

**INTRODUCTION**

**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.
* Study of plants science helps to enhance the abilities of plants to provide more food, medicines and others useful things.
* Plants can be a source of biofuels. Sugars, starches and cellulose can be fermented into ethanol. Ethanol is used as fuel.

**Number of organism, name of the major habitats of the world and need of classification**

* We have millions of different kind of plants, animals and microorganism occurs in different types of habitat sucha as Mountain, Coniferous Forest, Deciduous Forest, Grassland, Mediterranean areas, Tundra, Hot Desert, Tropical Rain Forest and Savanas. We need to scientifically identify, name and classify the entire living organism.

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| --- | --- |
| **Plants** | **No. of species** |
| Mosses | 15,000 |
| Ferns | 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 |

**Definition of Taxonomy**

* **Taxonomy / Systematics** is the branch of science deals with classification of organism.
* The branch of science deals with classification of organism plants such as Algae, fundi, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms is called as **Plant Taxonomy / Plant Systematics**

**Taxonomic Hierarchy**

* Carrolus Linnaeus first adopted the hierarchic system of taxonomy classification in the year 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 of Plant taxonomy**

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.

**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.

**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 in the herbarium.
* The FLORA is the main Resources of Taxonomic Information.
* **Flora**: It is the documentation of plants occurring in a particular region.

**PLANT STRUCTURE (MORPHOLOGY AND ANATOMY)**

**General introduction about Angiosperms:**

* The flowering plants are called as Angiosperms.
* There are two types of Angiospermic plants: Monocot Plants and Dicot Plants.
* Dates, Rice and Grass is a Monoct Plants.
* Mint and Cashew is a dicot plant.
* There are about 400,000 Angiosperms plants occurs in different parts of the world.
* Flowering plants occurs in all the climatic condition such as very cold to very hot climatic condition.
* *Wolfia* is a smallest Angiosperms.
* There are several Angiospermic plants which occurs in water called as aquatic plants.
* *Nymphea* is an example of aquatic plants.
* *Agave* is a common example of monot angiosperms occurs in desert condition.

**Morphology**

* **Plant Morphology:** Study of external structure of a plant.
* **Plant Anatomy:** Study of Internal structure of a plant.
* **Economic Botany:** The study of the relationship between people and plants.
* **Palynology:** Study of pollen grains.
* **Vegetative (non-reproductive) organs:** Flowering plants possess three kinds of vegetative (non-reproductive) organs: Roots, Stems, and Leaves.
* There are two types of systems in plants. They are root system and Shoot system.
* **Root system:** the root system anchors the plant, absorbs water and minerals from soil, storage the food, and sometimes helps in propagation or asexual reproduction.
* **Shoot system:** The shoot system consists of stem, leaf and reproductive parts. The Stem supports and places leaves, transports H2O and nutrients. The main function of Leaves is photosynthesis. The Reproductive structures of Angiospermic plant is Flowers.

**Root**

* **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 the plants.
* **Different types of roots:**
* **Tap Root:** A straight tapering root growing vertically downwards and forming the centre from which subsidiary rootlets spring.
* **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
* **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.
* **Adventitious Roots:** Some roots, called adventitious roots, arise from an organ other than the root, usually from stem, sometimes a leaf.
* **Prop roots:** The adventitious root when modified for aerial support, are called prop roots
* **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
* Carrot is modified root for storage

**Stem**

* **Stem:** the main body or stalk of a plant or shrub, typically rising above ground. The stem holds leaves and flowers.
* **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 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
* **Modification of stem:**
* Rhizome, Corm, bulb, and Tuber is modified stem.
* Zinger is Rhizome type of modified underground stem.
* Onion is Bulb type of modified underground stem.
* Potato is Tuber type of modified underground stem.

**Leaf**

* **Leaf:** A leaf is an organ of a vascular plant, and is the principal lateral appendage of the stem. 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. Midrib is the large central vein.
* **External Parts of the Leaf:**
* **Petiole:** Leaf stalk or part that connects the leaf to the stem.
* **Blade:** The large, flat part of a leaf.
* **Midrib:** The large center vein.
* Some plant species have evolved modified leaves that serve various functions. For example: climbing, pollinator attraction, storage, digestion, prevention of water loss, etc.
* **Types of Leaves:**
* There are two types of leaf. They are Simple leaf and Compound leaf.
* **Simple leaf:-** A simple leaf is a single, undivided blade.
* **Compound leaf:-** In a compound leaf, the blade consists of multiple leaflets. The leaflet has no axillary bud at its base.
* **Doubly compound leaf (Bipinnate):** In a doubly compound leaf, each leaflet is divided into smaller leaflets.
* **Palmately compound:** With leaflets from one point at end of petiole.
* **Pinnately compound:** With leaflets arranged oppositely or alternately along a common axis.
* **Bipinnately compound:** With two orders of leaflets, each pinnately compound
* **Leaf Venation:** The arrangement of veins in a leaf is called as Leaf Venation. The leaf venation is of two types. The leaf venation in monocot plant is of Parallel Type. Dates is common example of Parallel Type of Leaf Venation. In the Dicot plant the leaf venation is of Reticulate Type.
* There are large number of terminology leaf is based on Margin, Apex, Base, Venation, Arrangement, Petiole, Modifications
* **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. Spines in cactus is modified leaf.
* **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
* **Carnivorus 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

**Flower:**

* **Flower:** The flower is the reproductive organ of the Angiosperms / Flowering plants.
* **Flower:** The seed-bearing part of a plant consisting of reproductive organs (stamens and carpels) that are typically surrounded by a brightly colored corolla (petals) and a green calyx (sepals).

**Fruits and seeds:**

* **Fruit:** A fruit is the seed-bearing structure in flowering plants formed from the ovary after flowering.
* **Seed:** A seed is a sporophyte embryo with its own food supply in a protective coat.
* **Cotyledon:** An embryonic leaf in seed-bearing plants, one or more of which are the first leaves to appear from a germinating seed.
* Plants can be categorized in tow broad groups on the basis of cotyledon.
  + **Monocotyledons (Monocots):-** have a single cotyledon or seed leaf
  + **Dicotyledons (Dicots):-** have two cotyledon or seed leaves

**Plant Anatomy (internal morphology of the plant)**

**Plant Tissue:** Group of cells having similar structure and function is called as tissue). There are four plant tissue systems:

* **Ground tissue system:** (Parenchyma tissue, Collenchyma tissue, Sclerenchyma tissue)
* **Vascular tissue:** includes: (Xylem tissue and Phloem tissue)
* **Dermal tissue:** (Epidermis). The epidermis contains stomata. Openings in the epidermis on the underside of a leaf where gases are exchanged are called stomata.
* **Meristematic tissue:** (Dividing tissue)

**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 a flower:**
* **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.
* **Important terminology of the flower**
* **Unisexual and Bisexual Flower:**
* **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).
* **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).
* **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**
* **Hypogynous flower:** Superior ovary (ovary above stamens which are above perianth). Stamens and perianth hypogynous.
* **Perigynous flower:** Superior ovary. Stamens and perianth perigynous that is their bases are united into a hypanthium which holds then level with ovary.
* **Epigynous flower:** inferior ovary. Stamens and perianth epigynous that is positioned above the ovary in a hypanthium.
* **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).
* **Inflorescence**
* Inflorescence: An inflorescence is an arrangement of one or more flowers on a floral axis.
* The type of the inflorescence is determined by Number of flowers, Positional relationships, Degree of the development of their pedicels, Nature of their branching pattern.
* There are two different types of inflorescence. They are Simple Inflorescence and Compound Inflorescence.
* Terminal is a type of Simple Inflorescence. In the Terminal type of Simple Inflorescence the flower at the tip of a stem. The common example of this type of inflorescence is *Hibiscus coccineus*
* In the Compound Inflorescences there are two or more flowers in every inflorescence. For example Sunflower. Spike, Catkin, Raceme, Umbel, corymb, Panicles and head are the different types of compound inflorescence.
* **Spike:** elongate inflorescence; flowers are sessile, dense, or remote from one another.
* **Catkin:** A spike like inflorescence of unisexual flowers; found only in woody plants.
* **Raceme:** an elongate inflorescence of pedicellate flowers on an unbranched rachis.
* **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.
* **Corymb:** a flat-topped or somewhat rounded inflorescence in which the pedicels of varying length are inserted along the rachis.
* **Panicle:** a much-branched inflorescence with a central rachis which bears branches which are themselves branched.
* **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.

**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
* **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.
* **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
* **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
* **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:
* **Artificial** taxonomy was a system of grouping unrelated plant species by a common criteria (i.e. a flowers sexual organs)
* **Natural** 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 ‘Species Plantarum’ 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
* **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. The classification was as follows:

**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,

Subclass DICOTYLEDONES MONOCHLAMIDEÆ.

**Class GYMNOSPERMEÆ** (Gymnosperms are placed between Dicotyledons and Monocotyledons)

**Class MONOCOTYLEDONES**

* **Engler and Prantl System of Classification**
* 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:

Subdivision 1. Gymnospermae,

Subdivision 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

**Classification**

* + - 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

**NOMENCLATURE**

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

**Code I.** Principles

**Code II.** Rules and recommendations

**Code 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. **TYPIFICATION:** The application of names of taxonomic groups is determined by means of nomenclatural types / Typification.
3. **Priority Of Publication:** Nomenclature of a taxonomic group is based upon Priority Of Publication.
4. **Only One Correct Name:** 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. **Latin name:** Scientific names of taxonomic groups are treated as Latin, regardless of derivation.

* 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.

1. The rules of nomenclature are Retroactive (taking effect from a date in the past.), unless expressly limited.

* **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
* **Effective publication:** Effective publication in the journal, available to Botanist.
* **Date of valid publication (Principles of priority):** When it is necessary to choose between two or more names or epithets which have been applied within a given taxonomic group, the principle of priority of publication is applied, the earliest name or epithet which will be in accordance with the rules being chosen.
* **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 based 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.)

**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 Km2** | **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
* **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
* **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
* **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)
* **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
* **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
* **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

**TAXONOMIC EVIDENCES**

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

**Source of Taxonomic Evidences: Plant morphology - (External Characteristics) in Relation to Plant Taxonomy**

* 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.
* 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

Examples of some family possess C4 plants: 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

**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

**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.
* 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.

**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)

**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

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

* 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.
* 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).
* **Important terms related to phylogenetic tree**
* 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.

**Resources of Plant Taxonomy**

**Literature of plant taxonomy**

**Records:** Herbarium

**Publications:**

* **Flora:** Treatment of plants in a defined geographical area
* **Monograph:** covers a specific group of plants: family, genera, etc. (Revisions, Synopses)

**Taxonomic journals**

1. American Journal of Botany
2. Annals of the Missouri Botanic Garden
3. Australian Journal of Botany
4. Botanical Journal of the Linnaean Society
5. Botanical Review
6. Brittonia
7. Canadian Journal of Botany
8. Fieldiana (Botany)
9. Grana
10. International Journal of Plant Sciences
11. Molecular Biology & Evolution
12. Molecular Phylogenetics & Evolution
13. Nordic Journal of Botany
14. Novon
15. Smithsonian Contributions to Botany
16. Systematic Biology
17. Systematic Botany
18. Taxon

**HISTORY OF BOTANICAL STUDIES IN SAUDI ARABIA**

* 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).
* 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.
* 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).

**The End**