in Inner Mongolia.

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Botanical name in Latin

Rank indicated

Silene langshanensis L.Q. Zhao, Y.Z. Zhao & Z.M. Xin, *sp. nova* (Fig. 1)

Type Specimen indicated

HOLOTYPE: China. Inner Mongolia, Bayannaoer, Dengkou, Mt. Langshan, 40°43′58.4″N, 106°22′28.5″E, on stony mountain slopes, 1371 m a.s.l., 9 June 2014 *Li-Qing Zhao, Zhi-Ming Xin, Shuai Qin & Long Chen N14-001* (HIMC). — PARATYPES (all HIMC!): Same location as holotype, 9 June 2014 *Li-Qing Zhao, Zhi-Ming Xin, Shuai Qin & Long Chen N14-002, N14-003, N14-004*; Mt. Langshan, 40°39′27.7″N, 106°23′14.1″E, on stony mountain slopes, alt. 1185 m a.s.l., 10 September 2008 *Li-Qing Zhao & Zhi-Ming Xin N08-001*.

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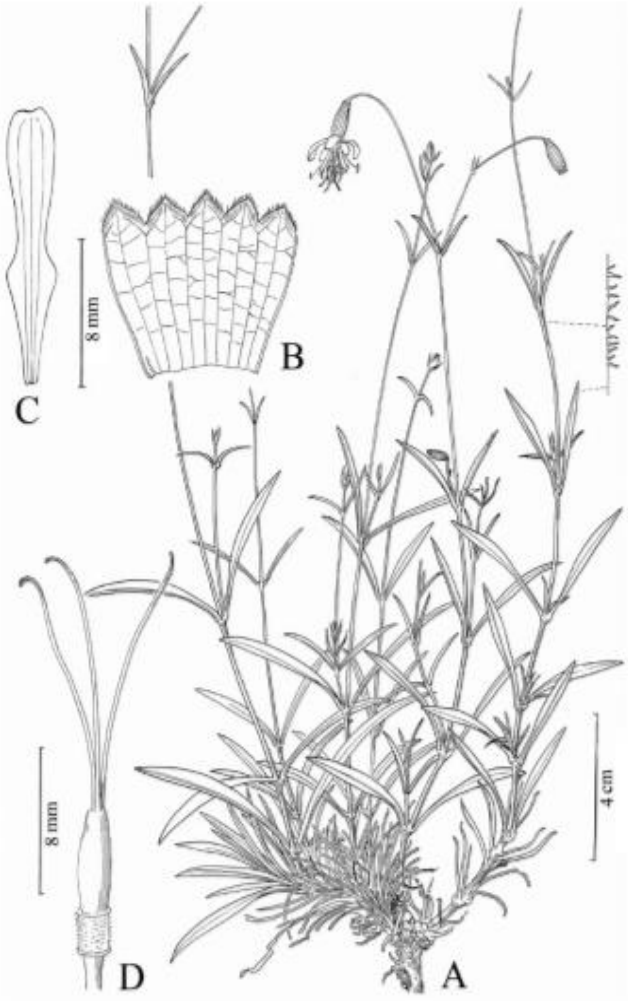
Taxonomic Description



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sometimes violet, narrowly campanulate, slightly inflated in fruit, 10–13 × 4–5 mm, glabrous; calyx teeth broadly triangular-ovate, apex obtuse or acute, margin membranous, ciliate. Carpophore 2–3 mm, basally pubescent. Petals ca. 15 mm, claws cuneate, glabrous, auricles obtuse; limbs yellowish green, narrowly obovate, margin entire or emarginate, coronal scales absent. Stamens and styles prominently exserted; filaments glabrous. Styles 3. Ovary ovate-elliptic, ca. 5 mm long. Capsule 6-valved. Flowering and fruiting in June–September.

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Line drawing

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3. Stems usually not branched; calyx 6–9 mm; petals pinkish abaxially ..... *S. pseudotenuis*
3. Stems branched; calyx 8–13 mm; petals yellowish green or yellowish white 4
4. Stem pubescent in lower part, glabrous and viscid above; cymes multiflowered; petals yellowish white, without obvious auricles; carpophore glabrous ..... *S. scabrifolia*
4. Stem with dense short hairs, upper part glabrescent when flowering; cymes 1-flow… green, with … cent …

Taxonomic Key for Identification

Acknowledgements

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This article is also available at http://www.annbot.net and http://www.bioone.org/loi/anbf

Synonyms and Related Terminology

Synonyms:

- **A name rejected due to misuse or difference in taxonomic judgement.**

Basionym:

- **The basionym is the first name ever given to a taxon. Further studies and revisions may reject the basionym as the most correct one, but it still is useful as a nomenclatural reference for that species.**

- **Also, according to the priority rules of the ICBN, after a taxonomic revision that results in a species being reclassified in another genus, the specific epithet must remain the same as the one in the Basionym.**

- **A short example: Linnaeus classified the Tea Plant as *Thea sinensis*. Some decades later, Sweet noticed that the genus *Thea* was not really different from the genus *Camellia*, and renamed all the *Theas* as *Camellias*. *Thea sinensis* became *Camellia sinensis*, because he had to keep the specific epithet the same as the original name (Basionym) for that species, given by Linnaeus.**

Homonym:

A case in which two or more identical names are baed on different type , of which only one can be a legitimate name , is called as homonym.

Tautonym

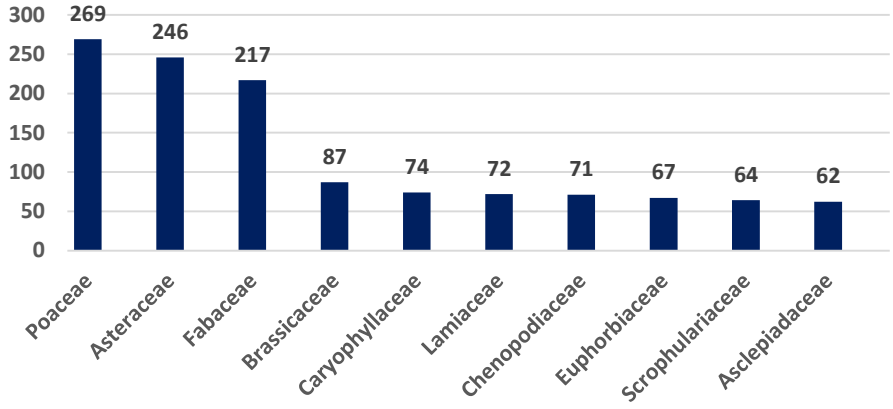
A case in which name of genus and the name of the species is the same.

Plant Biodiversity

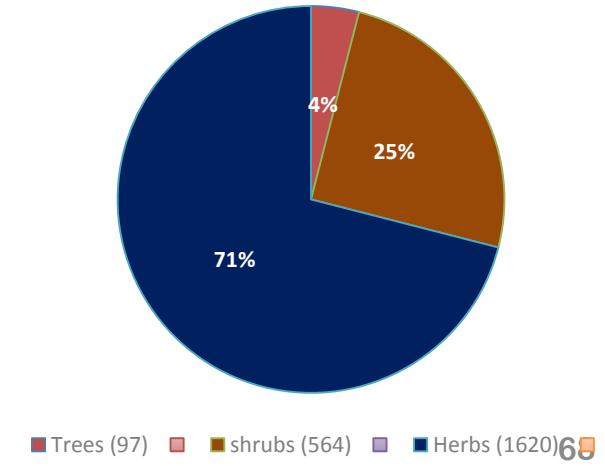
Plant Biodiversity of Saudi Arabia

- The flora of Saudi Arabia is somewhat a complex one, having affinities with the floras of East Africa, North Africa, the Mediterranean countries and the Irano-Turanian countries.
- Total number of species recorded: about 2300 species
- Gymnosperms: 9 species (*Juniperus phoenicea)*
- Pteridophytes : 27 species (Example: *Marsilea aegyptiaca)*
- Total number of families: 131
- Families represented by single species : 33
- 418 species belonging to 27 families are monocots
- 67 species are endangered (*Huernia saudi-Arabica)*
- 56 are endemic to the region (Example: *Aloe sheilae* Lavr.)

Major Families of Saudi flora



Percentage of Herbs, shrubs and Trees



Aromatic and Medicinal Plants of Saudi Arabia

Artemisia sieberi
(Family Compositae):

- **Leaves are used as an anthelmintic.**
- **Anthelmintic is an antiparasitic drugs that expel parasitic worms**

Ruta chalepensis
(Family Rutaceae)

- **Leaves are used to cure rheumatism**
- **Rheumatism is the disease marked by inflammation and pain in the joints, muscles, or fibrous tissue**

Withania somnifera
(Family Solanaceae)

- **Leaves and roots are used as a poultice**
- **Poultice is the term used for "applied to the body to relieve soreness and inflammation"**

Citrullus colocynthis
(Family Cucurbitaceae)

- **Leaves, seeds and roots are used in insect bits**

PLANT BIODIVERSITY AND CONSERVATION

- **Biodiversity** is the biological diversity which includes the variety of the whole species present on earth. It includes different animals, plants, micro-organisms)

- **Biodiversity conservation:**

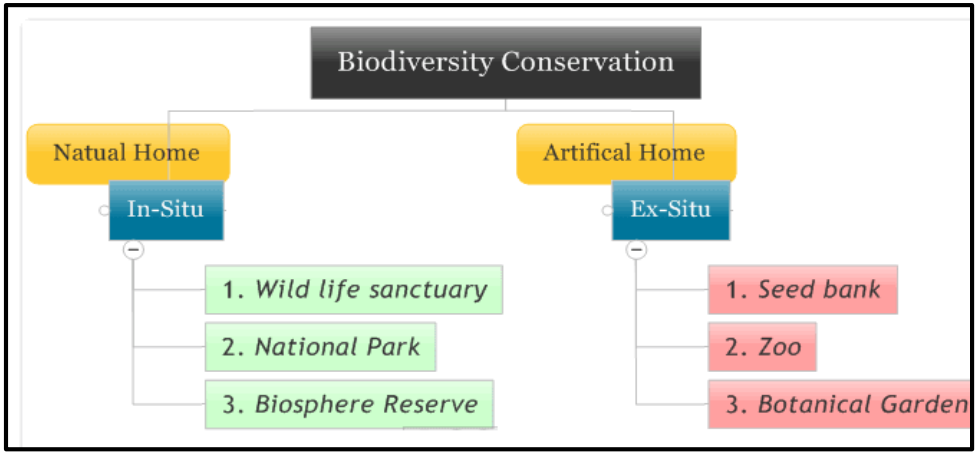
- Plant diversity is disappearing at an unprecedented rate as a direct impact of the way humankind uses the world's natural resources.
- Our flora is fundamentally important to human life as a source of food, shelter and medicine amongst many other things.
- The threats to plant diversity vary worldwide. These include habitat loss and degradation, invasive aliens, over-exploitation of resources, and even climate change.
- Species extinctions are on the rise.
- More than 80,000 seed-bearing plant species (20% of the total) are currently under threat.

- The biodiversity must should be conserve because of its benefit for example services and biological resources (medicine, food, wood products, fibers etc.) which are essential to live our life on earth.

- **In-situ conservation:** ***In-situ*** conservation means the conservation of species within their natural habitats. By *In-situ* biodiversity conservation method the biodiversity area may be covered in the form of natural park/ sanctuary/biosphere reserve etc.

- At present, Saudi Arabia has 15 protected areas. For example:

Area Name	Area Km^2	Declared Year
Harrat al Harrah	13,775	1987
Al Khunfah	20,450	1987
At Tubayq	12,200	1989



Ex-Situ conservation:

- Ex-situ conservation involves the conservation of biological diversity outside of their natural habitats.

- Ex-situ Biodiversity conservation can be done by forming Gene banks, seed banks, botanical garden, collections of In vitro plant tissue culture.

- Ex-situ biodiversity conservation strategy plays an important role in recovery programmes for endangered species.

- *Frerea indica* (Family Apocynaceae) is one of the world's 12 endangered medicinal species listed by IUCN (International Union for Conservation of Nature), and is endemic to western part of India

Botanical Garden

- The botanic gardens are institutions holding documented collections of living plants for the purposes of studied botany, taxonomy and systematics, multidisciplinary scientific research, conservation, display and education.
- Botanical gardens are often run by universities or scientific research organizations.
- Recently botanic gardens have seen a revival as scientific institutions due to the emergence of the conservation movement.

List of some important botanic garden of world:

1. New York Botanical Gardens, New York, America
2. Royal Botanical Gardens Sydney, Sydney, Australia
3. Kirstenbosch National Botanical Garden, Cape Town, South Africa
4. Botanischer Garten München, Munich, Germany
5. Orto botanico di Padova, Padua, Italy
6. Hawaii Tropical Botanical Garden, Pāpa'ikou, Hawaii
7. Jardin Botanique de Montreal, Montreal, Canada
8. Longwood Gardens, Philadelphia, USA
9. Kew Royal Botanical Gardens, London, England
10. Oman Botanic garden, Oman (Botanical Garden for the Future)

Identifying Plant Families

Caryophyllaceae

- Herbs
- Leaves in opposite pairs, unlobed, untoothed
- Flowers usually have 5 petals
- Flowers usually have 5 sepals
- Flowers in cymes (group of flowers, terminal flower opens first
- Single capsule fruit

Brassicaceae

- Herbs
- Alternate leaves
- No stipules
- Flowers have 4 petals in a cross
- Flowers have 4 sepals
- Many cultivated vegetables

Identifying Plant Families

Apiaceae

- Herbs
- Leaves usually alternate with sheathing, inflated leaf-stalk bases
- Flowers have 5 separate petals
- Flowers small
- Umbels type of inflorescence

Lamiaceae / Labiatae

Herbs
Square stems
Leaves opposite
Leaves often toothed
No stipules
Tubular flowers
Flowers usually have hood and prominent lower lip

Identifying Plant Families

Asteraceae / Compositae

- Largest family of flowering plants worldwide
- Herbs
- Leaves without stipules
- Flowers small in dense heads
- Petals always joined into a corolla-tube (petals fused together below forming a tube)

Cucurbitaceae

- Herbaceous vines
- Tendrils present
- Plants usually monecious
- Flowers 5-merous
- Ovary inferior
- Fruit usually a pepo

Identifying Plant Families

Asclepiadaceae

- Perennial herbs, vines, and shrubs with milky sap, some cactus-like
- Leaves opposite or whorled, simple, entire
- Flowers bisexual, actinomorphic, with elaborate corona containing hoods and horns
- Highly specialized pollination mechanism
- Pollen contained in waxy pollinia connected in pairs to glands
- Stamens and carpels united into gynostegium
- Fruit a follicle
- seeds with tuft of silky hairs

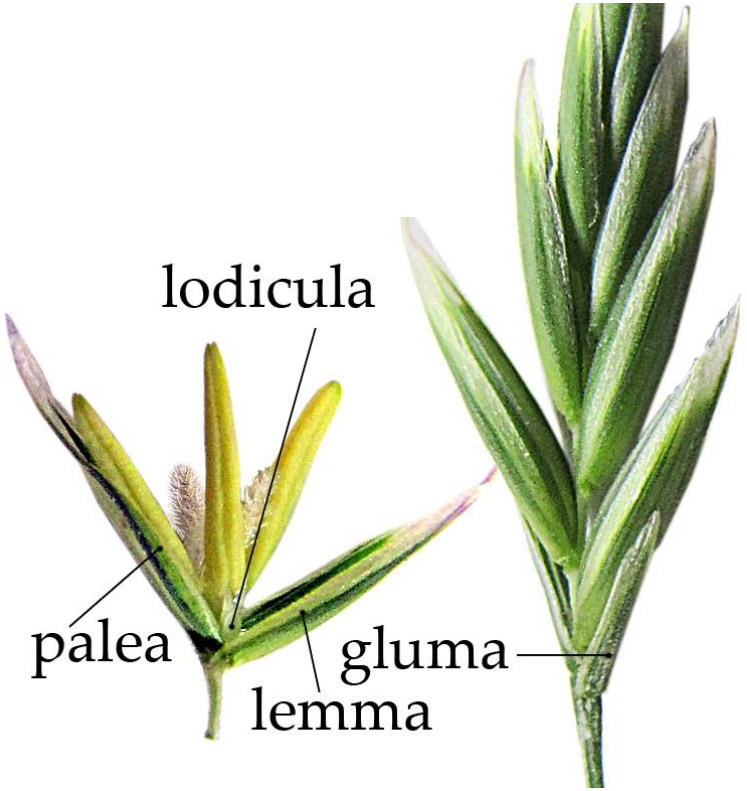
Euphorbiaceae

- Habit: herbs, shrubs, stem succulents, trees; often with milky sap
- Leaves: alternate, opposite, whorled; simple (rarely palmately compound); stipulate
- Plants: monoecious or dioecious
- Inflorescence: cymose, racemes, cyathium
- Perianth: 0 (4-6); distinct or basally connate, free or adnate at base to stamens
- Stamens: 1-many, distinct or variously connate
- Ovary: 3 carpels; connate; superior; 3 (1-4) locules with 1 or 2 apical-axile ovules per locule; styles 3 (1-4), often forked
- Fruit: schizocarpic capsule (drupe, berry, pod, samara)

Identifying Plant Families

Poaceae

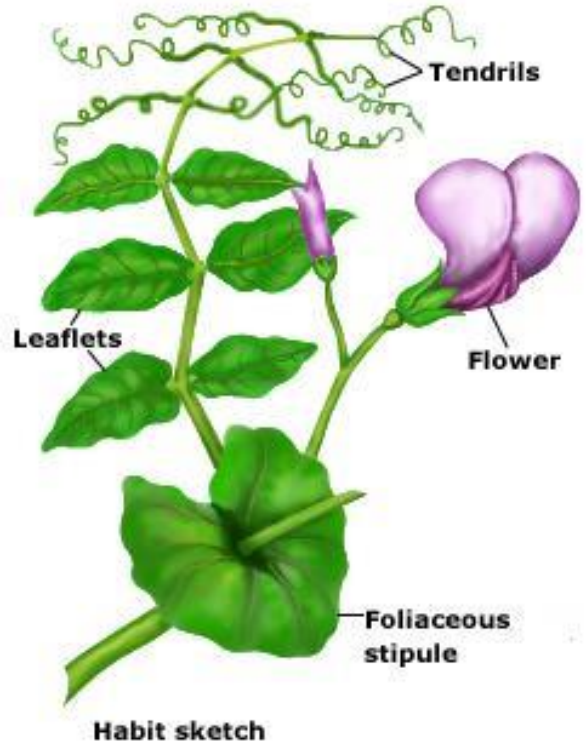
- Habit: Mainly herbs (annuals or perennials) or shrubs. Some are trees like
- Root: Adventitious, fibrous, branched or stilt (as in maize).
- Stem: Underground rhizome in all perennial grasses, cylindrical, distinct nodes and internodes, herbaceous or woody.
- Leaves: Alternate, simple, extipulate, sessile, leaf base forming tubular sheath, sheath open, surrounding the internodes completely, hairy or rough, linear, parallel venation.
- Inflorescence: Compound spike, sessile or stalked. Each unit is called spikelet, may be a spike of spikelets (Triticum) or panicle of spikelets (Avena).
- Perianth: Represented by membranous scales called lodicules, many (Ochlandra) or three or two or absent.
- Androecium: Stamens usually three, some times six (Bambusa) rarely one (species of Fistuca). Filaments long, anthers dithecous, versatile and linear.
- Gynoecium: Monocarpellary (presumed to be three of which two are aborted), unilocular, single ovule on basal placentation, style short or absent, stigma bifid, ovary superior.
- Fruit: A caryopsis with pericarp completely united with the seed coat, rarely a nut (Dendrocalamus) or a berry (Bambusa).
- Seed: Endospermic, with a single cotyledon called scutellum, pressed against the endosperm

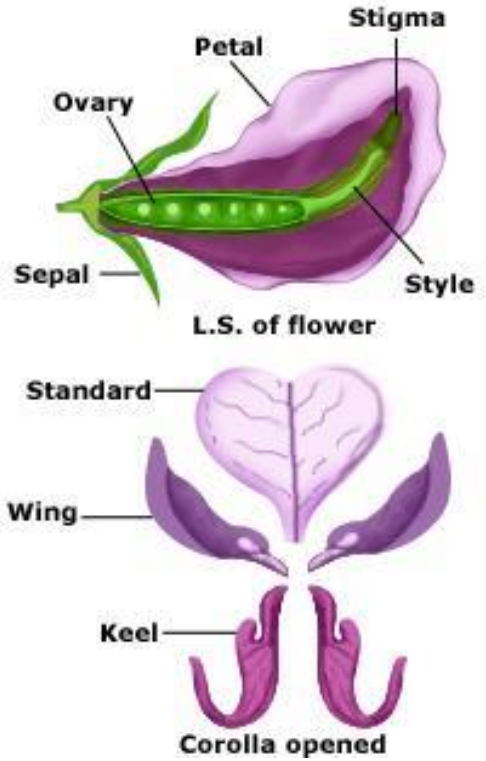


Identifying Plant Families

Fabaceae / Leguminosae

- Five-petalled flowers
- Leaves usually trifoliate or pinnate
- Wide standard petal at top
- 5 sepals forming calyx-tube (lower parts of sepals fused)
- Fruit an elongated pod





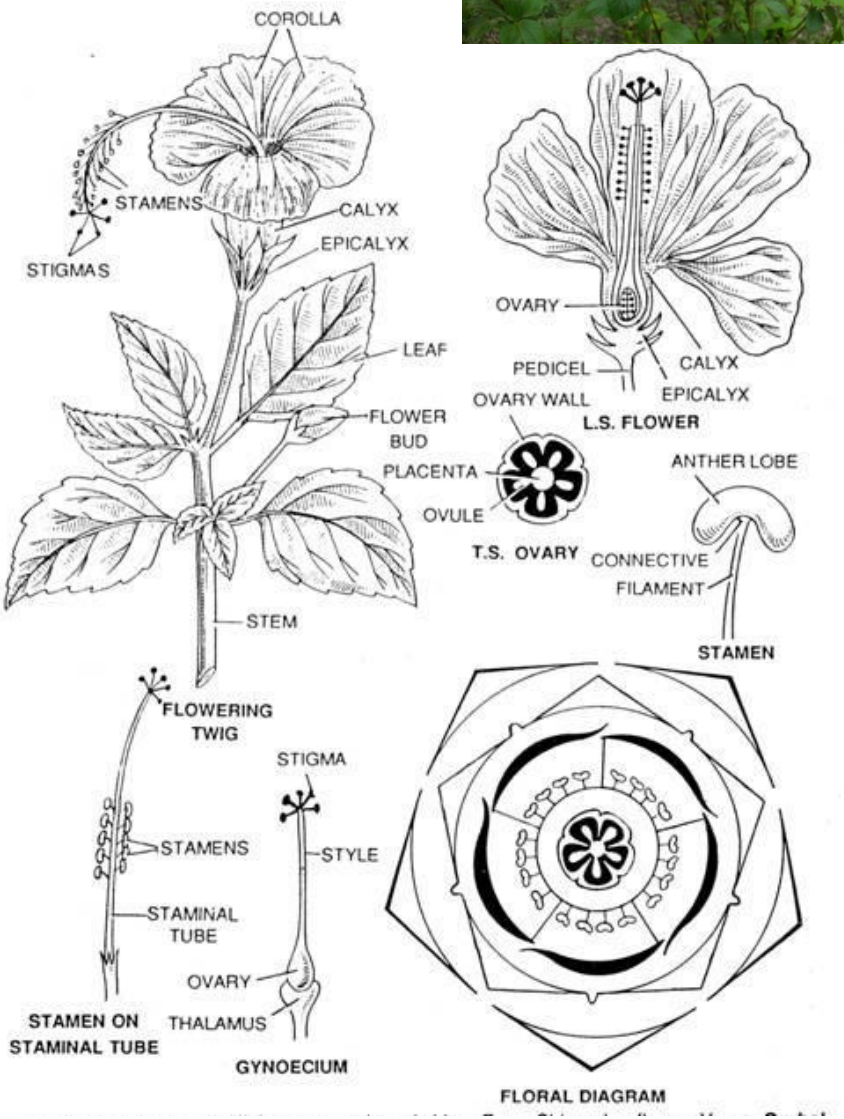
Identifying Plant Families

Characteristic of the family Malvaceae:

Presence of epicalyx
Petals with twisted aestivation
Stamens indefinite and monoadelphous
Anthers reniform and monothecous
Ovary two- many carpels with axile placentation.

Floral characteristics of family Malvaceae by dissection of *Hibiscus rosa-sinensis*

- **Inflorescence: Solitary axillary**
- **Floral characteristics: Pedicellate, complete, cyclic, bracteolate in the form of epicalyx, hermaphrodite, actinomorphic, hypogynous, regular and pentamerous.**
- **Epicalyx: Number- 5-7, Colour – Green, An additional whorl below calyx**
- **Calyx: Number- 5, Fusion- Gamosepalous, Aestivation- Valvate, Shape –bell shaped, Colour- Green**
- **Corolla: Number- 5, Fusion- Polypetalous, Aestivation- Twisted, Shape –Bell shaped, slightly fused due to fusion with staminal tube, Colour- red**
- **Androecium: Stamen, Number.-Indefinite, Cohesion- Monoadelphous. i.e forming a staminal tube around the style., Adhesion -Epipetalous i.e. filaments adnate to the basal part of the petal. Anthers- Reniform, i.e. kidney shaped, Free and monothecous. Basifixed, extrorse.**
- **Gynoecium: Carpel- Number of carpels-5, (Pentacarpellary), Fusion – Syncarpous, Ovary- Superior, pentalocular with 1 or 2 ovules in each locale, Style- Long, united below, free above, passes through staminal tube, Stigma-Five in number, capitate, Placentation-Axile.**

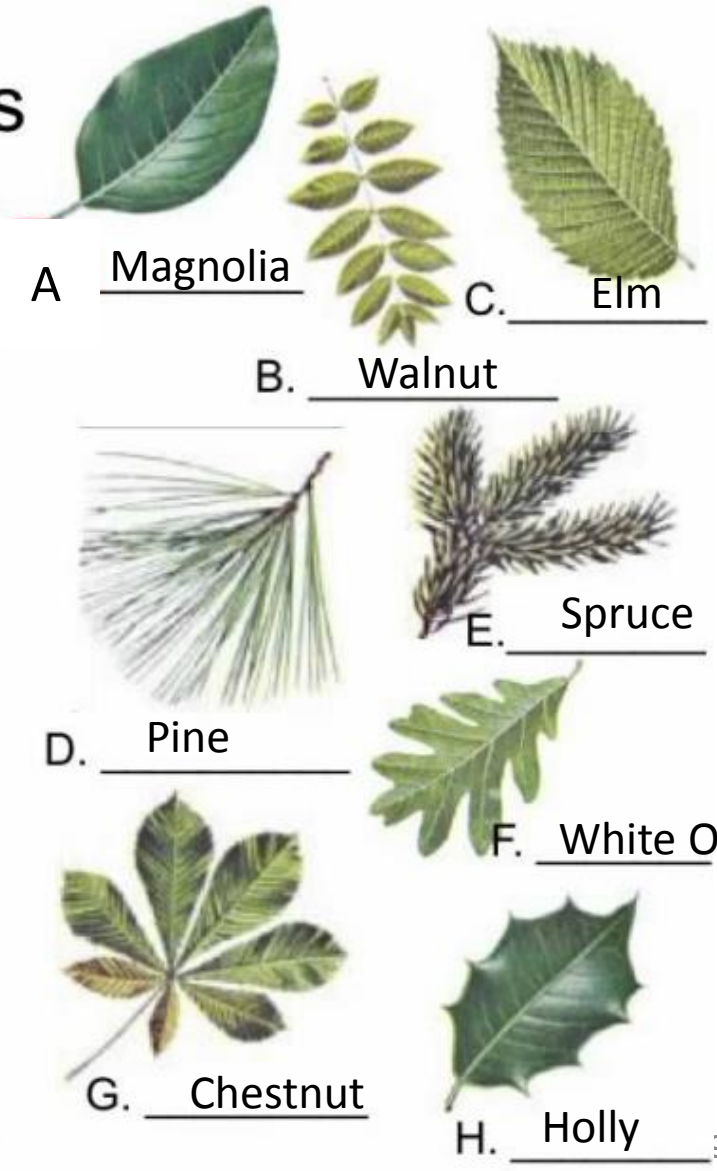


Taxonomic Key

An identification device, consisting of contrasting statements used to narrow down the identity of a taxon

Dichotomous Key For Leaves

1.	a. Needle leaves	go to 2
	b. Non-needle leaves	go to 3
2.	a. Needles are clustered	Pine
	b. Needles are in singlets	Spruce
3.	a. Simple leaves (single leaf)	go to 4
	b. Compound leaves (made of "leaflets")	go to 7
4.	a. Smooth edged	go to 5
	b. Jagged edge	go to 6
5.	a. Leaf edge is smooth	Magnolia
	b. Leaf edge is lobed	White Oak
6.	a. Leaf edge is small and tooth-like	Elm
	b. Leaf edge is large and thorny	Holly
7.	a. Leaflets attached at one single point	Chestnut
	b. Leaflets attached at multiple points	Walnut

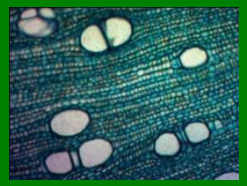


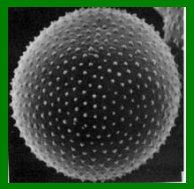
Taxonomic Evidences

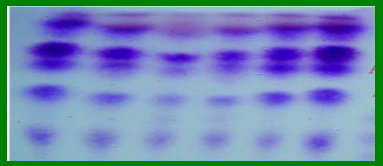
Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources

Morphology to Molecules

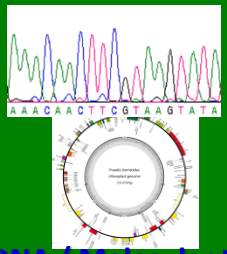

Morphology


Anatomy

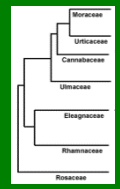

Pollen


Chemistry

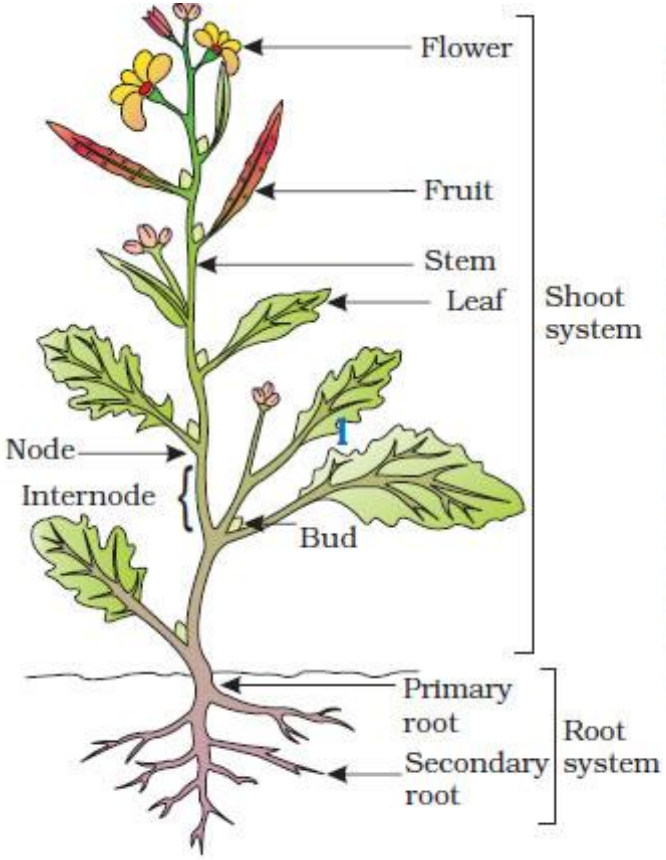

Chromosomes

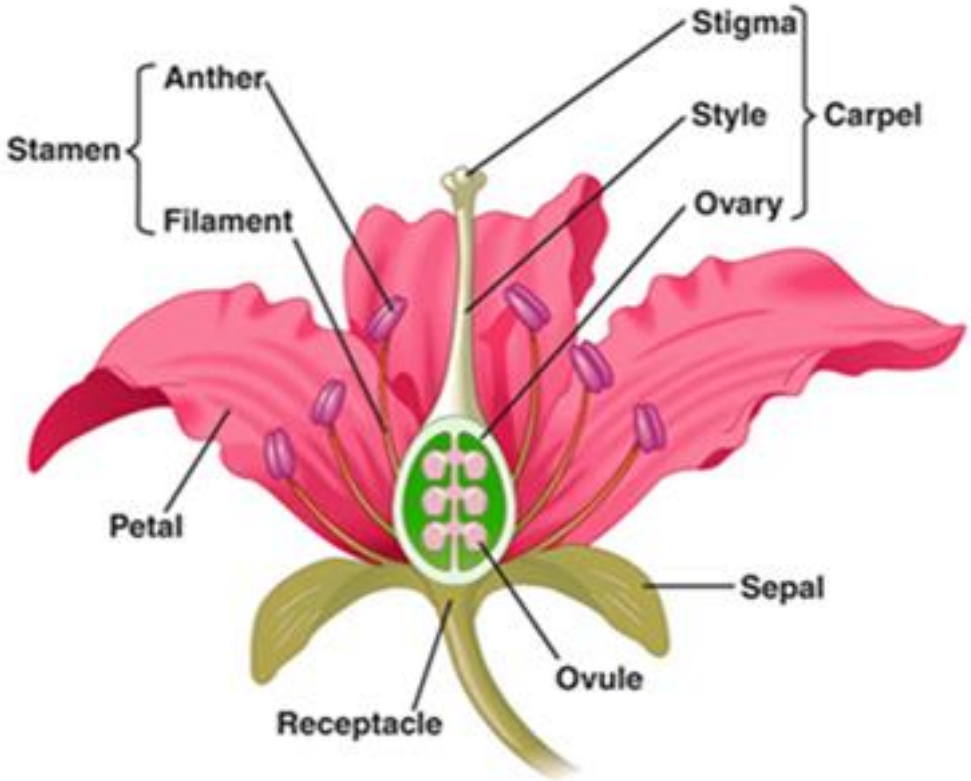


DNA / Molecular taxonomy



Source of Taxonomic Evidences: Vegetative and Floral Morphology





- **Since there is huge diversity in the vegetative (external plant characteristics) and floral morphology among flowering plants, the vegetative and floral morphological characters is the first step in the plant identification and classification of angiospermic plants.**

Source of Taxonomic Evidences: Plant Anatomy - (Internal Characteristics) and Physiology in Relation to Plant Taxonomy

- The Anatomical features is the most useful taxonomic characters in classification of the higher taxonomic categories .
- Anatomical features (plant cell & tissue types) (vs. morphological features) are somewhat more conservative characters that are not easily modified by growing conditions.
- Anatomical features of vegetative structures (roots, stems, leaves) are used to distinguish gymnosperms from angiosperms and monocots from dicots.

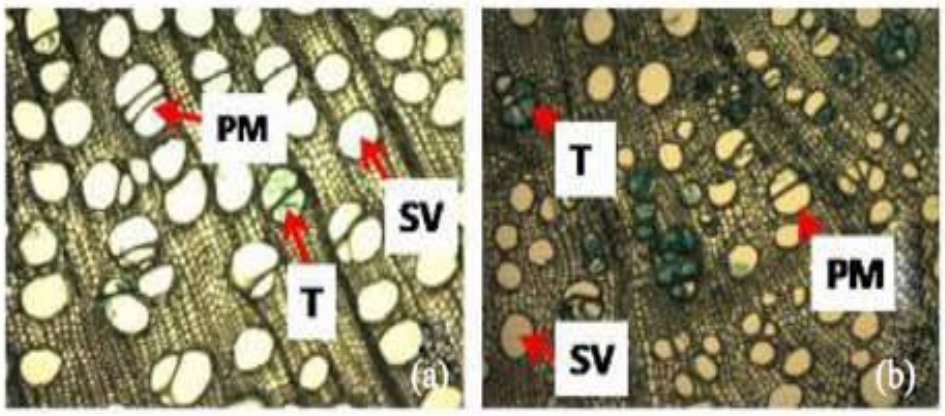
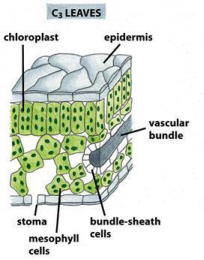


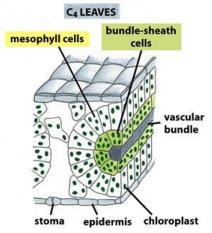
Figure: Transverse Sections of stem *Artocarpus atilis* (a) and *Artocarpus* communis (b).

- PM: Pore multiple
- T=Tylose (Tyloses are outgrowths on parenchyma cells of xylem vessels of secondary heartwood
- SV: Solitary vessel

- Physiological Evidence - C3 vs. C4 vs. CAM plants (in terms of their strategies for photosynthesizing.
- C4 photosynthesis occurs in about 10 unrelated families of monocots and dicots .... and is associated with plants that are adapted to arid environments.

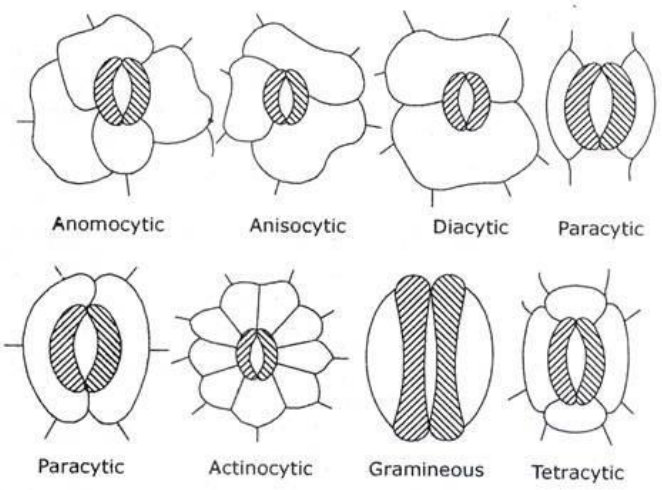
- Cyperaceae
- Hydrocharitaceae
- Poaceae / Gramineae
- Acanthaceae
- Aizoaceae
- Amaranthaceae
- Asteraceae
- Boraginaceae
- Capparidaceae
- Caryophyllaceae
- Euphorbiaceae
- Molluginaceae
- Nyctaginaceae
- Polygonaceae
- Portulacaceae
- Scrophulariaceae
- Zygophyllaceae





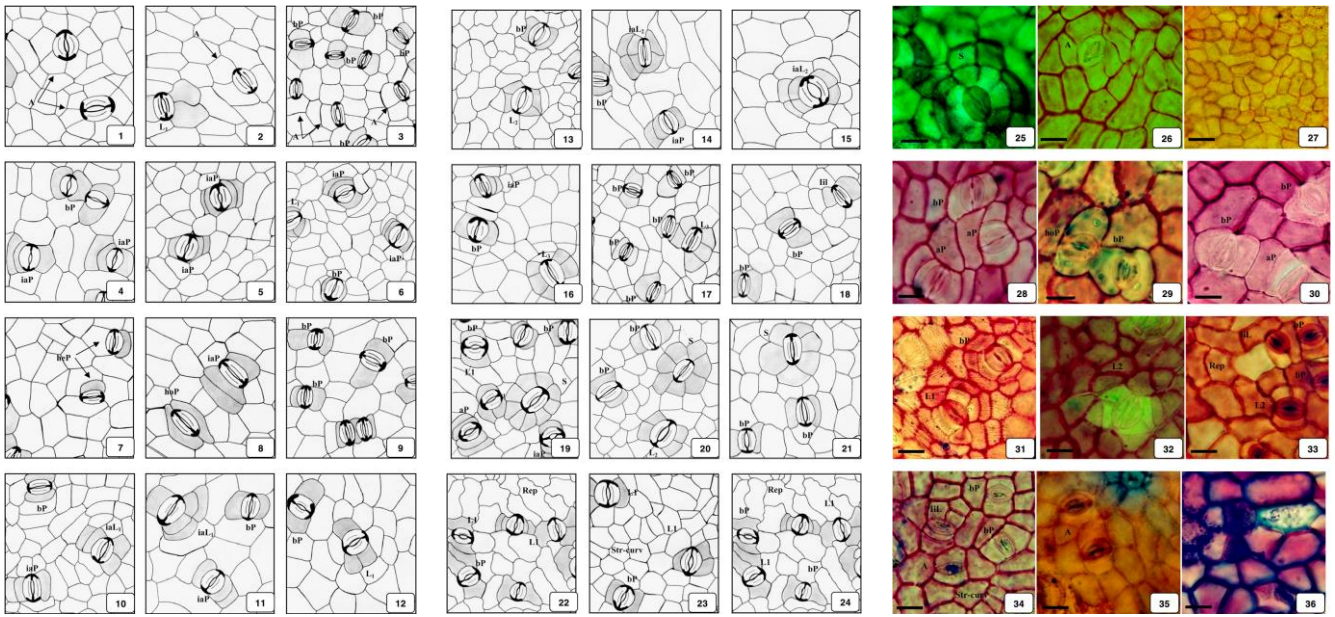
Source of Taxonomic Evidences: Systematic significance of Stomata

Stomata types produced by characteristic arrangements of guard cells and subsidiary cells can be of taxonomic use at the family or higher level.



Different stomatal apparatus in Angiosperms

- **Anomocytic type:** with epidermal cells around stomata not differentiated
- **Paracytic type:** with two or more cells parallel to the guard cells differentiated as subsidiary cells
- **Diacytic type:** with two subsidiary cells at right angles to the guards cells
- **Anisocytic type:** with three subsidiary cells of unequal size
- **Actinocytic type**: with stomata surrounded by a circle of radiating cells
- **Tetracytic type:** with four subsidiary cells
- **Cyclocytic type:** with concentric rings of subsidiary cells
- **Graminaceous type**: with dumb-bell shaped guard cells with two small subsidiary cells parallel to the guard cells.

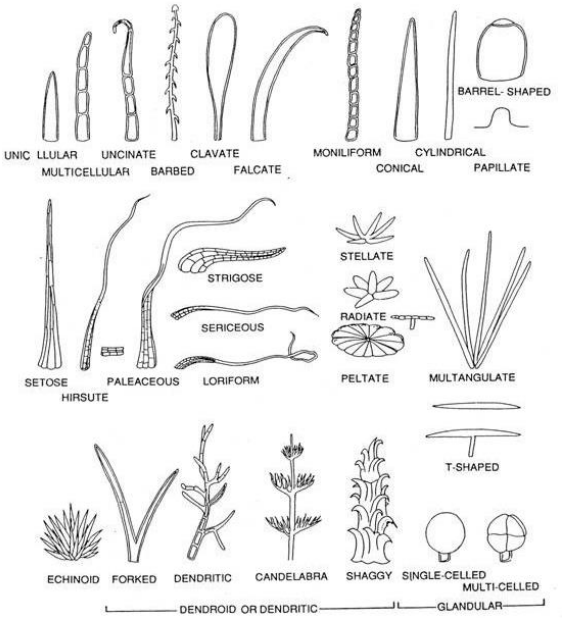


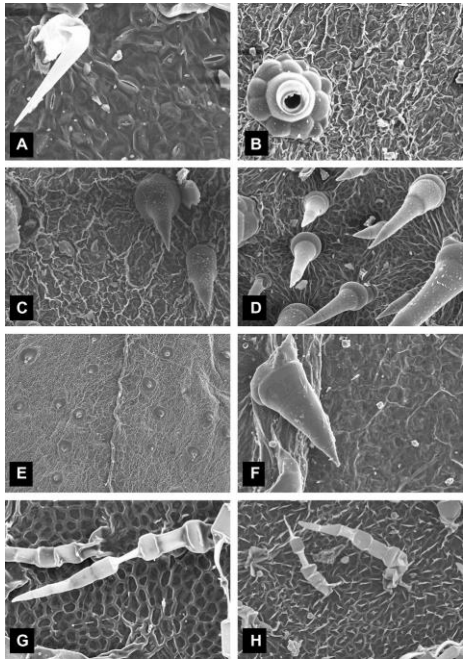
- **FARROKH et al., studies 32 *Salix speices of Salix* Species (Salicaceae) in order to find the systematic significance of trichomes in Angiosperms**

Source of Taxonomic Evidences: Systematic Significance of Micromorphological Character of Leaf Surface / Trichomes / Electron Microscopy in Relation to Taxonomy

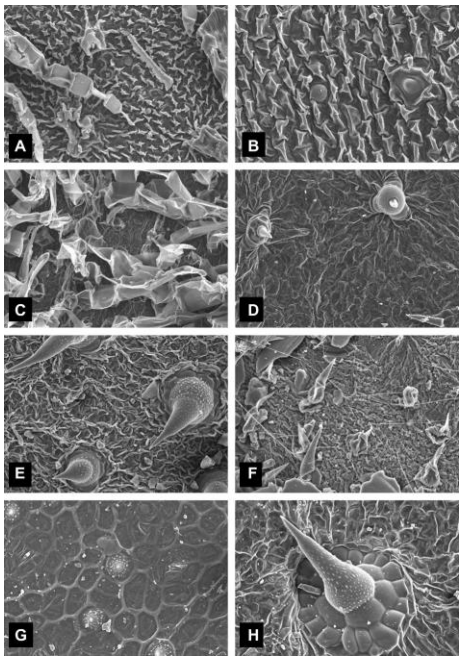
- **Trichomes meaning "hair", are fine outgrowths or appendages on plants.**

- **Ali and Al-Hemaid (2011) studies trichomes of 23 species of the member of the family Cucurbitaceae using Electron Microscope in order to find the systematic significance of micromorphological characters of trichomes**

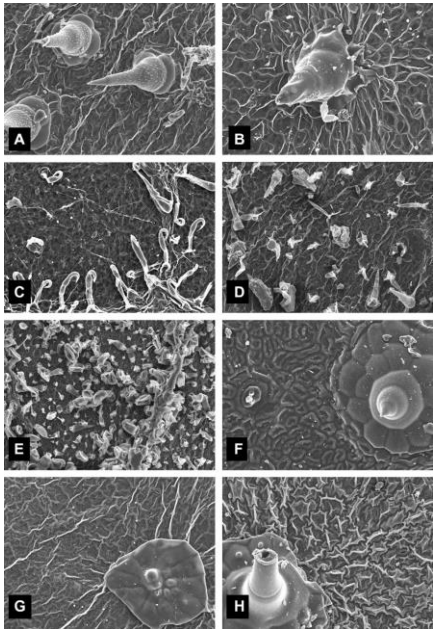




Trichomes morphology in Cucurbitaceae: (A) *Benincasa hispida* x300, (B) *Citrullus lanatus* x300, (C) *Cucumis melo* var. *agrestis* x300, (D) *C. sativus* x300, (E) *Diplocyclos palmatus* x50, (F) *Edgaria dargeelingensis* x300, (G) *Gynostemma burmanicum* x300, and (H) *G. pentaphyllum* x300.

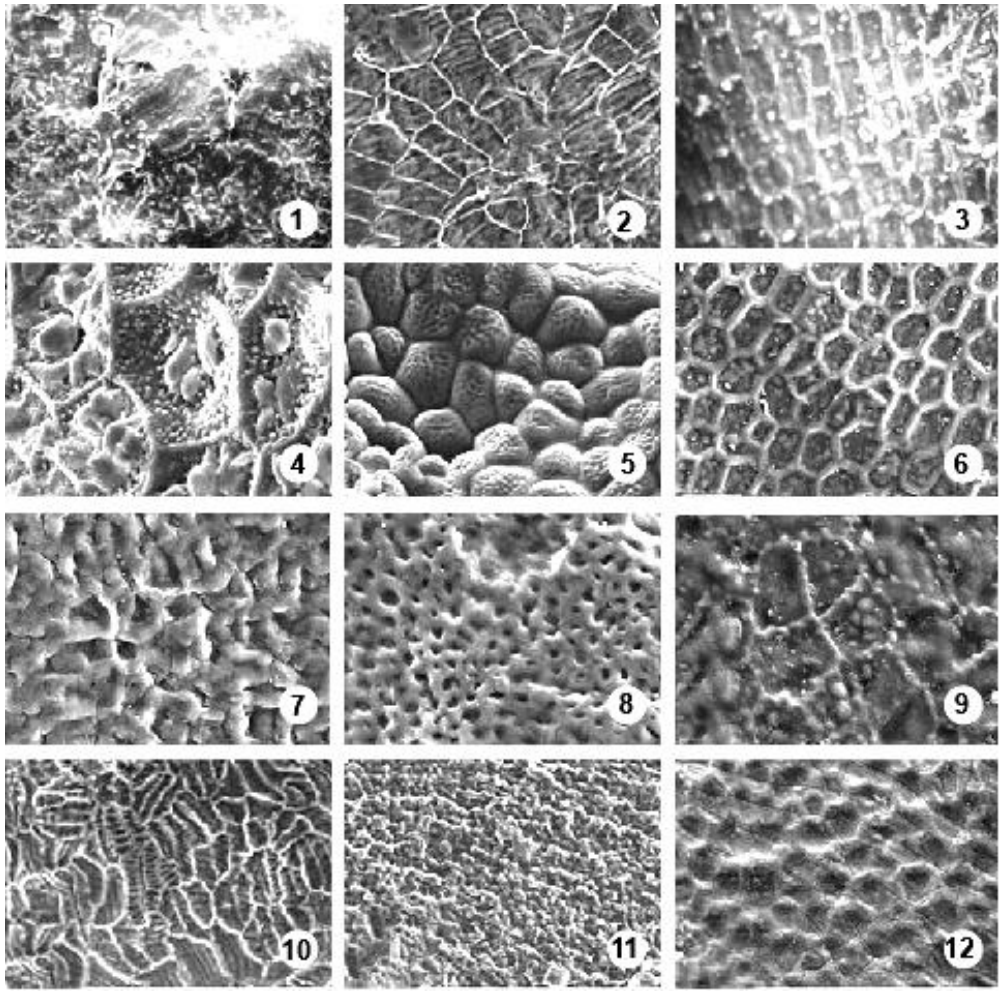


Trichomes morphology in Cucurbitaceae: (A) *Gynostemma pubescens* x300, (B) *Hemsleya diptrygia* x300, (C) *Lageneria siceraria* x300, (D) *Luffa acutangula* x300, (E) *L. cylindrica* x300, (F) *L. echinata* x300, (G) *Melothria heterophylla* x300, and (H) *M. leucocarpa* x300.



Trichomes morphology in Cucurbitaceae: (A) *Melothria maderspatana* ·300, (B) *Sechium edulae*, (C) *Thladiantha cordifolia* ·300, (D) *Trichosanthes cucumerina* ·300, (E) *T. cucumerina* var. *anguina* ·300, (F) *T. dioica* ·300, (G) *T. lepiniana* ·300, and (H) *T. tricuspidata* ·300.

Source of Taxonomic Evidences: Systematic Significance of Seed Micromorphological Character / Electron Microscopy in Relation to Taxonomy

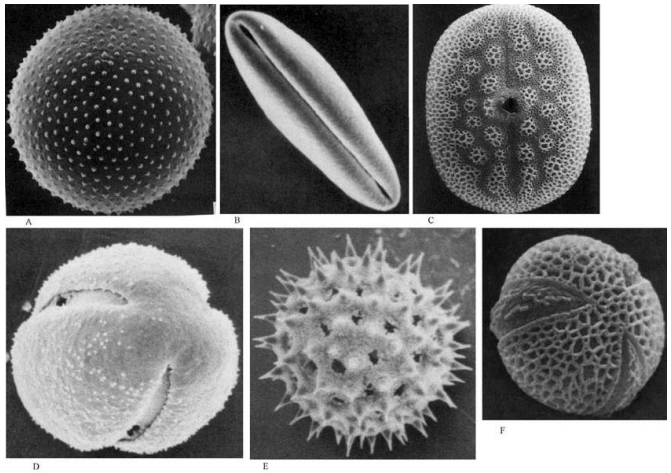


- Spermoderm refers to the pattern present on the seed coat of mature seeds.
- Seed characteristic, particularly exomorphic features as revealed by scanning electron microscopy, have been used by many workers in resolving taxonomic problems (Koul et al., 2000; Pandey and Ali, 2006) and evolutionary relationships (Kumar et al., 1999; Segarra and Mateu, 2001).
- Ali et al. (2003) studied the sppermoderm pattern of the members of the family cucurbitaceae using Electron Microscope in order to find the systematic significance of micromorphological characters seed surface

Scanning electron micrograph of the seed surface in Cucurbitaceae: 1. *Benincasa hispida* ×400 (rugulate); 2. *Citrullus colocynthis* ×400 (reticulate); 3. *Cucumis melo var. agrestis* ×400 (reticulate); 4. *Diplocyclos palmatus* ×1000 (reticulate); 5. *Gynostemma laxiflorum* ×600 (colliculate); 6. *Hemsleya longivillosa* ×400 (reticulate); 7. *Luffa echinata* ×1000 (reticulate); 8. *Momordica charantia* ×700 (reticulate); 9. *Momordica cymbalaria* ×1000 (reticulate); 10. *Schizopepon bryoniifolius* ×400 (reticulate); 11. *Sicyos angulatus* ×300 (rugulate); 12. *Trichosanthes cucumerina* ×320 (reticulate).

Source of Taxonomic Evidences: Systematic Significance of Palynology / Pollen Micromorphological Character / Electron Microscopy in Relation to Taxonomy

- **Palynology is the study of plant pollen and spores.**
- **There are two pollen types: monosulcate and tricolpate**
- **Monosulcate pollen are boat shaped with one long furrow and one germinal aperture (associated with primitive docots and the majority of monocots, the cycads and ferns).**
- **Triculpate pollen are found and typically have 3 apertures and is characteristic of the more advanced dicots.**



SEM of pollen grains. A: Nonaperturate pollen grain of *Persea americana; B: Monosulcate* pollen grain of *Magnolia grandiflora; C: Monoporate pollen grain of Siphonoglossa; D:* Tricolporate pollen grain of *Scaevola glabra; E: Polyporate spinose pollen grain of Ipomoaea wolcottiana; F: Tricolpate pollen grain of Disanthus cercidifolius.*

Erdtman (1963) used the pollen charactersin solving the taxonomic problem of 105 family

Source of Taxonomic Evidences: Systematic Significance of Embryology / Embryology in Relation to Taxonomy

- Embryology is the branch of biology that studies the prenatal development of gametes (sex cells), fertilization, and development of embryos and seed coats.
- The major embryological character that separates the monocots from the dicots is the number of embryonic cotyledon leaves.
- Embryological features are normally constant at the family level and below.
- The genus *Paeonia* was earlier included under the family Ranunculaceae. But *Paeonia* differs from Ranunculaceae in chromosome number, vascular anatomy, floral anatomy.
- Worsdell (1908) suggested its removal to a distinct family, Paeoniaceae.
- The separation is supported by the embryological features: (i) centrifugal stamens (not centripetal); (ii) pollen with reticulately-pitted exine with a large generative cell (not granular, papillate and smooth, small generative cell); (iii) unique embryogeny in which early divisions are free nuclear forming a coenocytic stage, later only the peripheral part becomes cellular (not onagrad or solanad type); and (iv) seed arillate.

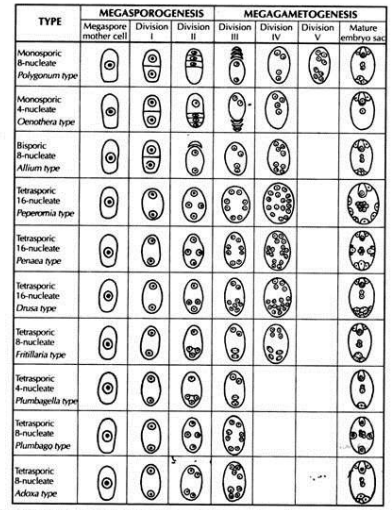
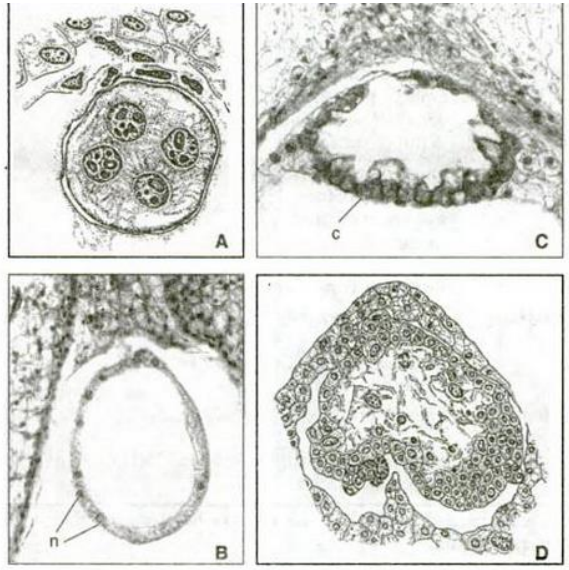


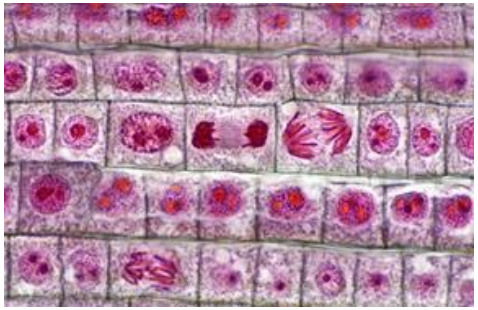
Fig. 3.8 : Development of different types of embryo sac in angiosperms (*after* Maheshwari)
[Micropyle above in all illustrations]



Early stages of embryogenesis in *Paeonia* sp. **A,B.** Coenocytic embryo. **C.** Cellularization. **D.** Formation of embryos in the coenocytic-cellular stage. *n*, nuclei; *c*, cells (*from* Czapik and Izmailow, 2001)

Source of Taxonomic Evidences: / Cytology in Relation to Taxonomy

- Cytology is the study of the cell.

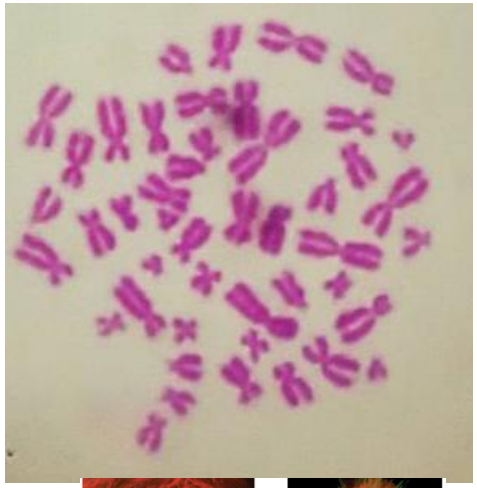


- Chromosome is a thread-like structure of nucleic acids and protein found in the nucleus of the living cells, carrying genetic information in the form of gene.

- Number of chromosome are fixed for a species.

Chromosome Set:

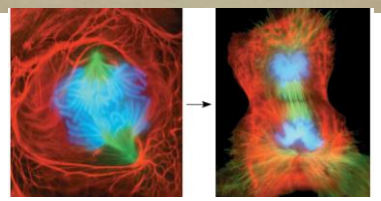
- Number of chromosome can be counted in the metaphase stage of cell division.



- One copy of each of the different chromosomes in the nucleus containing one copy of each different gene.

- Haploid Number (n): The number of chromosomes comprising one set.
- Diploid Number (2n): The number of chromosomes in a cell containing two sets.

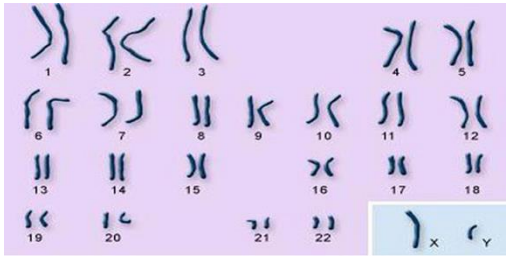
- Human Haploid (n)= 23, Diploid (2n)=46
- Dates Haploid (n)= 14, Diploid (2n)=28



- In plants, only information about chromosome number, shape or pairing at meiosis is used for classification purposes.

- The term karyotype is used for the phenotypic appearance for the somatic chromosomes.

- The diagrammatic representation of the karyotype is termed as idiogram.



- The characteristic of chromosome having taxonomic values are: chromosome number, chromosome size, chromosome morphology, and chromosome behavior during meiosis.

- The genus *Yucca* had long been treated as a member if Liliaceae because of the superior ovary. Hutchinson shifted *Yucca* to the family Agavaceae because the genus *Yucca* possess 25 small and 5 large chromosome which is similar to the member of family Agavaceae

Source of Taxonomic Evidences: / Chemotaxonomy / Chemical Information in Relation to Taxonomy

- Application of chemistry to taxonomy is called chemical taxonomy / chemotaxonomy.
- Some of the major classes of the chemical evidence include Anthocyanin, Flavonoids, Alkaloids, Glycosides, Terpenes, Amino acid, Fatty acids, Aromatic compounds, Polysaccharides, Carotenoids
- Caryophyllales produces Betalin and not anthocyanin
- Polygonales produce anthocyanin and not Betalin
- Highly aromatic compound are found in Lamiaceae

Source of Taxonomic Evidences: / Ecology in Relation to Taxonomy

- **The ecological criteria are of comparatively little direct importance in taxonomy.**

- **Ecological Evidence provides information about variation within plant taxa associated with plant adaptations and the distribution of plants.**

- **Plant ecologists frequently examine edaphic (soil) specializations, pollinating mechanisms (co-evolution), effect of habitat on hybridization, plant-herbivore interactions (co-evolution), seed-dispersal mechanisms, reproductive isolating mechanisms.**

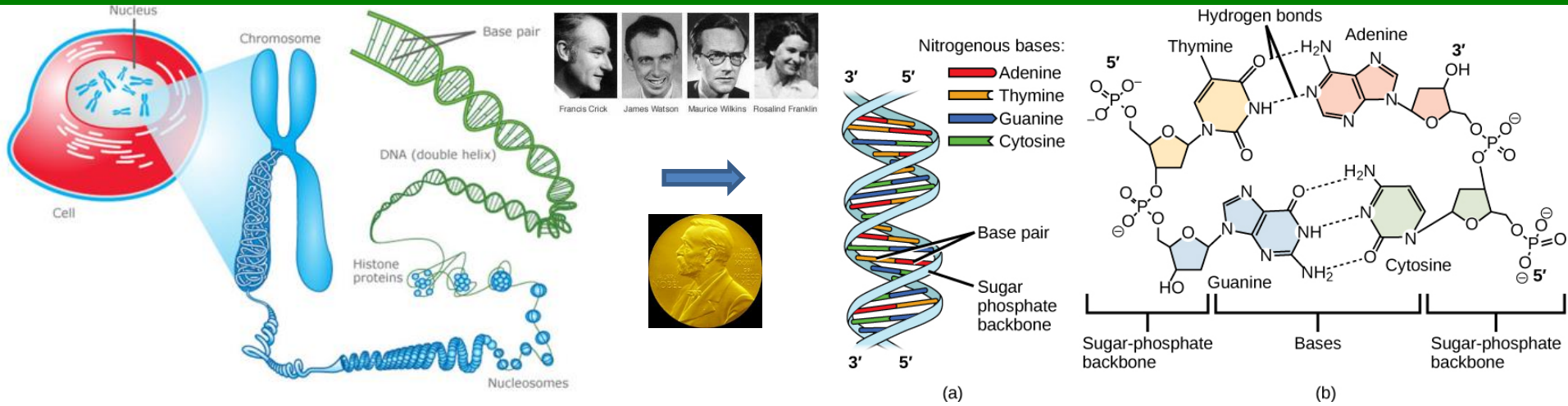
- **Information from plant ecology has implications for classification below the level of genus.**

- **Ecotypes:**
- **Ecotypes is a distinct form or race of a plant species occupying a particular habitat.**
- **Example; prostrate and erect form of *Euphorbia hira* (Euphorbiaeae)**

Erect form of *Euphorbia hira*

Prostrate form of *Euphorbia hira*

Source of Taxonomic Evidences: Molecular Data / DNA / Molecular Taxonomy



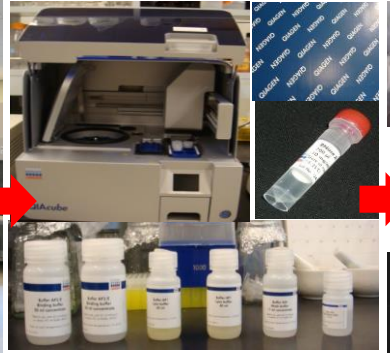
- **The Cell is the basic structural, functional and biological unit of all known living organisms. The Nucleus is enclosed in an envelope which is a double membrane structure. The Nucleus contains DNA in the form of loose threads called chromatin / Chromosomes**
- **The chromosomes are the thread-like structure of nucleic acids and protein found in the nucleus of the living cells, carrying genetic information in the form of gene.**
- **Genes passes genetic information from one generation to another generation. Genes lies on Chromosomes. Genes are made up of DNA. There are large number of genes occurs in each cell on each chromosomes.**
- **DNA (Deoxyribo Nucleic Acid) the genetic materials of living organism. The model of DNA was given by James Watson and Francis Crick in 1962.**
- **Protein synthesis is the main function of the gene. DNA transcribed in to RNA (called as Transcription), and then RNA translated into Amino Acids (called as Translation). There are 20 different types of amino acids. Several amino acids in a fixed sequenced forms protein.**
- **Gene expression is the process of converting information from gene to cellular product.**

Molecular systematics

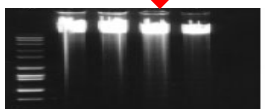
- Molecular systematics deals the utilization of nucleic acid data. As DNA sequence of a gene is constant in a species, hence advantage over morphological data for taxonomic studies.
- Taxonomist use molecular data from three different locations within a plant cell: chloroplast, mitochondrion and the nucleus.
- Molecular systematics involves following steps: (1) Sample collection, (2) DNA extraction, (3) Amplification using PCR –Polymerase chain Reaction, (4) DNA / Gene Sequencing, (5) Analysis of Sequence data.
- DNA barcoding can speed up identification of species. DNA barcoding helps in Wild plant identification / Medicinal plant authentication
- A DNA barcode is a short gene sequence taken from standardized portions of the genome, used to identify species

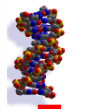
Collection of plant samples

A view of molecular biology laboratory

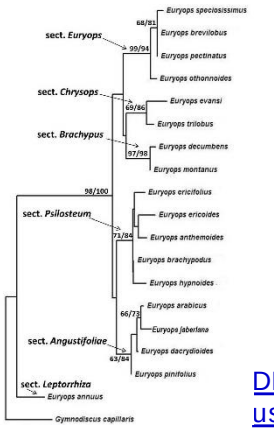


Gel electrophoresis

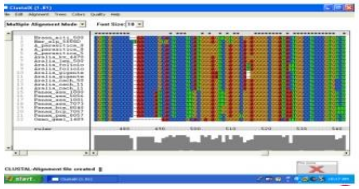




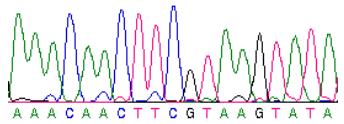
Doyle JJ, Doyle JL (1990) Isolation of plant DNA from fresh tissue. Focus 12:13–15

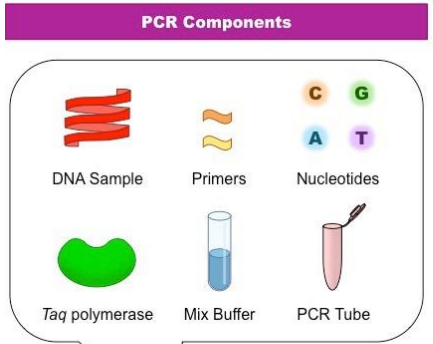


Building Tree



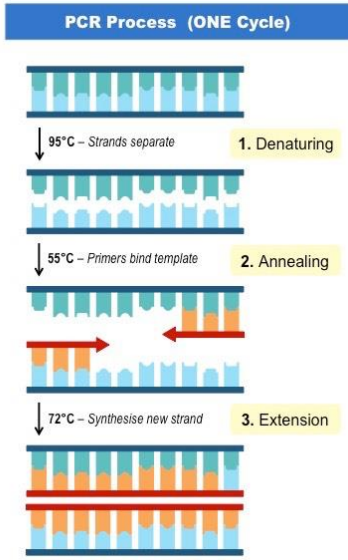
DNA sequence alignment using ClustalX

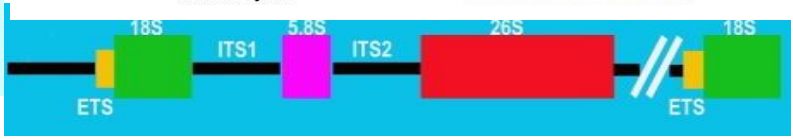


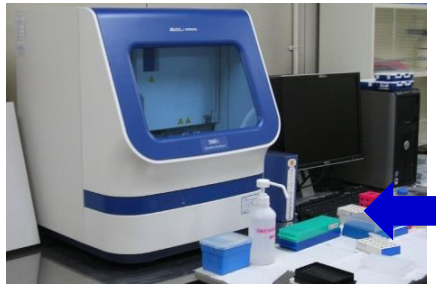


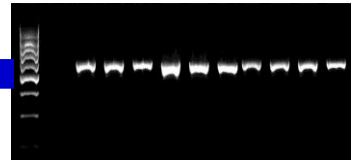
Thermal Cycler

PCR Cycle





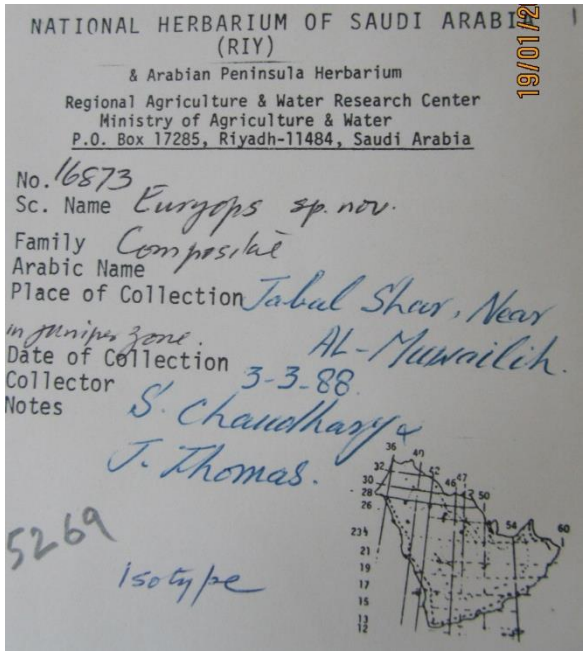




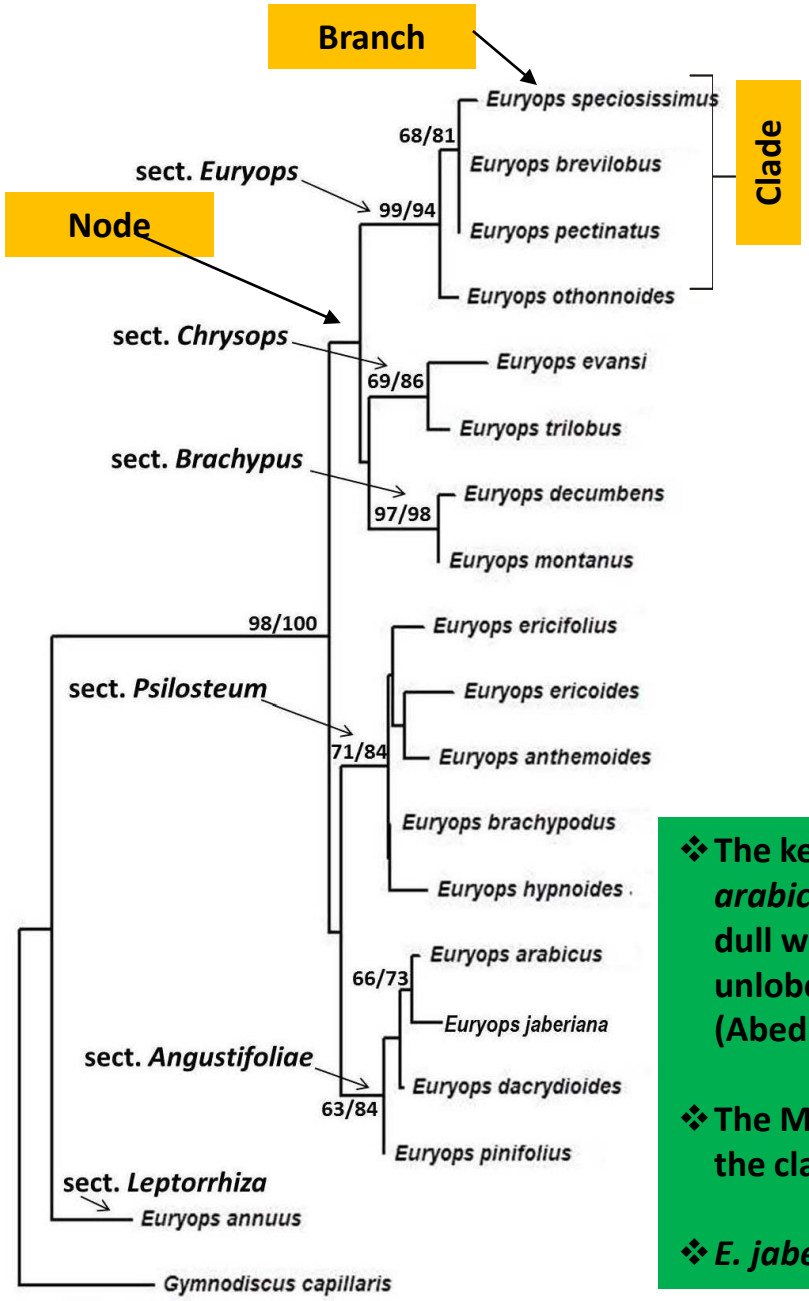
Phylogenetic Implication of Molecular Genotyping of *Euryops jaberiana* Abedin & Chaudhary (Asteraceae)

E. arabicus

- In Saudi Arabia, the genus *Euryops (*family Asteraceae) is represented by two species, *viz*. *E. arabicus* Steud. *ex* Jaub. & Spach, and *E. jaberiana* Abedin & Chaudhary.
- *E. arabicus* is is endemic to Arabian Peninsula, while *E. jaberiana* is endemic to northern Saudi Arabia.
- Morphologically *E. jaberiana* very closely resembles with *E. arabicus* / very narrow differences in m morphological characters (Abedin and Chaudhary, 2000).
- The taxonomic status of *Euryops jaberiana* Abedin & Chaudhary (tribe Senecioneae, was evaluated (Ali et al., 2016) based on molecular phylogenetic analyses of internal transcribed spacer sequence (ITS) of nuclear ribosomal DNA (nrDNA) in order to ascertain its position within the genus.



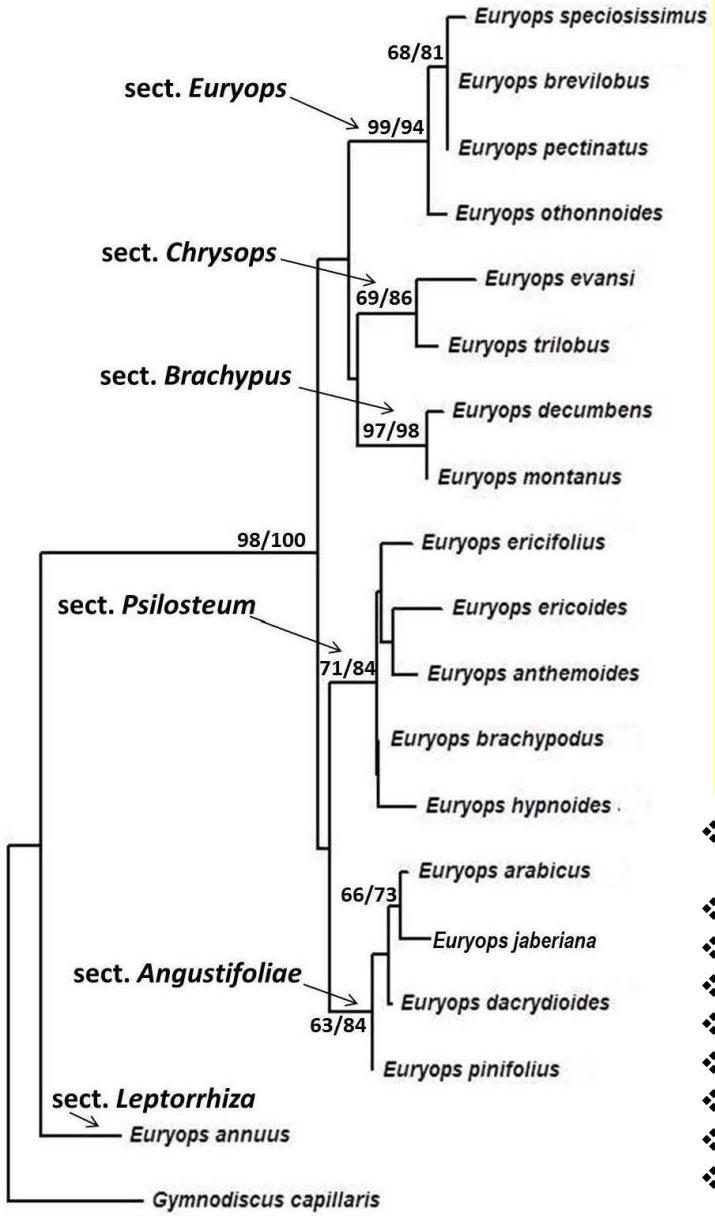
Phylogenetic Implication of Molecular Genotyping of *Euryops jaberiana* Abedin & Chaudhary (Asteraceae) Contd……

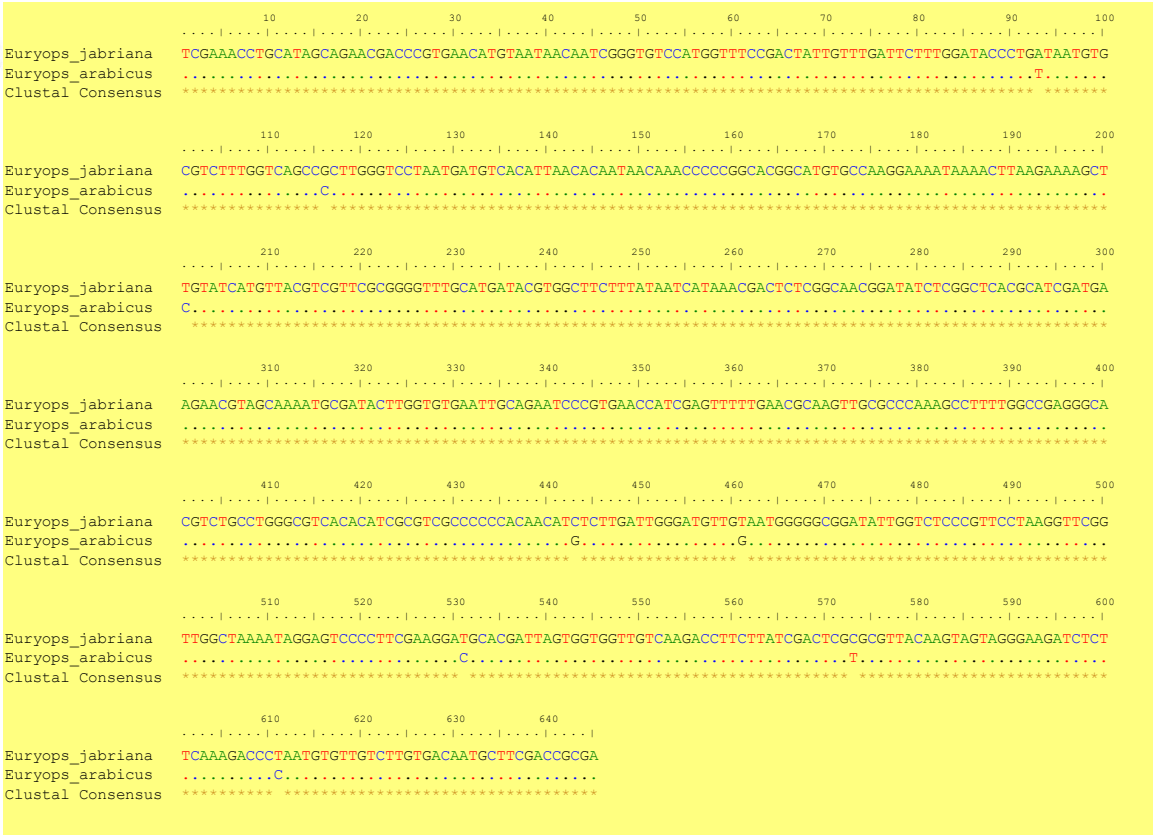


- In molecular taxonomic studies, the most convenient way of presenting taxonomic relationships among a group of organisms is the phylogenetic tree.
- Node: a branch point in a tree
- Branch: defines the relationship between the taxon
- Topology: the branching patterns of the tree
- Branch length: represents the number of changes that have occurred in the branch
- Clade: a group of two or more taxa closed together based on DNA sequences data analsysis
- Maximum parsimony is an optimality criterion under which the phylogenetic tree that minimizes the total number of character-state changes is to be preferred.
- Bootstrap: Bootstrapping is a procedure where DNA sequence data run for the phylogenetic analysis, and the reported value is the percentage of bootstrap replicates, for examples 100 means that the node is well-supported, it showed in all tress.

- The key morphological features which differentiate *E. jaberiana* from *E. arabicus* are: leaves 3-lobed at the tips, pappus hairs transparent or rarely dull white, and achenes glabrescent, while in *E. arabicus*, the leaves are unlobed, pappus hairs are dull white and achene densely lanate hairy (Abedin and Chaudhary, 2000).
- The Maximum Parsimony analyses reveals that *E. jaberiana* nested within the clade of the section *Angustifoliae*.
- *E. jaberiana* shows proximity with *E. arabicus* (66% bootstrap support.

Phylogenetic Implication of Molecular Genotyping of *Euryops jaberiana* Abedin & Chaudhary (Asteraceae) Contd……





- A total of eight specific nucleotide differences were detected between *E. jaberiana* and *E. Arabicus i.e.* at the alignment position:
- 93 (A →T)
- 116 (G → C)
- 201 (T → C)
- 443 (C → G)
- 461 (T → G)
- 531 (T → C)
- 573 (C → T)
- 611 (T → C)

Thus on the basis of phylogenetic relationships of *E. jaberiana* within the genus and nucleotide differences, Ali et al. (2016) recognized *E. jaberiana* as a distinct species and different from *E. arabicus.*

ONLINE RESOURCES OF PLANT TAXONOMY

- World Checklist of Selected Plant Families
- Tropicos **nomenclatural, bibliographic, and specimen data**
- Global Biodiversity Information Facility
- The New York Botanical Garden Virtual Herbarium
- National Center for Biotechnology Information
- GenBank — Nucleotide
  Alphabet of Life
- Biodiversity Heritage Library
- Wikispecies
- Catalogue of Life
- African Plant Database
- JSTOR Plant Science
- Herbarium Catalogue
  Royal Botanic Gardens, Kew
- Encyclopedia of Life
- Royal Botanic Gardens, Kew
  Plant information portal
- Google Images

LITERATURE OF PLANT TAXONOMY

Records: Library and Herbarium

Publications:

Monograph - covers a specific group of plants: family, genera, etc. (Revisions, Synopses)

Flora - Treatment of plants in a defined geographical area

Taxonomic journals

- **American Journal of Botany** (http://www.amjbot.org)
- **Annals of the Missouri Botanic Garden** (http://www.mbgpress.org/)
- **Australian Journal of Botany** (http://www.publish.csiro.au/nid/65.htm)
- **Botanical Journal of the Linnaean Society** (http://www.blackwellpublishing.com/jnl_default.asp)
- **Botanical Review** (http://sciweb.nybg.org/science2/BotanicalReview.asp)
- **Brittonia** (http://www.nybg.org/bsci/brit/)
- **Canadian** Journal of Botany (http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_desc_e?cjb)
- **Fieldiana** (Botany) http://www.fortsasbooks.com/publish.htm
- **Grana** (http://www.tandf.co.uk/journals/titles/00173134.asp)
- **International Journal of Plant Sciences** (http://www.journals.uchicago.edu/IJPS/home.html)
- **Molecular Biology & Evolution** (http://mbe.oupjournals.org)
- **Molecular Phylogenetics & Evolution** (http://www.elsevier.com)
- **Nordic Journal of Botany** (http://www.nathimus.ku.dk/bot/b_nordic.htm)
- **Novon**(http://www.mbgpress.org/)
- **Smithsonian Contributions to Botany** (http://www.sipress.si.edu/the_press/press_main.html)
- **Systematic Biology** (http://systbiol.org)
- **Systematic Botany** (http://www.sysbot.org/)
- **Taxon** (http://www.botanik.univie.ac.at/iapt/s_taxon.php)

History of Botanical Studies in Saudi Arabia Contd....

- Kitab al Nabat by A.H. Dinawari (895 A.D.): A comprehensive knowledge of the agriculture and medicinal practices of the Bedouins.
- Discussion about Arabian plants is available in the manuscript Istakhri (915-919 A.D.), Idrisi (11153 A.D.), A.Al-Fida (1331 A.D.).
- Peher Forsskal (1736-1763): Stay in the southern parts of the Arabian Peninsula, and collected a significant number of plants from Yemen and Jizan Region. Some of these plants were described as new in the posthumous publication "Flora Aegyptiaca-Arabica" by Niebuhr (1775).

FLORA
ÆGYPTIACO-ARABICA.
SIVE
DESCRIPTIONES
PLANTARUM,
QUAS
PER
ÆGYPTUM INFERIOREM
ET
ARABIAM FELICEM
DETEXIT, ILLUSTRAVIT
PETRUS FORSKÅL.
PROF. HAUN.

POST MORTEM AUCTORIS
EDIDIT
CARSTEN NIEBUHR.

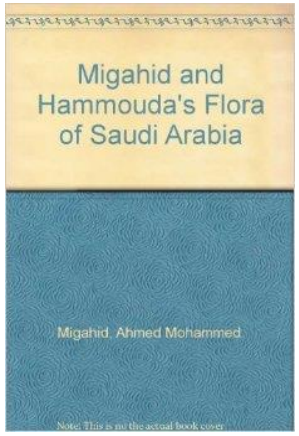
ACCEDIT
TABULA ARABIÆ FELICIS GEOGRAPHICO-BOTANICA.

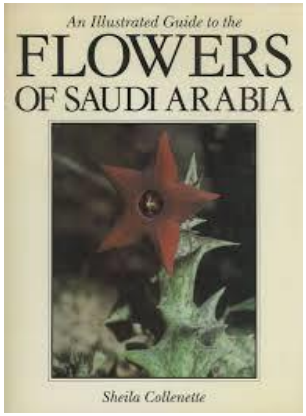
HAUNIÆ, 1775.
EX OFFICINA MÖLLERI, AULÆ TYPOGRAPHI.
PROSTAT APUD HEINECK ET FABER.

- Ehrenberg (1825) visited some of the Red Sea Islands, and Studied mainly microorganisms.
- There were some further visitors too in the Arabian Peninsula region but their collection are not available in any Herbarium), like Ehrenberg (1820-26), Aucher-Eloy (1830), Kotschy and Schimper (1836), Anderson (1859), Pelley (1865), Balfour (1880), Schweinfurth (1888), Deflers (1893).
- J.R. Wellsted (1833) traveled along the southern coast of Arabia and collected some plants.
- E. Combes and M.O. Tamisier in the middle of the 19th century accompanied an Egyptian expedition team to the mountains of Asir. Their records were published in the "Voyage en Abssinie et 1` Arabie" in 1851.

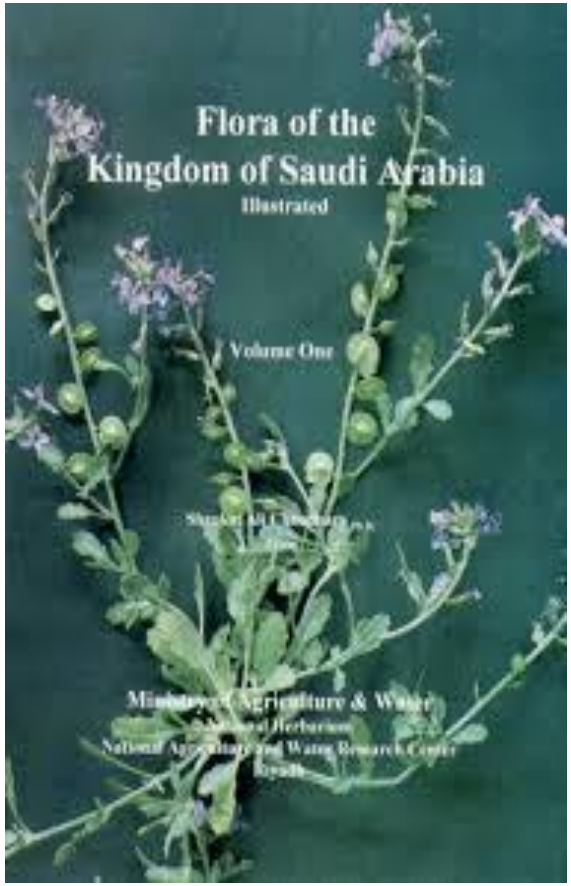
History of Botanical Studies in Saudi Arabia

- Musil (1909) and Philby (1917) were studied plants of arbian peninsula region during early 19th century.
- E. Blatter (1919-1936) compiled most of the major and minor collections of the previous visitors and published a detailed checklist of the wild plants of Arabia (Flora Arabica).
- The collections of DeMarco (DeMarco & Dinelli, 1974), as part of the work of Italconsult Company for the survey of Agriculture Development, and Mandaville (Saudi Aramco during 1960's) were also remarkable. These collections were deposited in the British Herbaria.





- A.M. Migahid, A.El-Sheikh, U. Bairele, P. Kong, H.M. Hassan, H.A. Abulfatih were also collected plant from different region of Saudi Arabia . The collections are deposited in the Herbarium (KSU) of Botany & Microbiology, King Saud University. The flora of Saudi Arabia appeared in 1974, 1978 and 1988-1990.
- S. Collenette (1972-1999) : Collections are deposited in the Royal Botanic Gardens (E), Edinburgh and RBG, Kew (K), a set of which is also deposited at the National Herbarium (RIY) of the Ministry of Agriculture.
- The floristic wealth of Saudi Arabia was enumerated approximately 15 years ago in the three volumes of ‘Flora of Saudi Arabia’ (by S. Chaudhary).



THANKS