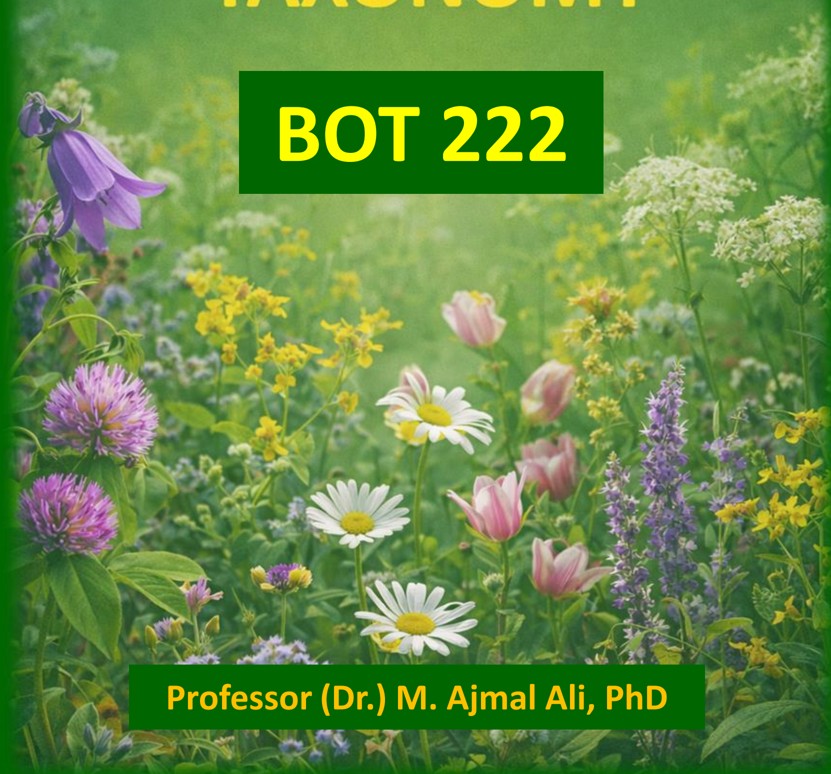
جامعة
الملك سعود
King Saud University

PRINCIPLES OF FLOWERING PLANT TAXONOMY

BOT 222



Professor (Dr.) M. Ajmal Ali, PhD

WEEK- 1

هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA

2023
TP-153

Course Specification
(Bachelor)

Course Title:	Principles of Flowering Plant Taxonomy
Course Code:	BOT 222
Program:	BSc-Botany
Department:	Botany and Microbiology
College:	Science
Institution:	King Saud University
Version:	2023
Last Revision Date:	Nov. 11, 24

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: 1 (1+0)	
3 (2+0+2)	
2. Course type	

A.	☐University	☐College	☒ Department	☐Track	☐Others
B.	☒ Required		☐Elective		

3. Level/year at which this course is offered: (5th level)

5th level

4. Course general Description:

- This course introduces students to the evolutionary relationships among the flowering plants and the processes that gave rise to their existing taxonomic hierarchy.
- The systematic identification of Ontario's major flowering plant families is learned in labs.
- The methods, rules, and history of flowering plant taxonomy are presented in lectures. An individual herbarium project is also completed.

5. Pre-requirements for this course (if any)**:**

BOT 102

6. Co-requisites for this course (if any)**:**

NA

7. Course Main Objective(s):

•Define the principles and rules of plant nomenclature
• Describe the various forms of taxonomic evidence used to classify flowering plants
• Recognize and describe the key characteristics of different flowering plant families, including their morphological characteristics, ecology, distribution, and principal uses
• Explain the principles of phylogenetic reconstruction and how understanding of evolutionary relationships is applied to studying plant systematics.
• Use a herbarium and know how to access herbarium databases
• Apply taxonomic methodology to identify unknown plant species
• Prepare botanical illustrations and floral diagrams
• Construct your plant descriptions using botanical vocabulary

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom		%100
2	Blended		
3	• E-learning		
4	Distance learning		
5	Other		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	Lectures	30
2.	Laboratory/Studio	30
3.	Tutorial	
4.	Others (specify)	
Total		60

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

By the end of this course students will be able to:

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	Ability to identify the principles and rules of plant nomenclature	K1	Lecture Topics Presentation, laboratories & e-learning	Monthly exams Topics discussions Practical. exam Presentations Final exam
1.2	Ability to describe the flowering plants (flower parts, inflorences, froutstypes, and seeds)	K3	Lecture Topics Presentation, laboratories & e-learning	Monthly exams Topics discussions Practical. exam Presentations Final exam
2.0	Skills			
2.1	Ability to collect related information about plant taxonomy and its terms.	S1	Web search report	Practical. exam Discussion. - Final exam
2.2	Ability to compare different information about different families.	S3	Web search report	Practical. exam Discussion. - Final exam
3.0	Values, autonomy, and responsibility			
3.1	Ability to work within a team and lead it if required	V2	Web search Peers	Practical. exam Discussion Instructor evaluation
...				

C. Course Content:

No	List of Topics	Contact Hours
1.	**Introduction of Flowering plant taxonomy and their Evolution.**	2
2.	**Botanical nomenclature.**	2
3.	**Plant morphology Terms: Stem-Roots-Leaves**	2
4.	**Plant morphology Terms: Flower (Parts and Placentation).**	2
5.	**Plant morphology Terms: Inflorescence, fruits and Floral formula and diagram**	2
6.	**Field trip**	2
7.	Med-Term Exam-1	2
8.	Monocots. Families: Poaceae (Gramineae), Liliaceae (or Alliaceae)	2
9.	Monocots. Families: Cannaceae, Iridaceae, Cyperaceae	2
10	Dicots. Families: Nyctaginaceae Malvaceae, Cruciferae.	2
11	Dicots. Families: Rosaceae, Solanaceae, Leguminosae (Fabaceae).	2
12	Dicots. Families: Verbenacea, Labiatae, Umbelliferae (Apiaceae).	2
13	Dicots. Families: Compositae (Astraceae)	2
14	Exam-2	2
15	Final exam	2
	Total	30

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	First monthly exam	7th	10%
2.	Second monthly exam	14th	10%
3.	Attendance: Topic presentation and discussion	1-14th	10%
4.	Practical	1-14th	30%
5	Final exam	15th	40%
	Total		100

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	1- T. G. Lammers, *Course Manual: Biol 304/504 Plant Taxonomy, 3rd* ed. (UWO Doc Services, 2007). 2- شكري سعد: تصنيف النباتات الزهري دار الفكر العربي-مصر
Supportive References	Journals in Plant Taxonomy Science

Electronic Materials	https://letstalkscience.ca/educational-resources/backgrounders/plant-taxonomy https://employees.csbsju.edu/SSAUPE/biol308/lecture_notes.htm
Other Learning Materials	Computer-based programs/CD, professional standards

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Lecture room provided with data show projector. e-learning room to enable students reading and revising the course. Internet to search new technology concerning the course- -Laboratories with many facilities e.g. dissecting microscopes. -Botanical Garden in Department.
Technology equipment (projector, smart board, software)	AV, data show, Smart Board
Other equipment (depending on the nature of the specialty)	Available

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	**Instructor or the Department**	**Peer to Peer Reviewing**
Effectiveness of Students assessment	**Students**	**Through three student surveys**
Quality of learning resources	**Students & Faculty**	**Evaluation survey,**
The extent to which CLOs have been achieved	**Faculty**	**Course report, analysis of the course evaluation survey, a sample of assignments, homework, answer sheets, and student grades.**
Other		

Assessors (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	ACADEMIC ACCREDITATION COMMITTEE FOR THE DEPARTMENT OF BOTANY AND MICROBIOLOGY
REFERENCE NO.	
DATE	Nov. 11, 24

Key Learning Outcomes for General Botany Programs

2024

S. No.	Topics	Domain	Course Learning Outcome	Teaching Strategies	Key Learning Outcomes Alignment	GKU & SKU Alignment	EKU-6 Alignment (General Biology SLO –	EKU-7 Alignment (Research Skills SLO	EKU-8 Alignment (Interpersonal Skills SLO	Specialized SKU Alignment
1	Introduction of Flowering Plant Taxonomy and their Evolution	Knowledge & Understanding	1.1 Ability to identify the principles and rules of plant nomenclature	Lecture	KLO1: Identify, describe, and define the basic terminology, concepts, methodologies, and theories used within the plant sciences and related disciplines including biology, chemistry, physics, statistics, and mathematics.	GKU 1.2 – Vascular Plant Systematics: Understanding plant classification systems and evolutionary relationships.	SLO 1 (EKU-6): Identify the causal basis of evolutionary diversification and using these concepts to comprehend evolutionary scenarios from the past and the present.	—	—	SKU1.2 SLO-1: Define the goals of systematics and the tools used to examine and explain the evolution of plant variety.
2	Botanical Nomenclature	Knowledge & Understanding	1.1 Ability to identify the principles and rules of plant nomenclature	Lecture, ICN rule-based exercises, short quizzes	KLO3: Demonstrate in-depth the cumulative knowledge in botany at the phenotypic, structural, and evolutionary levels…	GKU 1.1 – Plant Science & Systems: Scientific naming and classification principles.	SLO 2 (EKU-6): State different taxa in the tree of life along with their features and use analytical methods to understand their relationships.	—	—	SKU1.2 SLO-4: Explain… methods used to characterize, name, and categorize species.
3	Plant Morphology Terms: Stem–Roots–Leaves	Knowledge & Understanding	1.2 Ability to describe the flowering plants (flower parts, inflorescence, fruit types, and seeds)	Lecture, Demonstrations, labelled diagrams, guided observation	KLO1: Identify, describe, and define the basic terminology and concepts used within plant sciences.	GKU 1.3 – Plant Form & Function	SLO 1 (EKU-6): Identify the causal basis of evolutionary diversification…	—	—	SKU1.3 SLO-1: Address the fundamental concepts of plant structure and development.
4	Plant Morphology Terms: Flower (Parts and Placentation)	Knowledge & Understanding	1.2 Ability to describe the flowering plants (flower parts, inflorescence, fruit types, and seeds)	Hands-on lab sessions, specimen observation	KLO3: Demonstrate in-depth cumulative knowledge in botany… taxonomy and evolutionary biology.	GKU 1.5 – Basic Plant Anatomy	SLO 3 (EKU-6): Perform experimental and computational techniques to analyze evolutionary processes.	—	—	SKU1.5 SLO-3: Identify anatomical forms and evolutionary diversity based on comparative studies.
5	Plant Morphology Terms: Inflorescence, Fruits and Floral Formula & Diagram	Skills	2.2 Ability to compare different information about different families	Practical exercises, problem-based learning, taxonomy drawing practice	KLO4: Apply practical and field skills in botany and related disciplines.	GKU 1.2 – Vascular Plant Systematics	—	SLO 3 (EKU-7): Gather and analyze data… and evaluate statistical inference.	—	SKU1.2 SLO-2: Use conventional botanical terminology to determine vegetative and reproductive traits.
6	Field Trip	Skills	2.1 Ability to collect related information about plant taxonomy and its terms.	Field observation, specimen recording, guided fieldwork	KLO4: Apply practical and field skills in botany and related disciplines.	GKU 3.5 – Plant Diversity	SLO 4 (EKU-6): Discuss the dimensions of evolutionary concerns…	SLO 2 (EKU-7): Create a thorough experiment or sampling program.	—	SKU3.5 SLO-3: Identify plants, particularly flora of KSA.
7	Plant Families (Monocot and Dicot)	Values, Autonomy & Responsibility	3.1 Ability to work within a team and lead it if required	Group classification tasks, peer-learning, collaborative reporting	KLO10: Demonstrate a commitment to integrity, academic and professional ethics, and the ability to work collaboratively in botanical practices.	GKU 1.2 – Vascular Plant Systematics	—	—	SLO 4 (EKU-8): Recall various factors that influence communication.	SKU1.2 SLO-6: Collaborate with team members to explore biodiversity and systematics.

BOT 222 PRINCIPLES OF PLANT TAXONOMY

THEORY EXAMS (First Term 10 Marks, Second Term 10 Marks, Final 40 Marks= Total 60 MARKS)

FIRST TERM

Full marks: 10, Time 30 minutes

- Multiple choice question (each question possess one marks) (1 X 4 =4 marks)
- Fill in the blanks (each question possess one marks) (1 X 2 =2 marks)
- Mark the True / False (each question possess one marks) (1 X 2 =2 marks)
- Figure based question (each question possess one marks) (1 X 1 =1 marks)
- Short answer question (each question possess one marks) (1 X 1 =1 marks)

SECOND TERM

Full marks: 10, Time 30 minutes

- Multiple choice question (each question possess one marks) (1 X 4 =4 marks)
- Fill in the blanks (each question possess one marks) (1 X 2 =2 marks)
- Mark the True / False (each question possess one marks) (1 X 2 =2 marks)
- Figure based question (each question possess one marks) (1 X 1 =1 marks)
- Short answer question (each question possess one marks) (1 X 1 =1 marks)

FINAL EXAM

Full marks: 40, Time 2 hours

- Multiple choice question (each question possess one marks) (1 X 10 =10 marks)
- Fill in the blanks (each question possess one marks) (1 X 7 =7 marks)
- Mark the True / False (each question possess one marks) (1 X 8 =8 marks)
- Figure based question (each question possess one marks) (1 X 7 =7 marks)
- Match the following (each question possess one marks) (1 X 6 =6 marks)
- Short answer question (each question possess one marks) (1 X 2 =2 marks)

PRACTICAL

Time: 2 hours

Total Marks: 40

Tentative Date:-------------------------

1. Identification of Floral Parts (10 Marks)
- Students will be given dissected flowers. Identify five main floral parts.
- Each correct identification (name + function) carries 2 marks × 5 = 10 marks.

2. Identification of Plants (10 Marks)
- Each correct answer carries 2 marks × 5 = 10 marks.

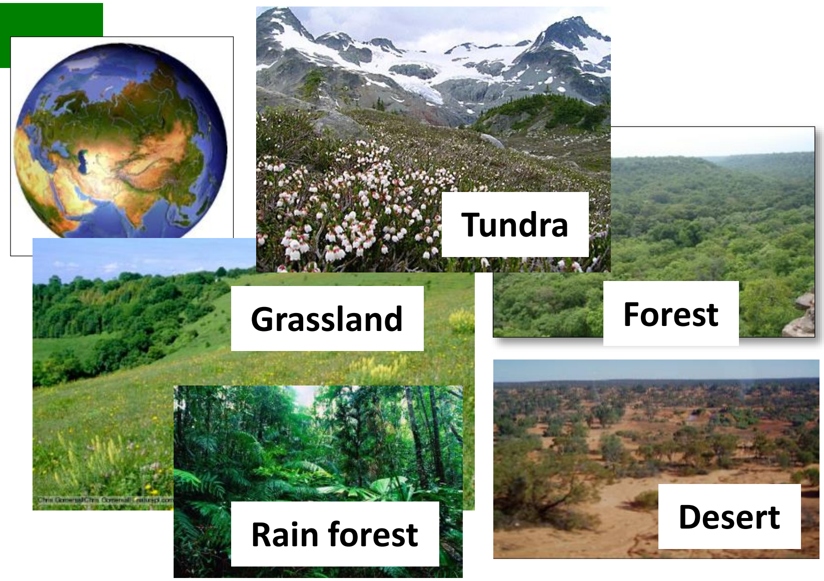
3. Submission of Practical Notebook (5 Marks)
- Students must submit a complete practical notebook with all required notes and experiments.

4. Homework Assignment (5 Marks)
- Write a 500-word essay on "Principles of Plant Taxonomy" in your own words.

5. Teamwork Report (5 Marks)
- Visit a botanical garden and prepare a brief 500-word report, including five photographs of plants.

6. Presentation (PPT) (5 Marks)
- Prepare a 5-slide PowerPoint presentation on "Basic Components of Plant Taxonomy".

What is Taxonomy / Systematics ?



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

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

- **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**

Why Do We Keep Things in Fixed Places or Arrange Them in a System?

Convenience:

Easily locate items when needed.

Saves time and effort during daily activities.

Organization:

Maintains a tidy and clutter-free space.

Enhances the overall aesthetics of the home.

Efficiency:

Promotes efficient use of space.

Prevents duplication or loss of items.

Stress Reduction:

Reduces frustration of searching for misplaced items.

Creates a sense of order and calmness.

Hygiene and Safety:

Keeps hazardous items out of reach.

Ensures a clean and safe living environment.

Conclusion:

"A well-organized home leads to a well-organized life."

"Every Human Being is a Taxonomist"

1.Natural Instinct to Classify:

1. Humans inherently group and categorize objects, people, and ideas based on similarities and differences.

2.Daily Life Examples:

1. **Organizing clothes**: Formal, casual, seasonal.
2. **Sorting groceries**: Fruits, vegetables, snacks.
3. **Arranging books**: Fiction, non-fiction, genres.

3.Purpose of Classification:

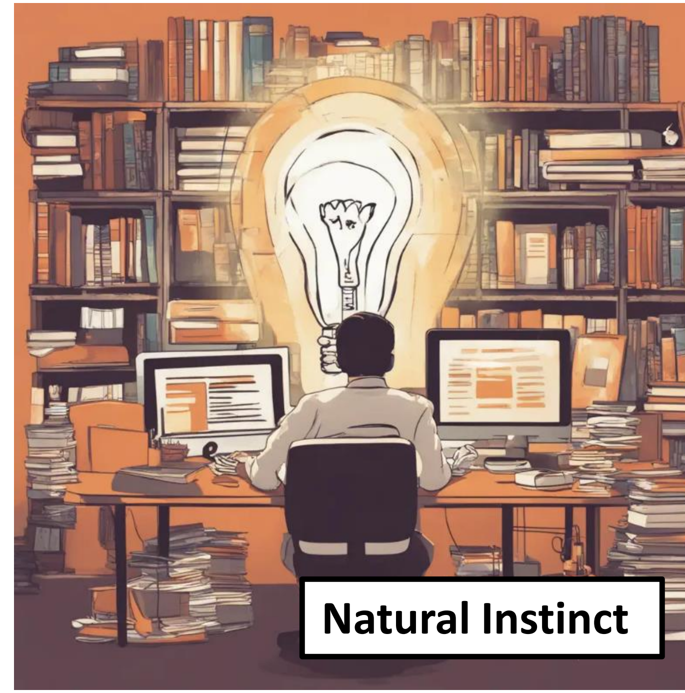
1. Simplifies understanding and decision-making.
2. Helps in recognizing patterns and relationships.

4.Relates to Taxonomy:

1. Just as taxonomy organizes living organisms into hierarchical groups, humans organize everything in life to bring order and clarity.

Conclusion:

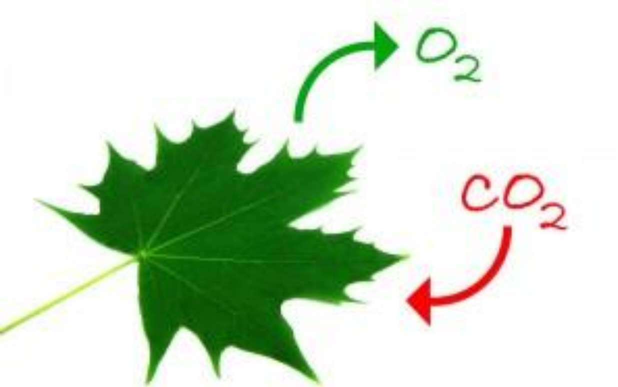
"From childhood to adulthood, everyone practices taxonomy in their own way."



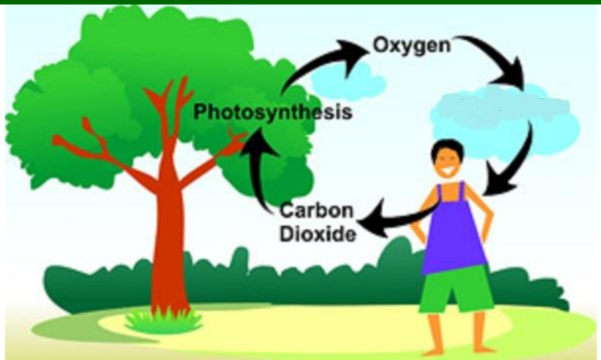
Animal Group	Number of Described Species	Estimated Total Species
Total Animals	~1.5 million	~7.8 million
- Vertebrates	~73,300	~80,000
- Mammals	~6,400	~6,500
- Birds	~11,100	~11,200
- Reptiles	~11,500	~12,000
- Amphibians	~8,400	~8,500
- Fishes	~36,000	~37,000
- Invertebrates	~1.4 million	~7.7 million
- Insects	~1 million	~5.5 million
- Mollusks	~85,000	~200,000
- Crustaceans	~47,000	~150,000

Category	Subcategory	Estimated Number of Species
Flowering Plants (Angiosperms)	Monocots (e.g., grasses, lilies)	~60,000
	Dicots (e.g., roses, sunflowers)	~240,000
Gymnosperms (Non-flowering)	Conifers (e.g., pine, spruce)	~600
	Cycads (e.g., sago palms)	~200
	Ginkgo (1 species)	1
	Gnetophytes (e.g., Welwitschia)	~70
Ferns and Fern Allies	True ferns	~10,500
	Lycophytes (e.g., club mosses)	~1,200
	Horsetails (Equisetum)	~15
Mosses and Liverworts	Mosses	~12,000
	Liverworts	~6,000
Algae	Green Algae	~9,000
	Red Algae	~7,000
	Brown Algae	~2,000
	Diatoms (a type of algae)	~12,000
Lichens	Crustose (flat, encrusting lichens)	~10,000
	Foliose (leafy lichens)	~5,000
	Fruticose (shrub-like lichens)	~5,000
Bryophytes (Mosses, Liverworts, Hornworts)	Hornworts	~300
Charophytes (Green Algae related to land plants)	Charophytes (group related to early land plants)	~500
Total Estimated Plants		**~390,000**

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

Why Do We Study Plants?

Essential for Life:

Plants produce oxygen through photosynthesis, vital for all living organisms.

They form the base of the food chain, supporting all ecosystems.

Source of Food:

Provide grains, fruits, vegetables, and other essential nutrients for humans and animals.

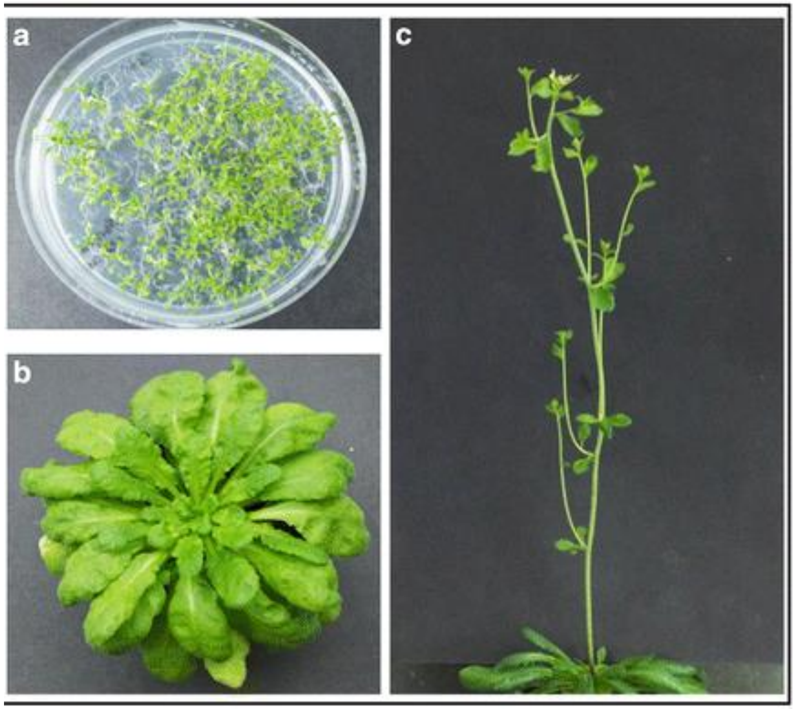
Medicinal Value:

Many medicines are derived from plants (e.g., aspirin from willow bark, quinine from cinchona).

Environmental Benefits:

Regulate climate, purify air, and prevent soil erosion.

Crucial for carbon sequestration and maintaining biodiversity.



Economic Importance:

Provide resources like wood, fibers, paper, and biofuels.

Support industries like agriculture, pharmaceuticals, and cosmetics.

Aesthetic and Cultural Significance:

Beautify surroundings and hold cultural or religious value.

Scientific Research:

Help understand genetics, ecology, and evolution.

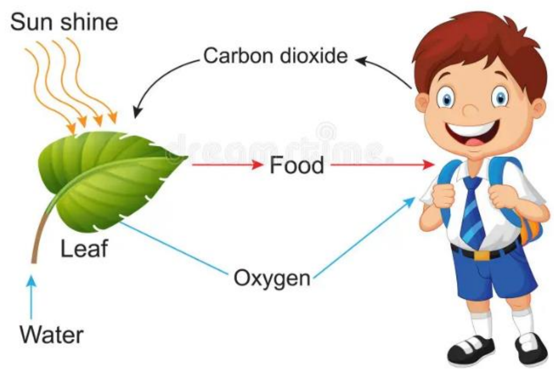
Model organisms for studies (e.g., Arabidopsis thaliana).

Conclusion:

"Studying plants is essential for sustaining life, advancing science, and protecting the planet."

Medicinal Value

Essential for Life



Aesthetic and Cultural Significance

Environmental Benefits

Economic Importance

Scientific Research

WEEK- 2

Plant Taxonomy

Taxonomy vs. Systematics

Taxonomy:

The science of naming, describing, and classifying organisms.

Focuses on creating a hierarchical framework (Domain → Species).

Includes classification, nomenclature, and identification.

Systematics:

The study of biological diversity and evolutionary relationships.

Integrates taxonomy with evolutionary biology.

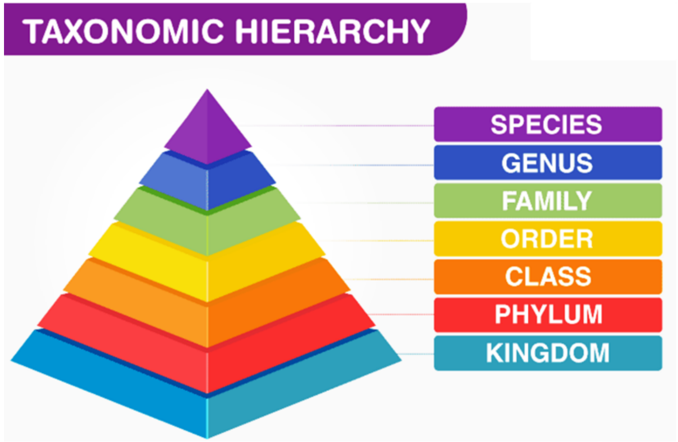
Uses phylogenetics to uncover evolutionary histories.

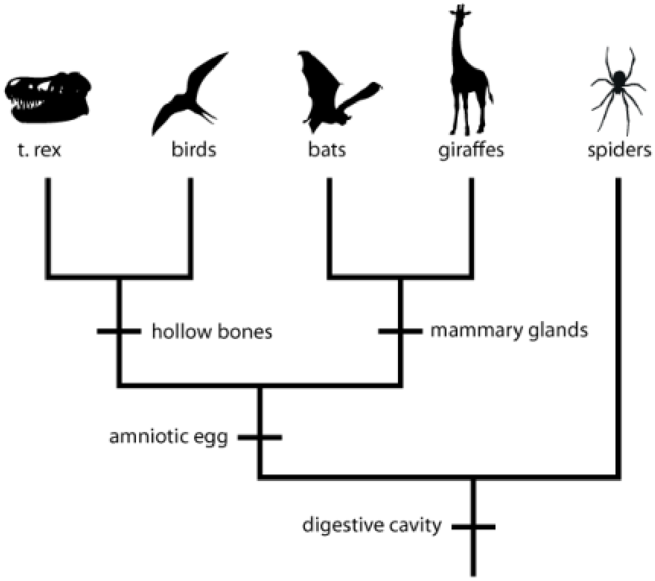
Key Differences:

Taxonomy emphasizes **organization**, while Systematics focuses on **relationships and evolution**.

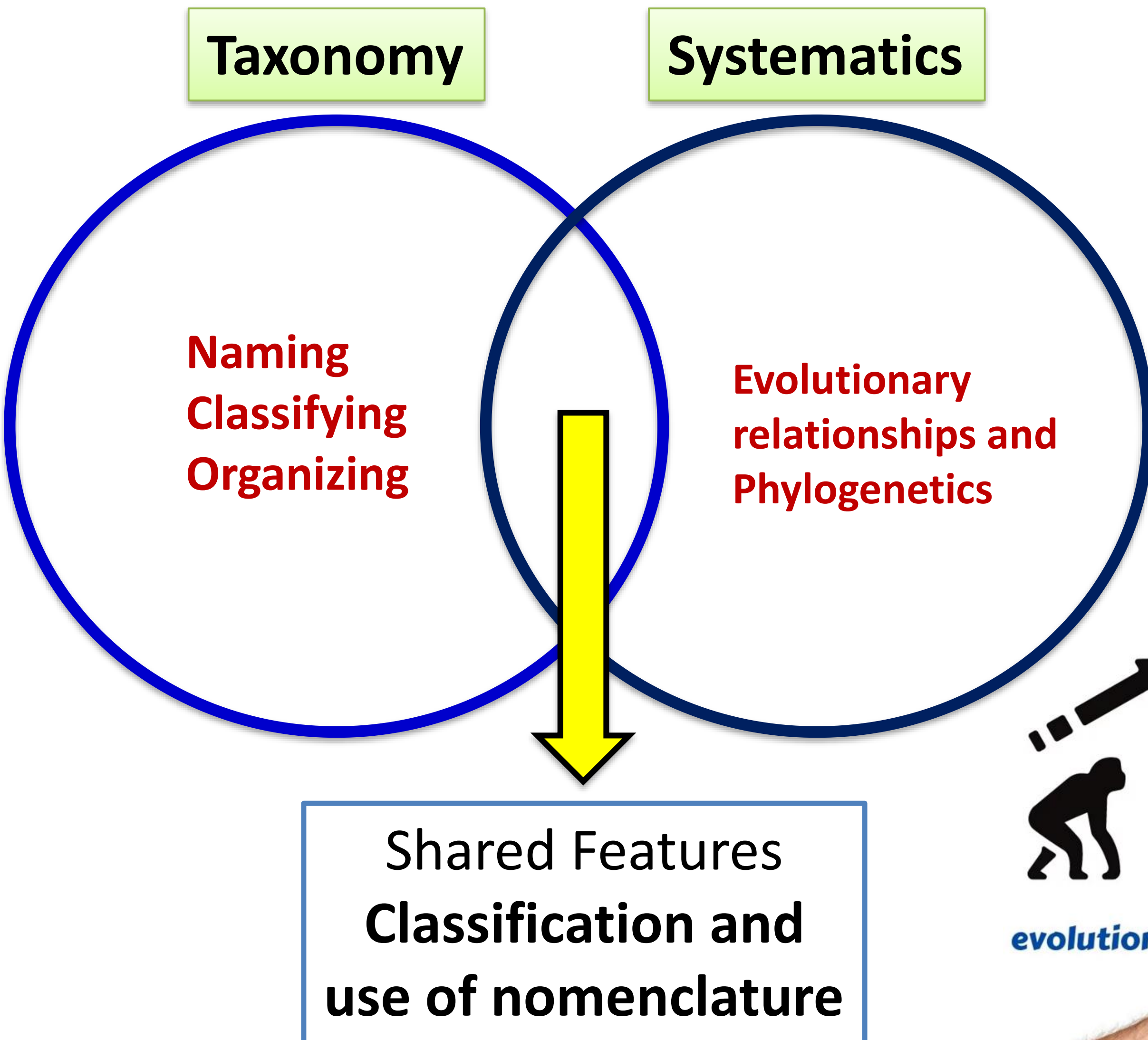
Significance:

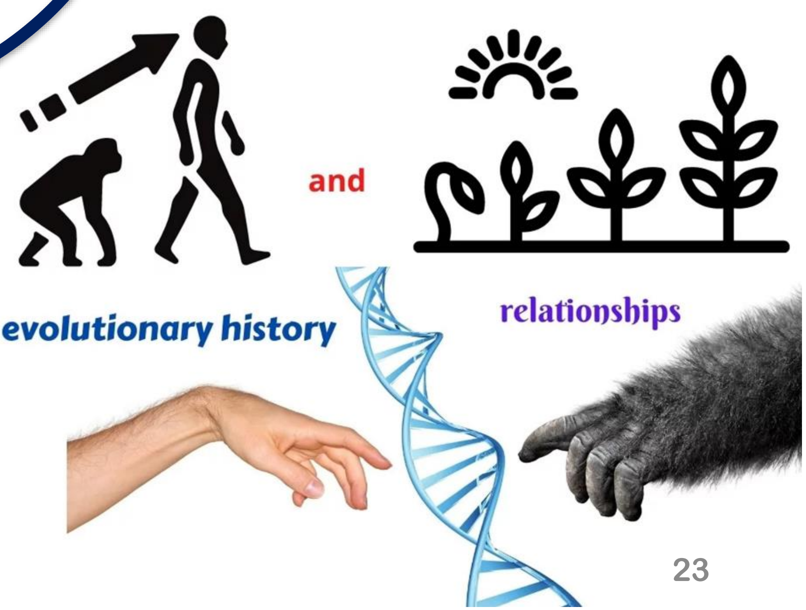
Provides a foundation for biological research, biodiversity conservation, and understanding evolutionary connections.





Comparison Between Taxonomy and Systematics





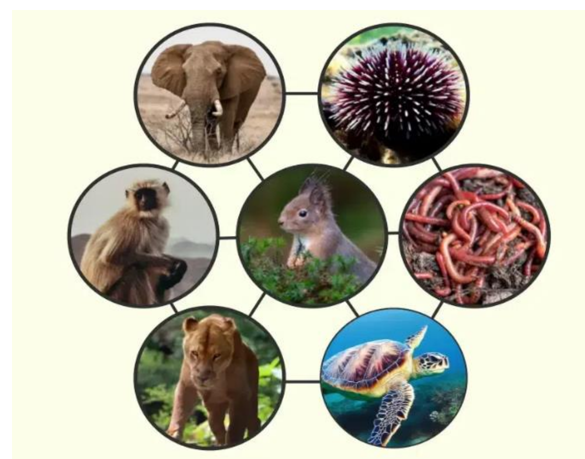
Plant Taxonomy vs. Plant Systematics

Plant Taxonomy:

- The branch of botany concerned with the **classification, naming, and identification** of plants.
- Focuses on creating a structured system (Kingdom → Species) for all plant species.
- Key processes include:
  - **Classification**: Grouping plants into categories.
  - **Nomenclature**: Assigning scientific names.
  - **Identification**: Determining plant species using keys or guides.

Plant Systematics:

- A broader field integrating taxonomy with **evolutionary relationships**.
- Studies plant diversity and **phylogenetic histories** (evolutionary trees).
- Uses tools like DNA sequencing and morphology to uncover relationships.



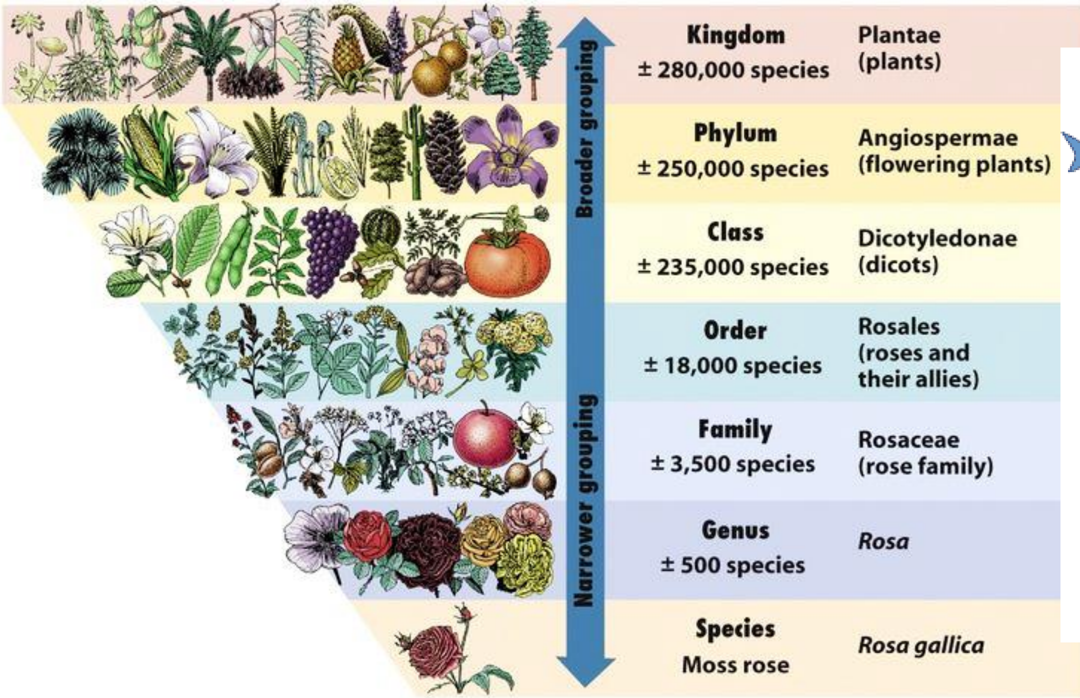
Key Differences:

Taxonomy is about organization and naming.

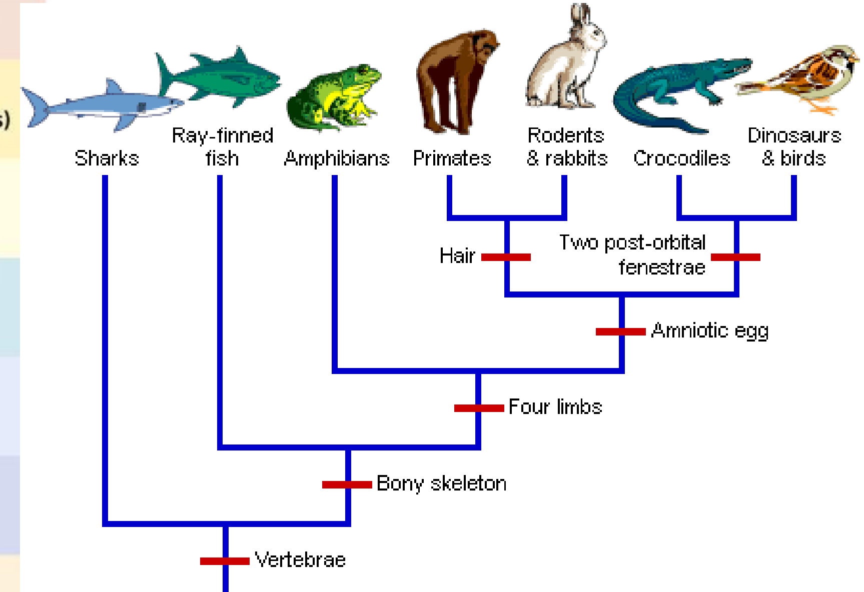
Systematics explores evolutionary connections among plants.

Importance:

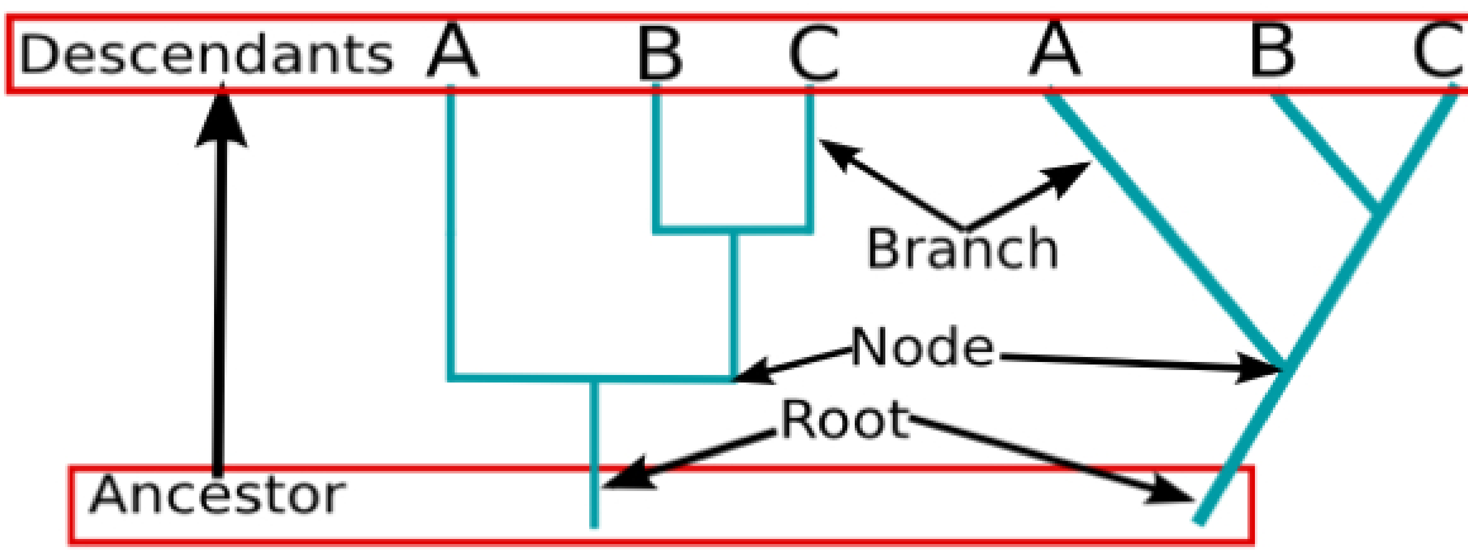
Provides a foundation for conservation, agriculture, and ecological studies.



Taxonomy



Evolutionary trees



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

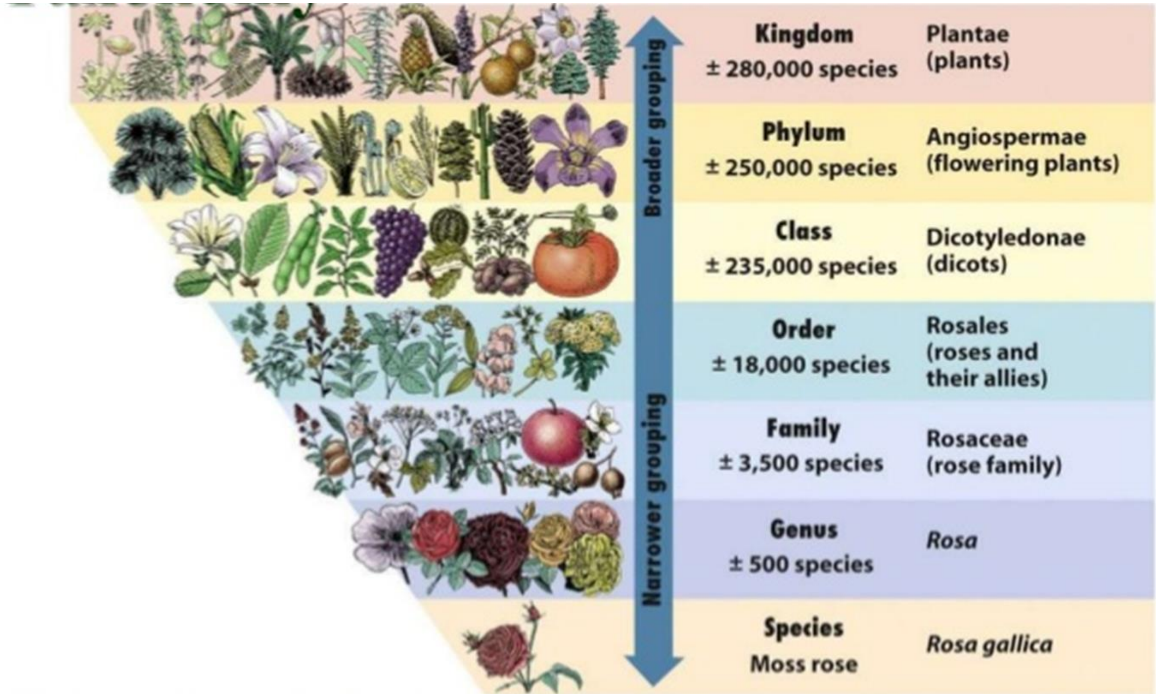
Family : Family is the closely related genera

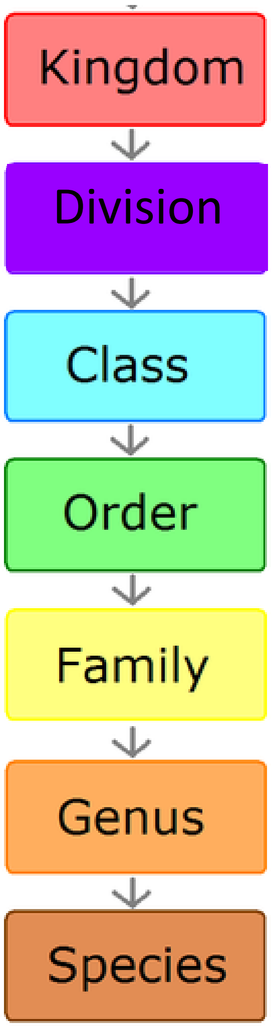
Order : Order is the closely related families

Class : Class are the closely related order

Division / Phylum: Division or Phylum is the related classes

Kingdom: Kingdom is the related Division / Phylum





Ranks in Taxonomic Hierarchy

The ranks are similar for both **plants** and **animals**, but there are slight differences in terminology, particularly for the rank equivalent to **Phylum** in plants.

Common Ranks in Plants and Animals

Domain:

Highest rank; includes all life forms.

Example: Eukarya (organisms with cells containing nuclei).

Kingdom:

Broad group of related organisms.

Plants: Plantae

Animals: Animalia

Phylum (Animals) / Division (Plants):

Groups organisms based on major structural features.

Plants: Magnoliophyta (flowering plants)

Animals: Chordata (vertebrates)

Class:

Subdivision of phylum/division.

Plants: Monocotyledons (monocots)

Animals: Mammalia (mammals)

Order:

Groups families with shared characteristics.

Plants: Rosales (roses, apples)

Animals: Carnivora (meat-eating mammals)

Family:

Collection of related genera.

Plants: Fabaceae (legume family)

Animals: Felidae (cat family)

Genus:

Groups species with close similarities.

Plants: Rosa (roses)

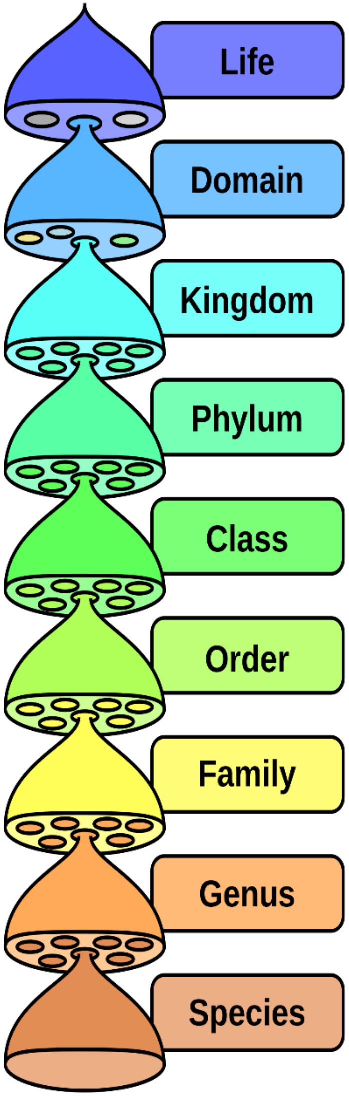
Animals: Panthera (big cats like lions, tigers)

Species:

Basic unit of classification; represents individual organisms.

Plants: Rosa indica (Indian rose)

Animals: Panthera leo (lion)



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.

Objectives / Goals / Aims of Plant Taxonomy

1.Identification:

1. To identify and distinguish different plant species.
2. Helps in assigning names and recognizing unknown plants.

2.Classification:

1. To organize plants into hierarchical groups based on shared characteristics.
2. Facilitates easier study and understanding of plant diversity.

3.Nomenclature:

1. To provide a standardized scientific naming system for plants.
2. Ensures uniform communication across languages and regions.

4.Understanding Evolutionary Relationships:

1. To explore phylogenetic connections and evolutionary histories of plants.
2. Helps trace lineage and ancestral traits.

5.Conservation Efforts:

1. To identify rare, endangered, or endemic plant species.
2. Aids in biodiversity conservation and habitat protection.

6.Economic and Medicinal Importance:

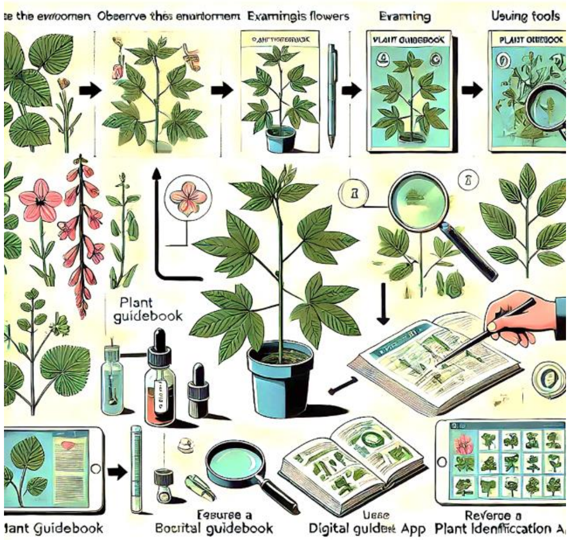
1. To discover plants useful in medicine, agriculture, and industry.
2. Helps in sustainable utilization of plant resources.

7.Biodiversity Documentation:

1. To document plant species in various ecosystems.
2. Provides baseline data for ecological and environmental studies.

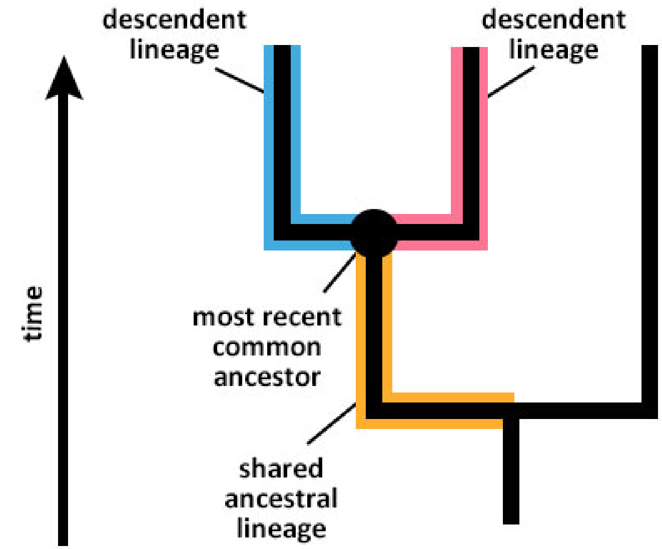
8.Facilitating Scientific Research:

1. Acts as a foundation for studies in genetics, ecology, and biotechnology.



Process of Identification

Conservation



Evolutionary Relationships

Economic and Medicinal Importance

Facilitating Scientific Research

Scope of Taxonomy

Classification and Organization:

Provides a framework to organize and classify all living organisms systematically.

Helps in understanding relationships between organisms.

Identification and Nomenclature:

Assigns scientific names to organisms following standardized rules (e.g., ICN, ICZN).

Facilitates universal communication in biological sciences.

Understanding Evolutionary Relationships:

Studies phylogenetic and evolutionary connections among organisms.

Reveals the history and lineage of species.

Biodiversity Documentation:

Catalogs species to record Earth's biological diversity.

Supports conservation efforts and sustainable resource management.

Applied Fields:

Supports agriculture (e.g., crop classification).

Aids in medicine by identifying medicinal plants and organisms.

Assists in environmental studies and ecosystem management.

Discovery of New Species:

Enables exploration and documentation of unknown or newly discovered species.

Tool for Research:

Forms the basis for studies in genetics, ecology, and biotechnology.

Provides a reference for scientific investigations and experiments.

Conservation Biology:

Helps prioritize and protect endangered species and habitats.

Global Collaboration:

Enables international cooperation by standardizing biological information.

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**

Basic Components (Principles) of Plant Taxonomy / Plant Systematics

1.Identification:

1. Recognizing and assigning plants to known taxa using diagnostic features.
2. Involves fieldwork, herbarium study, and comparative analysis.

2.Classification:

1. Arranging plants into hierarchical groups based on shared characteristics.
2. Systems can be:
   1. **Artificial**: Based on a few specific traits (e.g., size, color).
   2. **Natural**: Considers many morphological traits.
   3. **Phylogenetic**: Based on evolutionary relationships.

3.Nomenclature:

1. Assigning scientific names to plants following the International Code of Nomenclature for Algae, Fungi, and Plants (ICN).
2. Ensures uniformity and stability in naming.

4.Phylogeny:

1. Studying evolutionary relationships among plant groups.
2. Involves constructing phylogenetic trees to show common ancestry.

5.Morphology:

1. Analyzing physical traits (e.g., leaves, flowers, stems) to group plants.
2. A traditional cornerstone of taxonomy.

6.Anatomy and Cytology:

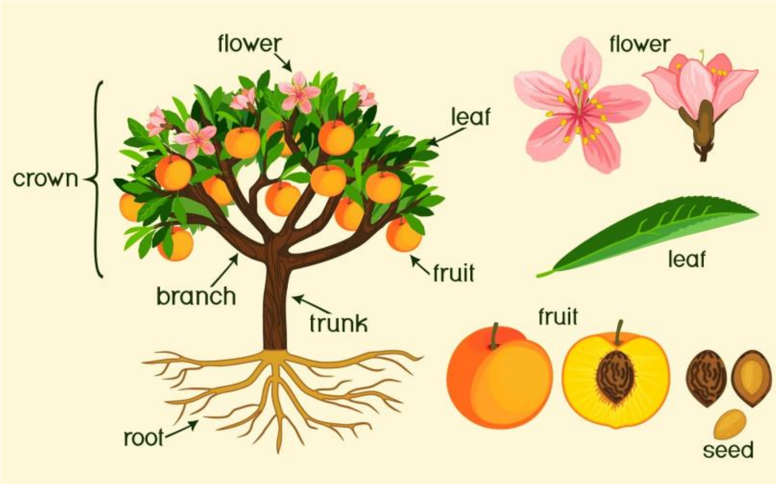
1. Examining internal structures and cell features, including chromosome number and structure.
2. Used for deeper insights into plant relationships.

7. **Biochemical and Molecular Analysis**:
    1. Using DNA, RNA, proteins, and secondary metabolites to study genetic relationships.
    2. Revolutionized plant taxonomy with tools like DNA barcoding.
8. **Ecology**:
    1. Considering the plant's habitat, ecological role, and interactions within ecosystems.
    2. Helps in understanding adaptation and distribution.
9. **Paleobotany**:
    1. Studying plant fossils to trace evolutionary history and extinct taxa.
10. **Documentation and Herbarium**:

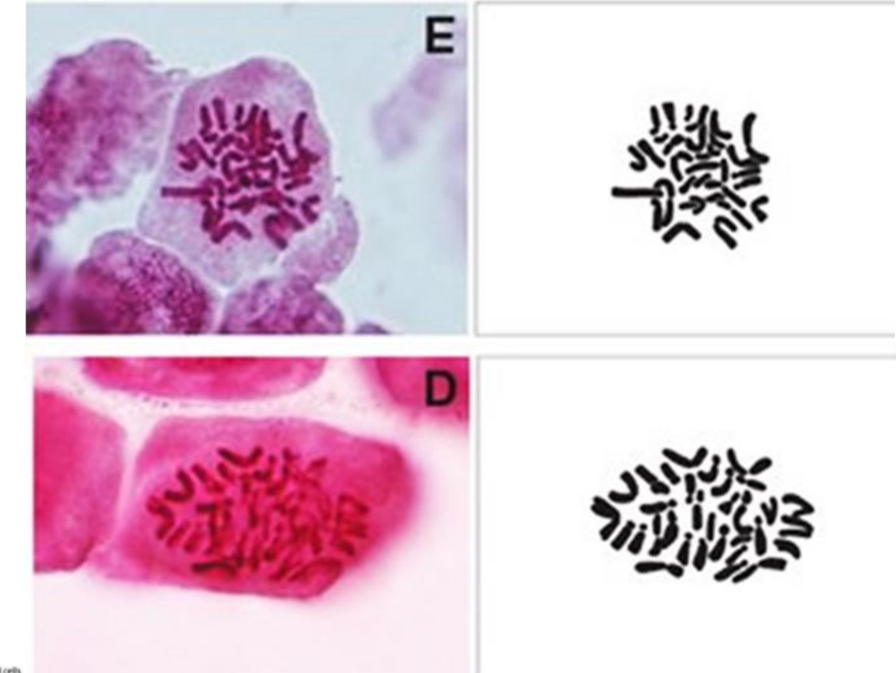
•Preserving plant specimens in herbaria for future study and reference.

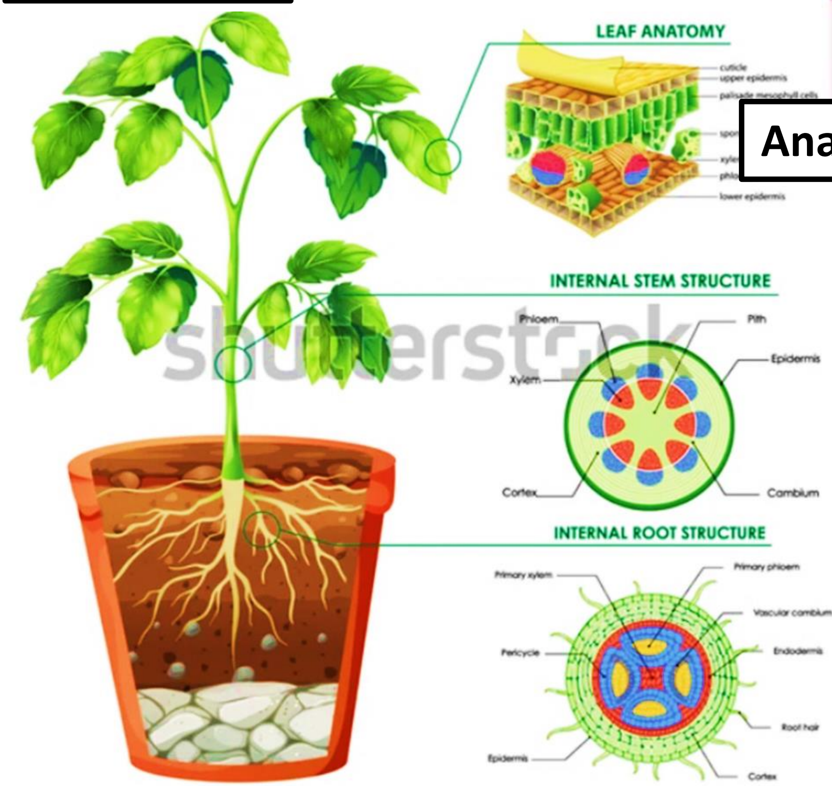
•Acts as a repository for taxonomic work.

Documentation and Herbarium

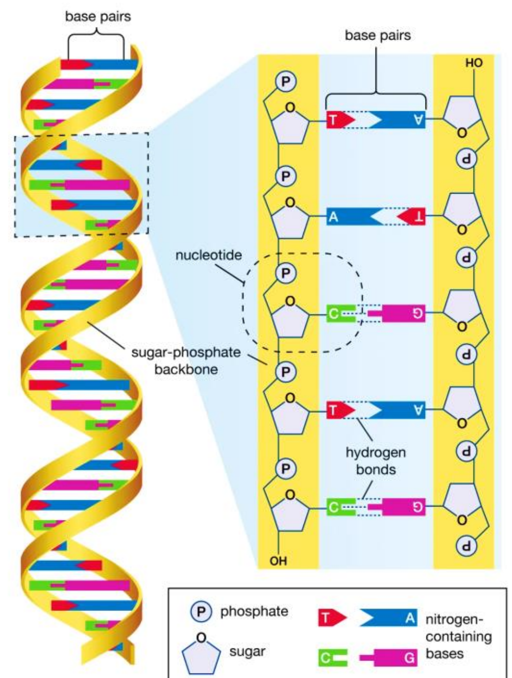


Morphology

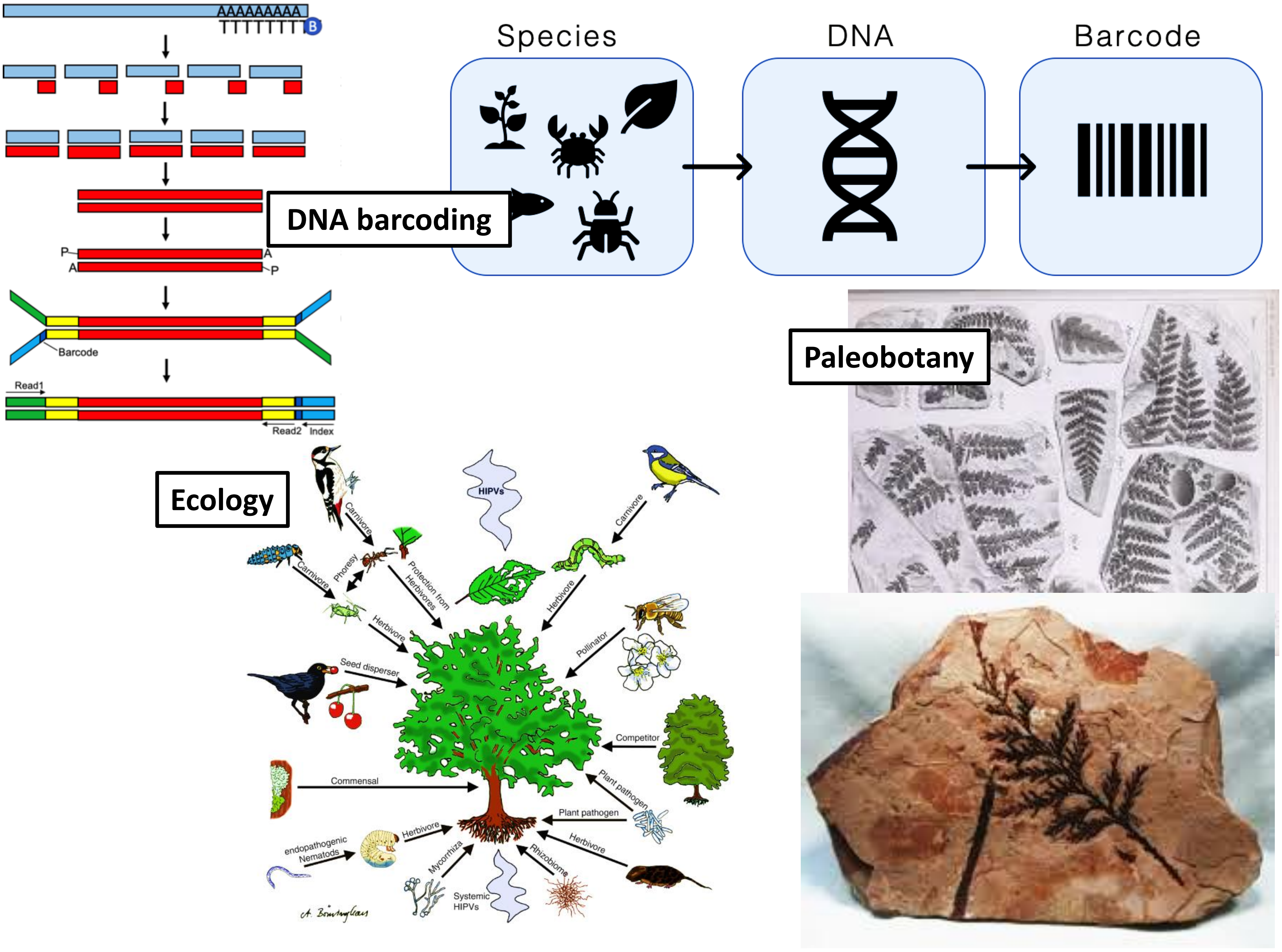




Anatomy and Cytology

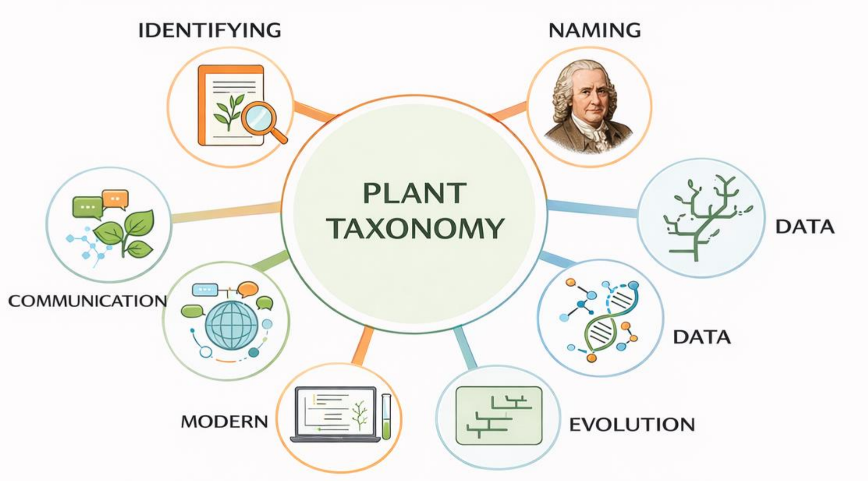


DNA


DNA barcoding
Species
DNA
Barcode
AAAAAAAAA
TTTTTTTT
B
P
A
Barcode
Read1
Read2
Index
Paleobotany
Ecology
Carnivore
Phoresy
Protection from Herbivores
HIPVs
Herbivore
Pollinator
Seed disperser
Competitor
Commensal
Plant pathogen
endopathogenic Nematods
Mycorrhiza
Systemic HIPVs
Rhizobiome

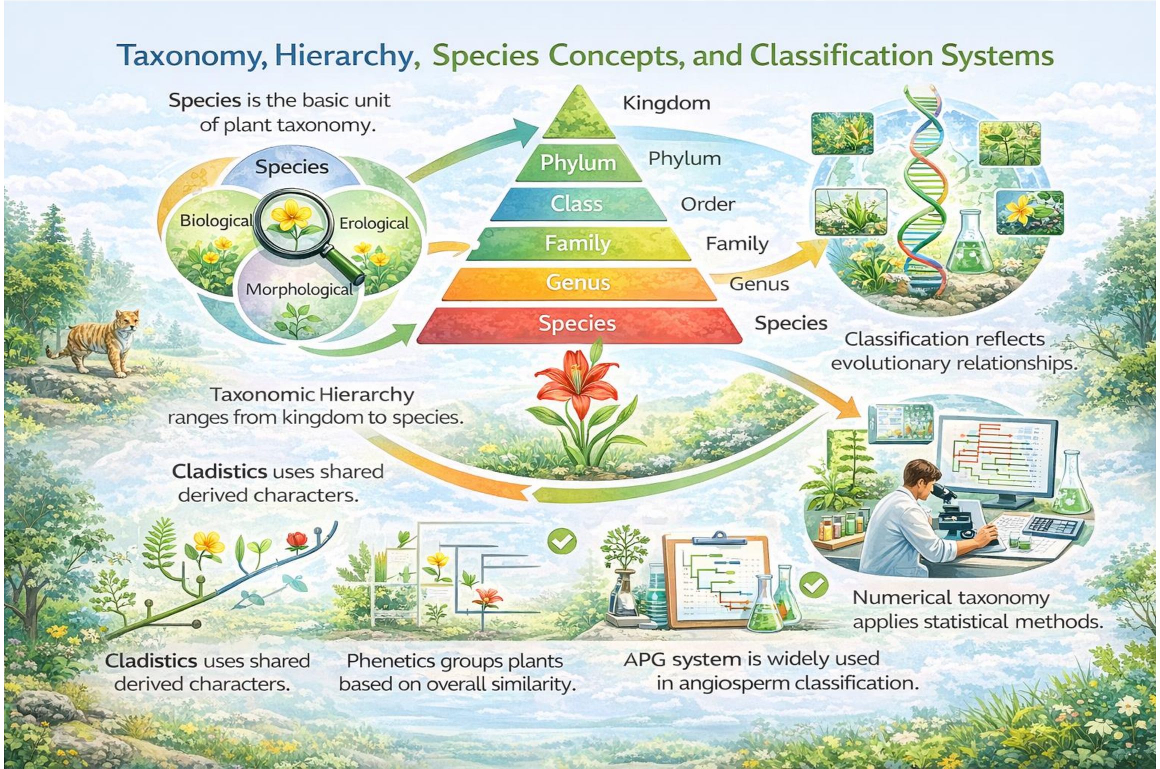
Foundations and Scope of Plant Taxonomy

- Plant taxonomy is the science of identifying, naming, and classifying plants.
- It defines the scope and objectives of plant classification systems.
- Taxonomy provides a framework for organizing plant diversity.
- Early plant classification was based mainly on morphology.
- Major milestones include Linnaeus' binomial nomenclature.
- Taxonomy supports communication among scientists worldwide.
- It plays a key role in understanding plant evolution.
- Modern taxonomy integrates molecular and computational data.
- Systematics links taxonomy with evolutionary biology.
- It forms the foundation of all botanical sciences.



Taxonomic Hierarchy, Species Concepts, and Classification Systems

- Species is the basic unit of plant taxonomy.
- Different species concepts explain variation and evolution.
- Taxonomic hierarchy ranges from kingdom to species.
- Classification reflects evolutionary relationships.
- Cladistics uses shared derived characters.
- Phylogenetic systems show ancestry-based relationships.
- APG system is widely used in angiosperm classification.
- Phenetics groups plants based on overall similarity.
- Numerical taxonomy applies statistical methods.
- Modern systems integrate morphology and molecular data.



WEEK-3

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

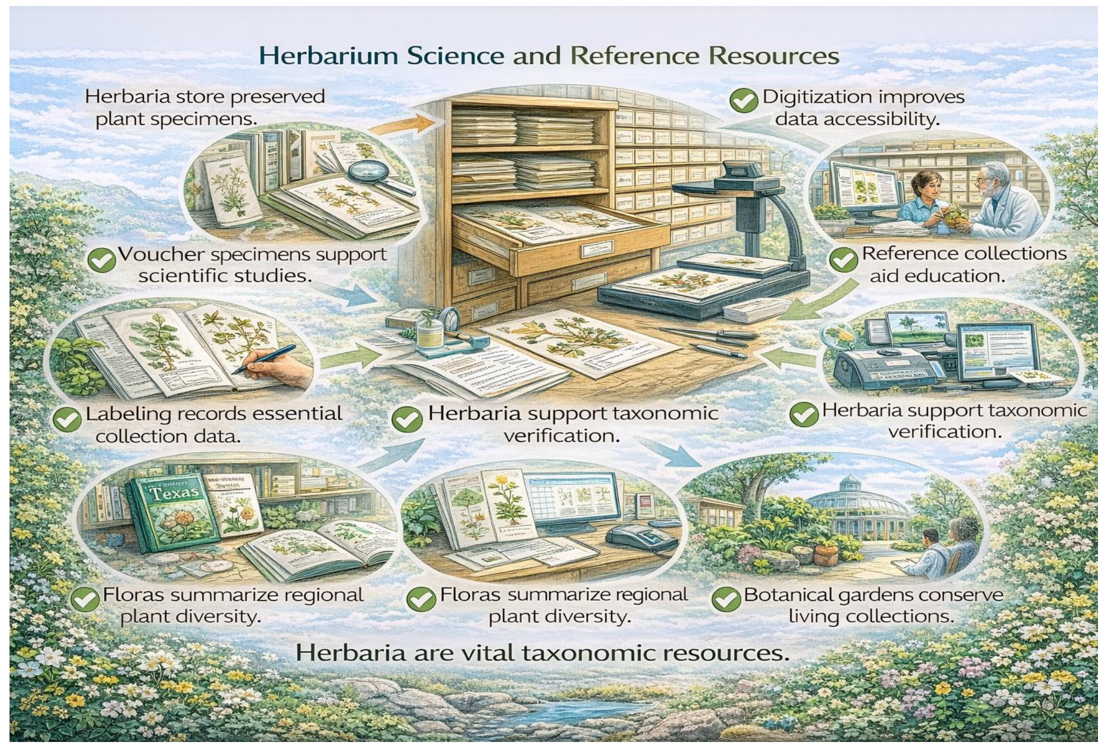
- **A HERBARIUM is a collection of dried plants systematically named and arranged for ready reference and study.**

- **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.**

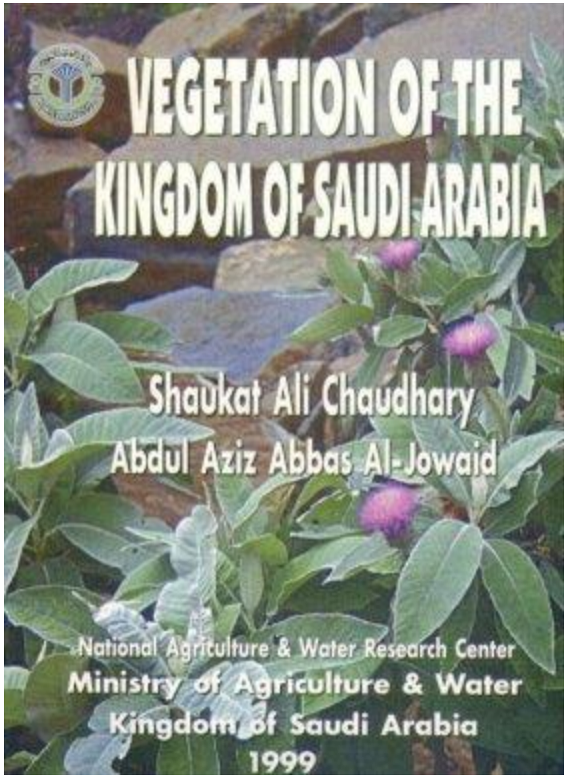
- **Herbarium techniques involve : (i) Collection, (ii) Drying, (iii) Poisoning, (iv) Mounting, (v) Stitching, (vi) Labelling, and (vii) Deposition.**

Herbarium Science and Reference Resources

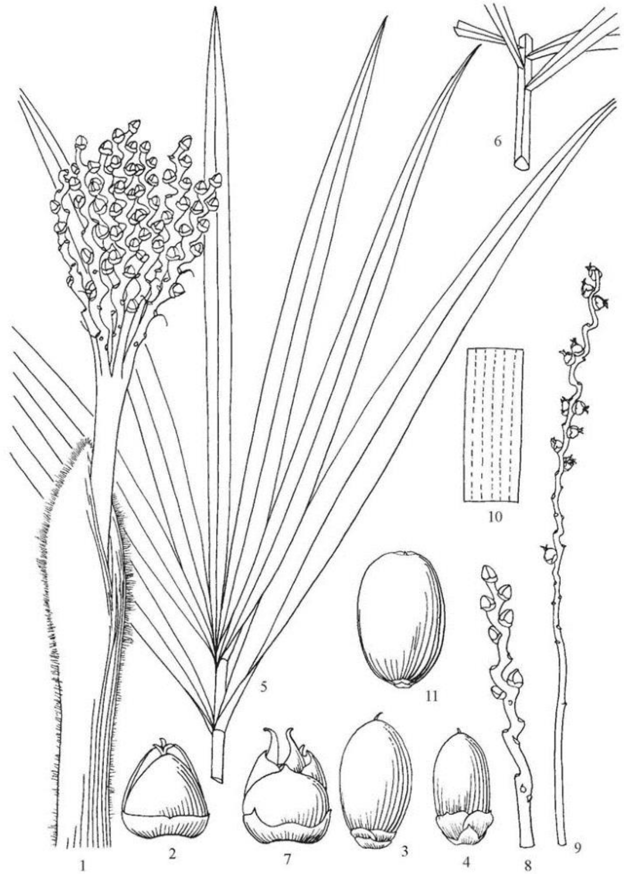
- Herbaria store preserved plant specimens.
- Voucher specimens support scientific studies.
- Proper curation ensures specimen longevity.
- Labeling records essential collection data.
- Herbaria support taxonomic verification.
- Floras summarize regional plant diversity.
- Botanical gardens conserve living collections.
- Reference collections aid education.
- Digitization improves data accessibility.
- Herbaria are vital taxonomic resources.



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

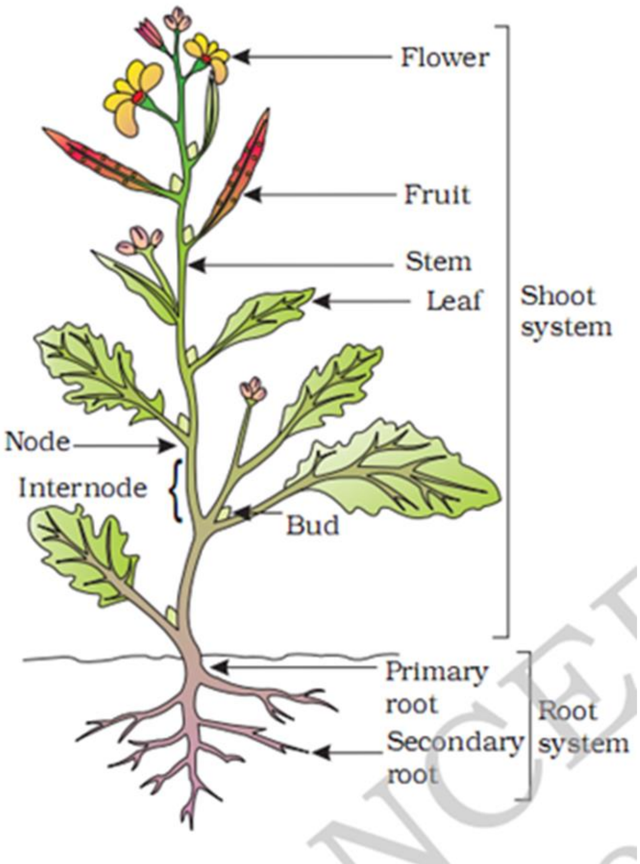
Phoenix dactylifera Linnaeus, Sp. Pl. 2: 1188. 1753.

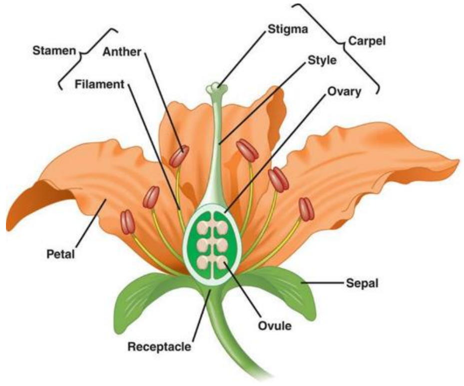
Stems solitary or clustered and then with few shoots, to 30 m tall, to 50 cm in diam., rough with persistent, diamond-shaped leaf bases. Leaves 3-5 m; sheath and petiole to 1 m; rachis 1-2 m; acanthophylls many per side of rachis; pinnae to 200 per side of rachis, linear, irregularly arranged and spreading 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

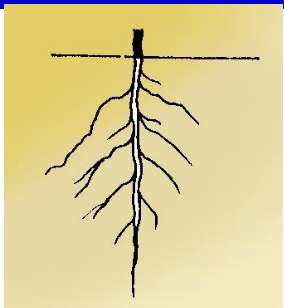
Herb. A usually low, soft or coarse plant with annual aboveground stems.
Shrub. A much-branched woody perennial plant usually without a single trunk.
Tree. A tall, woody perennial plant usually with a single trunk.
Vine ***or*** **Liana.** An elongate, weak-stemmed, often climbing annual or perennial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

Tree

Vines

shrubs

Different Types of Roots



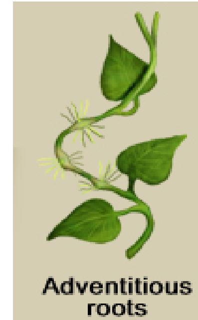
Tap Root:
A straight tapering root growing vertically downwards and forming the centre from which subsidiary rootlets spring.

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

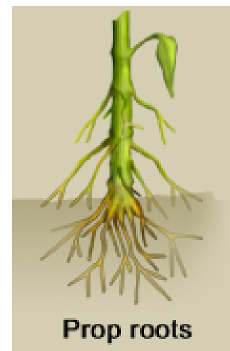
Respiratory Roots:

- 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 a stem, sometimes a leaf.

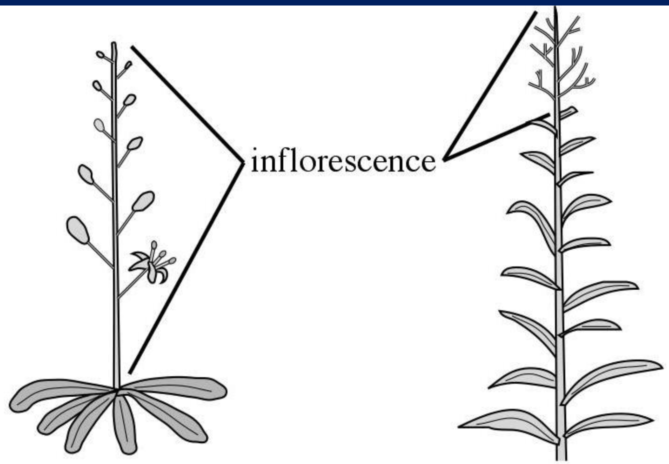


- **Prop roots**

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

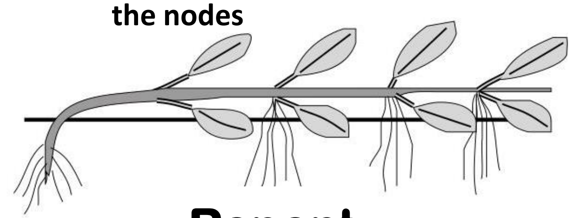
Parasitic Root:
A parasitic plant is a plant that derives some or all of its nutritional requirements from another living plant.
All parasitic plants have modified roots, named haustoria, which penetrate the host plants, connecting them to the conductive system – either the xylem, the phloem, or both

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



Prostrate

❖ Trailing or lying flat, not rooting at the nodes



Acaulescent

❖ Apparently a stemless plant having very inconspicuous reduced stem

Caulescent

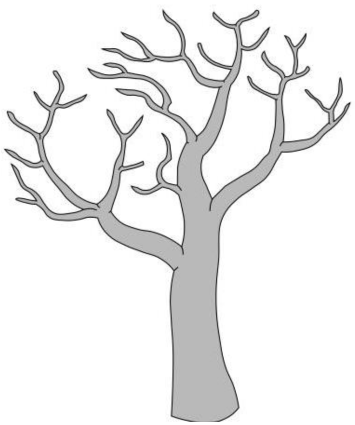
❖ With a distinct stem

Cespitose

❖ Short, much-branched, plant forming a cushion

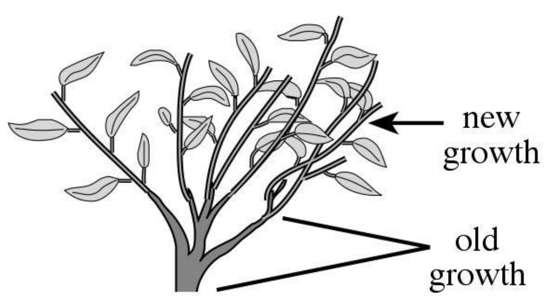
Repent

❖ Creeping or lying flat and rooting at the nodes



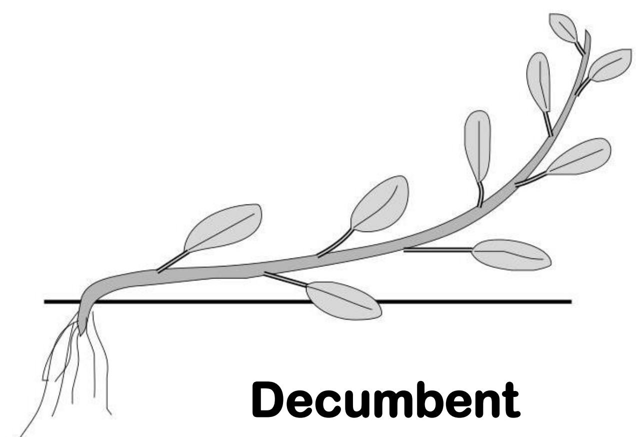
Arborescent

❖ Tree-like in appearance and size



Suffrutescent

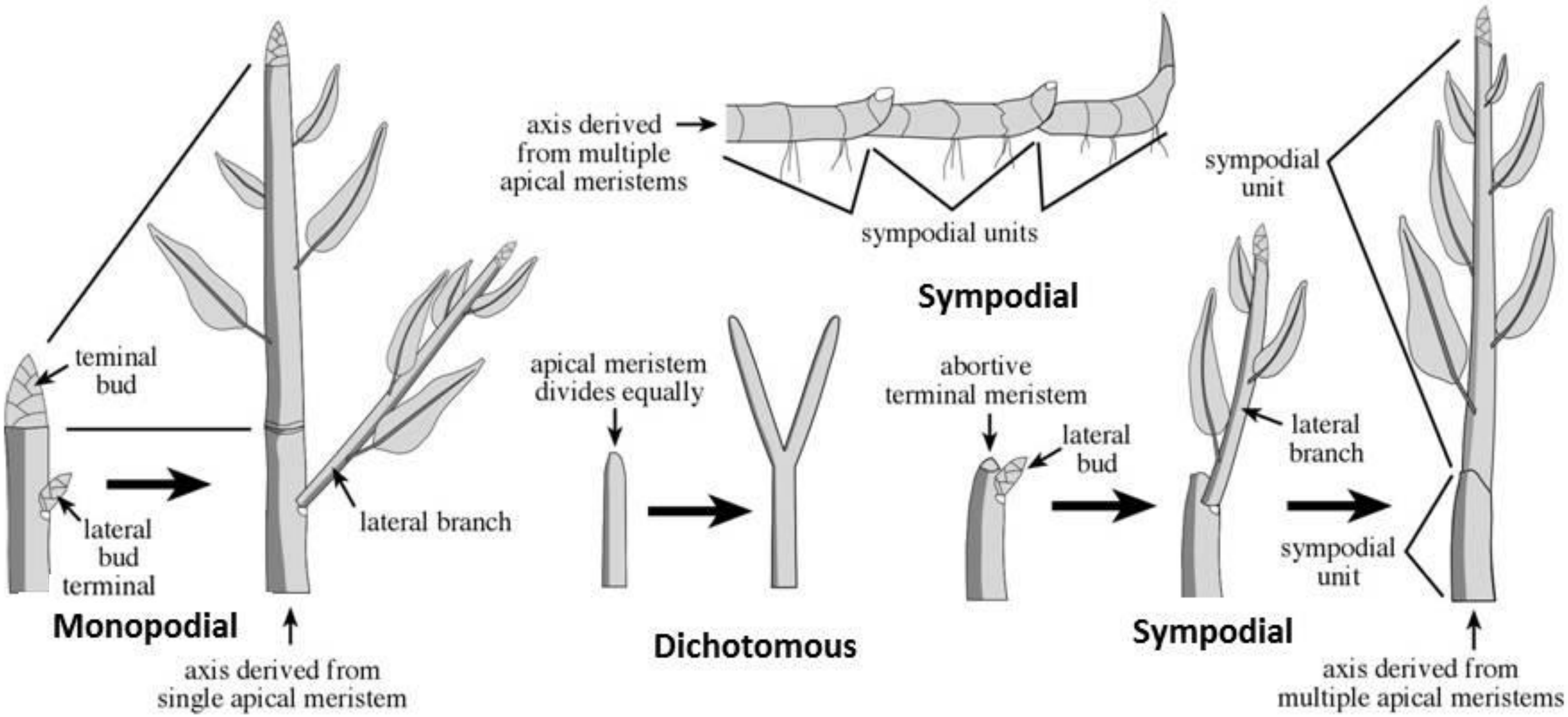
❖ Woody basally, herbaceous apically



Decumbent

❖ Lying on the ground with the tips ascending

Stem Branching



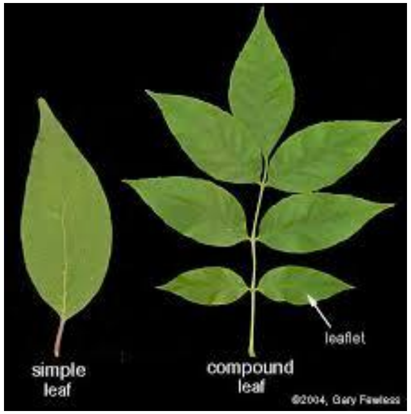
- **Monopodial:** Branching with a main axis and reduced or missing

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

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

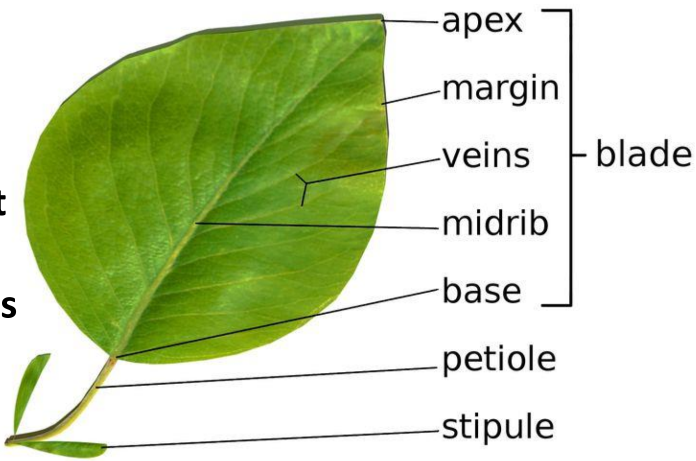
LEAVES

- 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.

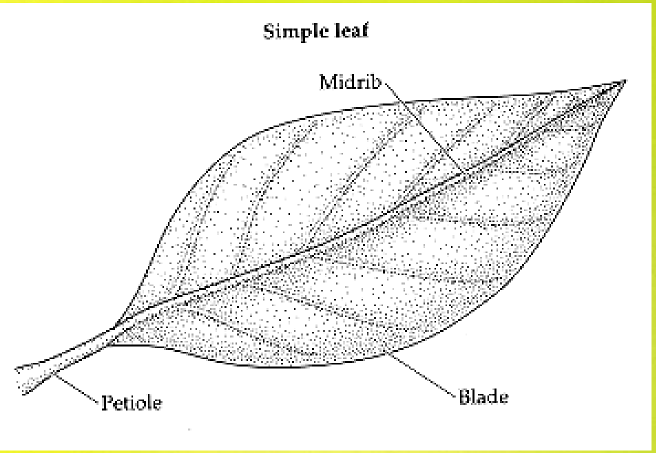


There are large number of terminology leaf based on:

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



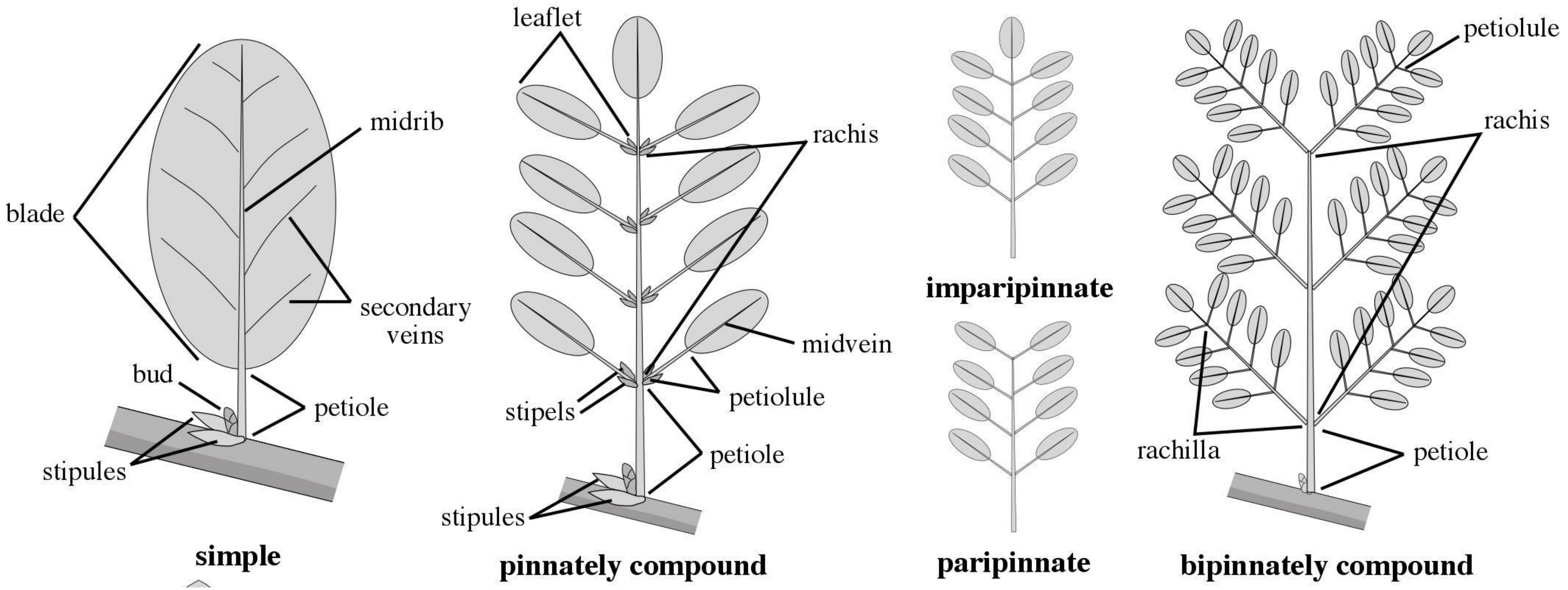
Leaves



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

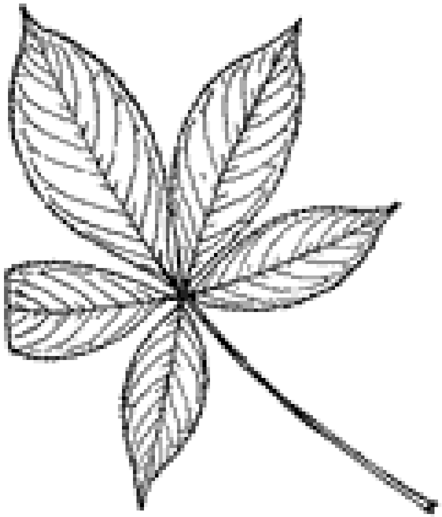


(a) **Simple leaf.** ورقة بسيطة A simple leaf is a single, undivided blade.

(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.

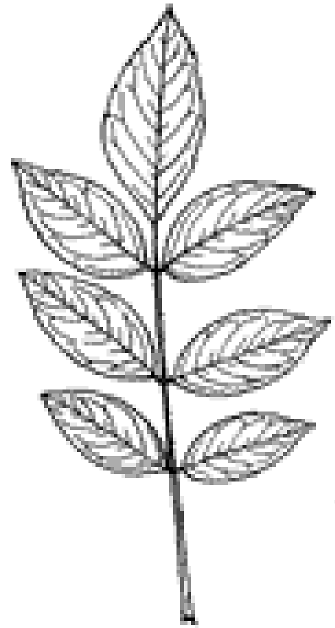
(c) **Doubly compound leaf (Bipinnate).** مركبة ريشية مزدوجة In a doubly compound leaf, each leaflet is divided into smaller leaflets.

Compound Leaves



palmately compound

❖ With leaflets from one point at end of petiole



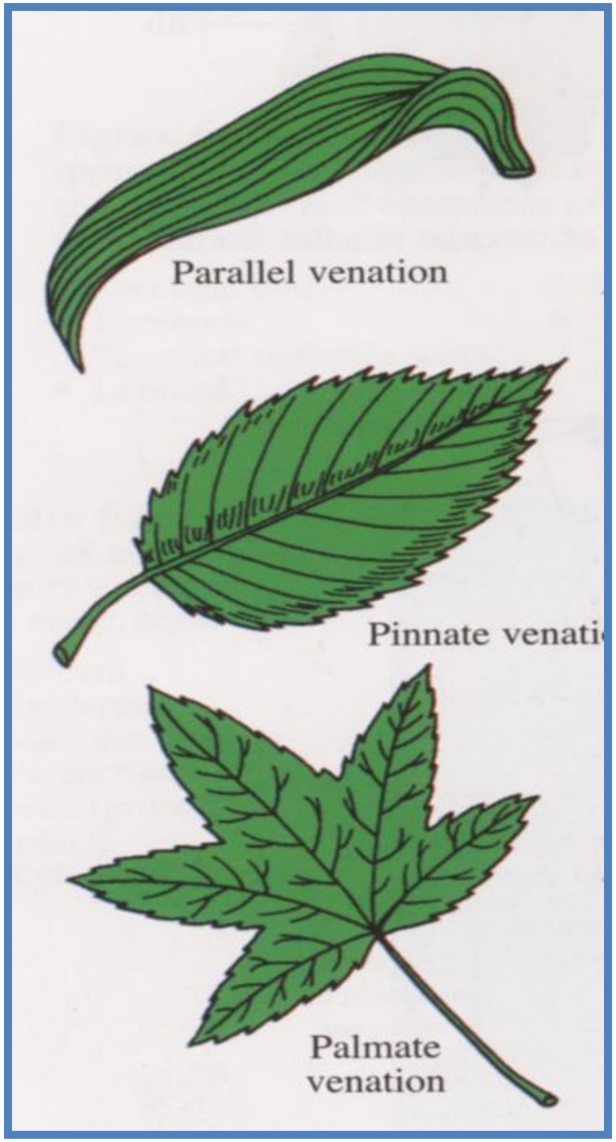
pinnately compound

❖ 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

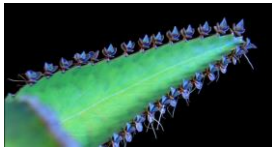
Some plant species have evolved modified leaves to serve various functions.

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*

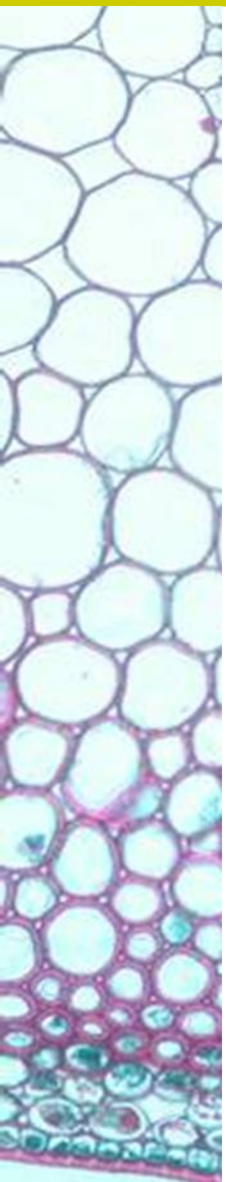
Carnivorus plants

- 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

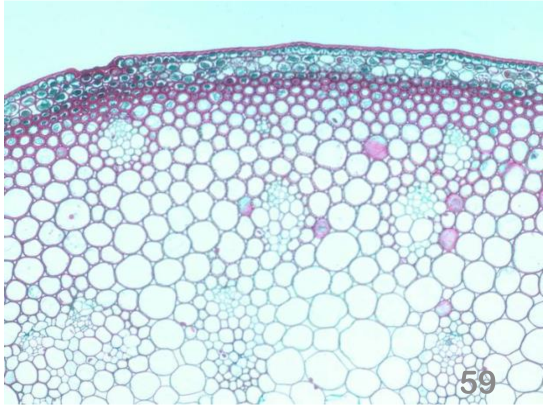
Pitcher plant:

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

PLANT ANATOMY
(Study of internal structure of plant)

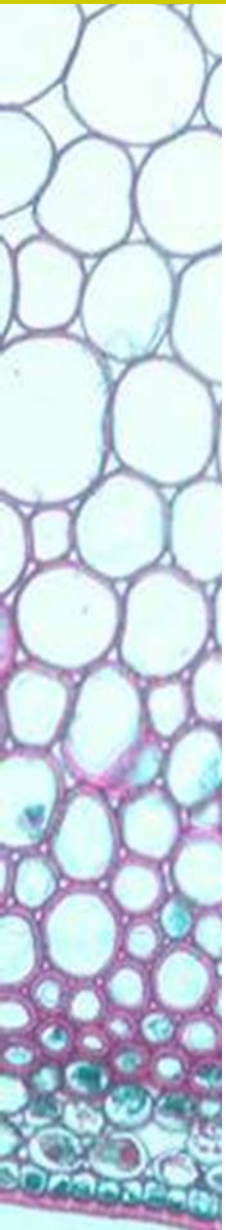


L.S ----Longitudinal section .
T.S ------ Transverse section .



Plant Tissue

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



Tissue Systems

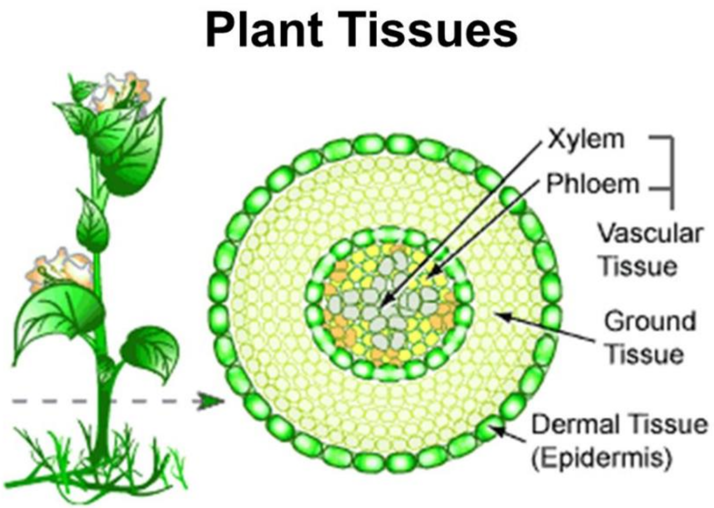
There are four plant tissue systems:

1. Ground tissue system :
- Parenchyma tissue
- Collenchyma tissue
- Sclerenchyma tissue

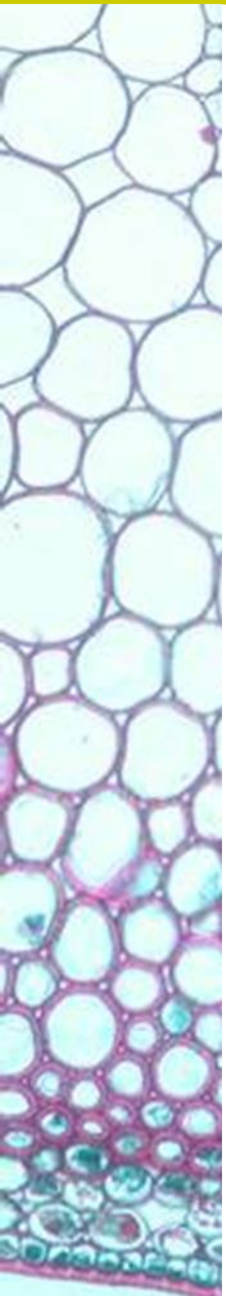
2. Vascular tissue includes:
- Xylem tissue
- Phloem tissue

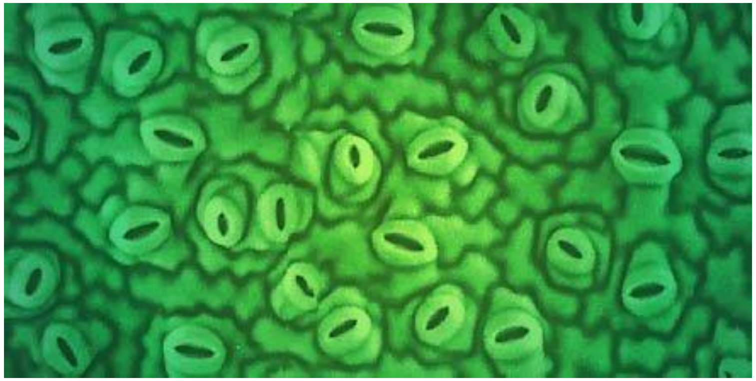
3. Dermal tissue:
- Epidermis

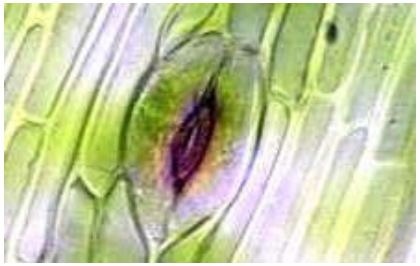
4. Meristematic tissue: (dividing tissue)



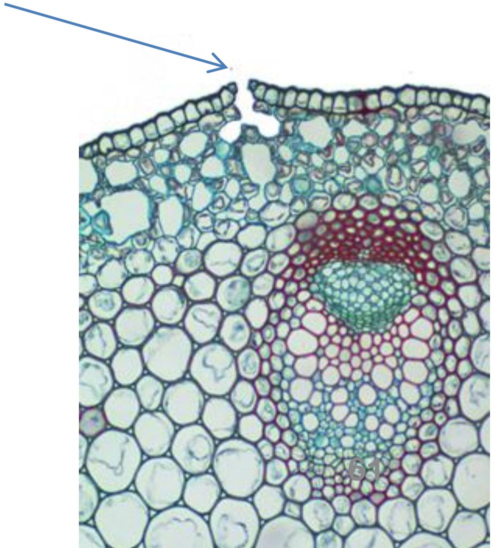
Dermal Tissue - Stomata





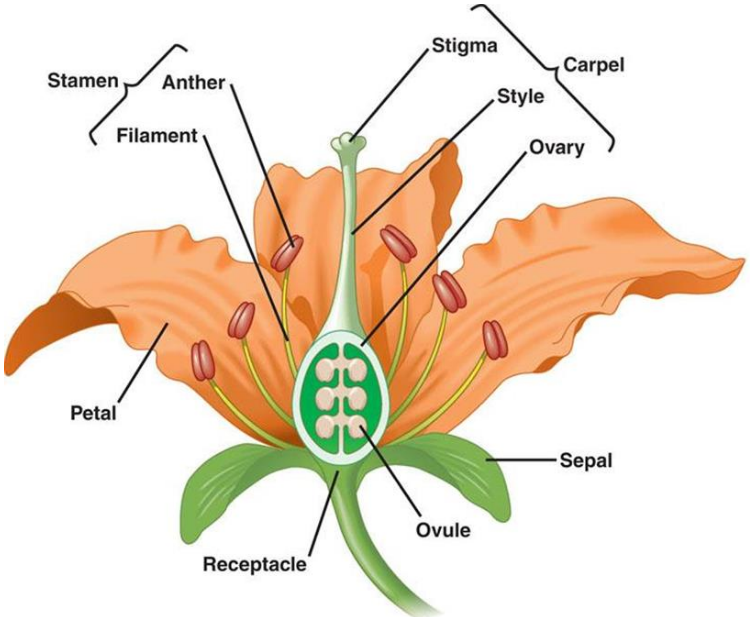


- **Openings in the epidermis on the underside of a leaf where gases are exchanged are called stomata.**



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).**

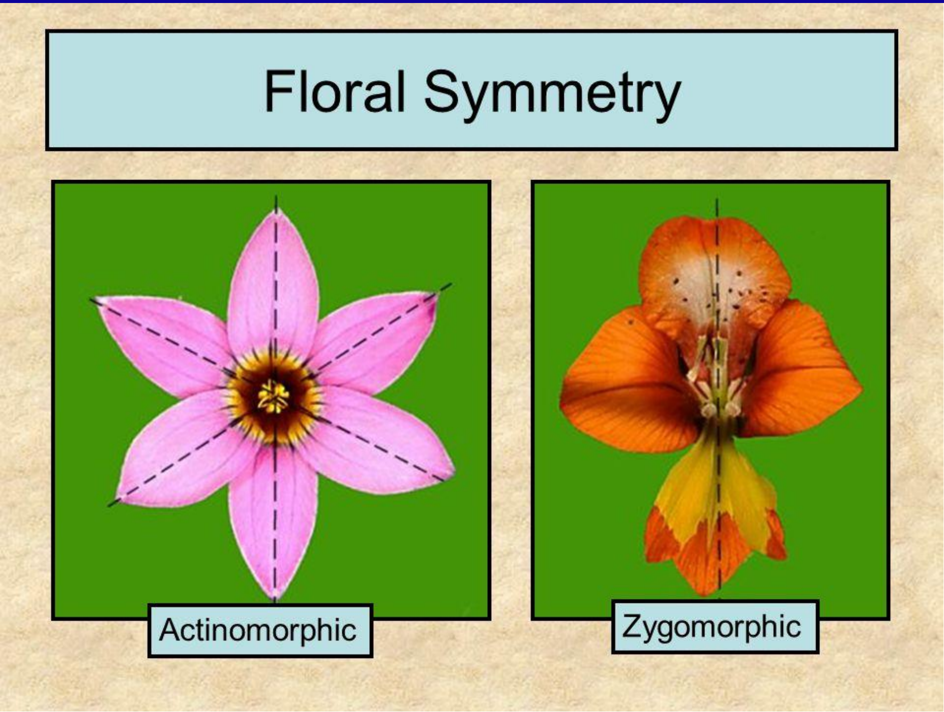
Unisexual flower:

- **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:

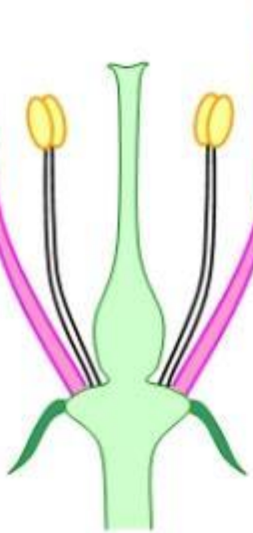
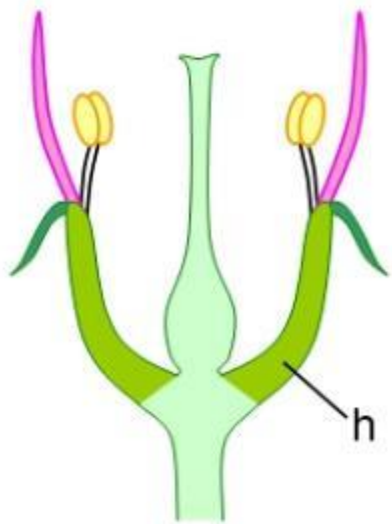
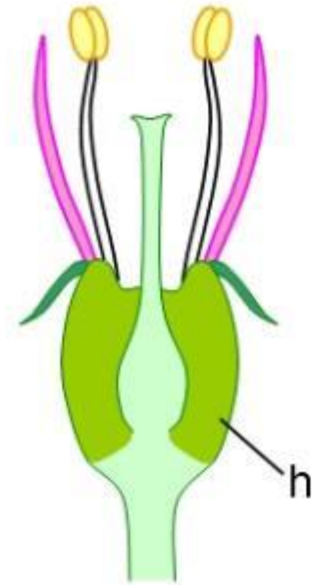
A normal flower with both the accessory whorls, i.e., calyx and corolla is called dichlamydous. Example, *Hibiscus* (chinarose).

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

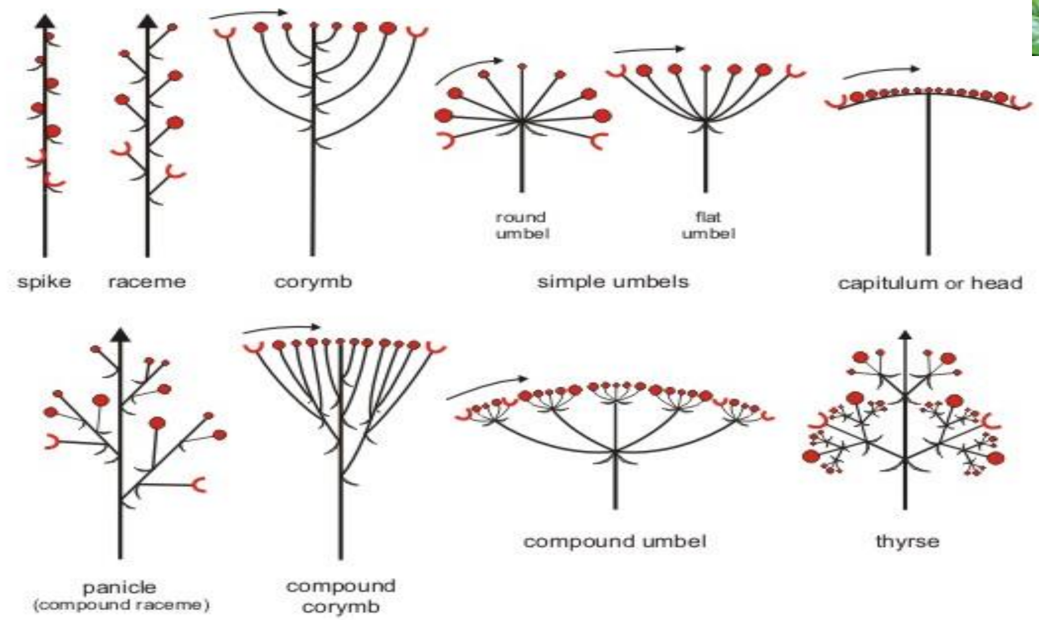
Relative Positions of Floral Appendages

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***

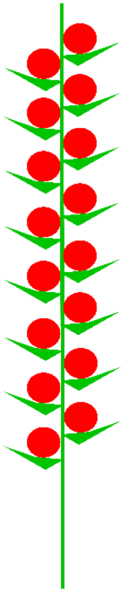
Scarlet rose-mallow (*Hibiscus coccineus)*

Compound Inflorescences

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

Compound Inflorescences

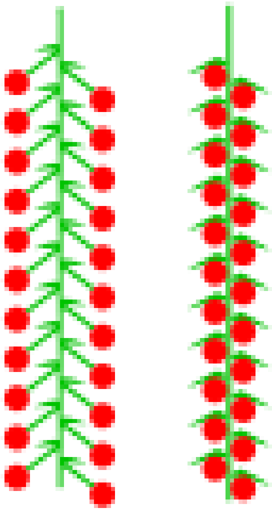
- **Spike**: elongate inflorescence; flowers are sessile, dense, or remote from one another



Spiked blazing star (*Liatris spicata*)

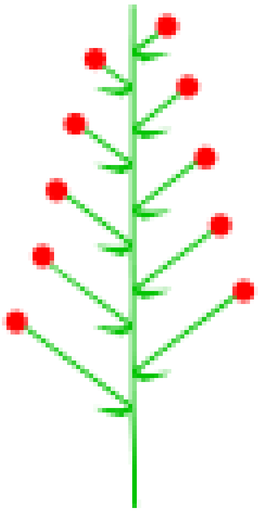
Compound Inflorescences

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



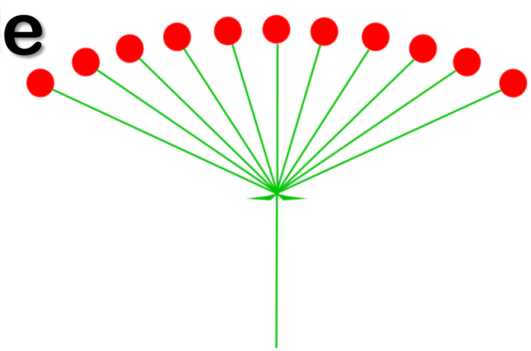
Compound Inflorescences

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



Compound Inflorescences

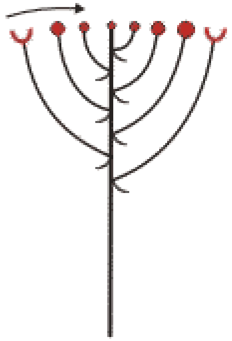
- **Umbel**: a flat-topped or somewhat rounded inflorescence in which all of the pedicels arise from a common point at the tip of the peduncle



Butterfly weed (*Asclepias* sp.)

Compound Inflorescences

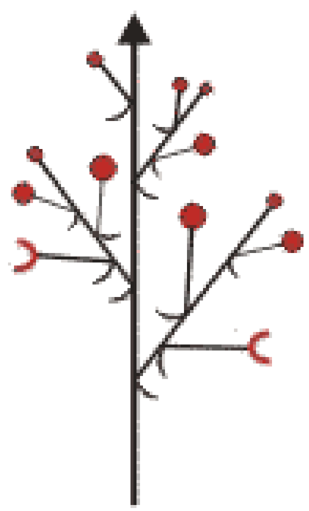
- **Corymb**: a flat-topped or somewhat rounded inflorescence in which the pedicels of varying length are inserted along the rachis



corymb

Compound Inflorescences

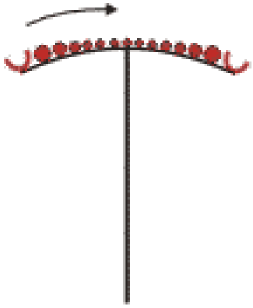
- **Panicle**: a much-branched inflorescence with a central rachis which bears branches which are themselves branched



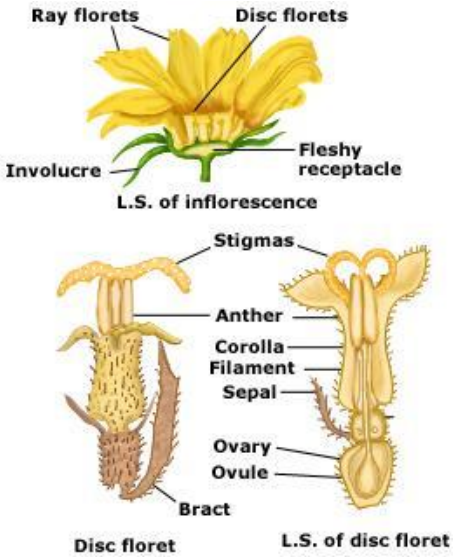
panicle
(compound raceme)

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.



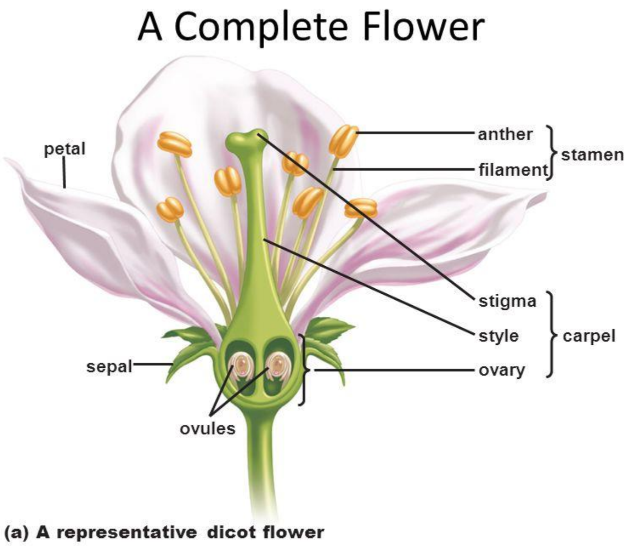
capitulum or head



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).**

Terms and Terminology used to Describe Plant

Vegetative and Reproductive Parts of Plants

1. Vegetative Parts

(Non-reproductive, responsible for growth and survival)

Root: Anchors the plant, absorbs water and nutrients.

Stem: Provides support, transports water, nutrients, and food.

Leaves: Conduct photosynthesis, exchange gases.

2. Reproductive Parts

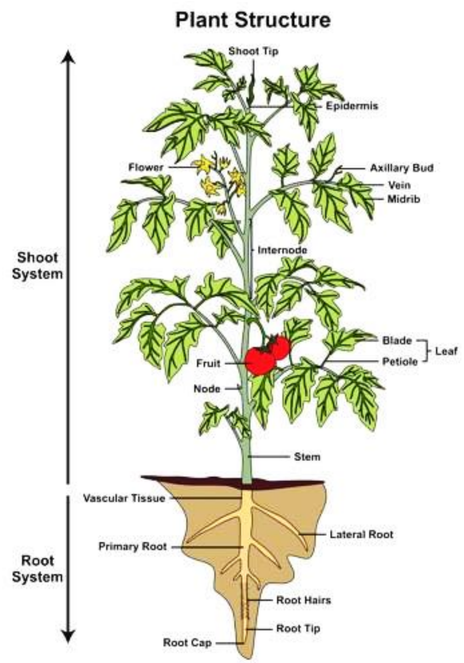
(Responsible for reproduction and propagation)

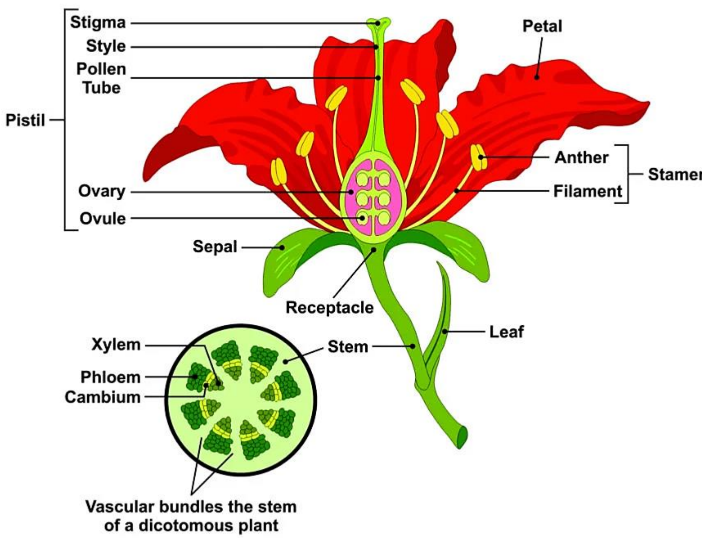
Flower: The reproductive organ (contains male and female structures).

- **Stamens** (Androecium): Male part producing pollen.
- **Carpels** (Gynoecium): Female part containing ovary, style, and stigma.

Fruits: Develop from the ovary, protect seeds.

Seeds: Contain the embryo for new plant growth.

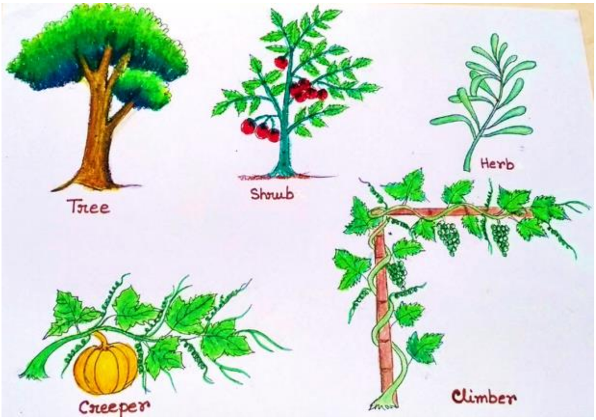




Serial list of key characters used to describe plants in a systematic and scientific manner:

1.Habit (Herb, shrub, tree, climber, or grass)

2. Habitat (Natural environment: forest, desert, marsh, etc.)



1. Habit
Refers to the general growth form or physical structure of a plant.
Examples: Herb, shrub, tree, climber, or creeper.

2. Herb
A small, non-woody plant with a soft and green stem.
Lifespan: Usually seasonal (short-lived).
Example: Spinach, coriander, wheat.

3. Shrub
A medium-sized, woody plant with multiple branches arising from the base.
Lifespan: Longer than herbs, but not as long as trees.
Example: Hibiscus, rose, jasmine.

4. Tree
A tall, woody plant with a single, prominent trunk and branches forming a canopy.
Lifespan: Long-lived (decades to centuries).
Example: Mango, neem, banyan.

5. Climber
A plant with weak stems that requires support to grow upward.
They use tendrils, hooks, or twining stems for support.
Example: Grapevine, pea, money plant.

3. Root Types and Modifications

1. Types of Roots

Taproot:

A single, thick primary root that grows deep into the soil.
Found in dicot plants. **Example:** Carrot, radish, mango.

Fibrous Root:

A cluster of thin, hair-like roots that spread out in the soil.
Found in monocot plants. **Example:** Grass, wheat, rice.

Adventitious Root:

Roots that arise from parts of the plant other than the radicle (e.g., stem, leaves). **Example:** Banyan tree (prop roots), maize (stilt roots).

2. Root Modifications

Storage Roots:

Store food and nutrients. **Examples:** Carrot, beetroot, sweet potato.

Prop Roots:

Aerial roots that provide support. **Example:** Banyan tree.

Pneumatophores:

Roots that grow upwards to facilitate gas exchange in waterlogged conditions. **Example:** Mangroves (Rhizophora).

Stilt Roots:

Arise from the lower nodes of the stem to support the plant. **Example:** Sugarcane, maize.

Buttress Roots:

Large roots at the base of the trunk that provide stability. **Example:** Silk cotton tree.

Climbing Roots:

Help climbers attach to a surface. **Example:** Money plant, ivy.

Climbing roots

Epiphytic roots

Buttress roots

Pneumatophores

Prop roots

4. Stem: Types, Shape, Surface Features, and Modifications

1. Types of Stems

Woody:

Hard and rigid stems.

Found in trees and shrubs. **Example:** Mango, rose.

Herbaceous:

Soft, green, and flexible stems.

Found in herbs. **Example:** Coriander, spinach.

Succulent:

Thick, fleshy stems adapted to store water. **Example:** Cactus, aloe vera.

Climbing:

Weak stems that need support to grow vertically. **Example:** Grapevine, money plant.

2. Shape and Structure of Stems

Cylindrical: Rounded, typical stem shape. **Example:** Bamboo.

Hollow: Stems with an internal cavity. **Example:** Wheat, barley.

Jointed: Stems divided into nodes and internodes. **Example:** Sugarcane.

3. Surface Features

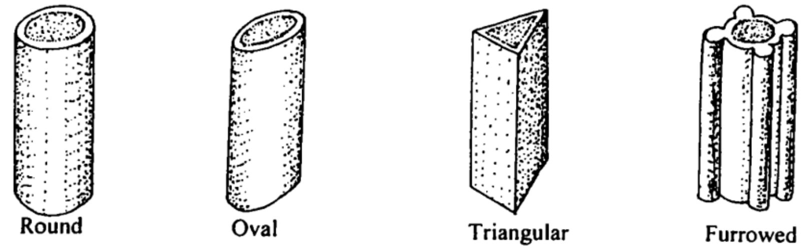
Smooth: Without any texture or projections. **Example:** Banana.

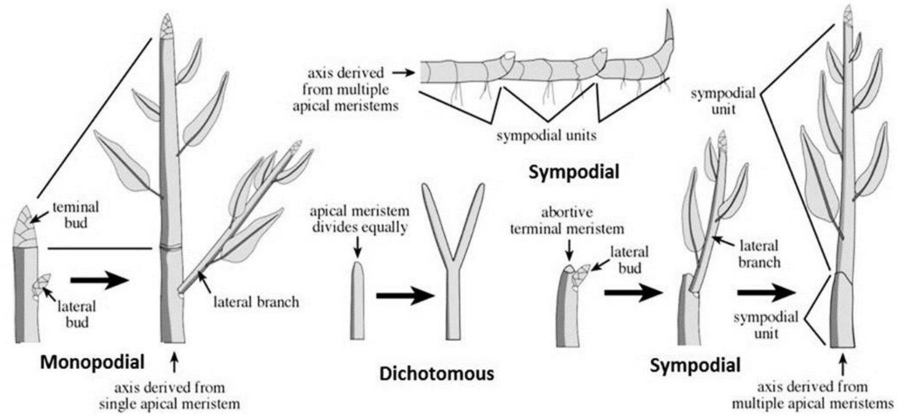
Hairy: Covered with tiny hairs. **Example:** Cotton.

Thorny: Possesses sharp thorns for protection. **Example:** Bougainvillea.

Spiny: Covered with spines or spiky projections. **Example:** Cactus.

4. 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





5. Special Modifications of Stems
Rhizomes: Underground stems for storage and vegetative propagation.
Example: Ginger, turmeric.
Stolons: Horizontal stems that grow above the ground and give rise to new plants.
Example: Strawberry.
Tubers: Swollen underground stems that store food.
Example: Potato.
Bulbs: Underground stems with fleshy leaves for food storage.
Example: Onion, garlic.
Thorns: Modified stems for protection.
Example: Citrus.
Tendrils: Thin, coiling stem structures for climbing.
Example: Grapevine.

5. Leaf: Arrangement, Attachment, Shape, and Other Features

1. Arrangement

Refers to how leaves are arranged on the stem or branch:

Alternate: One leaf per node, alternately placed. **Example:** Sunflower.

Opposite: Two leaves grow opposite to each other at the same node. **Example:** Guava.

Whorled: Three or more leaves arise from a single node, forming a ring. **Example:** Alstonia.

2. Attachment

Refers to how the leaf is attached to the stem or branch:

Petiole (Petiolate): Leaves are attached by a stalk (petiole). **Example:** Mango.

Sessile: Leaves are directly attached without a petiole. **Example:** Grass.

3. Shape

The overall form of the leaf:

Simple: A single, undivided leaf blade.**Example:** Mango, banana.

Compound: Leaf blade is divided into smaller leaflets.

- **Pinnate:** Leaflets arranged along both sides of a central axis (rachis). **Example:** Neem.
- **Palmate:** Leaflets radiate out from a single point. **Example:** Silk cotton.

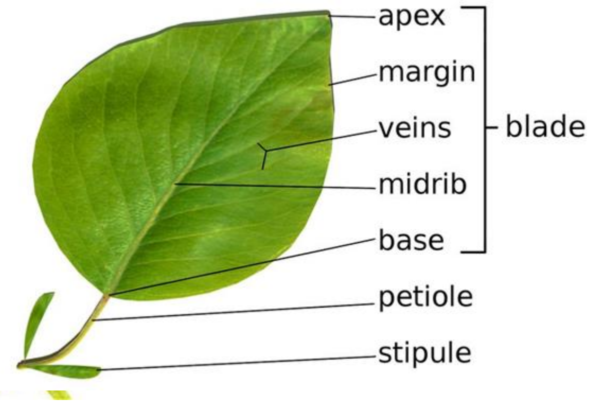
4. Venation

Refers to the pattern of veins in the leaf:

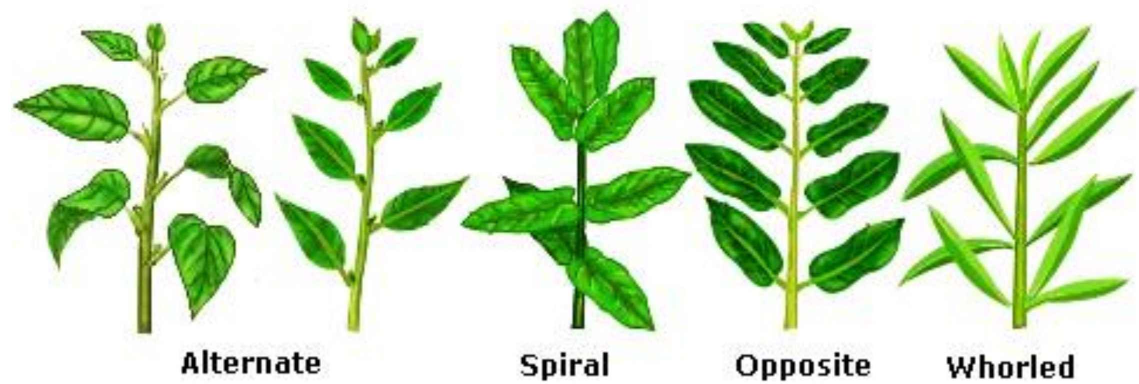
Reticulate: Veins form a network (found in dicots).**Example:** Peepal.

Parallel: Veins run parallel to each other (found in monocots). **Example:** Grass, maize.

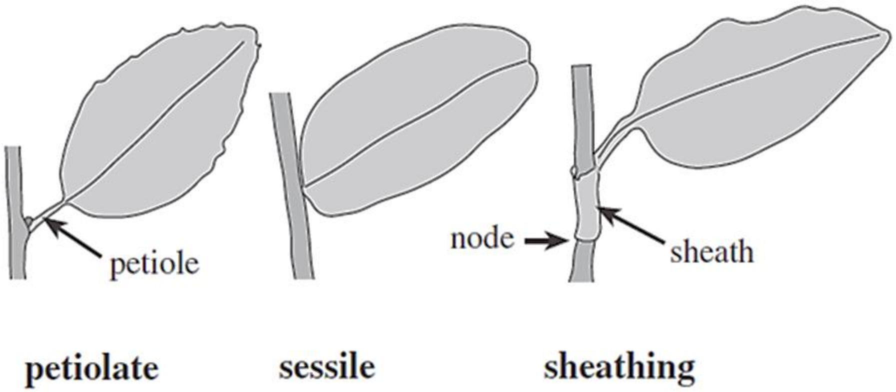
5. Margins
Describes the edge of the leaf:
Entire: Smooth and continuous.
  Example: Mango.
Serrated: Saw-toothed edge.
  Example: Rose.
Lobed: Deep cuts that form lobes.
  Example: Cotton.

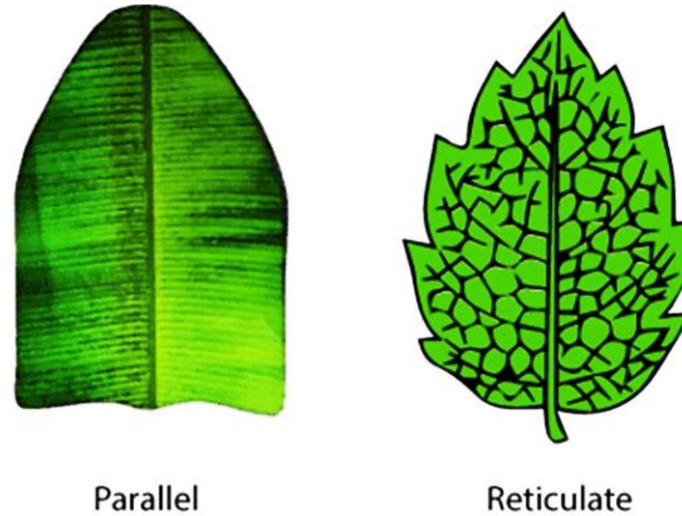


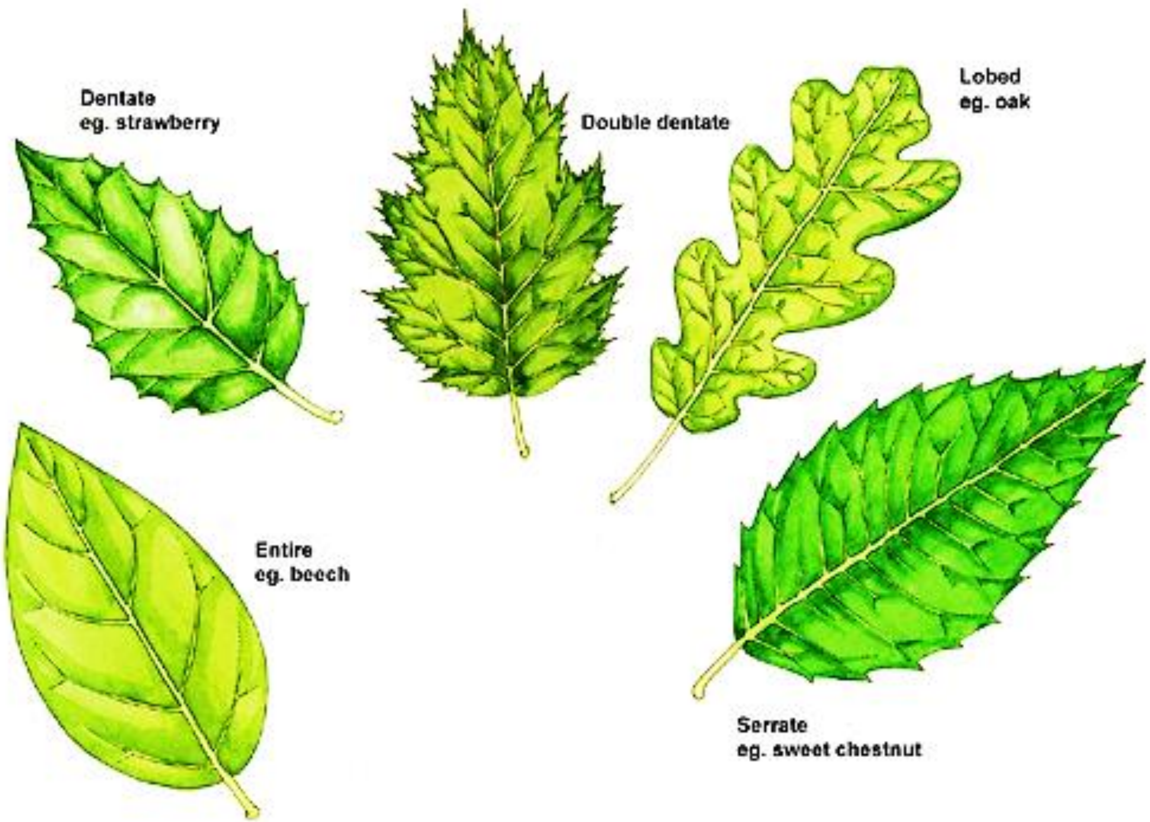
6. Surface
Describes the texture or covering of the leaf:
Glabrous: Smooth and without hairs.
  Example: Mango.
Hairy: Covered with tiny hairs.
  Example: Tomato.
Waxy: Covered with a waxy coating.
  Example: Lotus.



7. Other Features
Additional characteristics of leaves:
Aromatic: Leaves release fragrance when crushed.
  Example: Basil, mint.
Glandular: Presence of glands for secretion.
  Example: Citrus.


petiole
node
sheath
petiolate
sessile
sheathing


Parallel
Reticulate


Dentate
eg. strawberry
Double dentate
Lobed
eg. oak
Entire
eg. beech
Serrate
eg. sweet chestnut

3. Sexuality

Refers to the presence of male and female reproductive organs in a flower:

Unisexual:

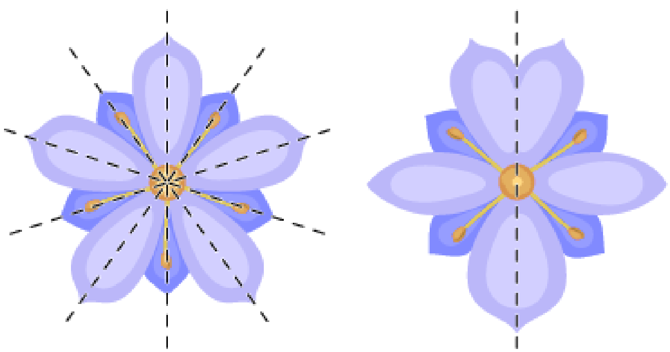
Flower has either male (staminate) or female (pistillate) reproductive parts.

Example: Papaya, watermelon.

Bisexual:

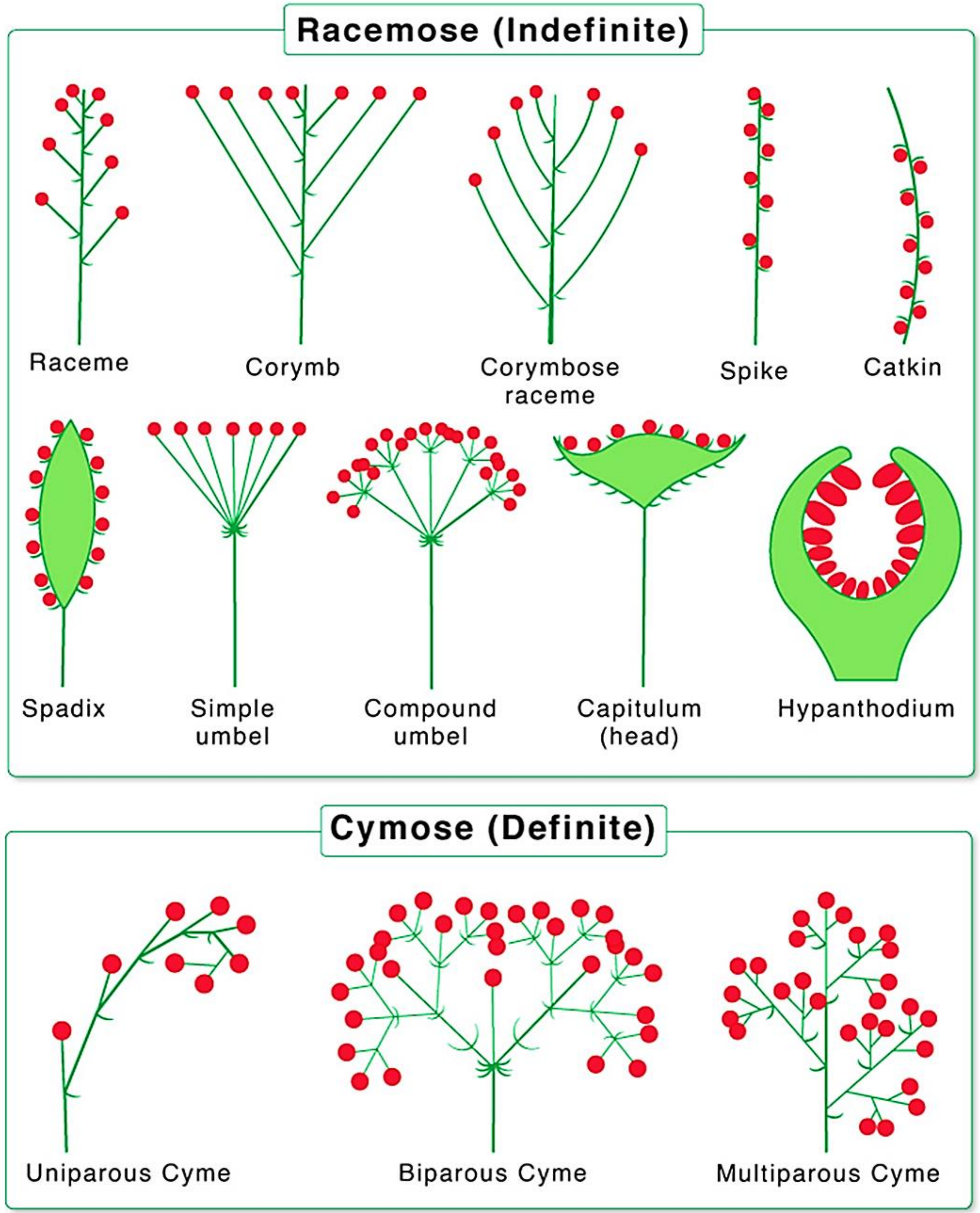
Flower has both male (stamens) and female (carpels) reproductive parts.

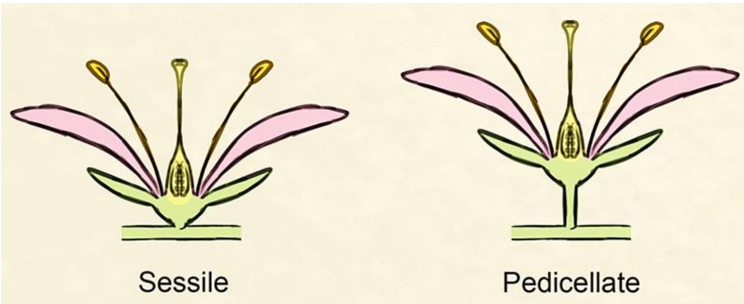
Example: Hibiscus, mustard.

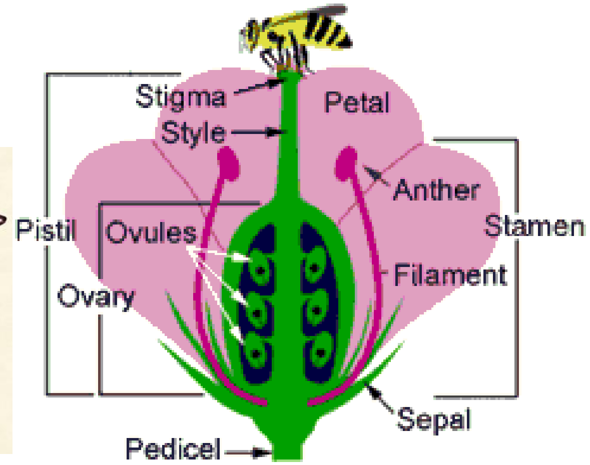


Actinomorphic Zygomorphic

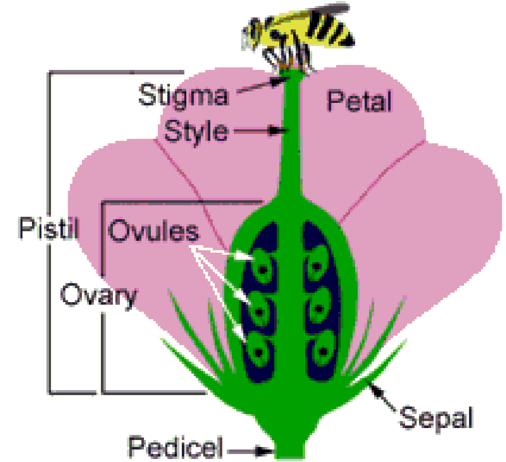
Types of Inflorescence



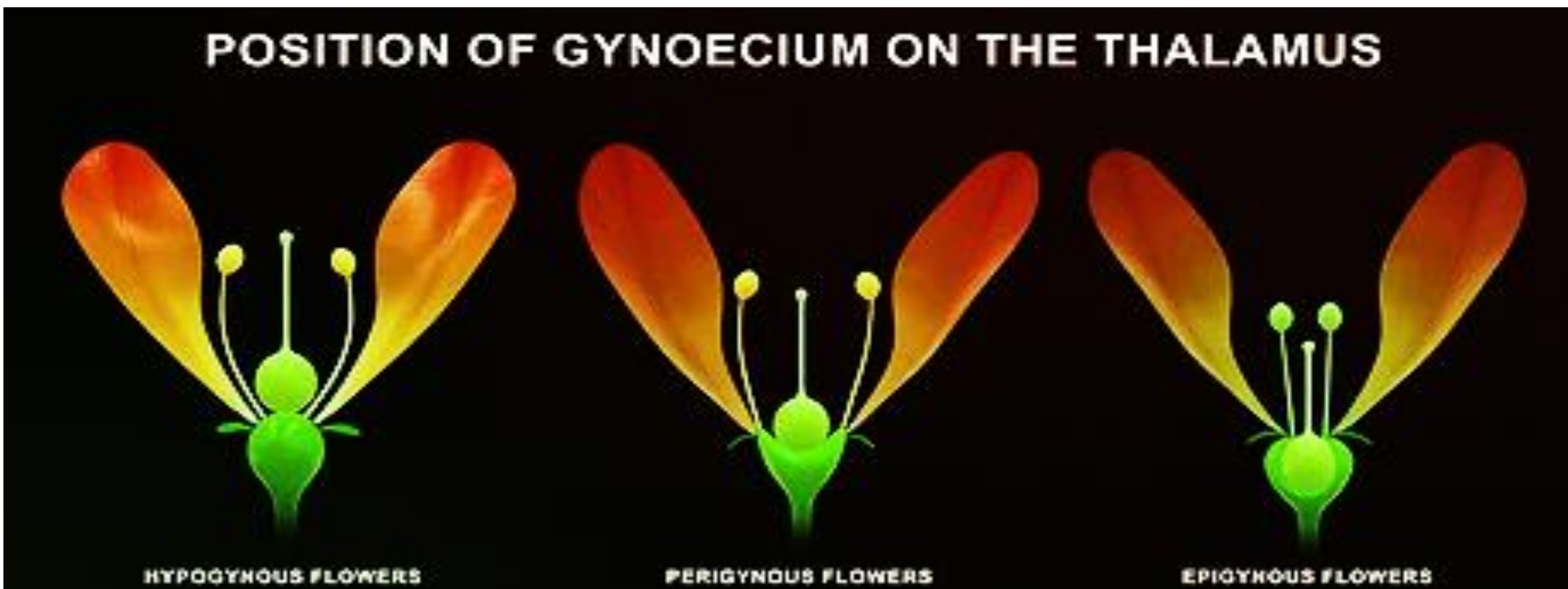


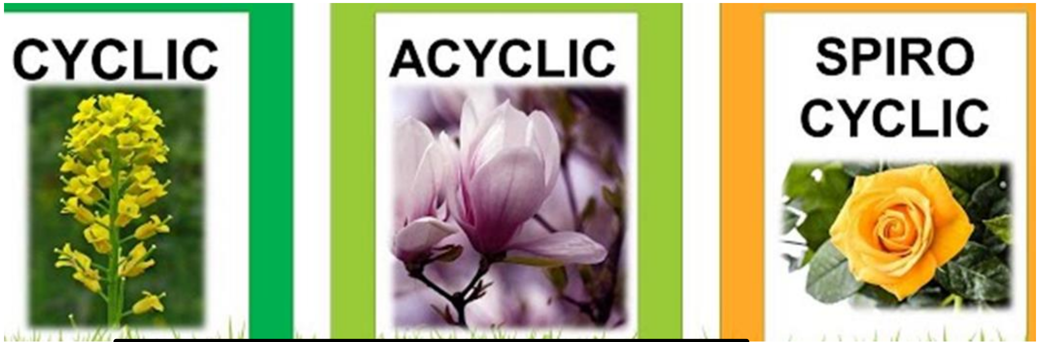


Complete flower



Incomplete flower

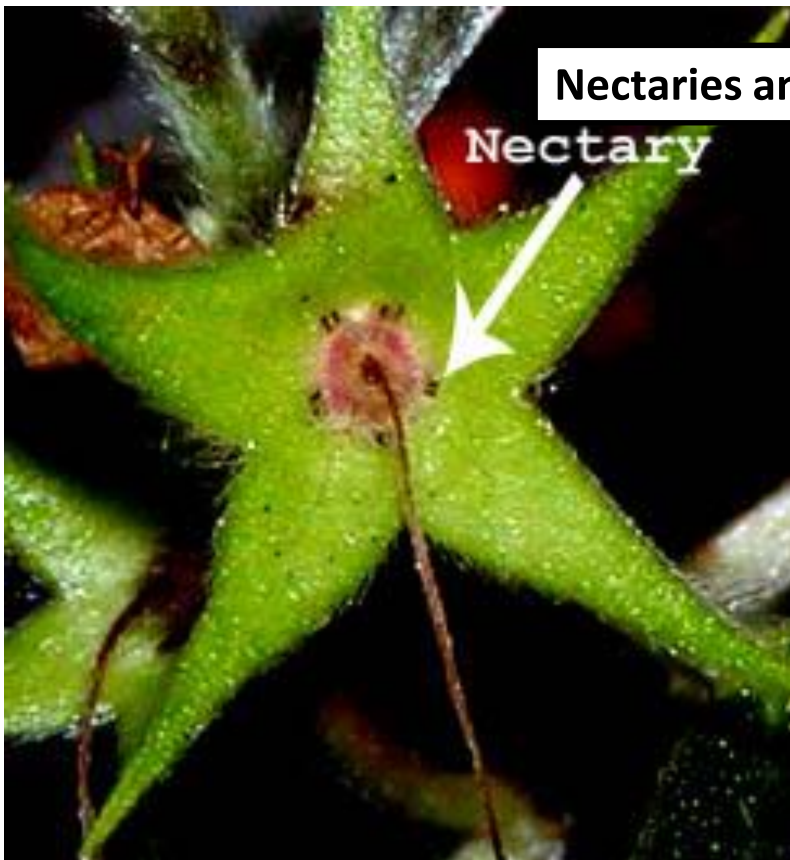


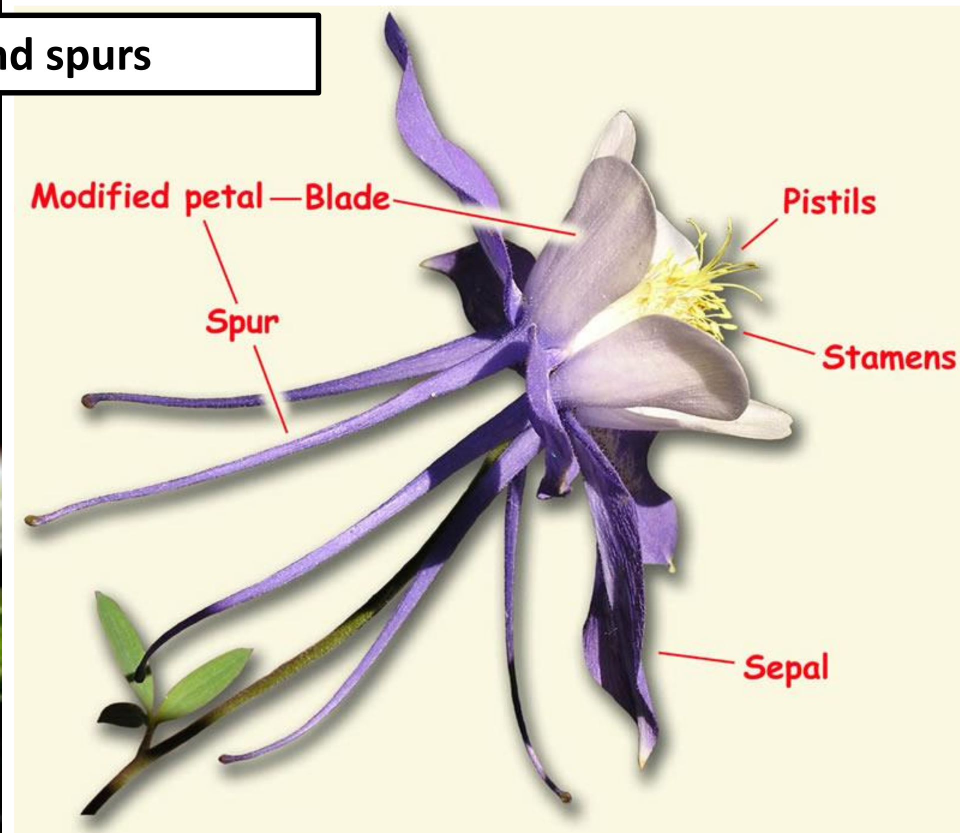


Arrangement of Floral Organs

Colour

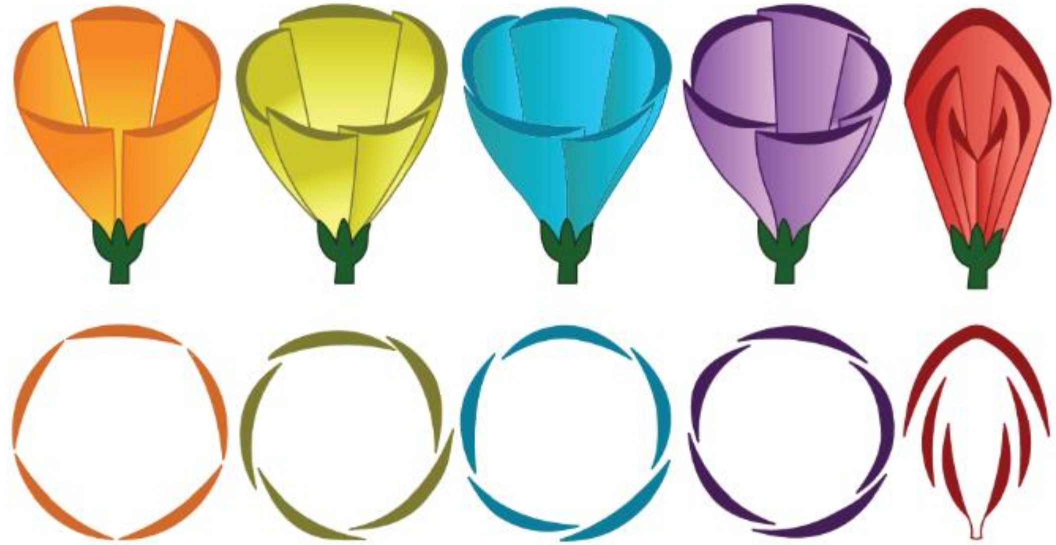
Nectaries and spurs





GAMOSEPALOUS

POLYSEPALOUS



A.Valvate B.Twisted C.Imbricate D.Quincuncial E.Vexillary

TYPES OF CALYX: BASED ON LOSS & PERSISTANCE

CADUCOUS

DECIDUCOUS

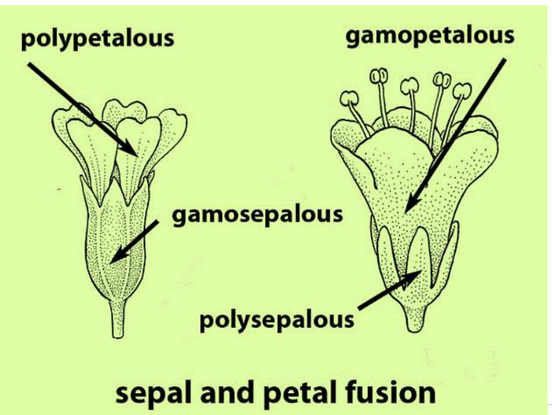
PERSISTENT

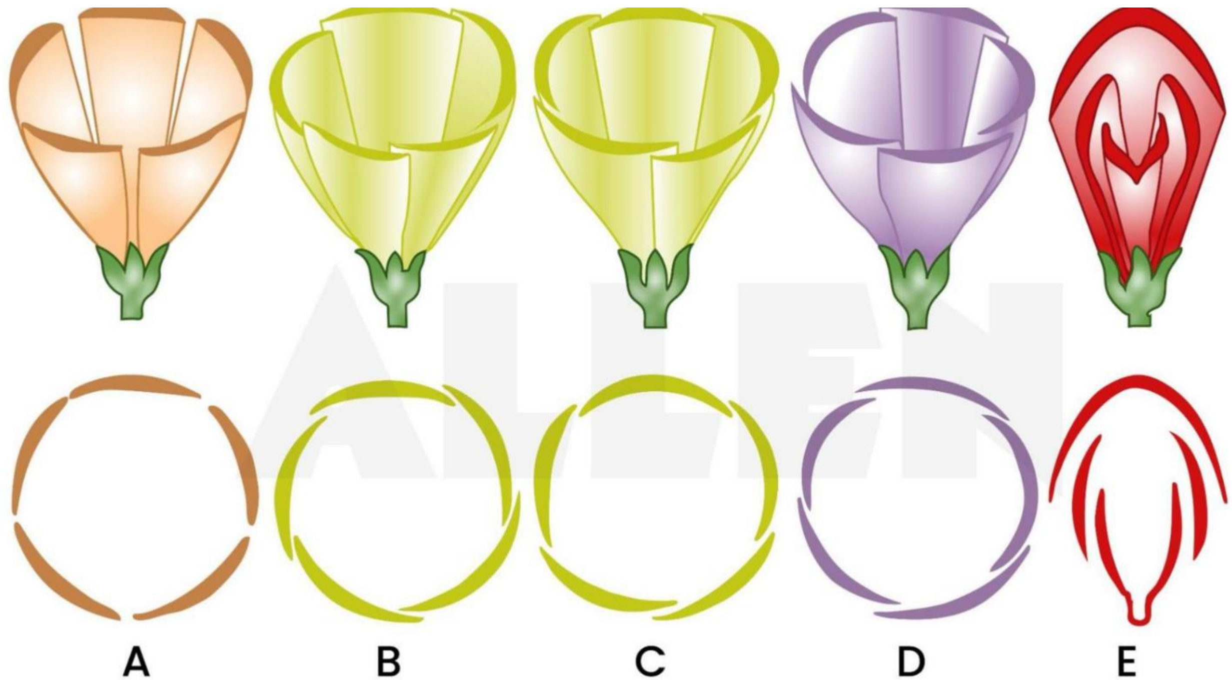
MARCESCENT

ACCRESCENT

A Flower

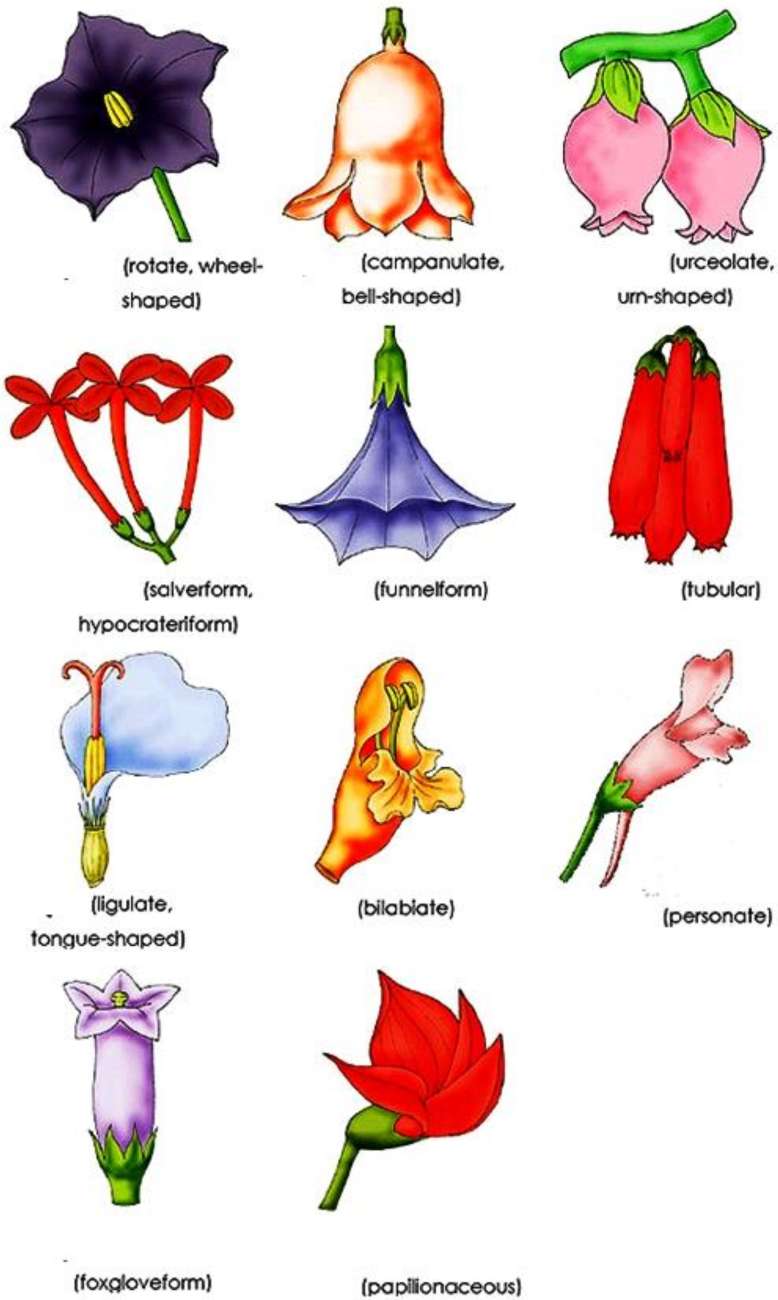
Corolla
(whorl of petals)

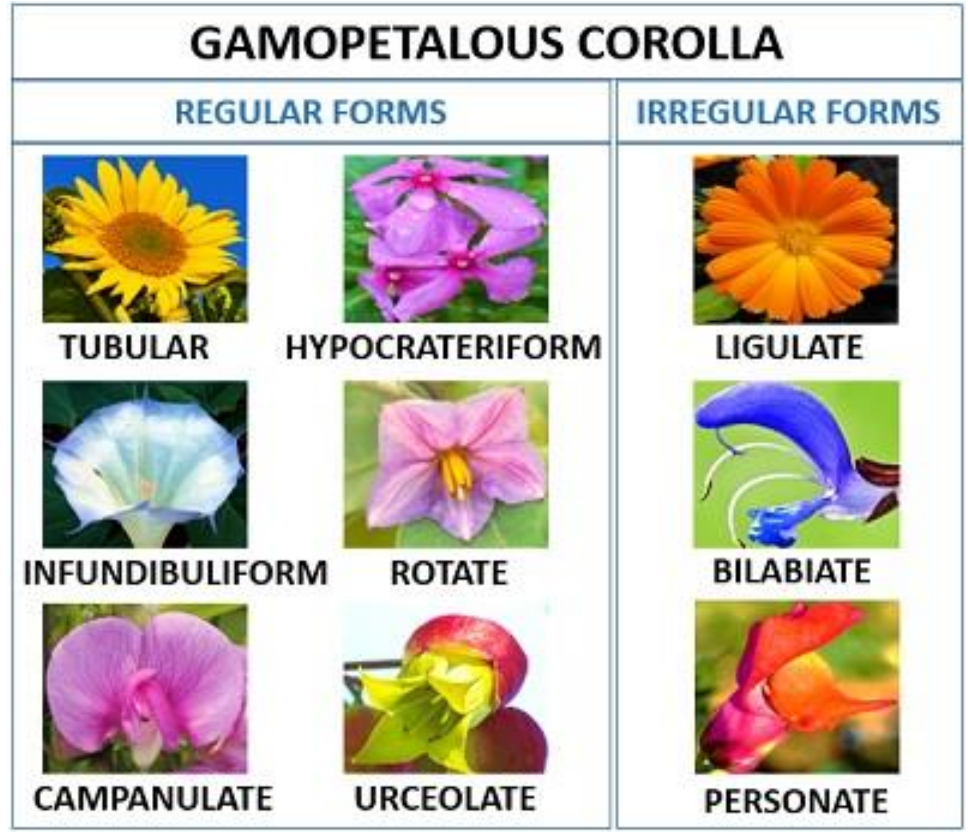




Different types of aestivation of calyx and corolla
A, Valvate, B, Twisted, C. Imbricate, D. Quincuncial, E. Vexillary

Shape of Corolla





[IV] Type

Type of Perianth: The general structure of the perianth.

Monocotyledonous (Monocot) Perianth: Perianth has tepals that are often similar in shape and size. **Example:** Lily, tulip.

Dichotomous (Dicot) Perianth: May exhibit some differentiation but cannot be completely divided into calyx and corolla. **Example:** Ranunculus.

[V] Aestivation

Aestivation of Tepals: The arrangement of tepals in the bud before flowering.

Types:

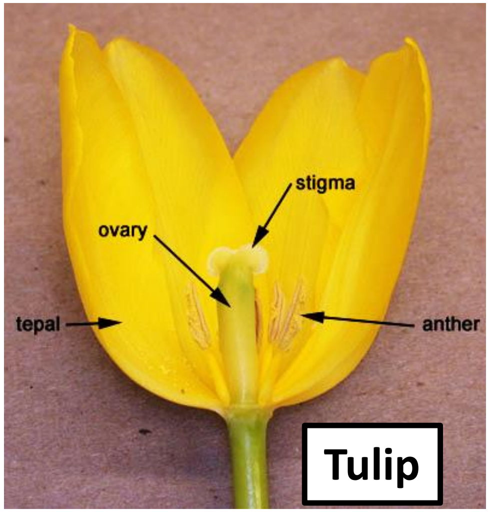
- **Valvate:** Tepals meet at the edges without overlapping. **Example:** Lily.
- **Imbricate:** Tepals overlap each other in a spiral manner. **Example:** Tulip.
- **Twisted:** Tepals overlap in a spiral fashion, often seen in some monocots. **Example:** Amaryllis.

[VI] Colour of Tepals

Colour: The color of the tepals varies widely across species.

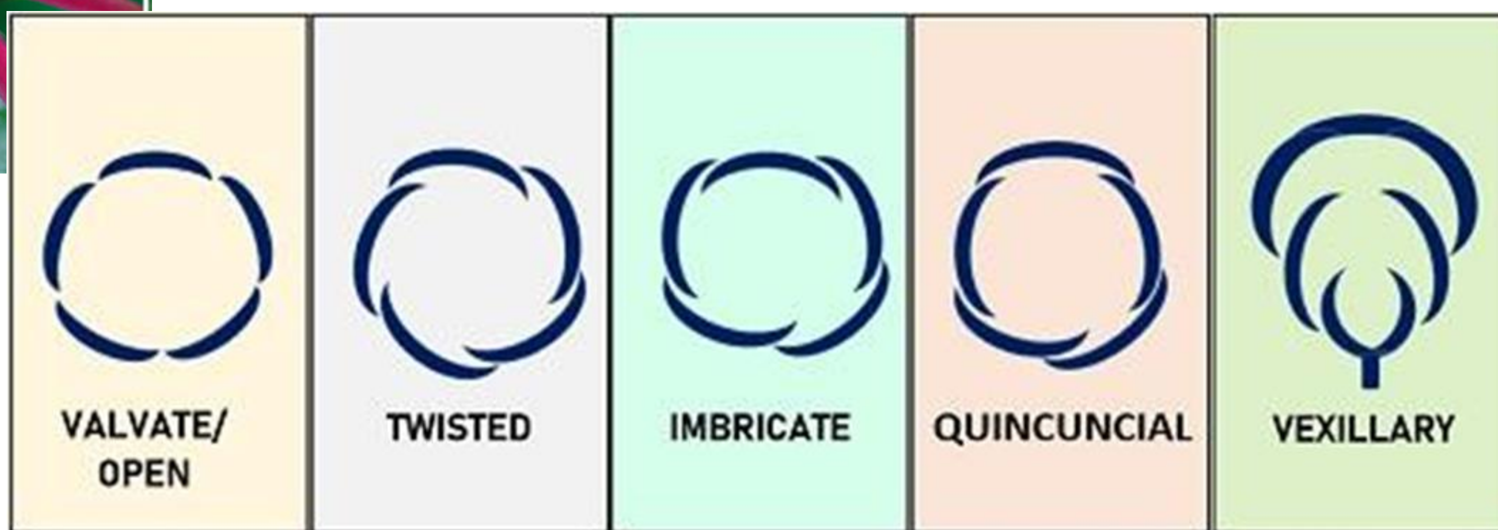
Example: White: Jasmine, lily.

- **Yellow:** Daffodil, tulip.
- **Red:** Lily, tulip.
- **Pink/Purple:** Orchids, hibiscus.
- **Multicoloured:** Petunia, tulip (gradient or multi-colored tepals).


stigma
ovary
tepal
anther
Tulip


Lily


perianth
undifferentiated
B


VALVATE/
OPEN
TWISTED
IMBRICATE
QUINCUNCIAL
VEXILLARY

11. Androecium: Key Features and Descriptions

[I] Number of Stamens

Number of Stamens: Refers to the count of stamens (male reproductive organs) in the flower.

Example: 3 stamens: Pea.

5 stamens: Mustard.

Numerous stamens: Hibiscus, sunflower.

[II] Fertility

Fertility of Stamens: Whether the stamens are capable of producing pollen.

Example:

Fertile: Stamens produce viable pollen grains. **Example:** Rose, sunflower.

Sterile: Stamens are not functional or produce no pollen. **Example:** Male flowers in papaya (where stamens are sterile).

[III] Cohesion of Stamens

Cohesion of Stamens: Refers to how the stamens are united.

Free (Polyandrous): Stamens are distinct and not fused. **Example:** Mustard.

Fused (Monadelphous, Diadelphous, etc.): Stamens are fused together in various patterns.

Monadelphous (single group): Stamens fused to form a tube-like structure. **Example:** Pea.

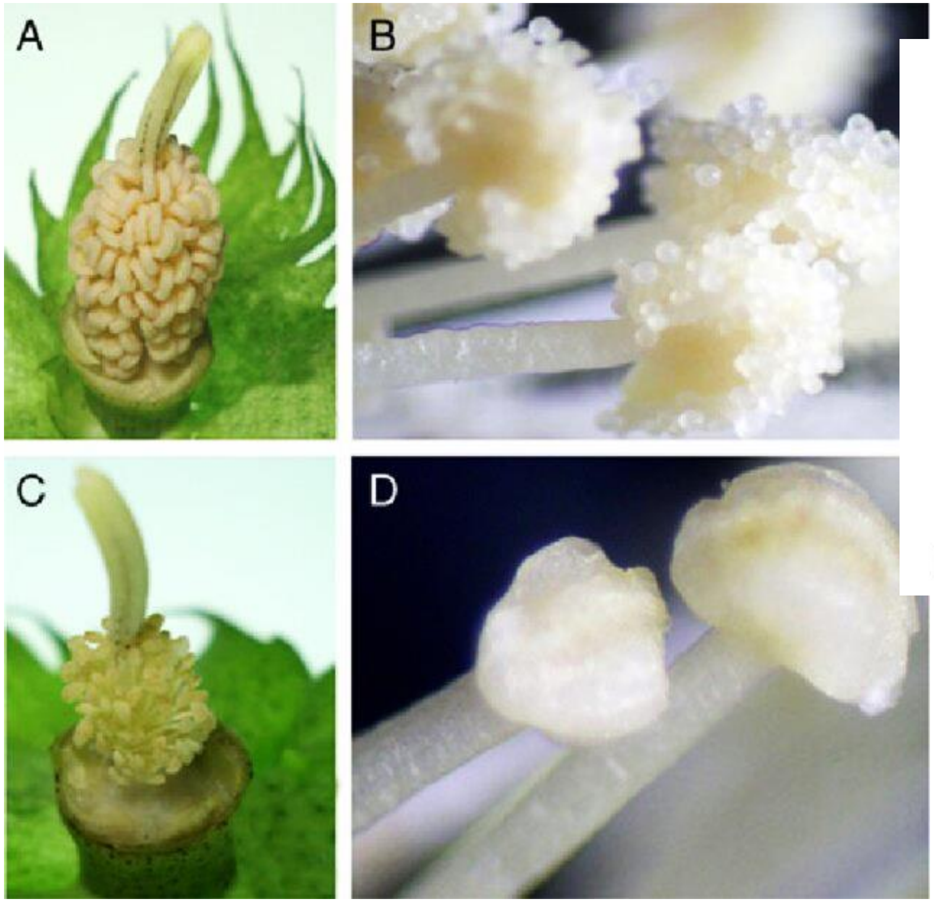
Diadelphous (two groups): Stamens in two groups. **Example:** Bean.

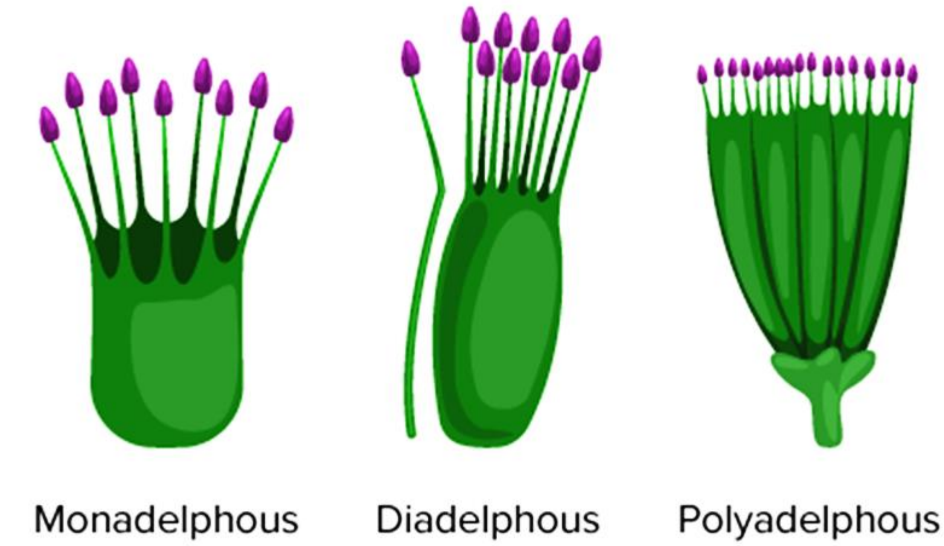
[IV] Adhesion of Stamens

Adhesion of Stamens to Other Floral Parts: Refers to how the stamens are attached to the petals or other parts of the flower.

Adnate: Stamens are fused to the corolla or other parts. **Example:** China rose.

Free: Stamens are not fused to other floral organs. **Example:** Mustard.





Cohesion of Stamens

Comparison between **fertile and sterile flowers** are shown A fertile anthers, B fertile pollen grains, C sterile anthers, D pollen grains are not present on the surface of pollen sacs

Adhesion

[V] Sequence of Staminal Whorls

Arrangement of Stamens: Refers to how the stamens are arranged in relation to other floral parts (usually in concentric whorls).

Example: Single whorl of stamens: Mustard.

Multiple whorls of stamens: Sunflower.

[VI] Length of Filaments

Length of Filaments: The length of the stalk (filament) supporting the anther.

Example: Short filaments: Rose, mustard.

Long filaments: Lily, sunflower.

[VII] Position of Stamens

Position of Stamens: Refers to where the stamens are positioned in relation to the flower's other parts.

Example:

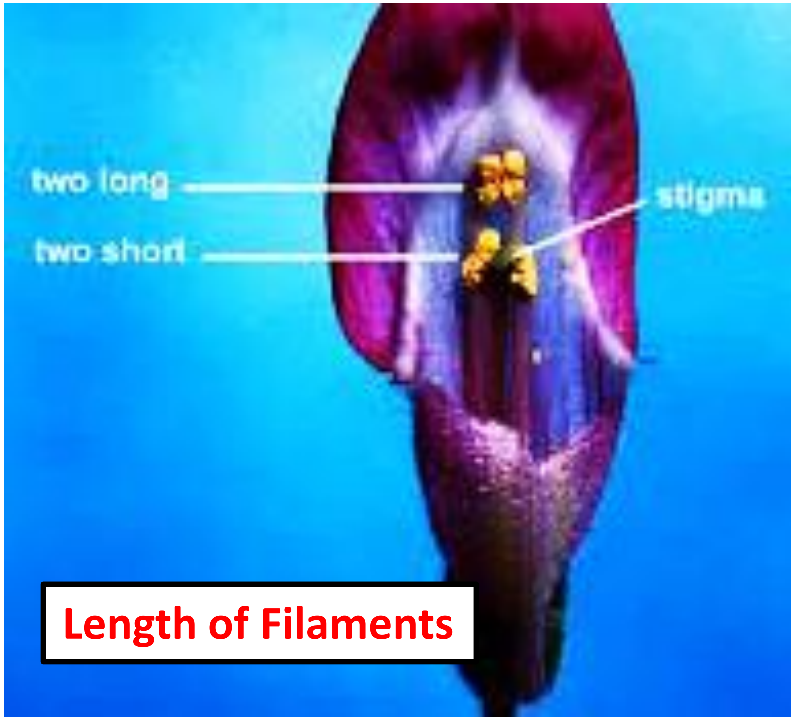
- **Epipetalous:** Stamens attached to the petals. **Example:** Tomato.
- **Introrse:** Anthers face inward toward the center of the flower. **Example:** Mustard.
- **Extrorse:** Anthers face outward. **Example:** Sunflower.

[VIII] Number of Locules

Number of Locules: Refers to how many chambers or compartments the anther has to contain pollen.

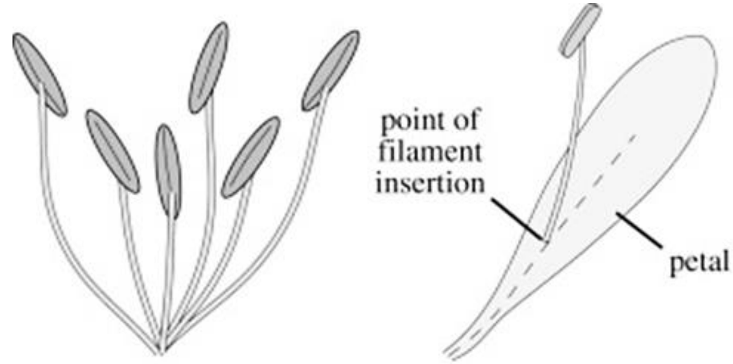
Example:

- **Two locules:** Mustard.
- **Four locules:** Lily.
- **Many locules:** Sunflower.



Length of Filaments

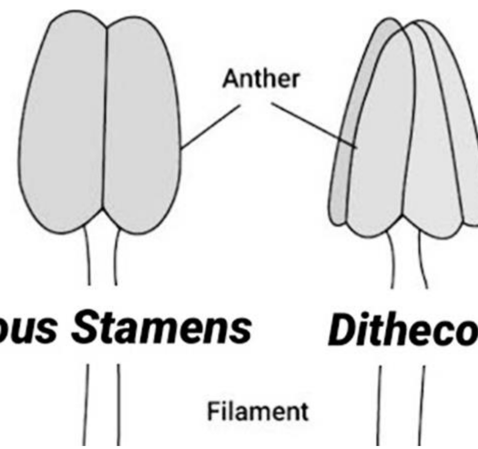
Position of Stamens



apostemonous epipetalous

Introrse Extrorse

Position of Stamens



Monothecous Stamens ***Dithecous Stamens***

Number of Locules

[IX] Attachment of Filament to Anther

Attachment of Filament: Refers to where the filament connects to the anther.

Example:

Basifixed: Filament is attached to the base of the anther. **Example:** Mustard.

Dorsifixed: Filament is attached to the back (or middle) of the anther.**Example:** Hibiscus.

Versatile: Filament is attached at the center of the anther, allowing it to swing freely. **Example:** Pea.

[X] Type of Connectives

Connective of Anther: The tissue that connects the two lobes of the anther.

Example:

Short connective: The two anther lobes are closely joined. **Example:** Mustard.

Long connective: The two lobes are separated by a longer connective tissue. **Example:** Sunflower.

[XI] Dehiscence

Dehiscence: Refers to how the anther opens to release pollen.

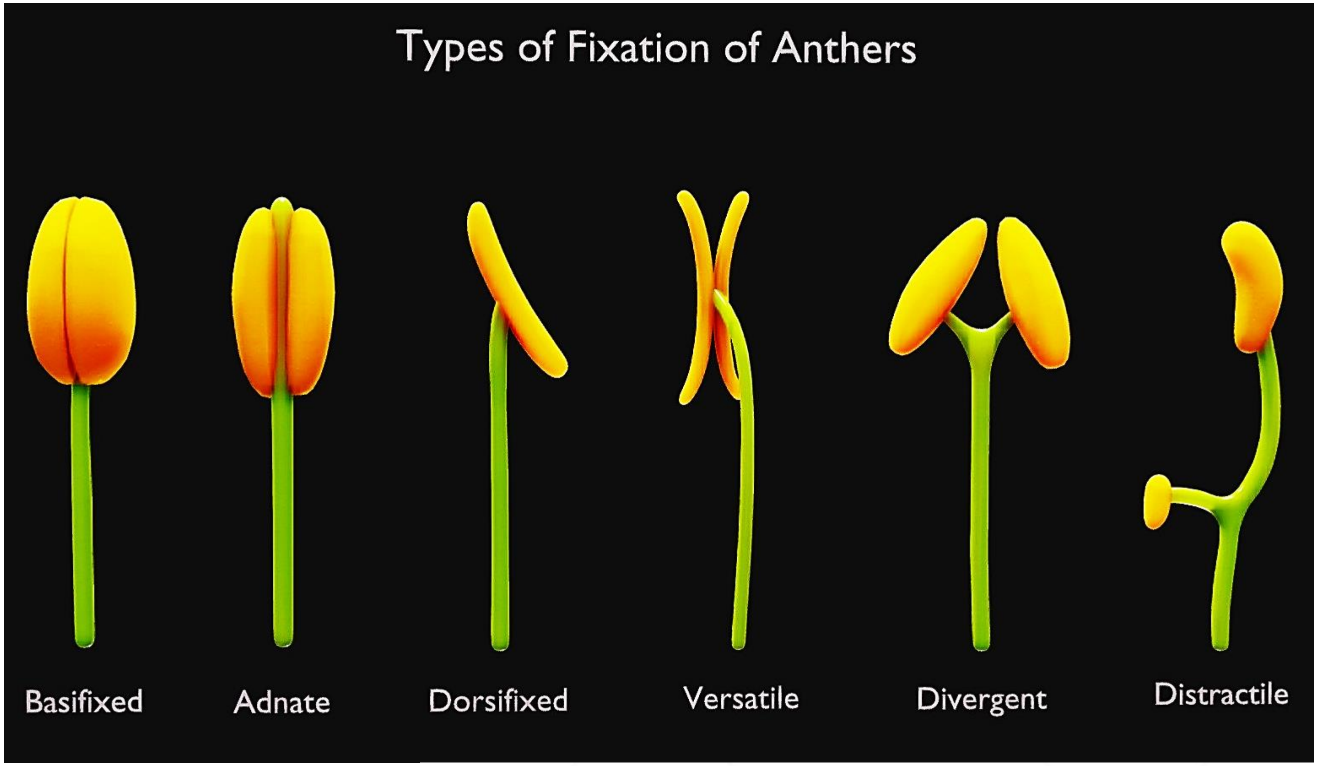
Types:

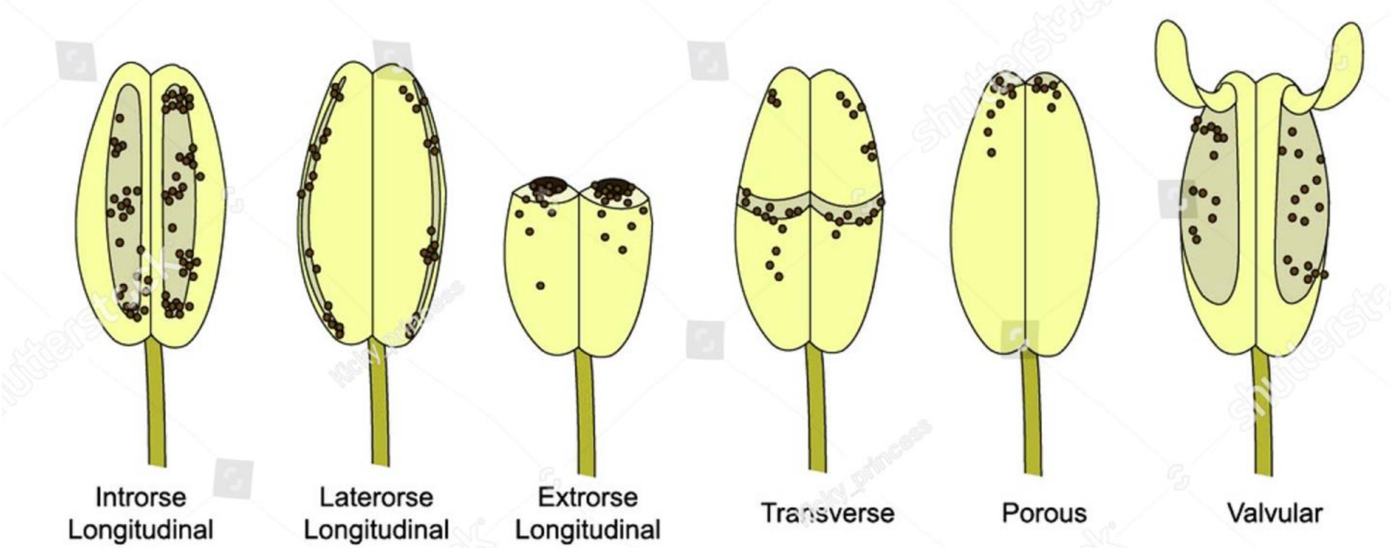
Longitudinal: Anther opens along one or more lines. **Example:** Mustard.

Transverse: Anther opens horizontally across its length. **Example:** Pea.

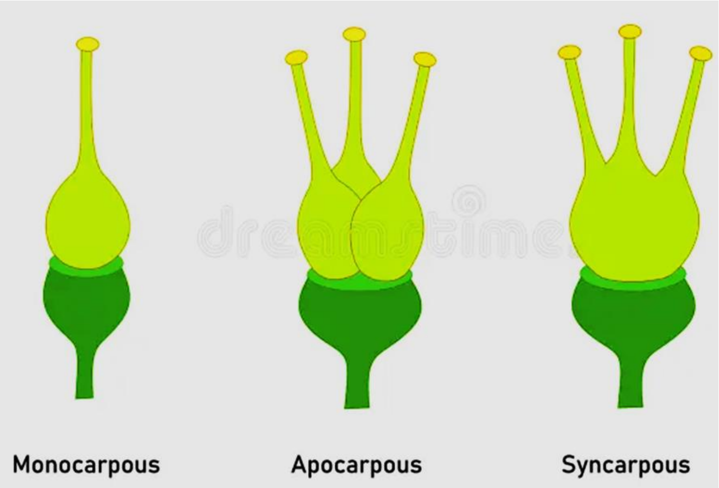
Poricidal: Pollen is released through small pores. **Example:** Bluebell.

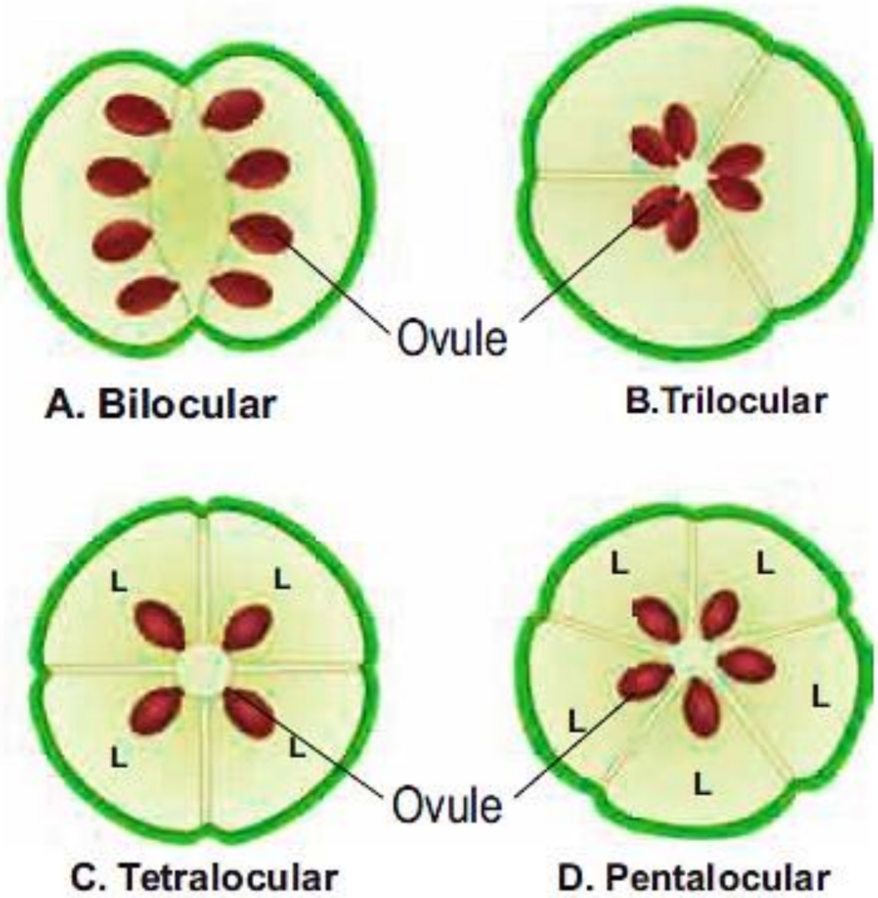
Slit Dehiscence: Anther splits open with slits. **Example:** Lily.

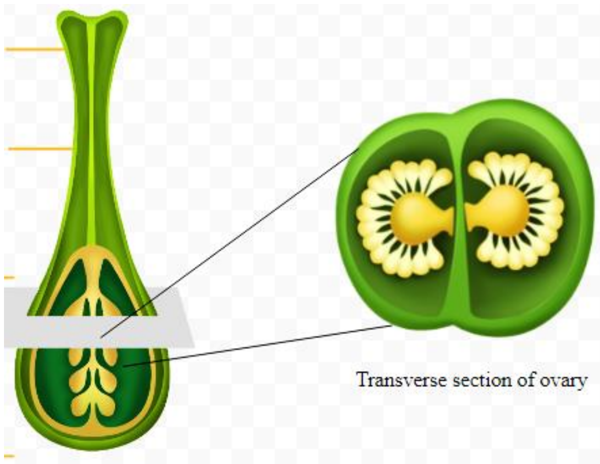


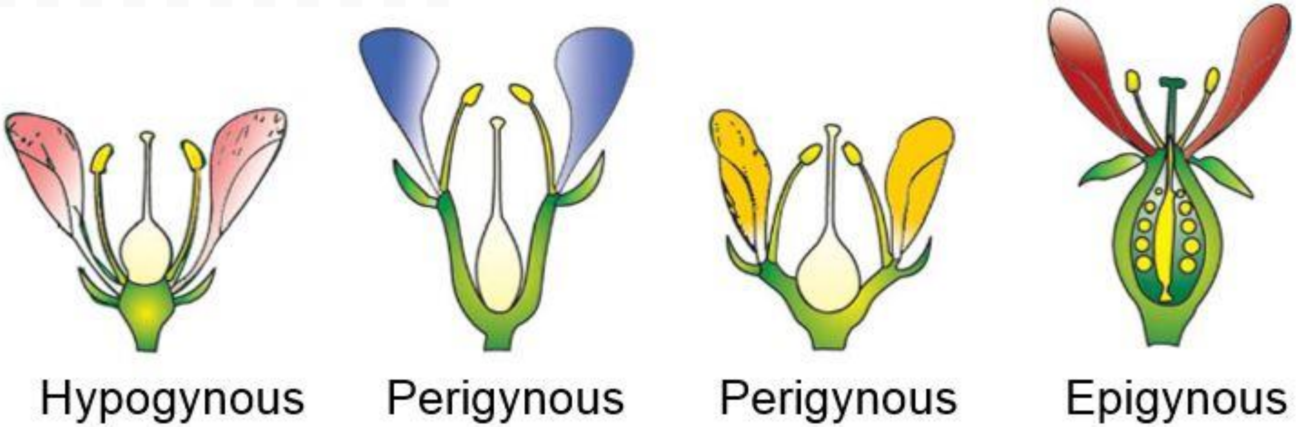


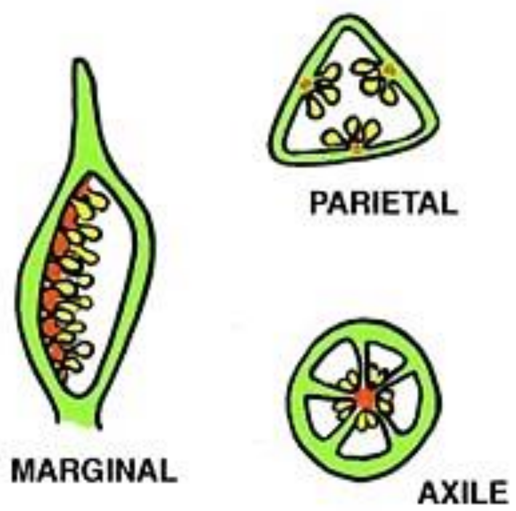
Dehiscence of anthers

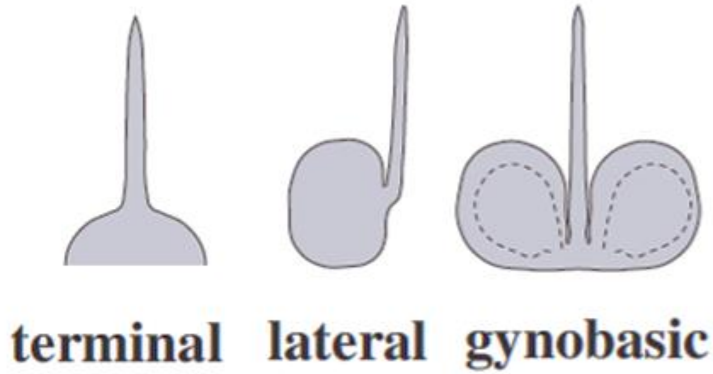

Monocarpous
Apocarpous
Syncarpous


Ovule
A. Bilocular
B.Trilocular
L
Ovule
C. Tetralocular
D. Pentalocular


Transverse section of ovary

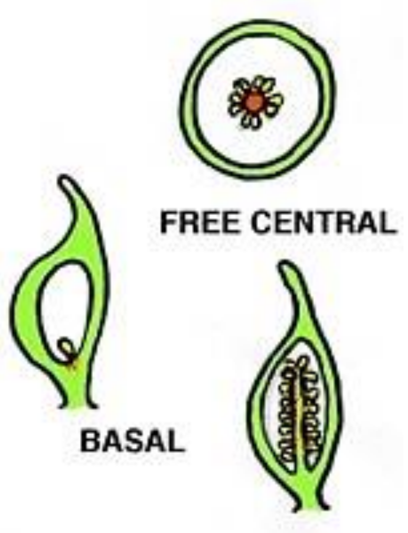

Hypogynous
Perigynous
Perigynous
Epigynous

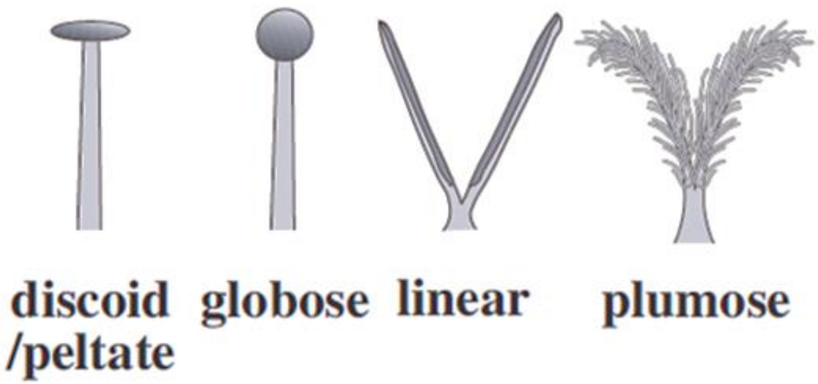

MARGINAL
PARIETAL
AXILE

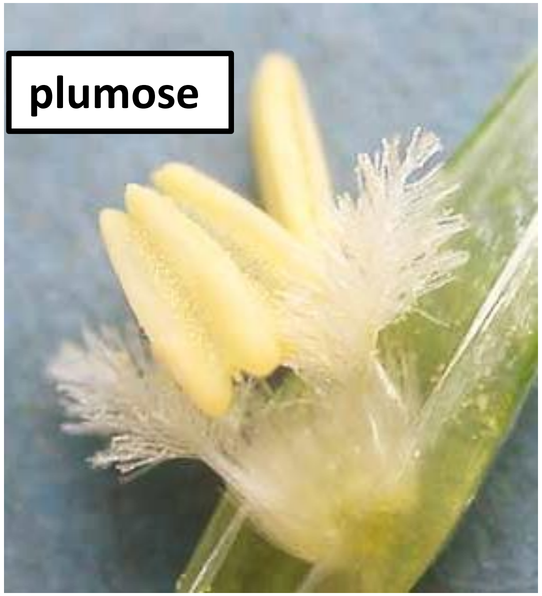

terminal
lateral
gynobasic


Gynobasic style

Stigma


FREE CENTRAL
BASAL


discoid
/peltate
globose
linear
plumose


plumose

13. Fruits: Types and Descriptions

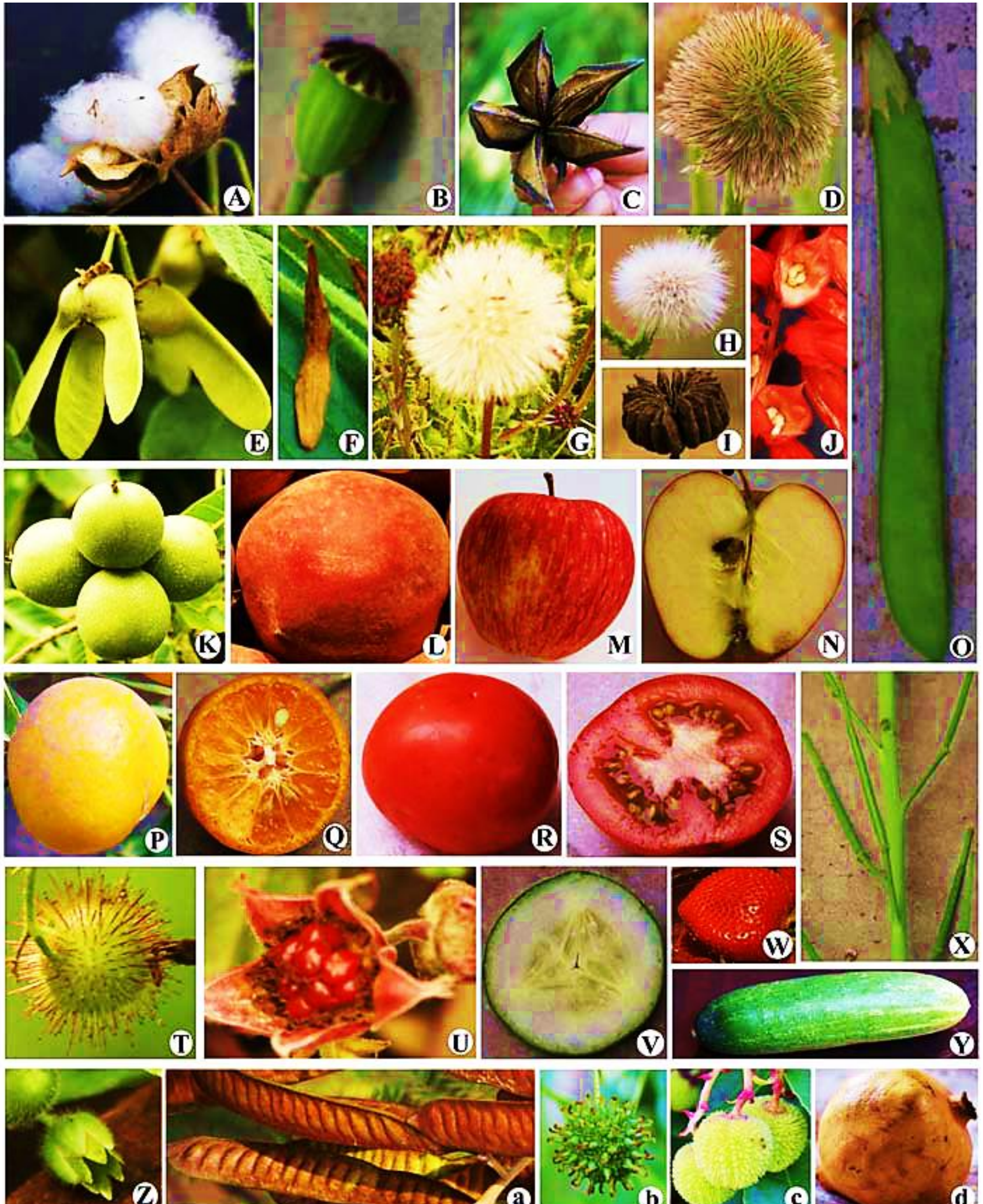
Fruits are the mature ovary of a flower that contains seeds. Based on their development and structure, fruits are categorized into three main types: **Simple**, **Aggregate**, and **Composite/Multiple**.

I. Simple Fruits

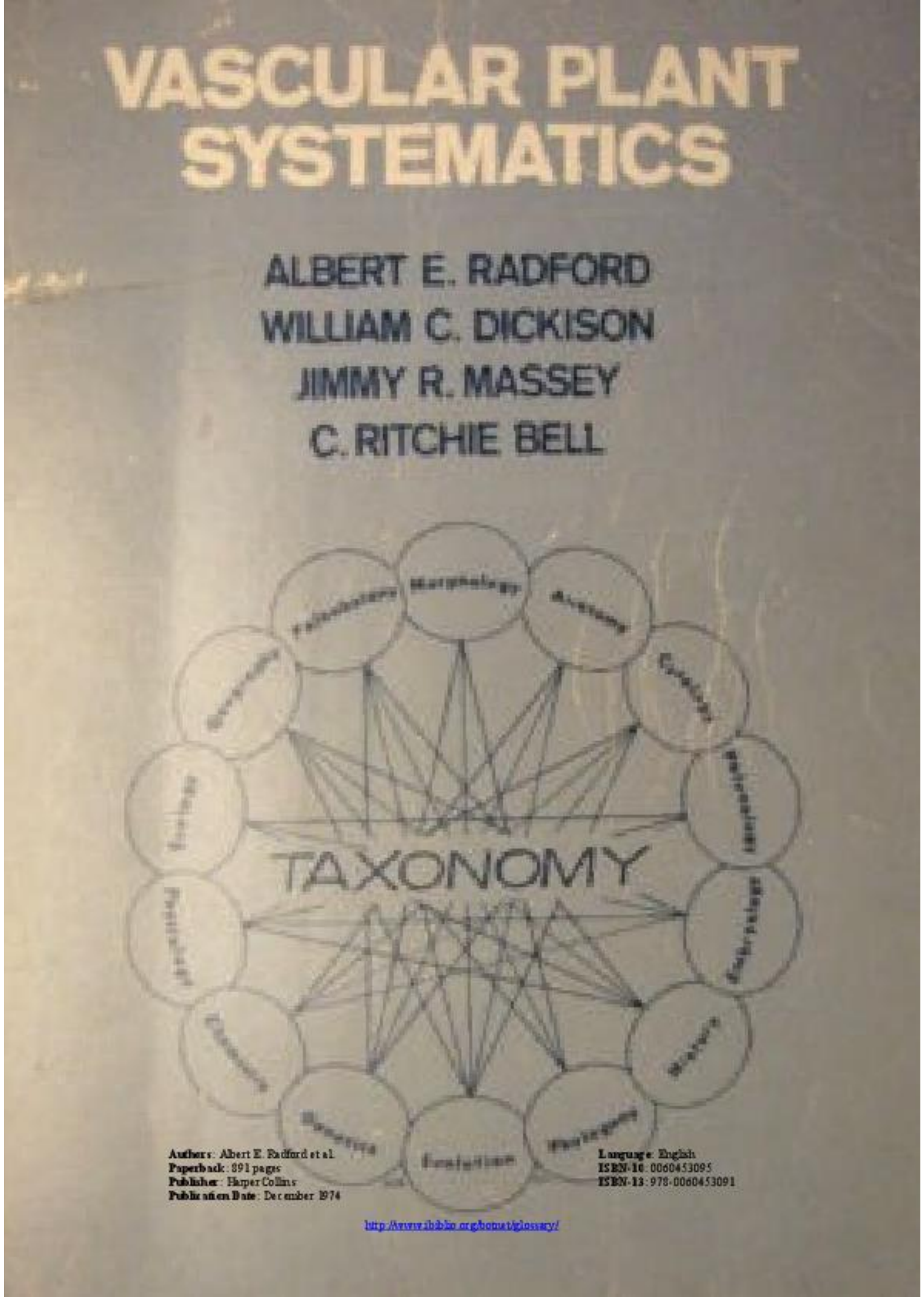
Develop from a single ovary of a single flower.

Dry Fruits: The pericarp (fruit wall) is dry at maturity.

- **Dehiscent (Splits open):**
  - **Legume (Pod):** Splits along two seams. Example: Pea, bean.
  - **Capsule:** Opens in various ways (e.g., pores, slits). Example: Poppy, cotton.
  - **Follicle:** Splits along one seam. Example: Larkspur, milkweed.
  - **Silique:** Splits into two parts with a persistent central partition. Example: Mustard.
- **Indehiscent (Does not split open):**
  - **Achene:** Small, one-seeded fruit with the seed not fused to the pericarp.
    Example: Sunflower.
  - **Caryopsis (Grain):** Seed fused with the pericarp.
    Example: Wheat, rice.
  - **Nut:** Large, one-seeded fruit with a hard pericarp.
    Example: Walnut, acorn.
  - **Samara:** Winged achene. Example: Maple, ash.



Fruits. A: Dehisced capsule of *Gossypium hirsutum* with exposed hairy seeds; **B:** Capsule of *Papaver orientale*; **C:** Dehisced capsule of *Chiranthodendron pentadactylon*; **D:** Etaerio of achenes of *Anemone occidentalis*; **E:** Double samara of *Acer griseum*; **F:** Pod of *Dalbergia sissoo*; **G:** Cypsela of *Haplopappus macrocephalus*; **H:** Cypsela of *Sonchus oleraceous*; **I:** Schizocarp of *Abutilon indicum*; **J:** Carcerulus of *Salvia splensens*; **K:** Drupe of *Juglans nigra*; **L:** Drupe of *Prunus persica*; **M:** Pome of *Malus pumila*; **N:** Same in Longitudinal section; **O:** Pod of *Clitoria ternatea*; **P:** Hesperidium of *Citrus sinensis*; **Q:** Same in Transverse section; **R:** Berry of *Lycopersicon esculentum*; **S:** Same in Transverse section; **T:** Berry of *Ribes menziesii*; **U:** Etaerio of drupes of *Rubus nepalensis*; **V:** Pepo of *Cucumis sativus* in Transverse section; **W:** Whole pepo; **X:** Accessory fruit of *Fragaria vesca*; **Y:** Siliqua of *Brassica campestris*; **Z:** Dehisced capsule of *Stellaria media*; **a:** Pod of *Leucaena leucocephala*; **b:** Multiple fruit of *Liquidambar styracifolia*; **c:** Multiple fruit of *Arbutus unedo*; **d:** Balausta of *Punica granatum*.



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Paperback: 891 pages
Publisher: Harper Collins
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ISBN-10: 0060453095
ISBN-13: 978-0060453091

http://www.ibiblio.org/botnet/glossary/

QUESTIONS FOR PRACTICE

Multiple Choice Questions (MCQs)

What is the primary focus of taxonomy?
a) Phylogenetic relationships
b) Evolutionary biology
c) Naming, describing, and classifying organisms
d) DNA sequencing
Answer: c) Naming, describing, and classifying organisms

Which rank is equivalent to the phylum in plant taxonomy?
a) Division
b) Family
c) Order
d) Class
Answer: a) Division

What is the highest rank in the taxonomic hierarchy?
a) Domain
b) Kingdom
c) Species
d) Phylum
Answer: a) Domain

What is the primary goal of plant systematics?
a) Classification of plants into ranks
b) Exploring evolutionary relationships among plants
c) Identifying unknown plant species
d) Assigning scientific names
Answer: b) Exploring evolutionary relationships among plants

Which principle of taxonomy involves the use of DNA sequencing?
a) Morphology
b) Nomenclature
c) Biochemical and molecular analysis
d) Anatomy and cytology
Answer: c) Biochemical and molecular analysis

Multiple Choice Questions (MCQs)

Which of the following is an artificial classification system based on?
a) Evolutionary traits
b) Morphological traits
c) Specific traits like size and color
d) Habitat
Answer: c) Specific traits like size and color

Which plant family does *Rosa indica* belong to?
a) Rosaceae
b) Fabaceae
c) Poaceae
d) Asteraceae
Answer: a) Rosaceae

What is the primary function of phylogenetics in systematics?
a) Assigning scientific names
b) Constructing evolutionary trees
c) Studying plant morphology
d) Documenting biodiversity
Answer: b) Constructing evolutionary trees

Which of the following is NOT a principle of taxonomy?
a) Identification
b) Classification
c) Fossilization
d) Nomenclature
Answer: c) Fossilization

Which of the following is a major goal of plant taxonomy?
a) Preventing ecological disasters
b) Promoting phylogenetic trees
c) Standardizing plant nomenclature
d) Enhancing genetic mutations
Answer: c) Standardizing plant nomenclature

Multiple Choice Questions (MCQs)

Which system of classification considers evolutionary relationships?
a) Artificial
b) Natural
c) Phylogenetic
d) Morphological
Answer: c) Phylogenetic

What does the herbarium primarily serve as?
a) A repository for fossils
b) A library for plant specimens
c) A database for ecological interactions
d) A storage for phylogenetic trees
Answer: b) A library for plant specimens

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Fill in the Blanks

The science of naming, describing, and classifying organisms is called _______.
Answer: Taxonomy

The taxonomic rank that groups species with close similarities is called _______.
Answer: Genus

_______ is the branch of botany that focuses on the classification, naming, and identification of plants.
Answer: Plant Taxonomy

The International Code of Nomenclature (ICN) is used for naming _______.
Answer: Algae, fungi, and plants

The study of biological diversity and evolutionary relationships is called _______.
Answer: Systematics

The hierarchical rank just below the family in taxonomy is _______.
Answer: Genus

_______ is a field that studies plant diversity and evolutionary relationships.
Answer: Plant Systematics

The _______ rank is the most specific and represents individual organisms.
Answer: Species

_______ trees visually represent the evolutionary history of organisms.
Answer: Phylogenetic

The study of plant fossils to trace evolutionary history is called _______.
Answer: Paleobotany

Short Answer Questions

What are the main components of plant taxonomy?
Answer: Identification, classification, nomenclature, phylogeny, morphology, anatomy and cytology, biochemical and molecular analysis, ecology, paleobotany, and documentation.

Why is studying plants important?
Answer: Plants produce oxygen, form the base of the food chain, provide food, have medicinal value, regulate the environment, support industries, and contribute to scientific research.

What is the purpose of classification in taxonomy?
Answer: To organize organisms into hierarchical groups based on shared characteristics, making them easier to study and understand.

What does the rank "family" represent in taxonomy?
Answer: A collection of related genera sharing common characteristics.

What is DNA barcoding used for in plant taxonomy?
Answer: To identify plant species and study genetic relationships.

What is the difference between taxonomy and systematics?
Answer: Taxonomy focuses on naming, describing, and classifying organisms, while systematics studies biological diversity and evolutionary relationships, integrating taxonomy with phylogenetics.

Why is phylogeny important in taxonomy?
Answer: Phylogeny helps understand evolutionary relationships and ancestry among organisms, providing a deeper insight into their connections.

What is the significance of studying plant morphology in taxonomy?
Answer: Morphology helps classify plants based on their physical traits, such as leaves, flowers, and stems, which are foundational to plant taxonomy.

How does plant taxonomy aid in biodiversity conservation?
Answer: By identifying and documenting rare, endangered, or endemic species, taxonomy provides crucial data for conservation planning.

What role does molecular analysis play in modern taxonomy?
Answer: Molecular analysis uses DNA, RNA, and proteins to determine genetic relationships, revolutionizing taxonomy by offering precise identification and evolutionary insights.

True or False

Taxonomy is solely concerned with evolutionary relationships.
Answer: False

The phylum rank in animals is equivalent to the division rank in plants.
Answer: True

Systematics integrates taxonomy with evolutionary biology.
Answer: True

Morphology studies internal structures and cell features of plants.
Answer: False

Nomenclature ensures uniformity and stability in naming organisms.
Answer: True

Artificial classification considers many morphological traits to group plants.
Answer: False

The family *Fabaceae* is also known as the legume family.
Answer: True

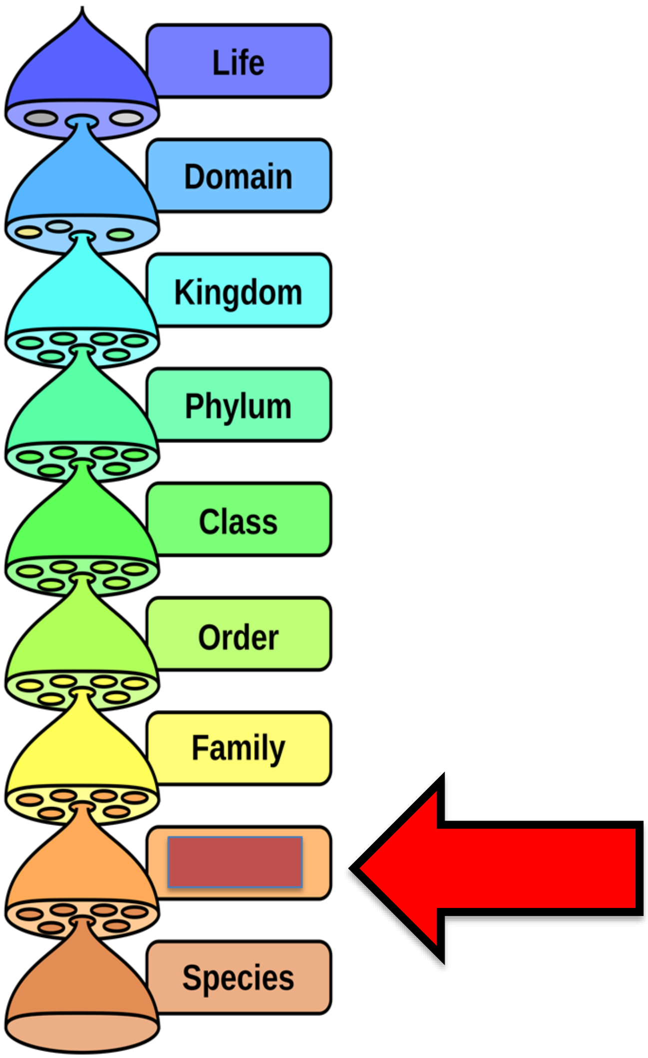
Paleobotany involves studying the role of plants in modern ecosystems.
Answer: False

The rank "class" is broader than the rank "family" in taxonomy.
Answer: True

Every human being inherently practices taxonomy in daily life.
Answer: True

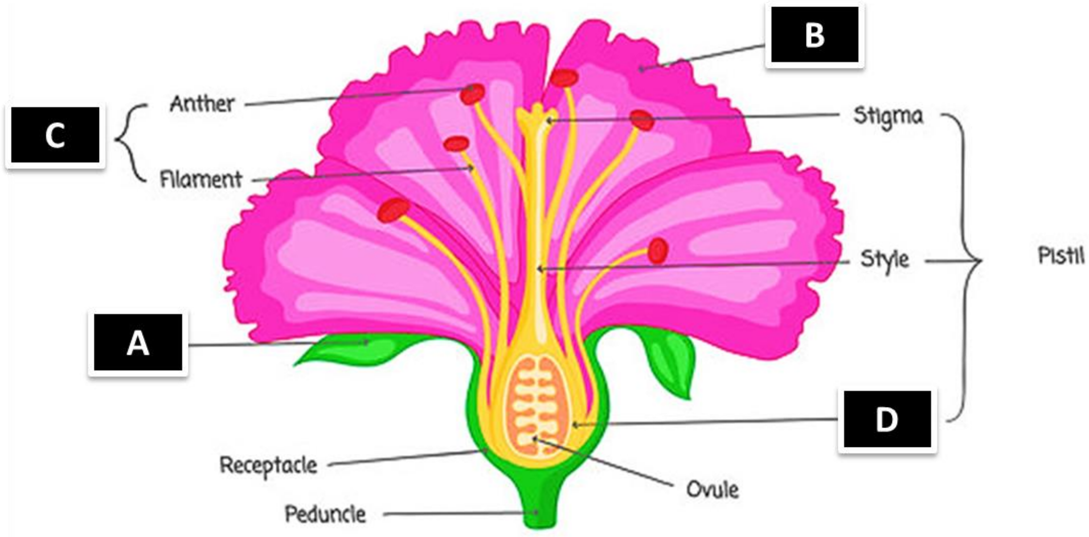
Image-Based Question

Question: Identify the rank indicated by the arrow in the given phylogenetic tree.



Answer: The answer depends on the arrow pointing to a specific rank is **Genus**.

Image-Based Question

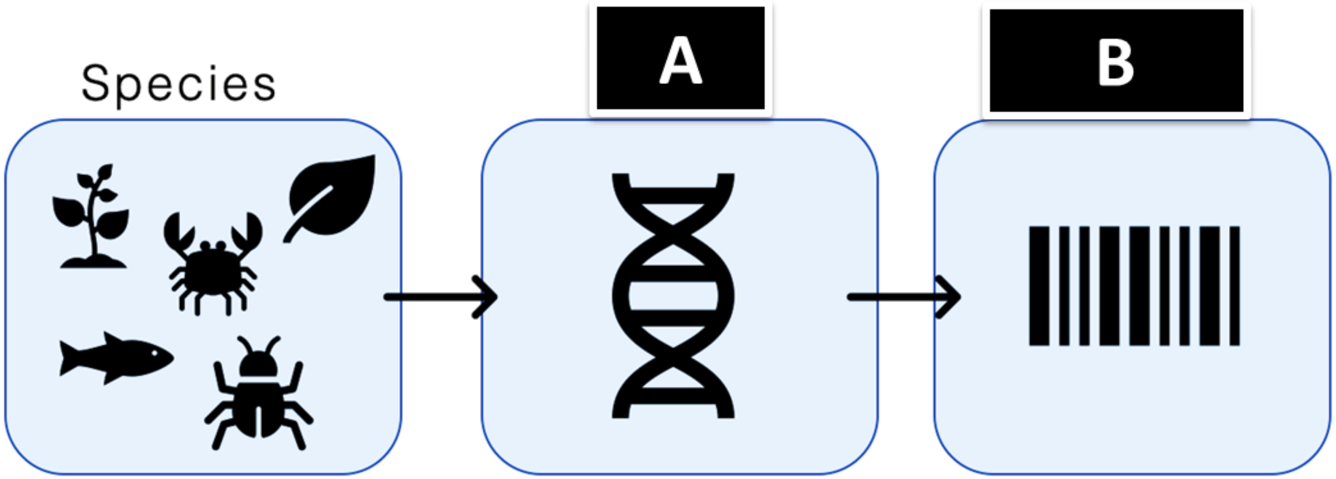


Question: Identify the parts of the flower labeled A, B, C, and D.

Answer:

A → Sepals
B → Petals
C → Stamens
D → Pistils

Image-Based Question



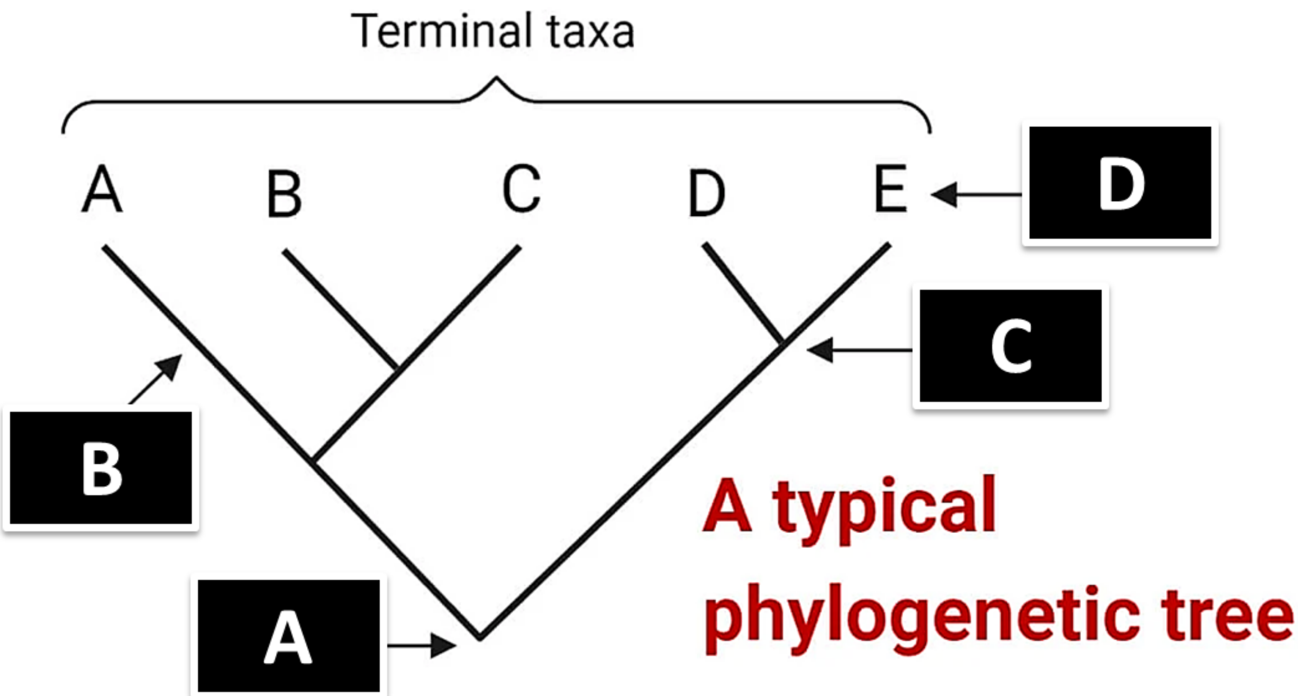
Question: Identify the labeled with A and B.

Answer:

A → DNA

B → DNA Barcode

Image-Based Question



Question: Identify the parts of the flower labeled A, B, C, and D.

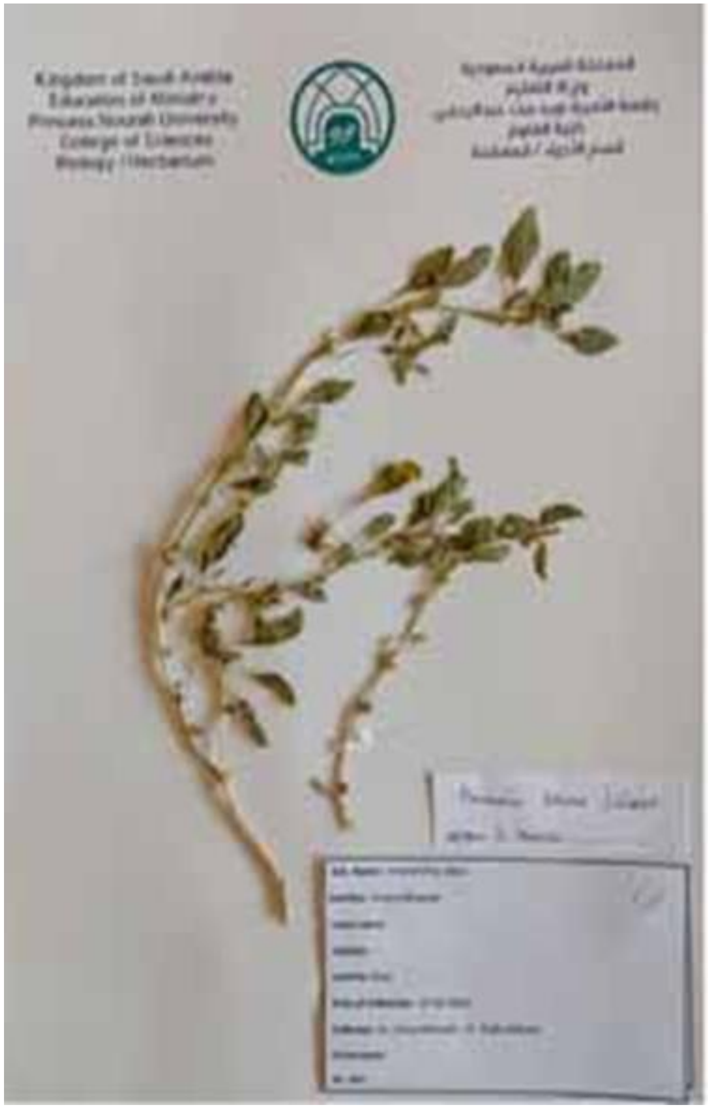
Answer: A → Root

B → Branch

C → Node

D → Taxon

Image-Based Question



Question: Identify the parts indicated by the arrow in the given picture.

Answer: Herbarium label

WEEK-4

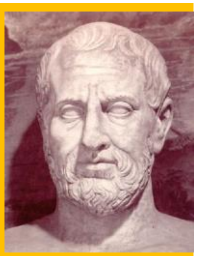
PLANT CLASSIFICATION

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:

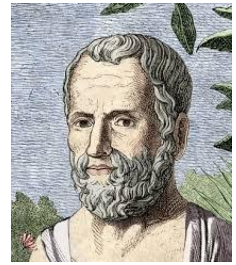
- 610-1100 AD saw the revival of literacy.
- Greek manuscripts were translated.

Ibual- Awwan described nearly 600 plants

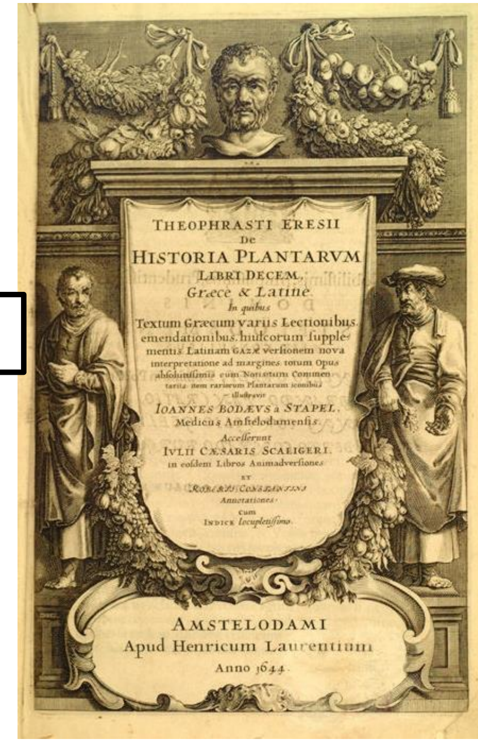
- Described sexuality as well as the role of insects in fig pollination
- But not develop any significant scheme of classification

Page from 15th century Arabic edition of Dioscorides herbal

Theophrastus (372 BCE – 287 BCE): The "Father of Botany"



Theophrastus was a **Greek philosopher and scientist**, widely regarded as the **Father of Botany** due to his pioneering work in plant classification and study. He was a student of **Plato** and later of **Aristotle**, succeeding Aristotle as the head of the **Lyceum** in Athens.



Historia Plantarum

Contributions to Botany

1. Theophrastus' Major Works

Theophrastus wrote several important texts on plants, the most notable being:

"Historia Plantarum" (*Enquiry into Plants*) – A systematic classification of plants.

"De Causis Plantarum" (*On the Causes of Plants*) – A study on plant physiology and reproduction.

These works are considered the **first scientific botanical studies** in history and influenced plant classification for centuries.

2. Theophrastus' Plant Classification System

Theophrastus classified plants based on **morphological characteristics** and **growth habits** rather than evolutionary relationships. His classification included:

Trees (e.g., oak, olive)
Shrubs (e.g., myrtle, pomegranate)
Herbs (e.g., wheat, barley)
Undershrubs (small woody plants)

He also recognized **differences in plant reproduction,** distinguishing between flowering and non-flowering plants.

De Causis Plantarum

Medieval Botany (5th–15th Century CE)

During the medieval period, botanical knowledge was largely preserved and expanded upon within **monasteries, Islamic centers of learning, and medieval universities.** Botanical studies in this era were primarily focused on **medicinal, agricultural, and religious applications**, rather than classification based on scientific principles.

1. Key Features of Medieval Botany

Herbalism and Medicine: Plants were studied for their **healing properties**, often based on Galenic and Dioscoridean traditions.

Monastic Gardens: Monks cultivated and documented plants in monastery gardens, preserving botanical knowledge.

Religious Influence: Many plants were linked to Christian symbolism, and classification often had a theological basis.

Translation Movement: Islamic scholars preserved and expanded on Greek botanical texts.

2. Major Contributions to Medieval Botany

(A) European Herbal Tradition

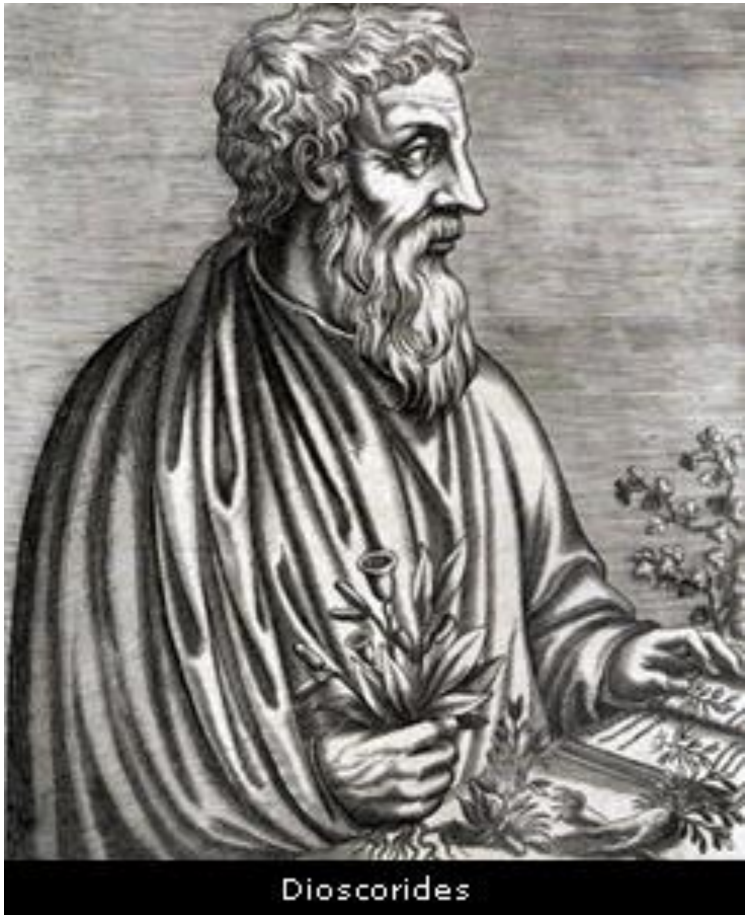
Dioscorides' ***De Materia Medica*** (1st Century CE) was the most influential botanical text, copied and used for centuries.

Monastic Herbals:

Monasteries became centers of botanical knowledge, with monks transcribing and illustrating **herbals** (books describing plants and their medicinal uses).

Example: The **St. Gall Monastery Plan (9th century CE)** included a medicinal garden layout.

Hildegard of Bingen (1098–1179): A Benedictine nun who wrote *Physica*, describing **medical uses of plants**.



Indigenous plant classification

(B) Islamic Golden Age (8th–13th Century CE)

Preservation and Expansion of Greek Knowledge:

Islamic scholars translated and improved upon the works of **Theophrastus, Dioscorides, and Galen.**

Notable Islamic Botanists:

Al-Dinawari (828–896 CE): Wrote *Kitab al-Nabat* (*Book of Plants*), a comprehensive botanical encyclopedia.

Ibn al-Baitar (1197–1248 CE): Authored *Kitab al-Jami fi al-Adwiya al-Mufrada*, documenting over **1,400 medicinal plants**.

Innovations in Agriculture:

Introduced new plant cultivation techniques, irrigation methods, and **crop rotation**.

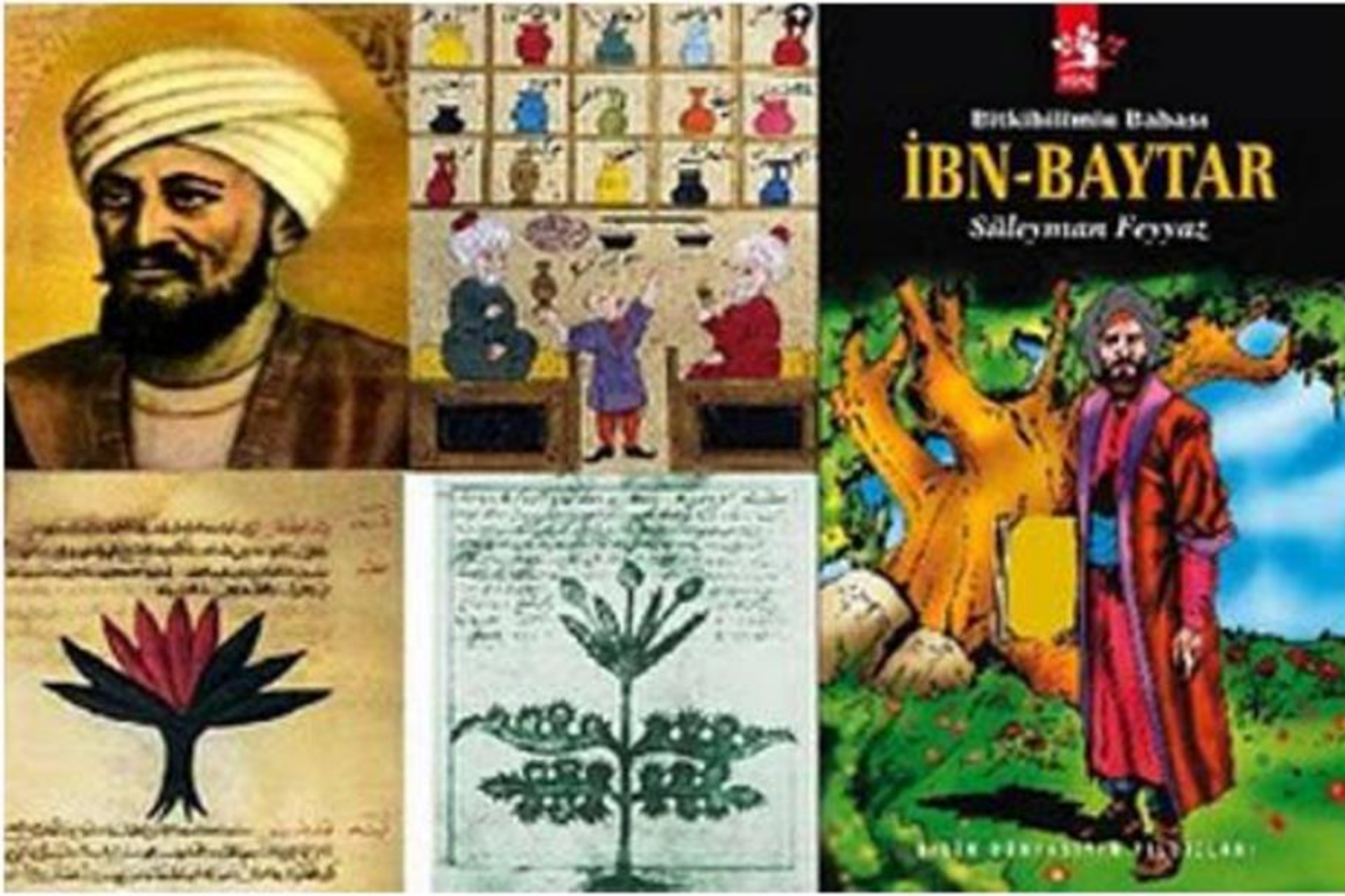
(C) Late Medieval Universities (12th–15th Century CE)

With the rise of **universities in Europe**, botany was incorporated into medical studies.

Albertus Magnus (1200–1280 CE) wrote *De Vegetabilibus*, classifying plants based on **structure and function**, making early attempts at a natural classification system.

Al-Dinawari (828–896 CE)

Albertus Magnus (1200–1280 CE)



Ibn al-Baitar (1197–1248 CE):

Islamic Botany (8th–15th Century CE)

During the **Islamic Golden Age (8th–15th century CE)**, botany flourished as scholars preserved, translated, and expanded upon **Greek, Roman, and Indian botanical knowledge.** Islamic botanists contributed significantly to **plant classification, medicinal botany, agriculture, and horticulture**, laying the foundation for later European botanical studies.

1. Characteristics of Islamic Botany

- **Preservation and Expansion of Ancient Knowledge:** Translations of works by **Theophrastus, Dioscorides, and Galen** formed the basis of early Islamic botany.
- **Systematic Plant Classification:** Early attempts to classify plants based on **morphology, medicinal use, and habitat.**
- **Medicinal Botany and Pharmacology:** Herbal medicine and the study of plant-based drugs were highly advanced.
- **Agricultural Innovations:** New irrigation techniques, crop rotation, and the introduction of exotic plants.
- **Botanical Gardens:** Experimentation with plant cultivation in **royal gardens and medical schools.**

2. Major Islamic Botanists and Their Contributions

(A) Al-Dinawari (828–896 CE) – "Father of Islamic Botany"

Wrote **Kitab al-Nabat** (*Book of Plants*), one of the earliest works on **systematic plant classification.**

Described **over 600 plant species**, their habitats, and growth patterns.

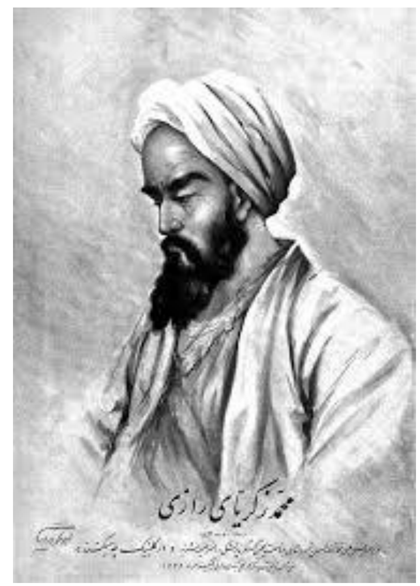
Studied **plant life cycles and environmental effects** on plant development.

(B) Abu Hanifa al-Dinawari (9th Century CE)

Introduced **detailed observations on plant morphology and reproduction.**

Recognized the role of **climate and soil** in plant growth.

Abu Hanifa al-Dinawari



Al-Razi (Rhazes) (865–925 CE)

(C) Al-Razi (Rhazes) (865–925 CE)
A **physician and botanist** who used plant-based medicines in **clinical treatments.**
His work influenced the development of **herbal medicine in Islamic and Western medicine.**
(D) Ibn Sina (Avicenna) (980–1037 CE)
Wrote **"The Canon of Medicine"**, which classified medicinal plants and their pharmacological effects.
His work influenced **European herbal medicine** for centuries.

Al-Razi (Rhazes) (865–925 CE)

(E) Ibn al-Baitar (1197–1248 CE) – The Great Herbalist

Authored **Kitab al-Jami fi al-Adwiya al-Mufrada** (*Compendium on Simple Medicaments and Foods*), documenting:

- **Over 1,400 medicinal plants and substances.**
- Information collected from **Greek, Roman, Indian, and Arab sources.**

One of the most **comprehensive medieval botanical and pharmacological texts.**

Ibn Sina (980–1037 CE)

Conceptual Development of Pre-Darwinian Taxonomy

Introduction

Taxonomy: The science of classifying organisms.

Early classification systems were based on observable traits, without considering evolutionary relationships.

Key Milestones in Pre-Darwinian Taxonomy

Ancient Greece and Aristotle (384–322 BCE)

- **Concept**: Scala Naturae ("The Great Chain of Being").
- Organized living organisms hierarchically based on complexity, from simple to more complex forms.
- Focused on traits like locomotion (e.g., animals vs. plants).

Medieval Period

- Emphasis on theological and symbolic classification.
- Little advancement in scientific approaches to taxonomy.

Carolus Linnaeus (1707–1778)

- **Contribution**: Introduced **binomial nomenclature** and hierarchical classification (e.g., kingdom, class, order, genus, species).
- Published *Systema Naturae* (1735).
- Based taxonomy on morphology (observable features).
- Believed species were fixed and unchanging.

Buffon's Contributions (1707–1788)

- Georges-Louis Leclerc, Comte de Buffon, proposed that species could adapt to environmental changes.
- Suggested relationships between organisms but did not include evolutionary mechanisms.

Theoretical Basis for the Classification of Organisms

Historical Perspectives in Taxonomy

Over time, taxonomists have proposed conflicting theories to classify organisms, grouped into five main approaches:

1. Essentialism

Origin: Rooted in **Aristotelian philosophy** (4th century BCE).
Key Concept: Organisms have fixed, unchanging "essences" that define their identity.
Focus: Classification based on idealized, intrinsic traits that are immutable.
Limitation: Ignored variation and adaptability within species.
Historical Influence: Dominated pre-Darwinian taxonomy.

2. Nominalism

Key Idea: Organisms are grouped into species based on human-imposed labels rather than inherent natural differences.
Philosophical Basis: Denies the existence of universal forms; species are artificial constructs.
Proponents: Early Renaissance scholars critical of Aristotelian essentialism.
Limitation: Lacked acknowledgment of biological relationships or evolutionary connections.

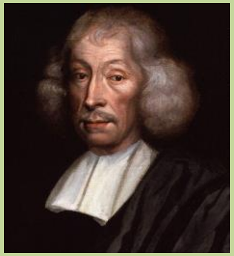
3. Empiricism

Key Concept: Classification based solely on observable, measurable traits (morphology, anatomy, etc.).
Proponents: Carolus Linnaeus, Georges Cuvier.
Focus: Objectivity and practical utility in identifying and grouping organisms.
Strength: Established the **binomial nomenclature** and a structured hierarchical system.
Limitation: Did not incorporate evolutionary relationships or genetic data.

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

Jean-Baptiste Lamarck (1744–1829)

Proposed the **Theory of Inheritance of Acquired Characteristics**.

Suggested species evolved through use and disuse of traits.

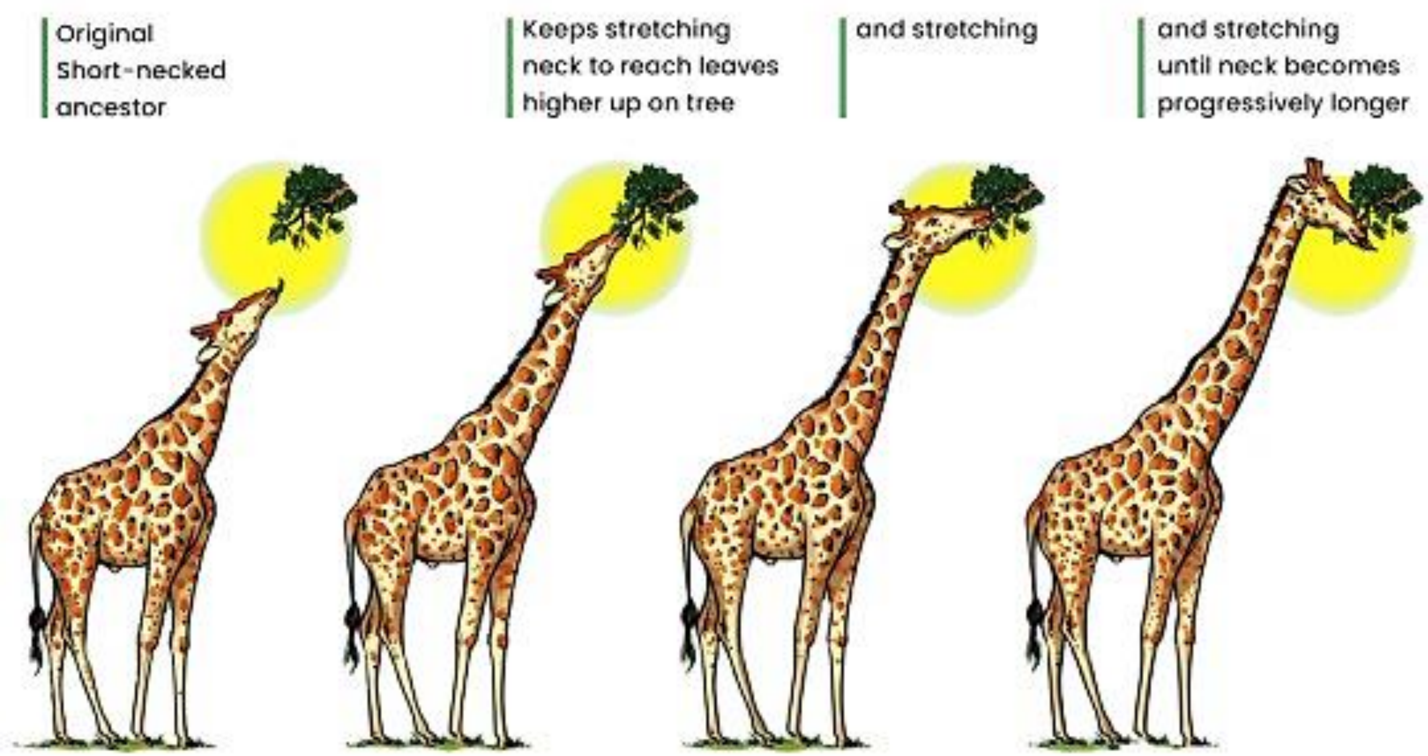
Classification began to consider change over time.

Limitations of Pre-Darwinian Taxonomy

Lack of understanding of evolutionary processes.

Focused on static traits rather than dynamic relationships.

Influenced by theology and belief in species immutability.



Pre-Linnaean Classification (16th–17th Century)

Before Carl Linnaeus introduced **binomial nomenclature** in the 18th century, plant classification systems in the **16th and 17th centuries** were primarily based on **habit, form, medicinal use, and reproductive structures.** These early systems laid the foundation for modern taxonomy but lacked consistency and a universal naming system.

1. Characteristics of Pre-Linnaean Classification

Based on Morphology: Plants were grouped by **external characteristics**, such as size, shape, and habitat.

No Fixed Naming System: Names varied widely across regions, often being long and descriptive.

Medicinal Influence: Many classifications were based on **herbal medicine** traditions.

Early Attempts at Natural Classification: Some botanists moved beyond arbitrary groupings to classify plants **based on multiple characteristics.**

2. Key Pre-Linnaean Botanists and Their Contributions

(A) Andrea Cesalpino (1519–1603) – First Attempt at Natural Classification

Published *De Plantis* (1583), grouping plants based on **seed structure and fruit type** rather than habit (trees, herbs, etc.). Considered one of the earliest botanists to move toward a **natural classification system.** Classified **1500 plant species** but lacked binomial names.

(B) John Ray (1627–1705) – Definition of Species

Introduced the **biological concept of species**, defining them as organisms that reproduce their own kind.

Published *Historia Plantarum* (1686–1704), which classified **18,000 species** based on multiple traits.

Distinguished between **monocots and dicots** (seed structure).

Laid the foundation for **Linnaean taxonomy.**

(C) Joseph Pitton de Tournefort (1656–1708) – Concept of Genera

Developed a system based on **flower structure**, grouping plants into **genus (genera)** for the first time.

Published *Éléments de botanique* (1694), which influenced Linnaeus.

Classified **about 9,000 species** into 700 genera.

John Ray

Tournefort

3. Other Notable Contributions

Caspar Bauhin (1560–1624): Used **binomial names** (Genus + Species) before Linnaeus but without a structured system.

Gaspard Bauhin (1560–1624): Differentiated plants more precisely and influenced Linnaeus' binomial nomenclature.

Augustus Rivinus (1652–1723): Focused on **flower morphology** as a basis for classification.

Caspar Bauhin

Augustus Rivinus

Carolus Linnaeus and the System of Plant Classification

Carolus Linnaeus (1707–1778) was a Swedish botanist, physician, and zoologist who revolutionized biological classification. His **binomial nomenclature system** remains the foundation of modern taxonomy. Linnaeus' classification system was based primarily on **floral structures and reproductive organs**, making it more systematic than earlier pre-Linnaean methods.

1. Key Features of Linnaeus' Classification System

A. Binomial Nomenclature (1735) – Standardized Naming System

Each species is given a **two-part Latin name**:

Genus name (capitalized) + **Species name** (lowercase).

Example: *Homo sapiens*, *Rosa indica*, *Zea mays*.

Provided **universal consistency**, eliminating confusion from long descriptive names.

B. Hierarchical Classification System

Linnaeus organized plants (and all organisms) into a **hierarchical structure**:

- **Kingdom**
- **Class**
- **Order**
- **Genus**
- **Species**

Example (Classification of Wheat - *Triticum aestivum*):

- **Kingdom:** Plantae
- **Class:** Monocotyledonae
- **Order:** Poales
- **Genus:** *Triticum*
- **Species:** *T. aestivum*

This hierarchical system remains the basis of **modern biological classification**.

C. Sexual System of Classification (1735)

Linnaeus grouped plants based on their **reproductive organs (stamens & pistils).**
Divided plants into **24 classes**, based on the **number, arrangement, and fusion of stamens (male reproductive parts).**
Example:

Class Monandria – Plants with **one stamen**.
Class Diandria – Plants with **two stamens**.
Class Polyandria – Plants with **many stamens**.

Although artificial, this system allowed for **easy plant identification**.

2. Major Works of Linnaeus

📖 **Systema Naturae (1735)** – Introduced the hierarchical classification of organisms.

📖 **Species Plantarum (1753)** – First systematic plant classification using **binomial nomenclature** (basis of modern plant taxonomy).

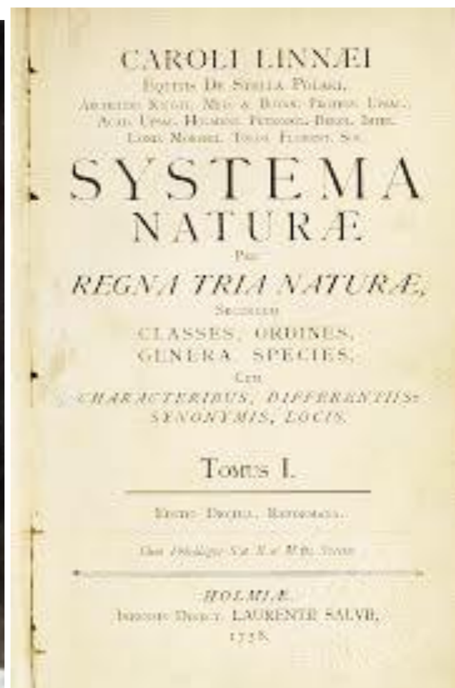
📖 **Philosophia Botanica (1751)** – Explained principles of botanical classification.

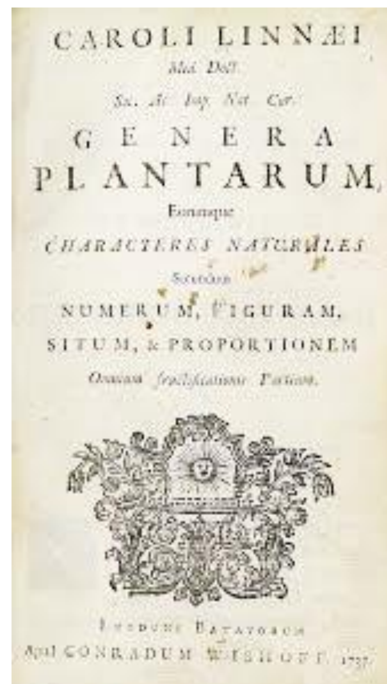
3. Limitations of Linnaean Classification

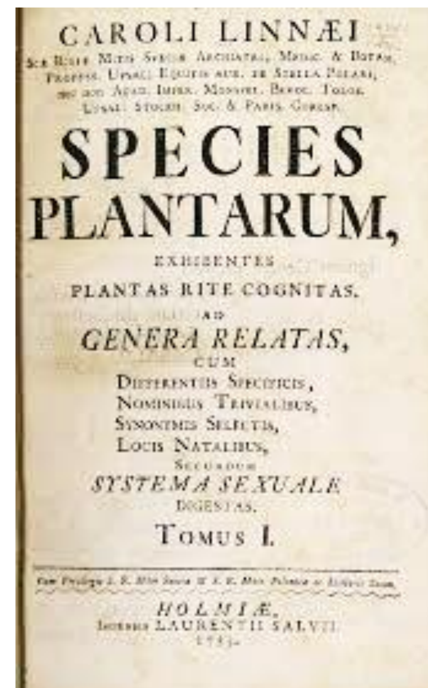
Artificial System: Focused on **stamens & pistils** rather than evolutionary relationships.

Did not reflect common ancestry: Modern classification is based on **phylogenetics & DNA analysis**.

Later replaced by Natural & Phylogenetic Systems in the 19th and 20th centuries.







Natural Classification Systems (Late 18th–Early 19th Century)

After Linnaeus' artificial classification based on **floral structure**, botanists sought a **natural classification system** that grouped plants based on their **overall similarities, structural characteristics, and evolutionary relationships** rather than just reproductive organs. These systems aimed to reflect the **true affinities among plant species** by considering multiple traits.

1. Key Features of Natural Classification Systems

Based on **morphological, anatomical, and physiological traits**, not just reproductive organs.

Considered **growth patterns, leaves, roots, flowers, and other structures**.

More **holistic and evolutionary**, laying the foundation for modern phylogenetics.

Introduced **the concept of plant families** as natural groupings.

2. Major Contributors and Their Classification Systems

(A) Antoine Laurent de Jussieu (1748–1836) – First Major Natural System

Published *Genera Plantarum* (1789), classifying plants into **families** for the first time.

Divided plants into **three main groups (based on cotyledons in seeds):**

- **Acotyledons** (no seed leaves) → e.g., ferns, mosses.
- **Monocotyledons** (one seed leaf) → e.g., grasses, palms.
- **Dicotyledons** (two seed leaves) → e.g., roses, legumes.

Placed **greater emphasis on overall plant structure** rather than just stamens.

His system influenced **modern botanical classification** and was used throughout the 19th century.

(B) Augustin Pyramus de Candolle (1778–1841) – Expanded Natural Classification

Further developed Jussieu's system in *Théorie élémentaire de la botanique* (1813).

Introduced the term **taxonomy** and defined **endogenous (monocots) vs. exogenous (dicots) plants**.

Distinguished **vascular and non-vascular plants**.

Introduced **plant families** based on multiple traits, refining classification.

(C) Robert Brown (1773–1858) – Importance of Plant Embryos

Discovered **the nucleus** in plant cells.

Studied **pollen and seed development** to distinguish major plant groups.

His work influenced later classifications based on embryology.

(D) Bentham & Hooker System (1862–1883) – Practical Natural Classification

George Bentham & Joseph Dalton Hooker classified **97,205 species** in *Genera Plantarum* (1862–1883).

Divided flowering plants into **Monocotyledons and Dicotyledons**.

Used extensively in **herbaria and botanical gardens** worldwide.

Still used in modified form in many **botanical references today**.

Antoine Laurent de Jussieu

Augustin P de Candolle

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***

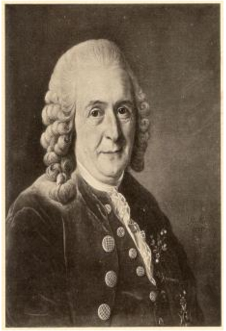
➢ **Carolus Linneaus published the book '<u>Species Plantarum</u>' in 1753.**

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

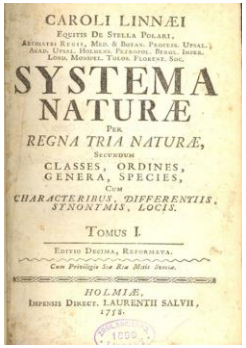
➢ **Produced his sexual system of classification (Artificial classification)**

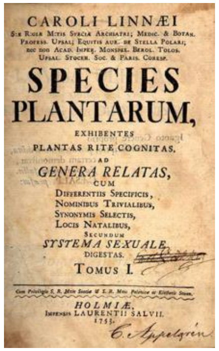
➢ **Carolus Linneaus divided plants into 24 classes. The Classes in the Linneaus is based largely on the amount, union and length of stamens**

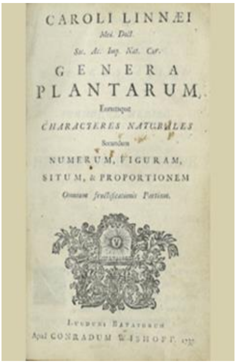
Classes

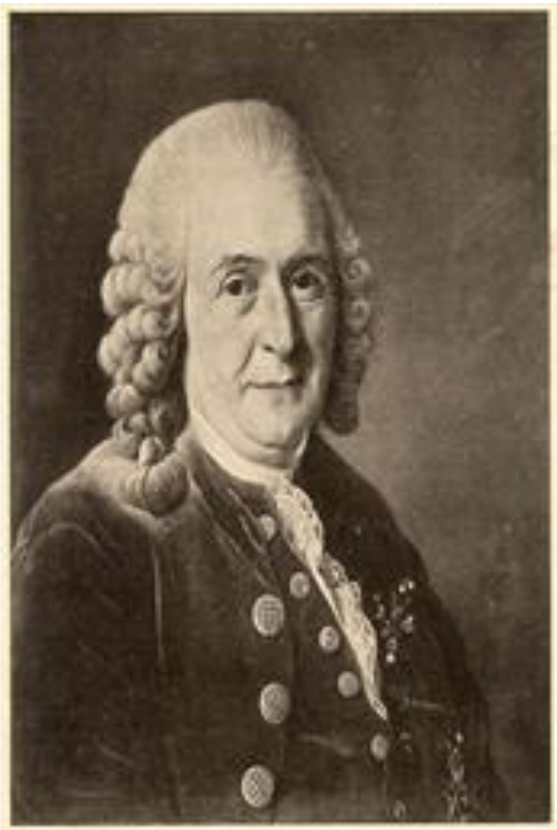


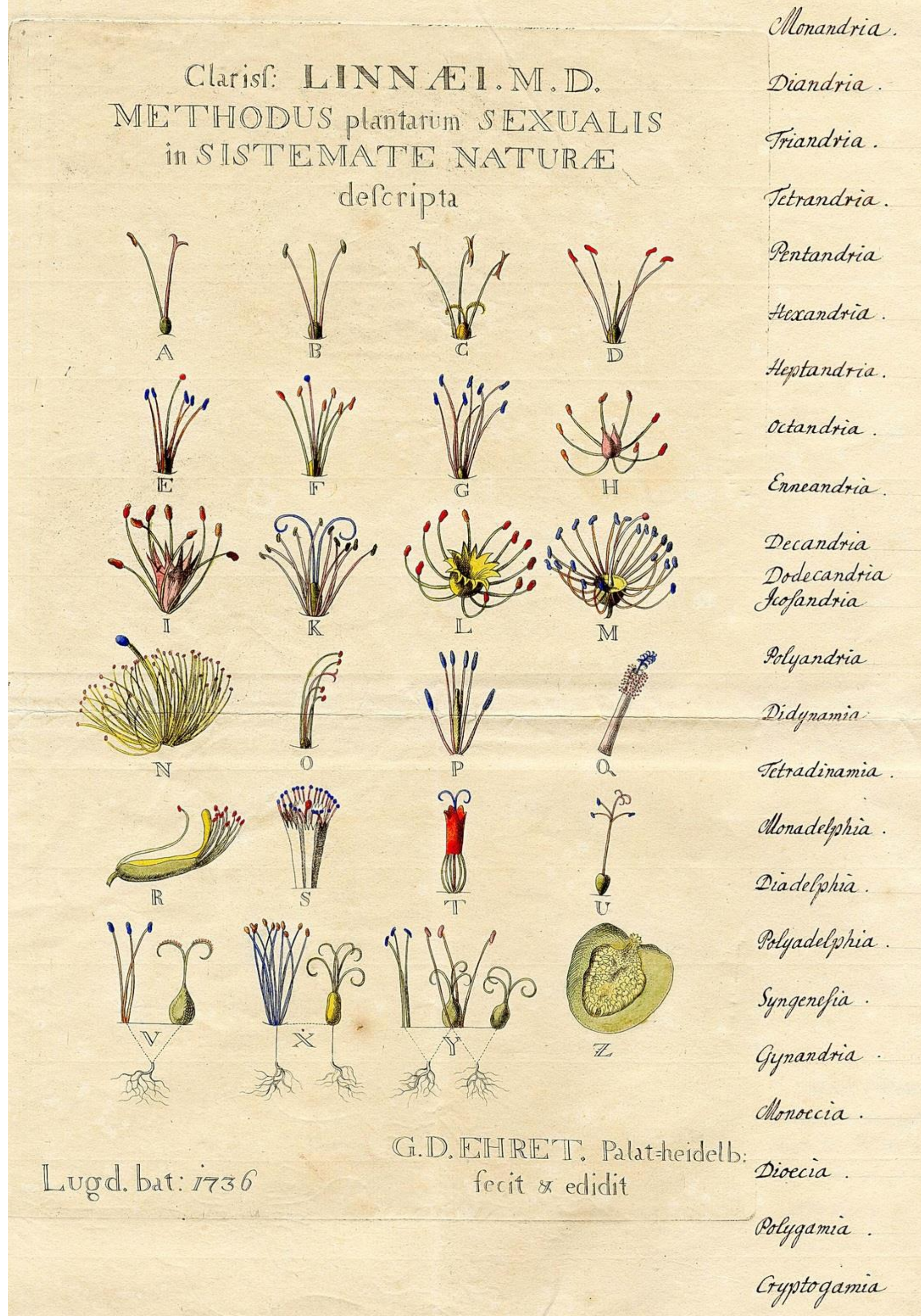
1. Monandria- stamen one
2. Diandria- stamens two
3. Triandria- stamens three
4. Tetrandria- stamens four
5. Pentandria- stamens five
6. Hexandria- stamens six
7. Heptandria- stamens seven
8. Octandria- stamens eight
9. Ennandria- stamens nine
10. Decandria- stamens ten
11. Dodecandria- stamens 11-19
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







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Icosandria
Polyandria
Didynamia
Tetradinamia.
Monadelphia.
Diadelphia.
Polyadelphia.
Syngenesia.
Gynandria.
Monoecia.
Dioecia.
Polygamia.
Cryptogamia

Michel Adanson (1727-1806)

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

Jean B.P. Lamarck (1744-1829)

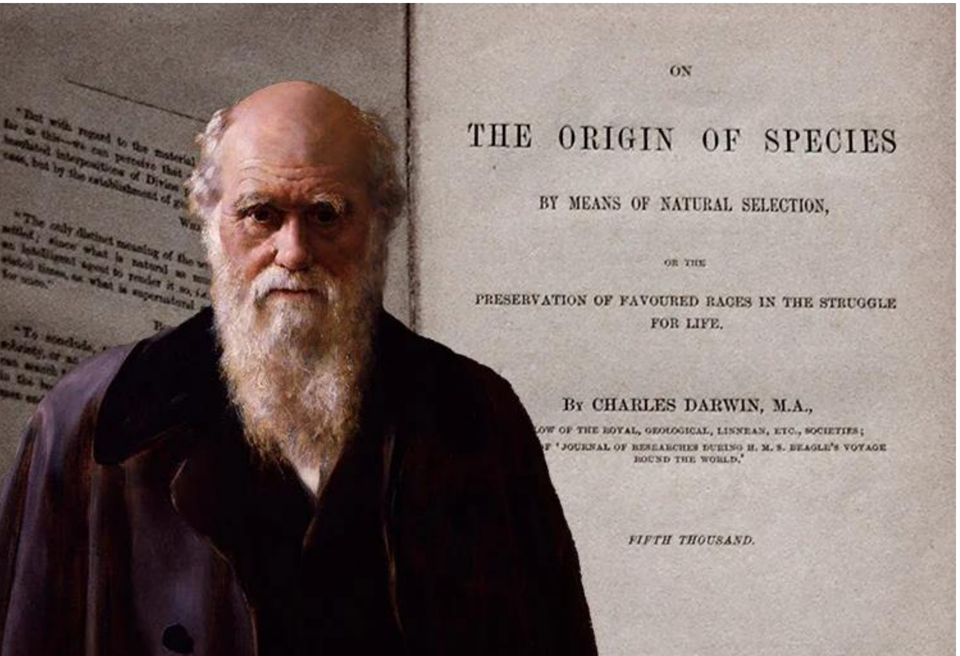
- A French naturalist
- Published *Flore Francaise (1778)*
- Proposed key for identification of plants
- Proposed principles concerning the natural grouping of species, orders and families

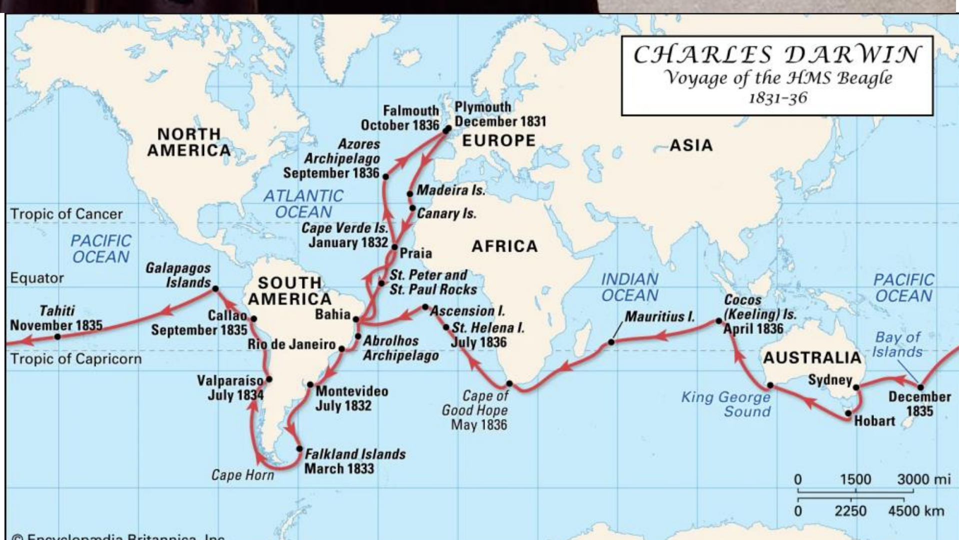
Antoine Laurent de Jussieu (1748-1836)

- 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


ON
THE ORIGIN OF SPECIES
BY MEANS OF NATURAL SELECTION,
OR THE
PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.
By CHARLES DARWIN, M.A.,
FIFTH THOUSAND.


CHARLES DARWIN
Voyage of the HMS Beagle
1831–36
NORTH AMERICA
SOUTH AMERICA
EUROPE
ASIA
AFRICA
AUSTRALIA
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
PACIFIC OCEAN
Tropic of Cancer
Equator
Tropic of Capricorn
Falmouth October 1836
Plymouth December 1831
Azores Archipelago September 1836
Madeira Is.
Canary Is.
Cape Verde Is. January 1832
Praia
St. Peter and St. Paul Rocks
Galapagos Islands
Tahiti November 1835
Callao September 1835
Bahia
Rio de Janeiro
Abrolhos Archipelago
Ascension I.
St. Helena I. July 1836
Valparaiso July 1834
Montevideo July 1832
Falkland Islands March 1833
Cape Horn
Cape of Good Hope May 1836
Mauritius I.
Cocos (Keeling) Is. April 1836
Bay of Islands
Sydney
December 1835
Hobart
King George Sound
0 1500 3000 mi
0 2250 4500 km
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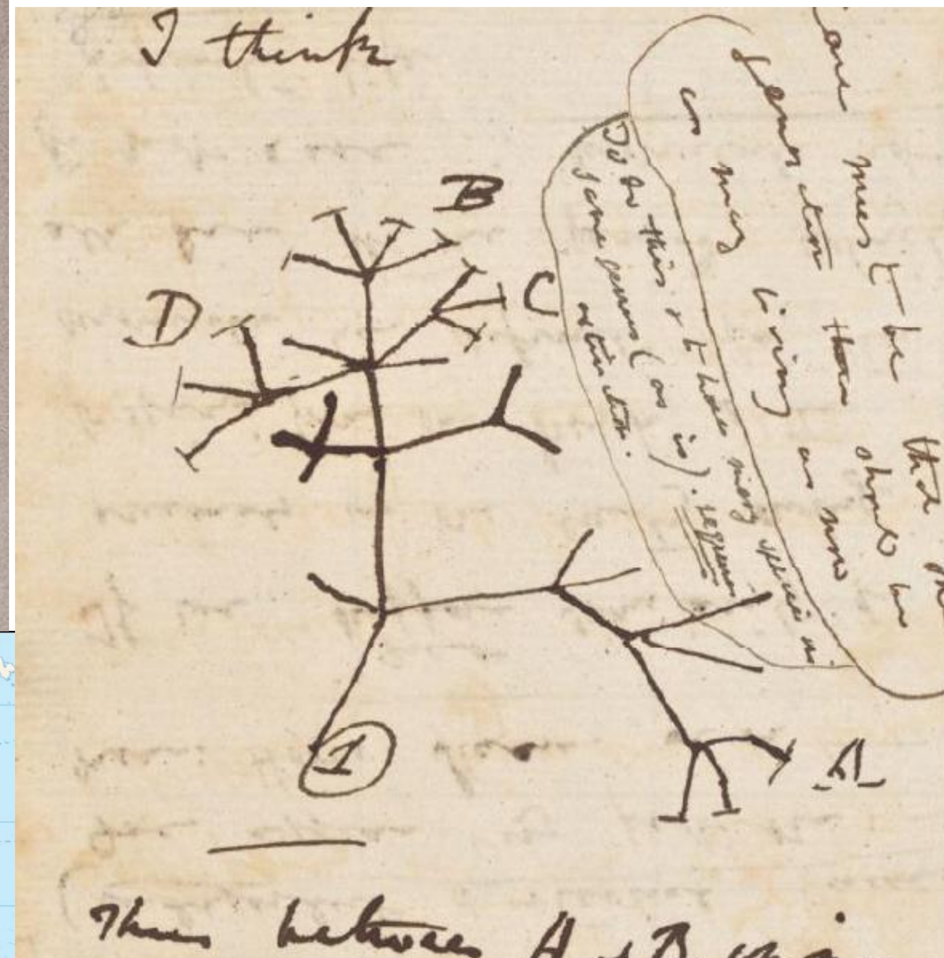

I think
B
C
D
1
A

Development of Post-Darwinian classification systems

Introduction

Post-Darwinian classification systems emerged after Charles Darwin's theory of evolution (1859), incorporating evolutionary relationships, phylogenetics, and genetic data into plant taxonomy. These systems moved beyond morphological features to include evolutionary ancestry, molecular biology, and cladistics. They aimed to reflect the natural relationships among plants based on descent and common ancestry.

Key Features of Post-Darwinian Systems

Based on **evolutionary relationships** rather than artificial traits.

Incorporates **morphology, anatomy, embryology, paleobotany, and molecular genetics**.

Uses **phylogenetic principles** and **cladistics** to establish evolutionary lineage.

Replaces traditional artificial and natural systems with a **more scientific, evidence-based** approach.

Major Post-Darwinian Classification Systems

Engler and Prantl System (1887–1915) – Proposed a phylogenetic classification, arranging plants from simple to complex forms.

Bessey's Cactus System (1915) – Based on evolutionary trends in flowering plants.

Hutchinson’s System (1926, 1934, 1959) – Focused on the evolutionary divergence of dicots and monocots.

Takhtajan’s System (1954, 1980, 1997) – Considered both fossil records and modern plants.

Cronquist’s System (1968, 1981, 1988) – One of the most widely used evolutionary classification systems.

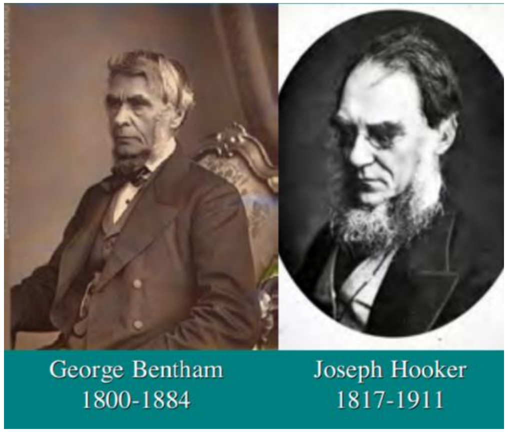
Dahlgren’s System (1975, 1980s) – Used anatomical and chemical data for classification.

Thorne’s System (1958, 1968, 1992, 2007) – An evolutionary classification that was periodically revised.

APG System (Angiosperm Phylogeny Group) (1998, 2003, 2009, 2016) – Based on molecular phylogenetics and DNA sequencing.

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:

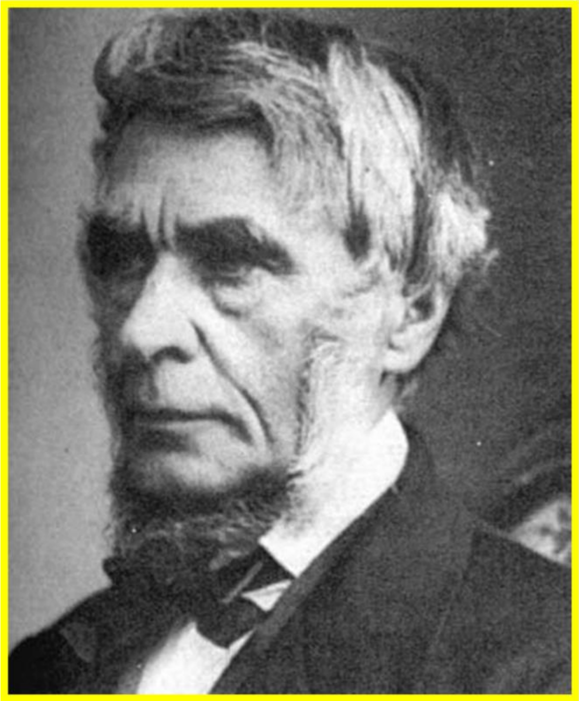
Subclass POLYPETALE with three series Series 1. THALAMIFLORÆ, Series 2. DISCIFLORÆ, Series 3. CALYCIFLORÆ;
Subclass DICOTYLEDONES (GAMOPETALÆ) with three series that is Series 1. INFERÆ, Series 2. HETEROMERÆ, Series 3. BICARPELLATÆ, and
Subclass DICOTYLEDONES MONOCHLAMIDEÆ.

Class GYMNOSPERMEÆ (Gymnosperms are placed between Dicotyledons and Monocotyledons)

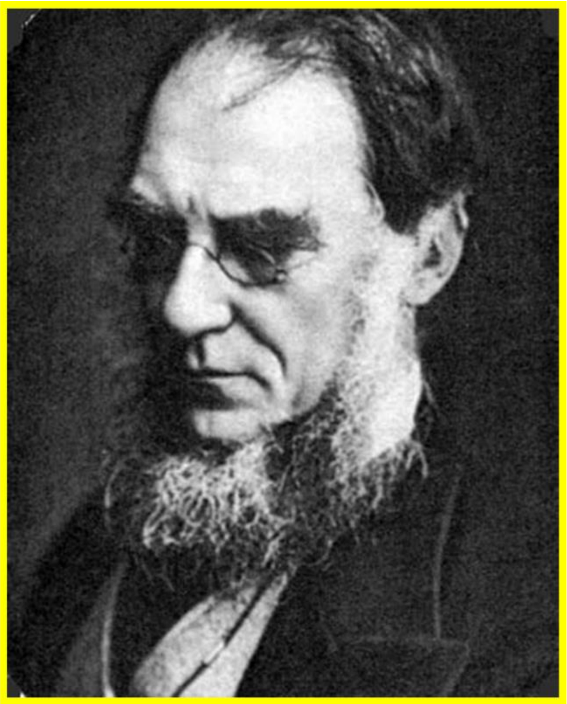
Class MONOCOTYLEDONES

Bentham & Hooker System of Classification (1862–1883)

The **Bentham & Hooker system** is one of the most influential **natural classification systems** for flowering plants. It was developed by **George Bentham (1800–1884) and Joseph Dalton Hooker (1817–1911)** and published in their three-volume work, *Genera Plantarum* (1862–1883). This system was widely used in **herbaria and botanical gardens** and is still referenced today.



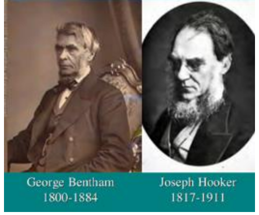
George Bentham (1800-1884)



Sir Joseph Dalton Hooker (1817-1911)

1. Key Features of the Bentham & Hooker System

- **Natural system** – Based on **morphological characteristics**, especially reproductive structures.
- **Classification of seed plants (Phanerogams)** – Focused only on **flowering plants (Spermatophytes)**.
- **Hierarchical structure** – Divided plants into **classes, orders, and families**.
- **Extensive plant coverage** – Classified **97,205 species** in 202 families.
- **Used worldwide** – Particularly in **British botanical studies, herbaria, and gardens**.



2. Classification Structure

(A) Division: Phanerogamia (Seed Plants)

Bentham & Hooker divided flowering plants (**Phanerogams**) into **three classes**:

Dicotyledons (two seed leaves)

Gymnosperms (naked-seed plants, later considered a separate

Monocotyledons (one seed leaf)

(B) Classification of Dicotyledons

Divided into three sub-classes based on floral characteristics:

1. Polypetalae (Separate Petals)

Corolla (petals) **free and distinct**.

Further divided into **three series** based on stamen arrangement:

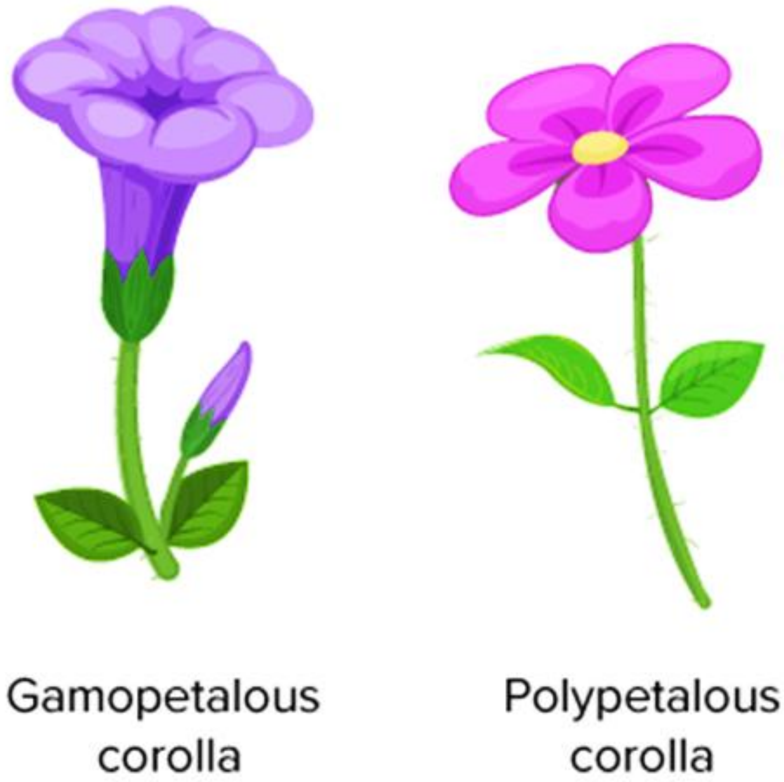
- **Thalamiflorae** (stamens on receptacle) → *e.g., Ranunculaceae, Papaveraceae*
- **Disciflorae** (stamens on a floral disc) → *e.g., Rutaceae, Meliaceae*
- **Calyciflorae** (stamens fused with calyx) → *e.g., Rosaceae, Leguminosae*

2. Gamopetalae (Fused Petals)

Corolla **petals fused (sympetalous)**.

Further divided into **three series**:

- **Inferae** (ovary inferior) → *e.g., Rubiaceae, Compositae (Asteraceae)*
- **Heteromerae** (ovary superior, more than two carpels) → *e.g., Primulaceae, Myrsinaceae*
- **Bicarpellatae** (ovary superior, two carpels) → *e.g., Solanaceae, Lamiaceae*



3. Monochlamydeae (No Corolla / Incomplete Flowers)

Perianth **single or absent** (no distinct sepals and petals).

Includes **apetalous plants**.

Example families: **Amaranthaceae, Polygonaceae, Euphorbiaceae**.

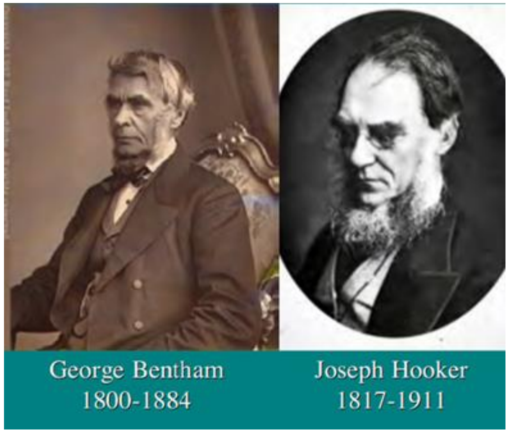
(C) Classification of Single cotyledon (seed leaf).

Parallel-veined leaves.

Floral parts in multiples of three.

Divided into **seven series**, including:

- **Microspermae** (*e.g., Orchidaceae*)
- **Epigynae** (*e.g., Liliaceae, Amaryllidaceae*)
- **Coronarieae** (*e.g., Iridaceae*)
- **Glumaceae** (*e.g., Poaceae, Cyperaceae*)

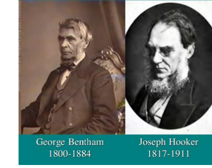


(D) Classification of Gymnosperms

Naked seeds, **no true flowers**.

Placed separately from **angiosperms (flowering plants)**.

Example families: **Cycadaceae, Pinaceae, Gnetaceae**.



Strengths of the Bentham & Hooker System

✔ **Simple and practical** – Easy to use for plant identification.

✔ **Extensive plant coverage** – One of the most detailed classifications of its time.

✔ **Based on real specimens** – Studied herbarium collections rather than just descriptions.

✔ **Widely used in botanical studies, herbaria, and gardens.**

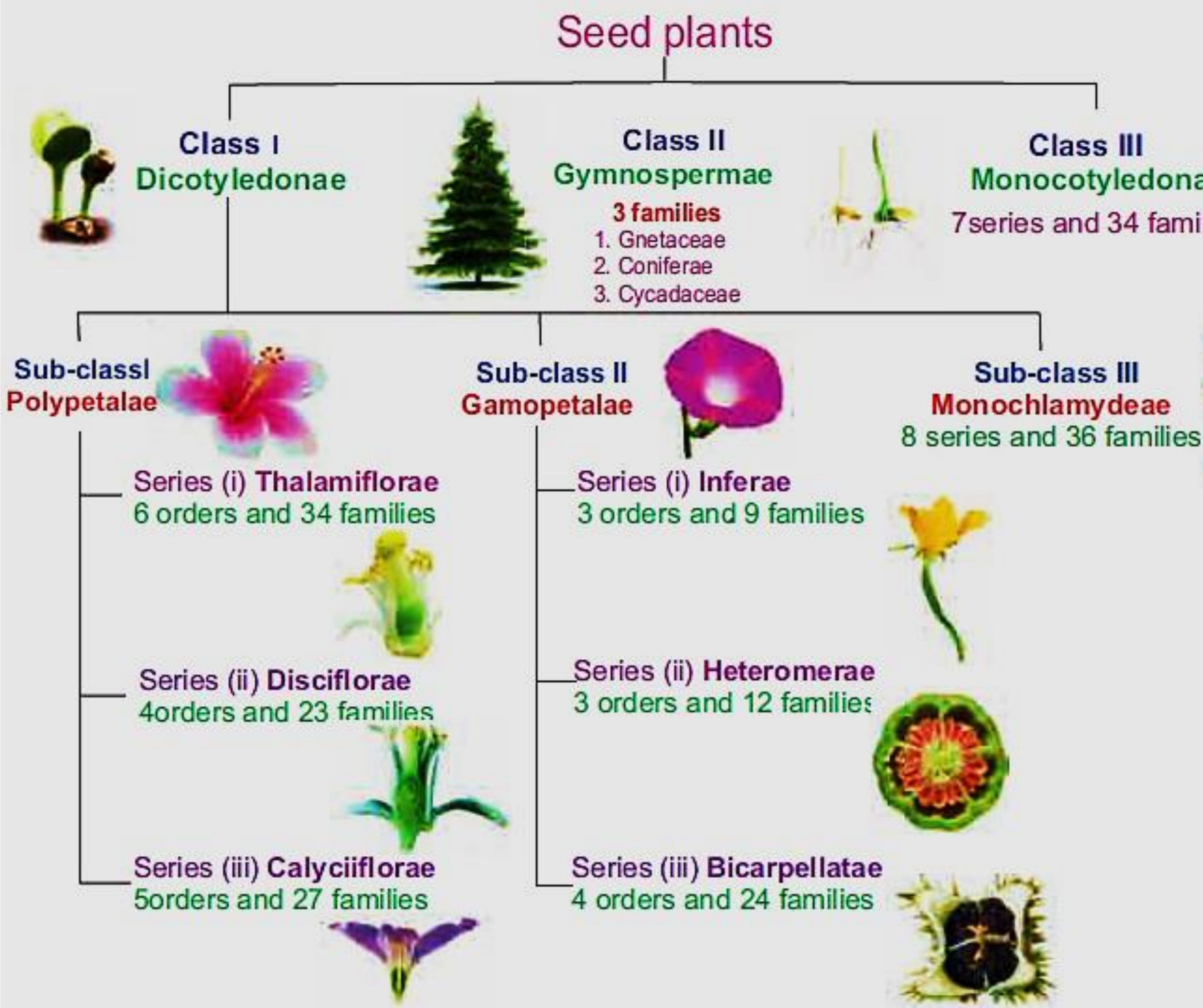
Limitations of the System

✖ **Did not consider evolutionary relationships** – Based only on external morphology.

✖ **Gymnosperms placed with Angiosperms** – Modern systems treat them as separate groups.

✖ **Artificial in some aspects** – Some groups (e.g., Monochlamydeae) were **unnatural**.

✖ **Later replaced by phylogenetic systems** – Engler & Prantl (1887), Cronquist (1968), and APG (1998–present) refined classification based on **evolution and molecular data**.


Seed plants
Class I
Dicotyledonae
Class II
Gymnospermae
3 families
1. Gnetaceae
2. Coniferae
3. Cycadaceae
Class III
Monocotyledonae
7series and 34 families
Sub-classI
Polypetalae
Sub-class II
Gamopetalae
Sub-class III
Monochlamydeae
8 series and 36 families
Series (i) Thalamiflorae
6 orders and 34 families
Series (ii) Disciflorae
4orders and 23 families
Series (iii) Calyciiflorae
5orders and 27 families
Series (i) Inferae
3 orders and 9 families
Series (ii) Heteromerae
3 orders and 12 families
Series (iii) Bicarpellatae
4 orders and 24 families


George Bentham
1800-1884
Joseph Hooker
1817-1911

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.

Evolutionary theories for biological classification

Introduction

Definition: Evolutionary classification is the organization of living organisms based on their evolutionary history and shared ancestry.

Core Principle: Reflects the relationships and descent from common ancestors.

Historical Background:

Aristotle (384–322 BCE): Early attempts at classifying organisms based on observable traits.

Carl Linnaeus (1707–1778): Developed binomial nomenclature, focusing on morphology.

Charles Darwin (1809–1882): Proposed that classification should reflect evolutionary relationships through natural selection.

Importance of Evolutionary Classification:

Shows **phylogenetic relationships** between species.

Explains **divergence** and **adaptation** over time.

Basis for modern tools like **cladistics** and **phylogenetic trees**.

Modern Approach:

Incorporates molecular data like DNA sequencing and comparative genomics.

Uses tools like computational modeling to refine evolutionary trees.

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).

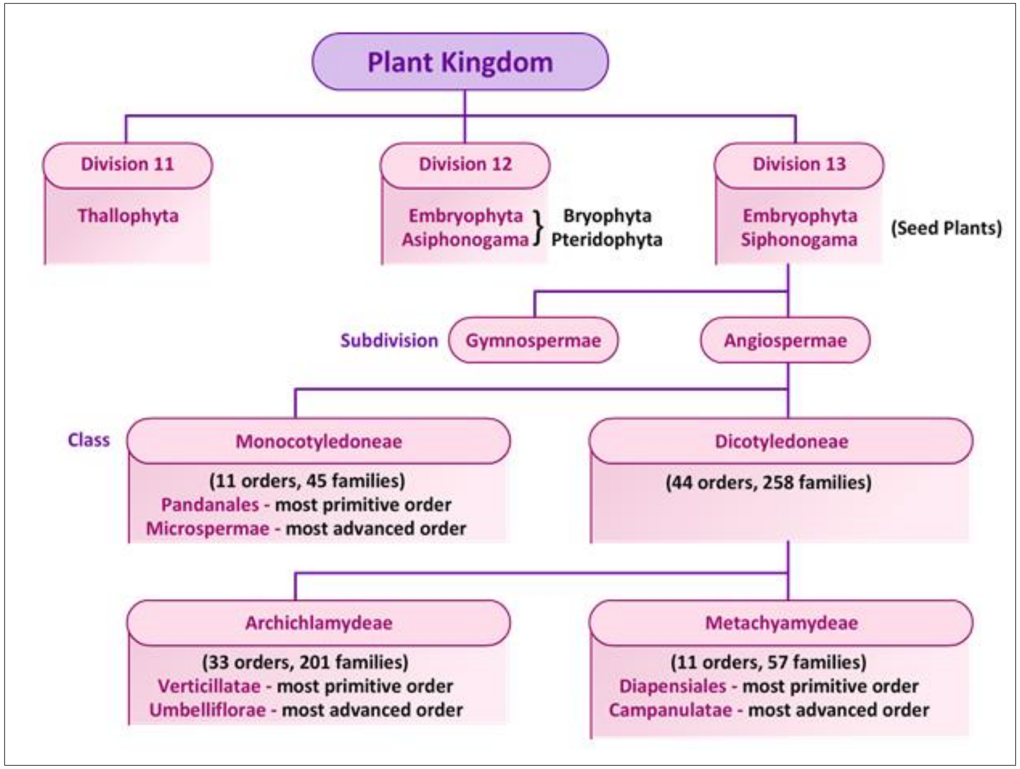
❖ The 13th division in the Engler and Prantl System of Classification is *Embryophyta Siphonogama* (plants with embryos and pollen tubes) which includes seed plants. This is divided into 2 subdivisions:

1. Gymnospermae,
2. Angiospermae

❖ The subdivision Angiospermae is further divided into 2 classes:

Class 1. Monocotyledoneae
Class 2. Dicotyledoneae

Adolph Engler 1844-1930 Karl Prantl 1849-1893



Engler and Prantl System (1887–1915)

Introduction

The Engler and Prantl system, developed by **Adolf Engler** and **Karl Prantl**, was one of the first **phylogenetic classification systems** based on evolutionary principles. It was published in **"Die Natürlichen Pflanzenfamilien"** (1887–1915) and influenced botanical taxonomy for decades.

Key Features

Classified plants from **primitive to advanced forms**.

Considered **gymnosperms** more primitive than **angiosperms**.

Divided angiosperms into **monocots first**, followed by **dicots**, assuming monocots were more primitive.

Used **floral reduction** and **simple reproductive structures** as primitive traits.

Emphasized **fossil records** in classification.

Classification Structure

Cryptogams (Non-seed plants) – Algae, Fungi, Bryophytes, Pteridophytes.

Phanerogams (Seed plants)

- **Gymnosperms** – Considered primitive seed plants.
- **Angiosperms**
  - **Monocotyledons (Monocots)** – Considered more primitive than dicots.
  - **Dicotyledons (Dicots)** – Further divided based on floral structures.

Strengths

✔ First **phylogenetic** system based on **evolutionary trends**.

✔ Provided a **detailed classification** for cryptogams and seed plants.

✔ Widely adopted in **herbaria and botanical gardens**.

Limitations

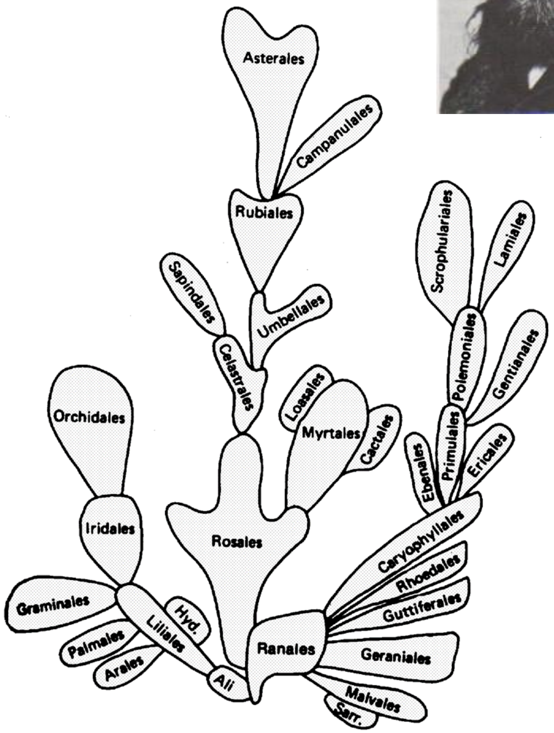
✚ Assumed **monocots were more primitive** than dicots, which is now considered incorrect.

✚ Overemphasized **floral reduction** as a primitive trait.

✚ Lacked **genetic and molecular evidence**.

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.



Bessey's Cactus System (1915)

Introduction

Developed by **Charles Edwin Bessey**, the **Cactus System (1915)** was an evolutionary classification of angiosperms. It was one of the first **natural systems** to incorporate **Darwinian evolutionary principles** into plant taxonomy. The system is visually represented as a **cactus-like diagram**, showing evolutionary relationships among plant groups.

Key Features

Based on **evolutionary trends** rather than morphology alone.

Considered **dicotyledons (Magnoliopsida) as the most primitive group**, evolving into monocotyledons.

Recognized **Ranales (Magnoliales) as the ancestral angiosperms**.

Arranged plants in a **phylogenetic tree** rather than a strict hierarchical order.

Emphasized **floral structures**, particularly **primitive vs. advanced flowers**.

Classification Structure

Primitive Dicotyledons (Ranales group)

Thought to be the ancestors of all flowering plants.

Derived Dicotyledons

More advanced groups evolved from Ranales.

Monocotyledons

Evolved from primitive dicots through reduction and modification.

Strengths

✔ **First classification** to explicitly follow **evolutionary principles**.

✔ Highlighted the **importance of primitive flowers** in plant evolution.

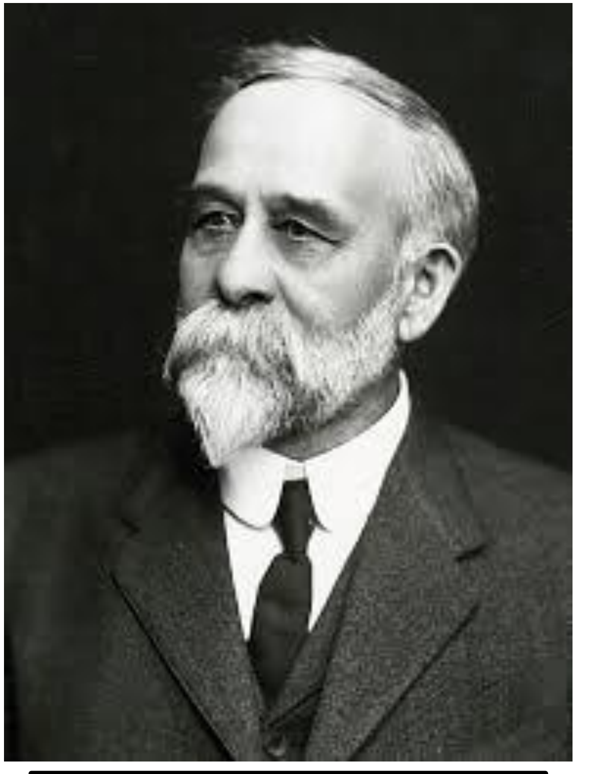
✔ Provided a **clear phylogenetic framework** for angiosperms.

Limitations

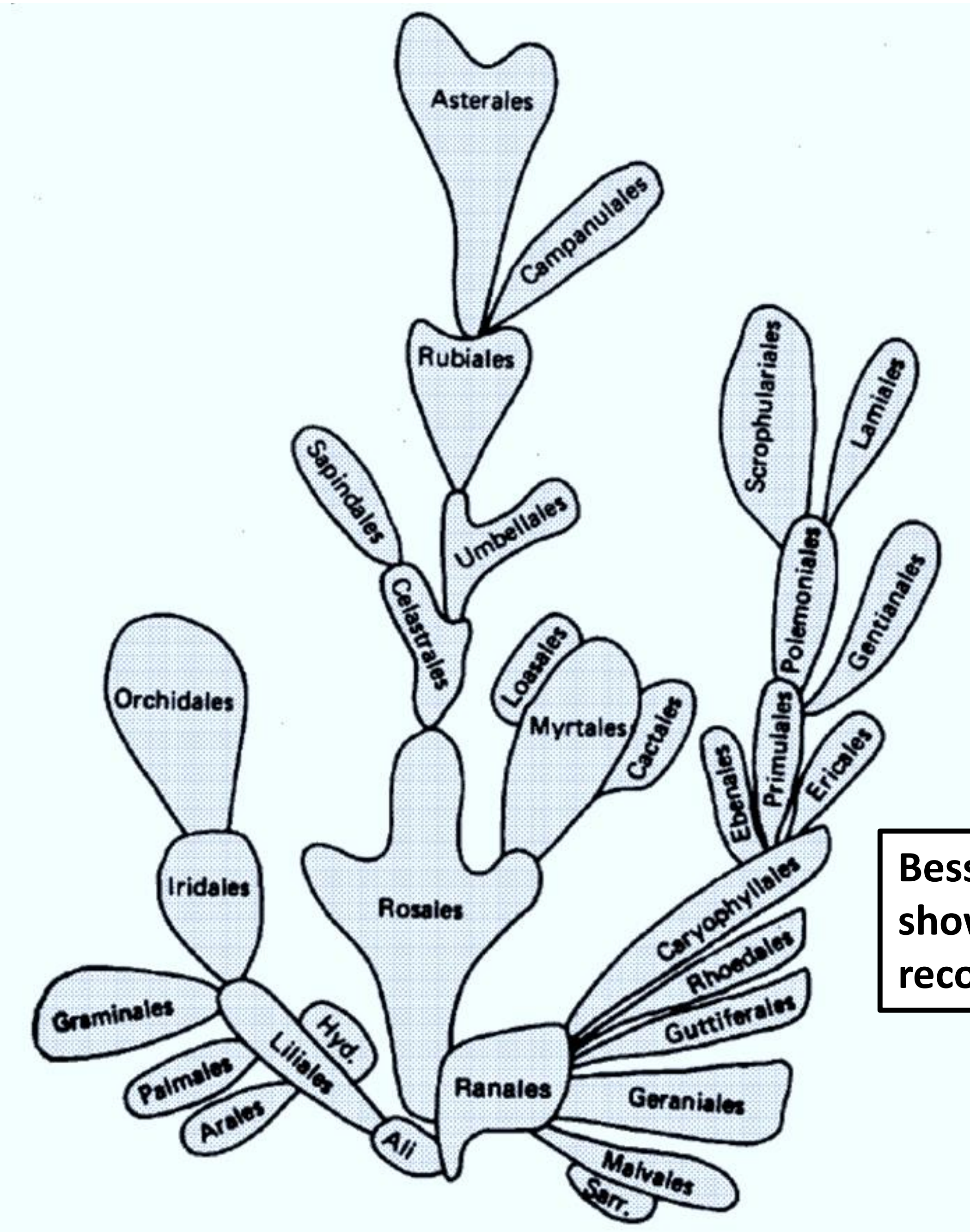
✚ Overemphasized **Ranales as the ancestors** of all angiosperms.

✚ Lacked **molecular and genetic evidence**.

✚ Did not account for **parallel evolution** in some plant groups.



C.A. Bessey (1845–1915



Besseyan cactus or Opuntia Besseyi showing the relationship of orders recognized by Bessey

Conceptual Development of Post-Darwinian Taxonomy

Introduction

Post-Darwinian taxonomy developed after Charles Darwin’s theory of evolution in *On the Origin of Species* (1859).

Emphasized the evolutionary relationships among organisms and their descent from common ancestors.

Introduced a dynamic and scientific foundation for classification.

Key Milestones in Post-Darwinian Taxonomy

Evolutionary Systematics (Late 19th–Early 20th Century)

- **Focus**: Integration of evolutionary theory with taxonomy.
- **Key Proponents**: Ernst Haeckel, George Gaylord Simpson.
- **Approach**:
  - Classified organisms based on both **evolutionary history** and **degree of divergence**.
  - Incorporated morphology, behavior, and ecology.
- **Strength**: Linked taxonomy with Darwinian evolution.
- **Limitation**: Lacked objective criteria for evolutionary relationships.

Cladistics (Phylogenetic Systematics) (Mid-20th Century)

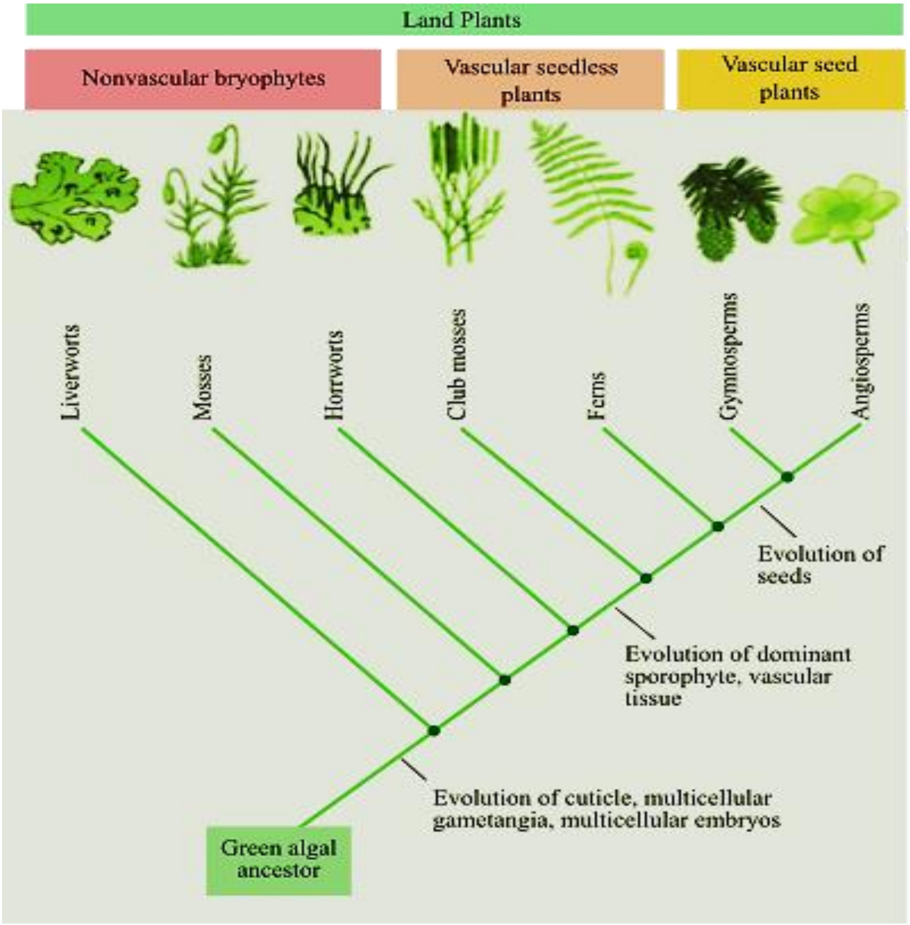
- **Founder**: Willi Hennig (1950s).
- **Key Principle**: Classifies organisms based on **shared derived characteristics (synapomorphies)** and **common ancestry**.
- **Tools**: Development of **cladograms** (branching diagrams).
- **Impact**:
  - Shifted taxonomy towards objectivity and precision.
  - Rejected reliance on subjective traits like overall similarity.

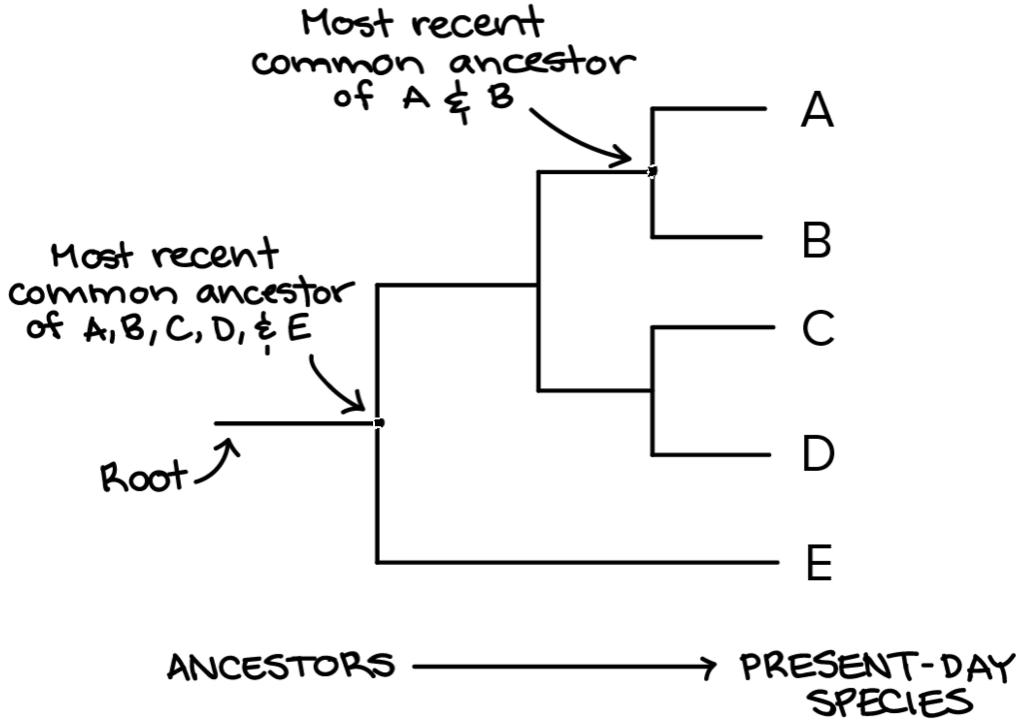
4. Evolutionary Systematics

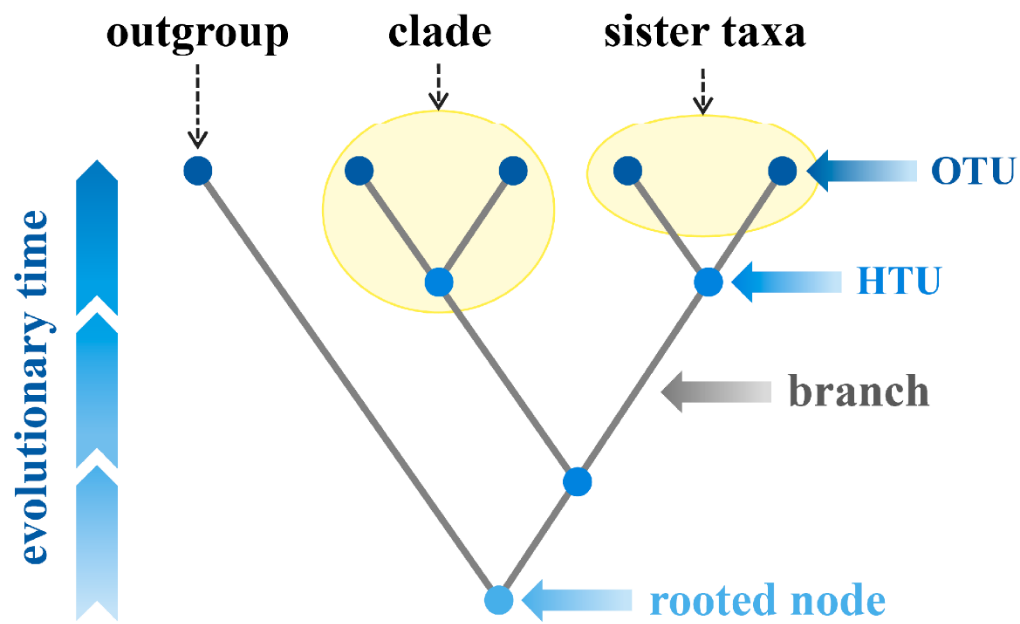
Key Concept: Classification reflects evolutionary history and degrees of evolutionary divergence.
Foundation: Based on **Charles Darwin's theory of evolution** through natural selection.
Approach: Combines morphological, ecological, and evolutionary traits to group organisms.
Strength: Recognized the importance of descent from common ancestors.
Limitation: Lacked precision in distinguishing between analogous (similar function) and homologous (common ancestry) traits.

5. Phylogenetic Systematics (Cladistics)

Key Concept: Classifies organisms based on shared derived characteristics (**synapomorphies**) and common ancestry.
Pioneers: Willi Hennig (mid-20th century).
Tools: Modern methods like molecular data, DNA sequencing, and computational algorithms.
Focus: Constructs **phylogenetic trees** (cladograms) to show evolutionary relationships.
Strength: Objective and systematic; aligns with modern evolutionary biology.
Limitation: Can oversimplify complex evolutionary patterns.




Most recent common ancestor of A & B
A
B
Most recent common ancestor of A, B, C, D, & E
C
D
Root
E
ANCESTORS
PRESENT-DAY SPECIES


outgroup
clade
sister taxa
OTU
HTU
branch
evolutionary time
rooted node

Numerical Taxonomy (Phenetics) (1950s–1960s)

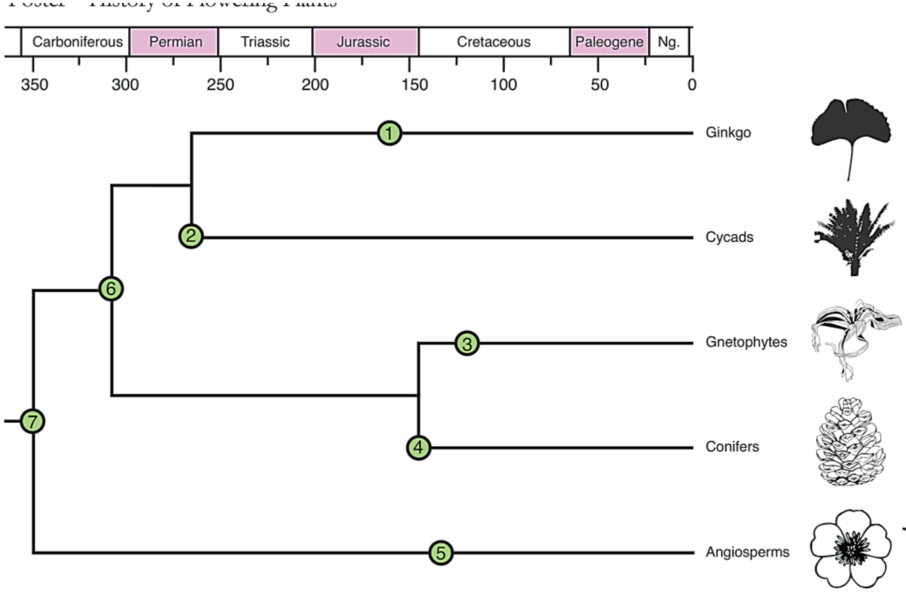
Proponents: Robert R. Sokal and Peter H. A. Sneath.

Approach:

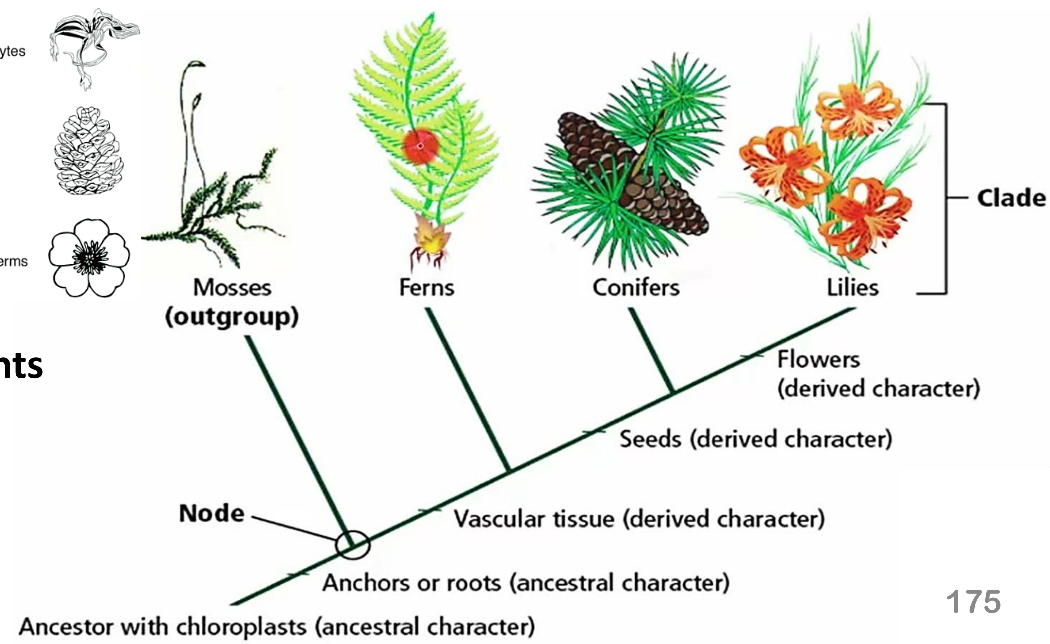
- Used mathematical algorithms to group organisms based on overall similarity.
- Relied on large datasets of traits and characteristics.

Strength: Introduced computational methods to taxonomy.

Limitation: Did not account for evolutionary history.

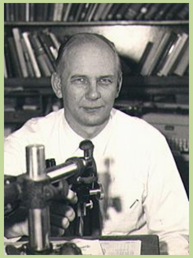


The evolutionary history of flowering plants



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

Hutchinson's System of Classification (1926, 1934, 1959)

Introduction

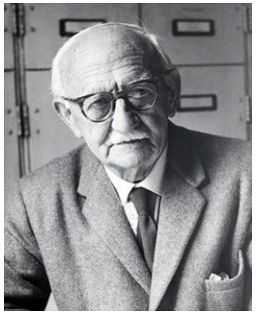
Developed by **John Hutchinson**, this system proposed a **phylogenetic classification of flowering plants (angiosperms)** based on **evolutionary trends**.

It was published in multiple editions:

First Edition (1926, 1934) – *The Families of Flowering Plants* (2 volumes).

Revised Edition (1959) – Incorporated new evolutionary insights.

Key Features



Evolutionary approach: Based on phylogenetic principles rather than morphology alone.

Emphasized primitive vs. advanced traits in angiosperms.

Recognized dicots as more primitive than monocots.

Separated dicots into two major evolutionary lines:

- **Lignosae** (woody plants, considered more primitive).
- **Herbaceae** (herbaceous plants, considered more advanced).

Monocots derived from dicots, evolving through **reduction and modification**.

Considered free floral parts primitive, and fused floral parts as advanced.

Classification Structure

Dicotyledons (Magnoliopsida)

- Divided into **Lignosae (woody)** and **Herbaceae (herbaceous)** groups.

Monocotyledons (Liliopsida)

Considered advanced, evolving from dicots through reduction.

Strengths

✔ Introduced **phylogenetic trends** into plant classification.

✔ Recognized **herbaceous plants as an evolutionary advancement**.

✔ First to propose the **Lignosae–Herbaceae division** in dicots.

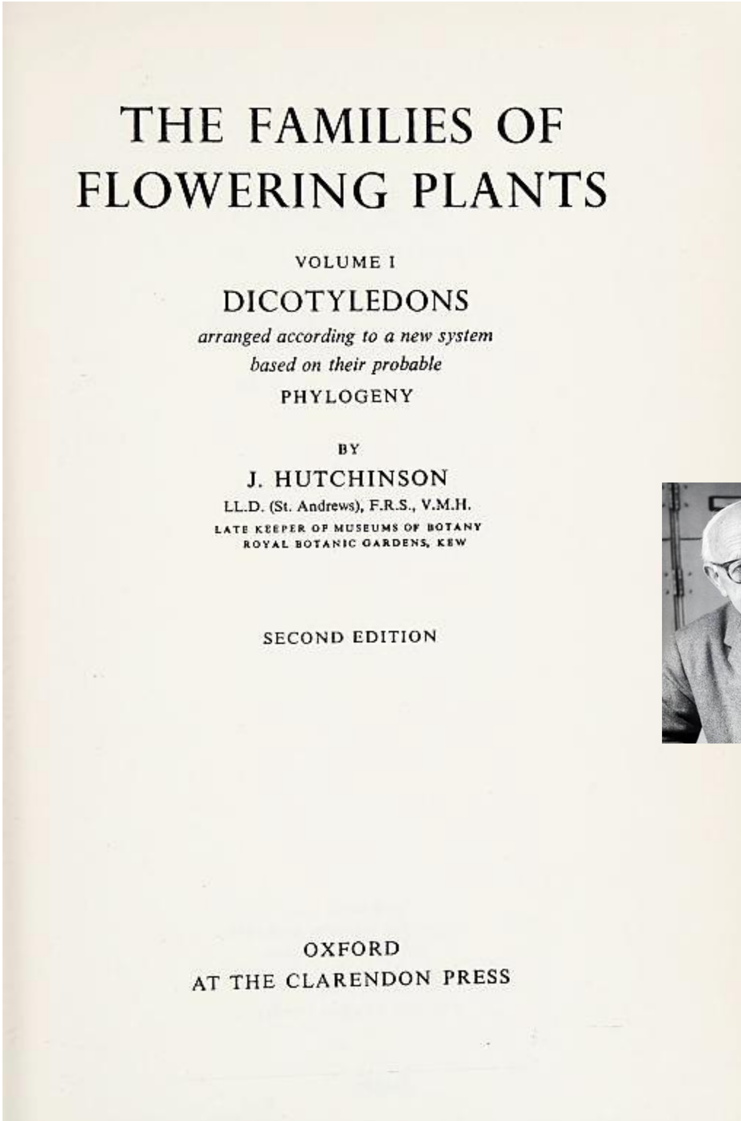
Limitations

✚ Overemphasized the **dicot-monocot evolutionary sequence**.

✚ Lacked **molecular data**, which later systems incorporated.

✚ Some relationships were **over-simplified**.

John Hutchinson (1884-1972)



THE FAMILIES OF
FLOWERING PLANTS

VOLUME I

DICOTYLEDONS

arranged according to a new system
based on their probable
PHYLOGENY

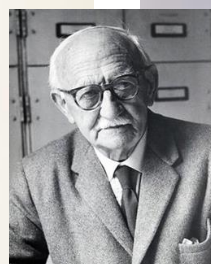
BY

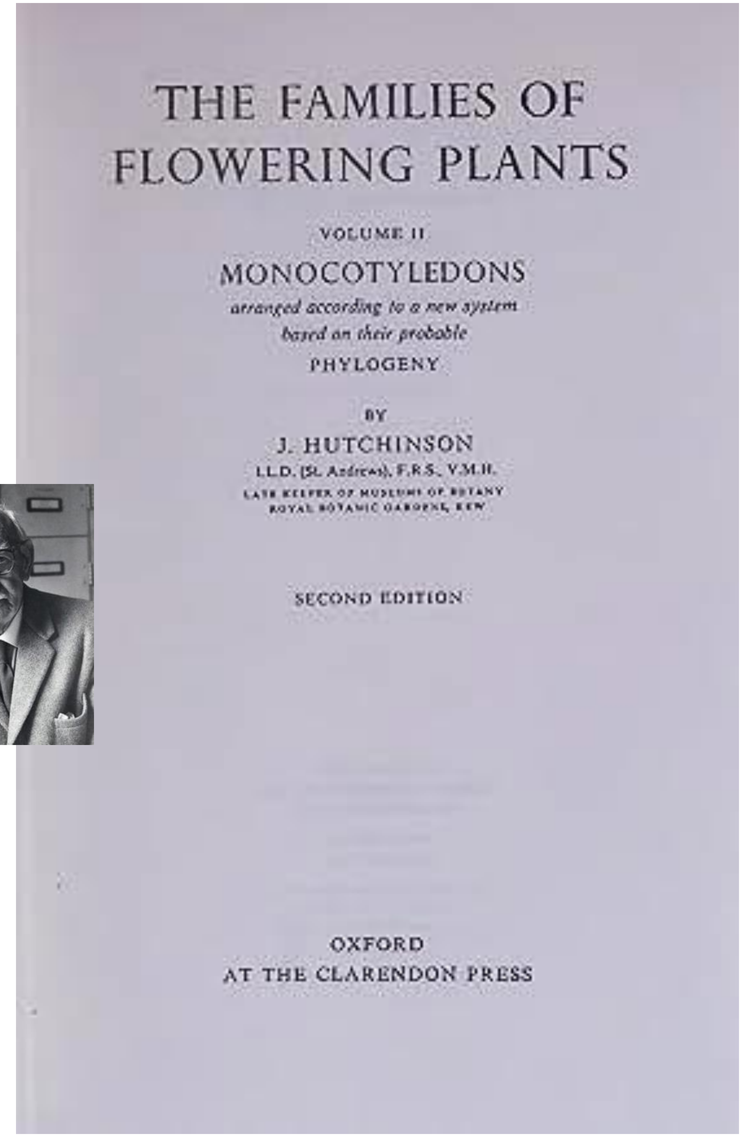
J. HUTCHINSON

LL.D. (St. Andrews), F.R.S., V.M.H.
LATE KEEPER OF MUSEUMS OF BOTANY
ROYAL BOTANIC GARDENS, KEW

SECOND EDITION

OXFORD
AT THE CLARENDON PRESS





THE FAMILIES OF
FLOWERING PLANTS

VOLUME II

MONOCOTYLEDONS

arranged according to a new system
based on their probable
PHYLOGENY

BY

J. HUTCHINSON

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LATE KEEPER OF MUSEUMS OF BOTANY
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***The Families of Flowering Plants*: Volume 1 (Dicotyledons): Volume 2 (Monocotyledons):**

Takhtajan's System of Classification (1954, 1980, 1997)

Introduction

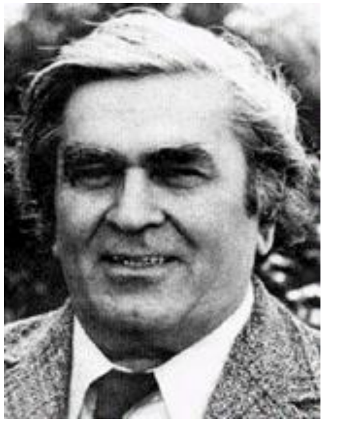
Developed by **Armen Takhtajan**, this system is a **phylogenetic classification of angiosperms**, emphasizing **evolutionary relationships, morphology, and biogeography**. It was published in multiple versions:

1954 – Initial classification proposal.

1980 – Refinements incorporating new morphological and anatomical data.

1997 – Further updated system, integrating molecular insights.

Key Features



Phylogenetic approach: Based on evolutionary relationships.

Recognized angiosperms as a monophyletic group.

Divided angiosperms into two classes:

- **Magnoliopsida (Dicotyledons)**
- **Liliopsida (Monocotyledons)**

Further divided into subclasses, orders, and families based on:

- Floral structure
- Wood anatomy
- Pollination mechanisms
- Biogeographical distribution

Emphasized primitive vs. advanced characteristics:

Primitive plants: Woody, spirally arranged floral parts, numerous stamens.

Advanced plants: Herbaceous, reduced floral parts, fused structures.

Classification Structure

Magnoliopsida (Dicotyledons)

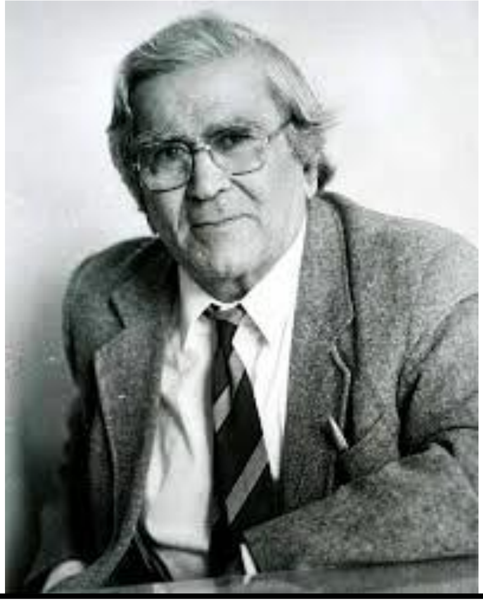
Considered primitive.

Divided into **several subclasses**, starting with Magnoliidae (most primitive).

Liliopsida (Monocotyledons)

Considered derived from dicots.

Includes families like Poaceae, Orchidaceae.



Armen Takhtajan (1910–2009)

Strengths

✔ One of the **most detailed phylogenetic classifications**.

✔ Incorporated **morphology, anatomy, and biogeography**.

✔ Recognized the **evolutionary divergence** within dicots and monocots.

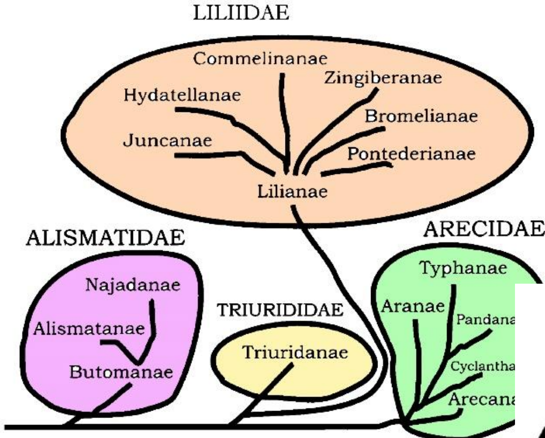
Limitations

✚ Relied heavily on **morphological data**, with **limited molecular evidence**.

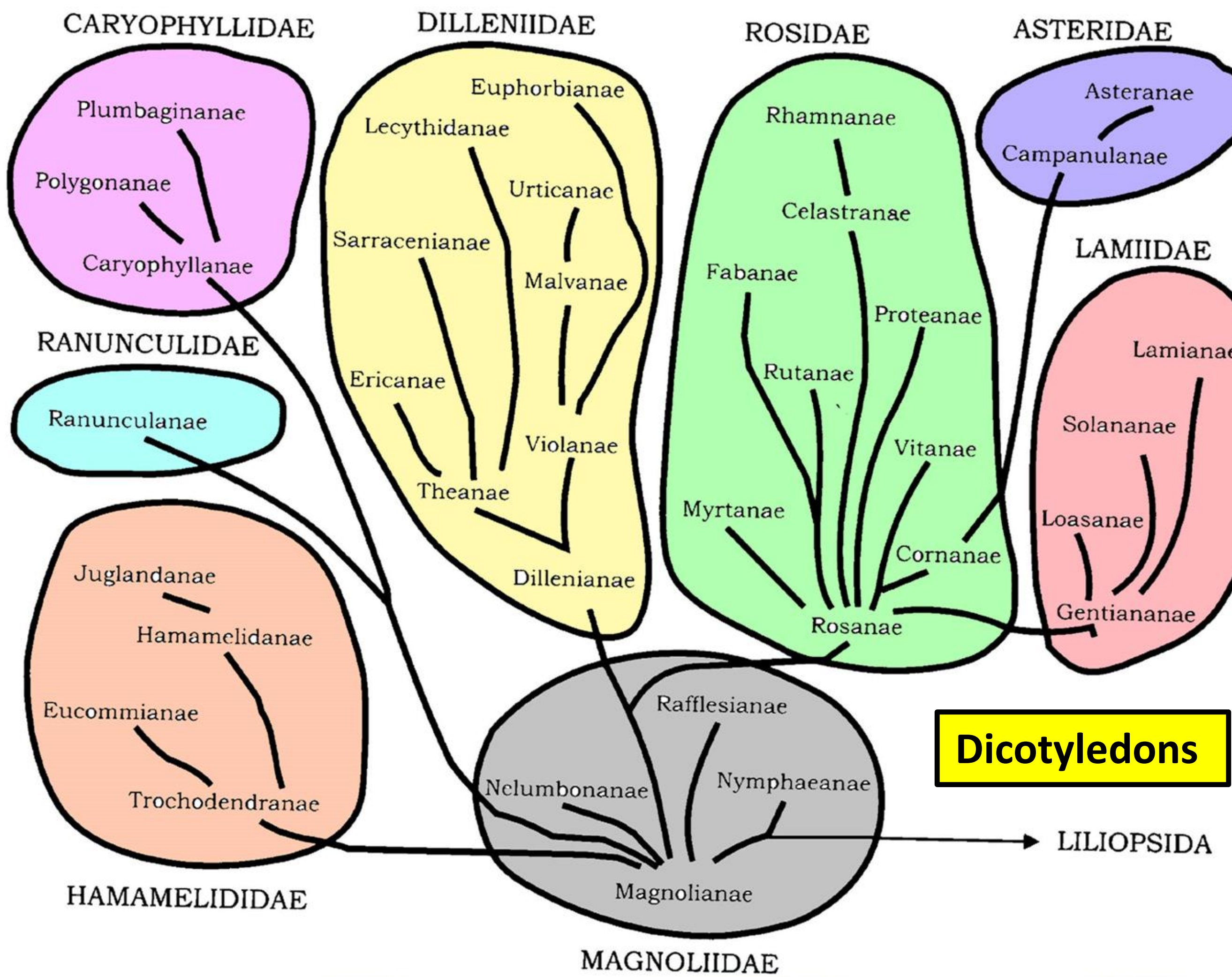
✚ Overemphasized **biogeographical factors** in classification.

✚ Some **groupings later revised** in APG systems.

Bubble diagram of Takhtajan showing the probable relationship between different subclasses and superorders of mono and dicotyledons (based on Takhtajan, 1987). 1997 classification does not include a bubble diagram.



Monocotyledons



Cronquist's System of Classification (1968, 1981, 1988)

Introduction

Developed by **Arthur Cronquist**, this system is a **phylogenetic classification of angiosperms** based on **morphological, anatomical, and physiological characteristics**.

Major versions:

- **1968** – Initial proposal.
- **1981** – Published in *An Integrated System of Classification of Flowering Plants*.
- **1988** – Further refinements in *The Evolution and Classification of Flowering Plants*.

Key Features

Divided angiosperms into two classes:

- **Magnoliopsida (Dicotyledons)**
- **Liliopsida (Monocotyledons)**

Emphasized traditional morphological traits, such as:

- Vascular system differences.
- Leaf venation (net-veined in dicots, parallel-veined in monocots).
- Floral structures and reproductive organs.

Subdivided into subclasses, orders, and families based on **evolutionary trends**.

Considered **dicots as the ancestral group** and **monocots as derived**.

Classification Structure

Class: Magnoliopsida (Dicotyledons)

6 subclasses, including Magnoliidae (primitive) and Asteridae (advanced).

Class: Liliopsida (Monocotyledons)

5 subclasses, including Alismatidae (primitive) and Commelinidae (advanced).

Strengths

✔ **Comprehensive and widely accepted** for decades.

✔ **Morphology-based**, making it **practical for plant identification**.

✔ Influenced **botanical textbooks and floras worldwide**.

Limitations

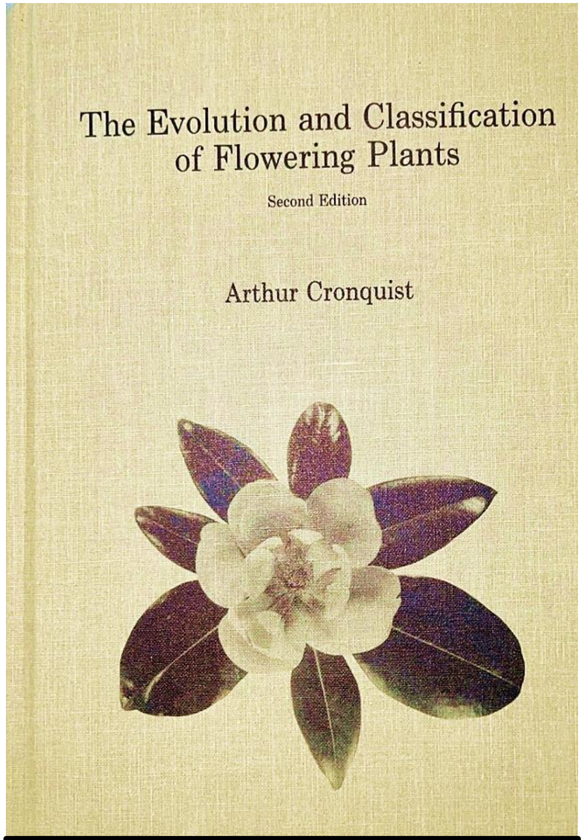
✚ Lacked **molecular phylogenetic support**.

✚ Some **groupings later revised** in APG systems.

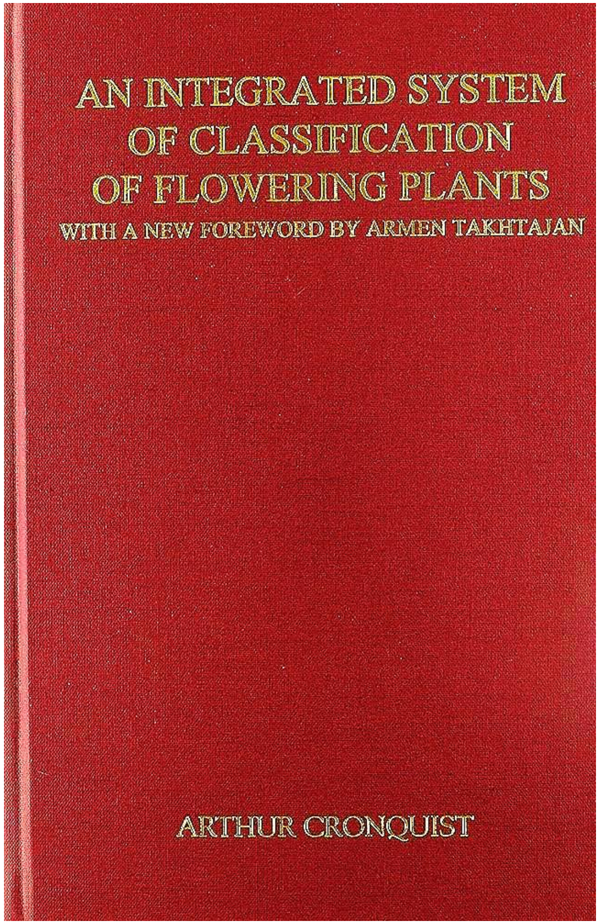
✚ **Considered artificial** in parts due to reliance on traditional traits.

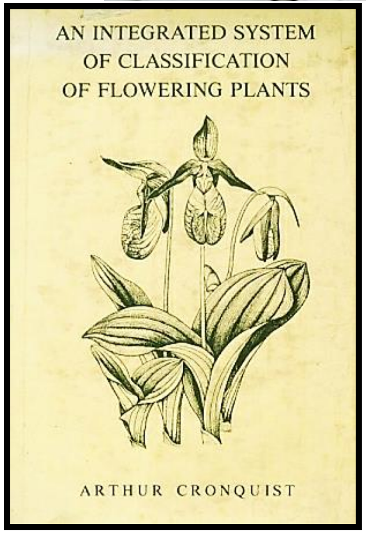
Arthur John Cronquist (March 19, 1919 – March 22, 1992)

An Integrated System of Classification of Flowering Plants **(1981)**



The Evolution and Classification of Flowering Plants **(revised 1988)**





Broad outline of the classification of angiosperms presented by Cronquist (1988).

Dahlgren's System of Classification (1975, 1980s)

Introduction

Developed by **Rolf Dahlgren**, a Swedish botanist.

A **phylogenetic system** based on **morphological, anatomical, chemical, and cytological** characteristics.

Introduced in the **1970s** and refined in the **1980s**.

Key Features

Emphasized monocots, providing **detailed classification**.

Used **chemical traits (phytochemistry)**, such as alkaloids and flavonoids, to determine evolutionary relationships.

Considered **pollen morphology**, seed structure, and embryology in classification.

Divided angiosperms into two classes:

- **Magnoliopsida (Dicotyledons)**
- **Liliopsida (Monocotyledons)**

Classification Structure

Monocots given high importance, with finer subdivisions than previous systems.

Used **superorders** as an additional taxonomic rank between class and order.

Strengths

✔ **Integrated multiple disciplines** (morphology, chemistry, anatomy).

✔ **Provided a detailed classification of monocots**.

✔ Introduced **superorders**, influencing modern systems like APG.

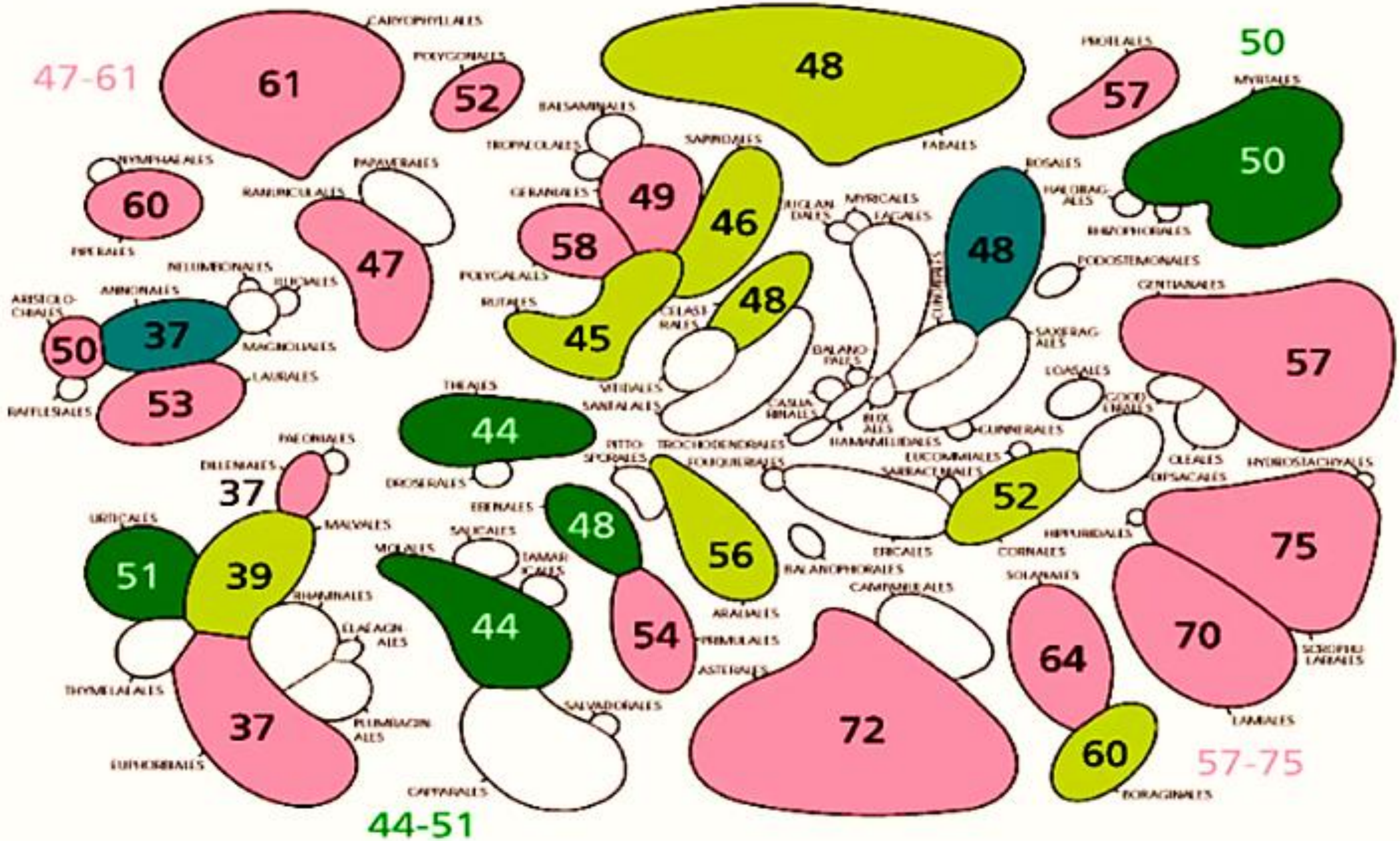
Limitations

✚ **Relied on morphology and chemistry**, lacking molecular data.

✚ **Not widely adopted globally**, as APG systems later replaced it.

✚ **Some family placements were controversial**.

Rolf F. Dahlgren and his wife Gertrud Dahlgren



angiosperm classification (both dicots and monocots included) showing orders, combined into superorders (Courtesy G. Dahlgren)

Thorne's System of Classification (1958, 1968, 1992, 2007)

Introduction

Developed by **Robert Folger Thorne**, an American botanist.

A **phylogenetic system** emphasizing **evolutionary relationships** among angiosperms.

Continuously revised from **1958 to 2007** based on new botanical discoveries.

Key Features

Recognized angiosperms as a monophyletic group.

Classified plants into **Magnoliopsida (dicots) and Liliopsida (monocots)**.

Used **superorders** to better represent evolutionary lineages.

Considered **anatomy, morphology, and cytology**, but also **early molecular data** in later versions.

Focused on **natural relationships rather than artificial groupings**.

Classification Structure

Two major classes:

Dicotyledonae (Magnoliopsida)

Monocotyledonae (Liliopsida)

Further divided into **superorders, orders, families, genera, and species**.

Strengths

✔ **Emphasized evolutionary relationships**, influencing later systems.

✔ **Refined superorders concept**, later adopted in APG classification.

✔ **Adapted with new data**, incorporating early molecular findings.

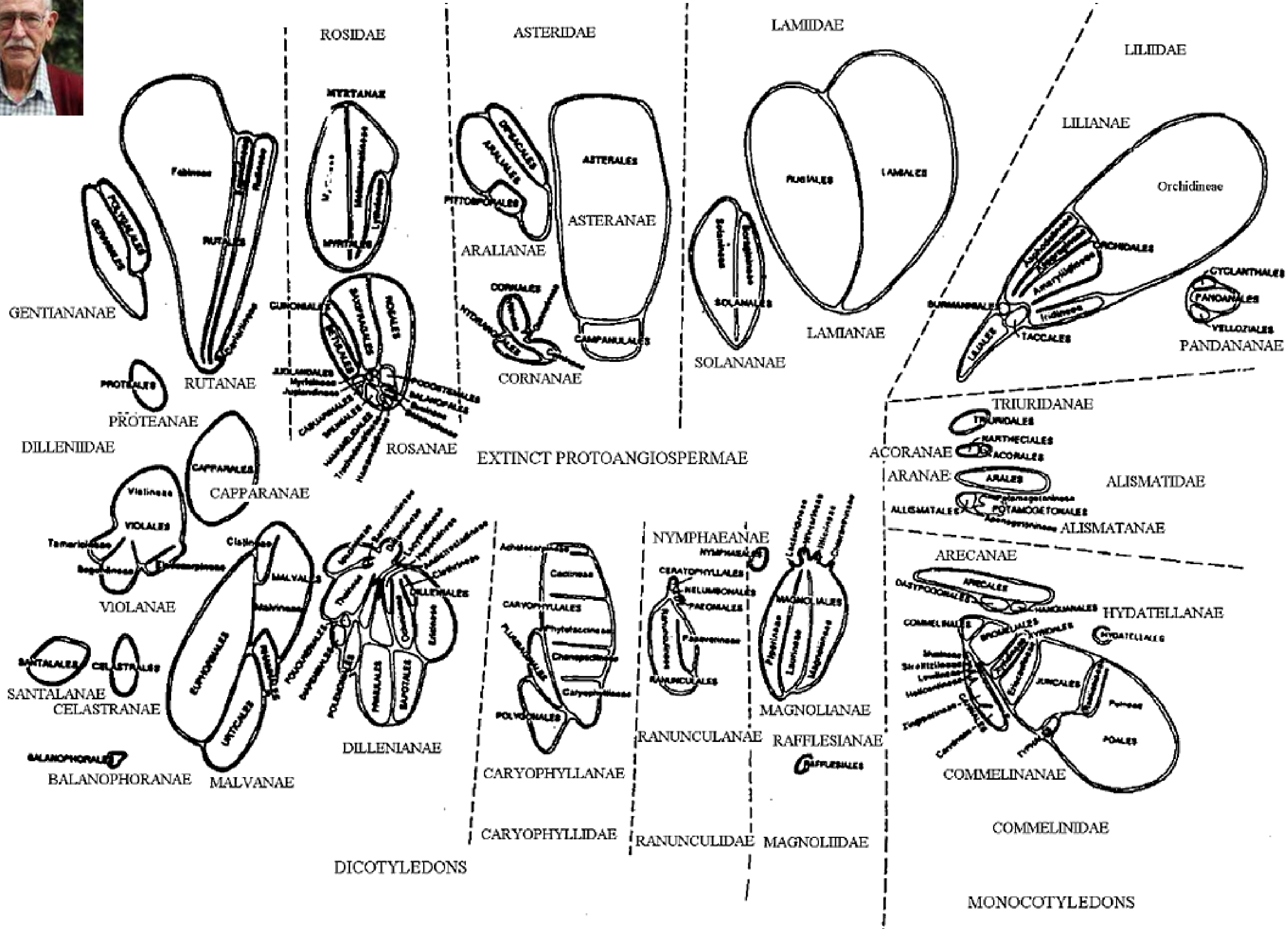
Limitations

✚ **Complex structure** with frequent revisions.

✚ **Some groupings were later modified** based on molecular phylogenetics.

Robert F. Thorne (1920-2015)

Robert Thorne of Rancho Santa Botanic Garden.



Thorne's Phylogenetic shrub of Angiospermae

Molecular Systematics (Late 20th Century)

Focus: Use of genetic data (DNA, RNA, protein sequences) to determine evolutionary relationships.

Key Developments:

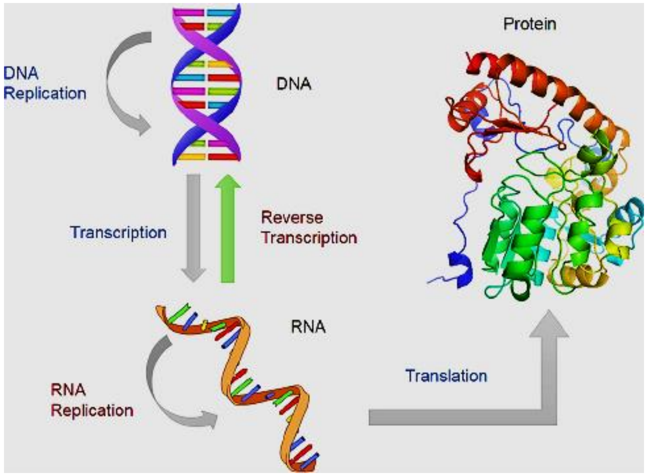
DNA sequencing (1970s).

Introduction of **molecular clocks** to estimate divergence times.

Impact:

Revolutionized taxonomy by providing accurate phylogenies.

Resolved complex relationships between organisms.



Modern Phylogenetics (21st Century)

Approach: Integration of molecular, computational, and statistical methods.

Key Innovations:

Genome sequencing.

Bioinformatics and machine learning for large-scale data analysis.

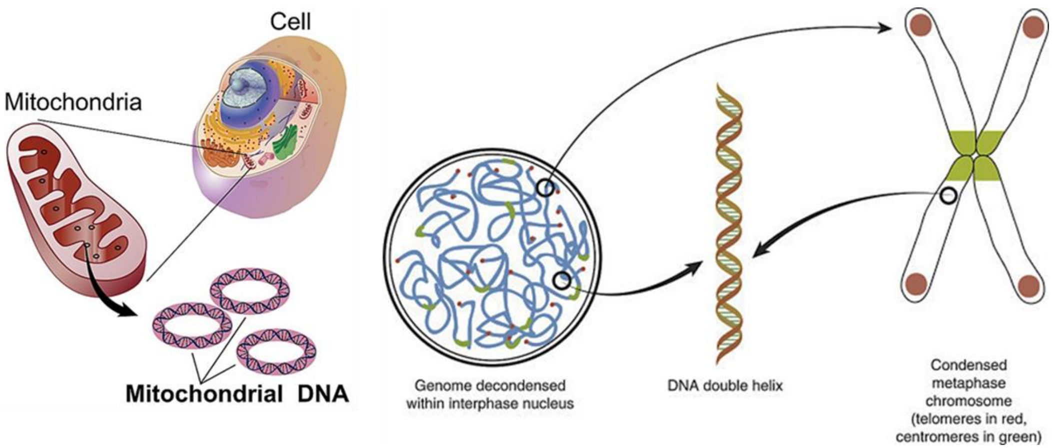
Bayesian and maximum likelihood models for tree construction.

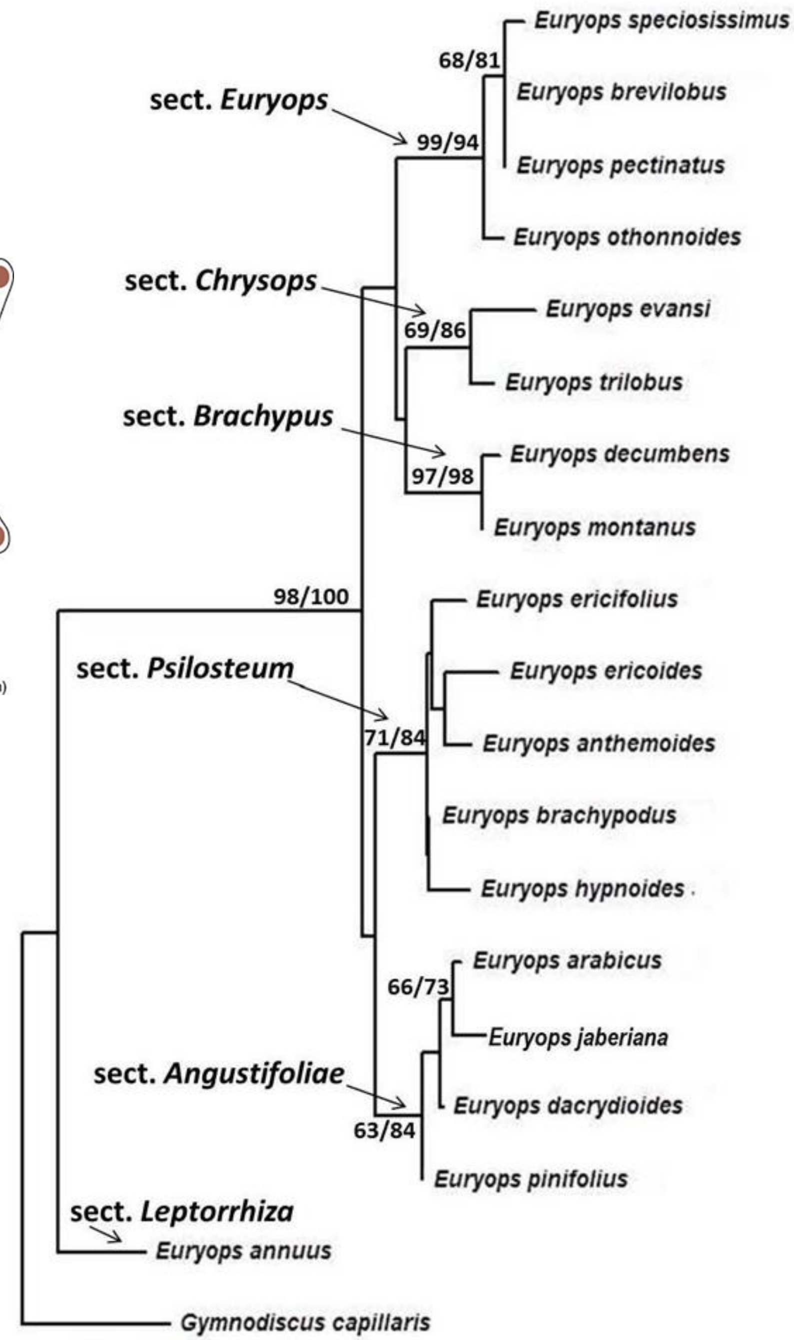
Impact:

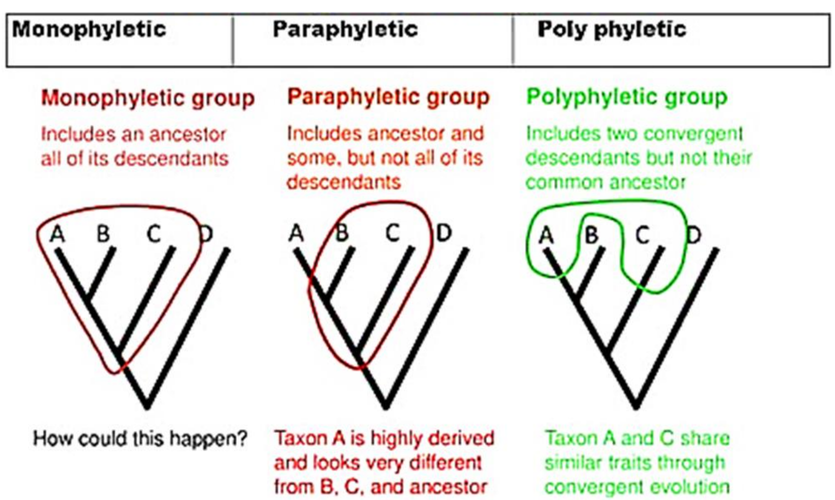
Refinement of evolutionary trees.

Discovery of horizontal gene transfer and its role in evolution.

Molecular phylogeny







APG System (Angiosperm Phylogeny Group) – 1998, 2003, 2009, 2016

Introduction

Developed by the **Angiosperm Phylogeny Group (APG)**, an international team of botanists.

First published in **1998**, with updates in **2003 (APG II), 2009 (APG III), and 2016 (APG IV)**.

Based on **molecular phylogenetics**, especially **DNA sequence data**.

Key Features

A **cladistic system**, classifying plants based on **evolutionary relationships**.

Rejected **artificial and traditional morphological classifications**.

Divided angiosperms into **monophyletic clades** rather than fixed ranks.

Introduced **major clades**:

- **Basal Angiosperms** (e.g., Amborellaceae, Nymphaeaceae)
- **Monocots** (e.g., Poales, Arecales, Orchidales)
- **Eudicots** (e.g., Rosids, Asterids)

Classification Structure

No formal ranks like **Dicotyledonae or Monocotyledonae**; instead, groups based on **common ancestry**.

Uses **orders and families**, refining relationships based on **DNA analysis**.

Examples of Clades:

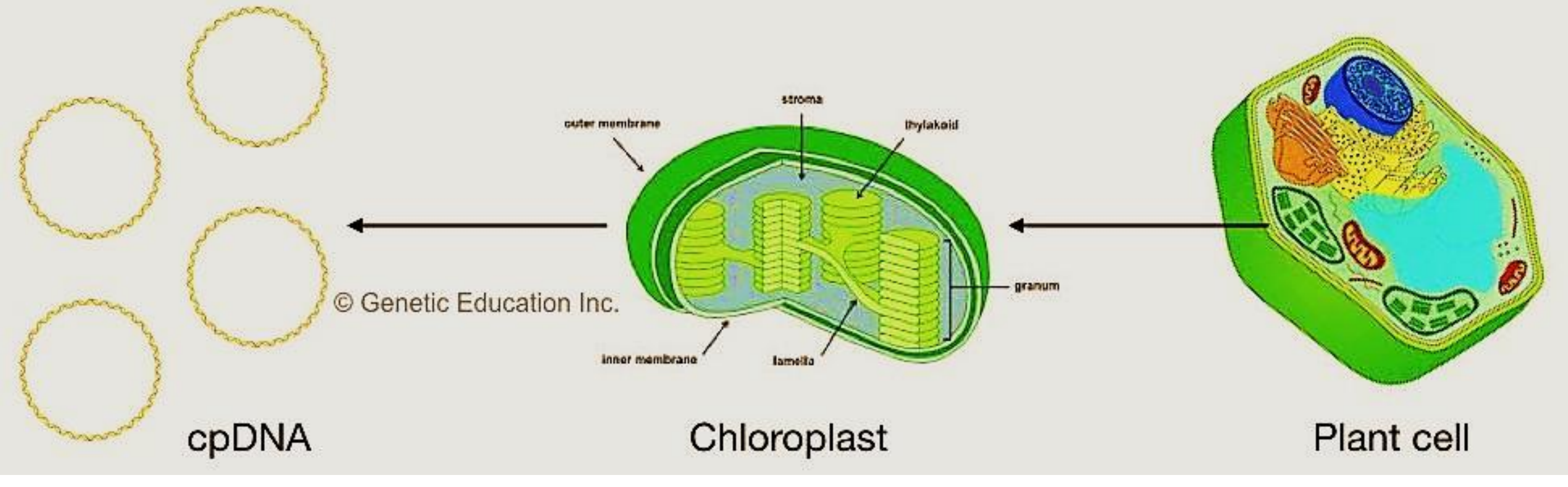
Basal Angiosperms → Amborellales, Nymphaeales
Monocots → Poaceae, Orchidaceae, Arecaceae
Eudicots → Rosaceae, Fabaceae, Asteraceae

Strengths

✔ **Phylogenetic accuracy** – based on molecular data, reflecting real evolutionary relationships.
✔ **Internationally accepted** – used widely in modern botanical research.
✔ **Continuously updated** – adapts to new discoveries in plant genetics.

Limitations

➕ **Frequent changes** – new DNA studies sometimes lead to reclassifications.
➕ **Complex terminology** – not as intuitive as traditional classification systems.



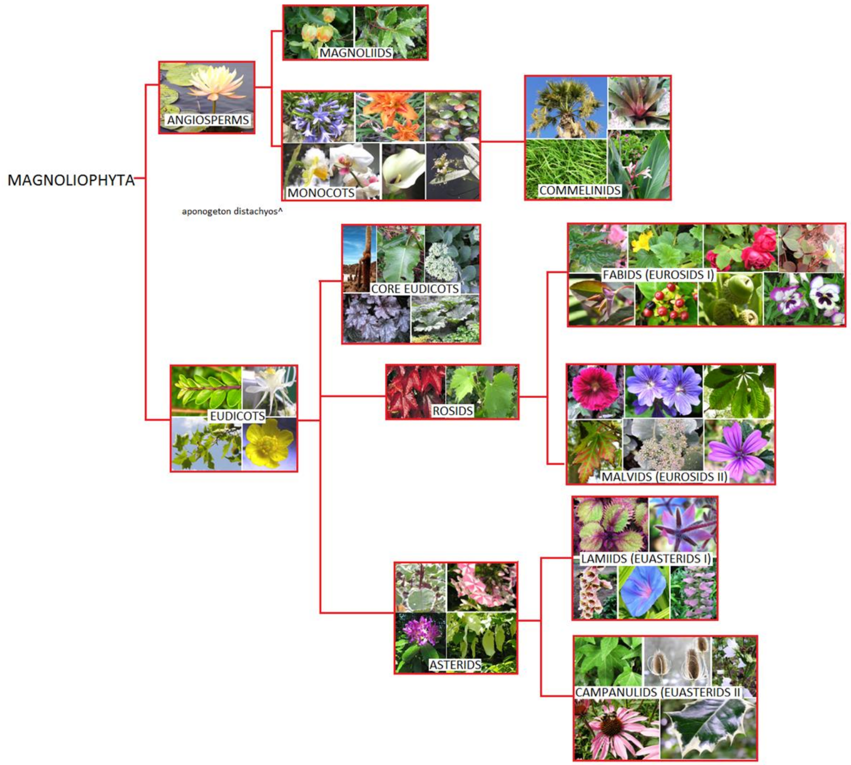
Angiosperm Phylogeny Group (APG)

- 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.

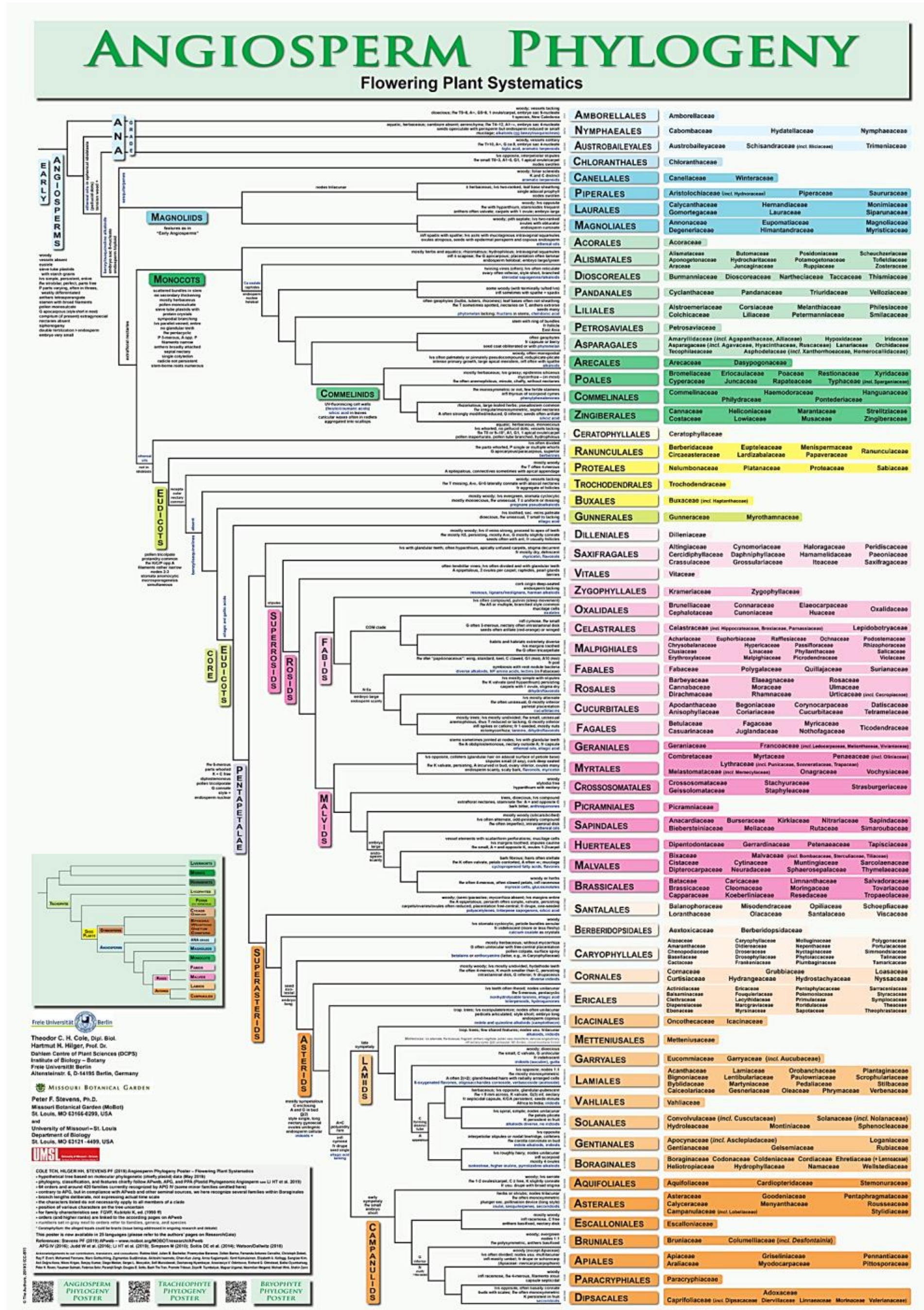
- Currently the APG IV system recognizes a total of 64 angiosperm orders and 416 families.

- 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



Comparison Table of APG Classifications:

Feature	APG I (1998)	APG II (2003)	APG III (2009)	APG IV (2016)
Introduction	First molecular-based classification.	Enhanced flexibility in taxonomy.	Broader taxonomic coverage.	Further refinements with latest data.
Major Groups	Monocots, Eudicots, Basal Clades.	Same as APG I.	Same as APG II, but with expanded definitions.	Same as APG III.
Number of Orders	40	45	59	64
Number of Families	462	457	415	416
Formal Ranks	Excluded above order.	Same as APG I.	Same as APG II.	Same as APG III.
Phylogenetic Evidence	Chloroplast DNA.	Additional molecular data.	Increased use of nuclear genes.	Comprehensive use of next-gen sequencing.
Significance	First to emphasize monophyly.	Improved resolution of phylogeny.	Expanded taxonomic coverage and clarity.	Most refined and widely accepted version.


ANGIOSPERM PHYLOGENY
Flowering Plant Systematics
AMBORELLALES
NYMPHAEALES
AUSTROBAILEYALES
CHLORANTHALES
CANELLALES
PIPERALES
LAURALES
MAGNOLIALES
ACORALES
ALISMATALES
DIOSCOREALES
PANDANALES
LILIALES
PETROSAVIALES
ASPARAGALES
ARECALES
POALES
COMMELINALES
ZINGIBERALES
CERATOPHYLLALES
RANUNCULALES
PROTEALES
TROCHODENDRALES
BUXALES
GUNNERALES
DILLENIALES
SAXIFRAGALES
VITALES
ZYGOPHYLLALES
OXALIDALES
CELASTRALES
MALPIGHIALES
FABALES
ROSALES
CUCURBITALES
FAGALES
GERANIALES
MYRTALES
CROSSOSOMATALES
PICRAMNIALES
SAPINDALES
HUERTEALES
MALVALES
BRASSICALES
SANTALALES
BERBERIDOPSIDALES
CARYOPHYLLALES
CORNALES
ERICALES
ICACINALES
METTENIUSALES
GARRYALES
LAMIALES
VAHLIALES
SOLANALES
GENTIANALES
BORAGINALES
AQUIFOLIALES
ASTERALES
ESCALLONIALES
BRUNIALES
APIALES
PARACRYPHIALES
DIPSACALES
MAGNOLIIDS
MONOCOTS
COMMELINIDS
EUDICOTS
CORE EUDICOTS
SUPERROSIDS
ROSIDS
FABIDS
MALVIDS
PENTAPETALAE
SUPERASTERIDS
ASTERIDS
LAMIIDS
CAMPANULIDS
EARLY ANGIOSPERMS
ANA
Freie Universität Berlin
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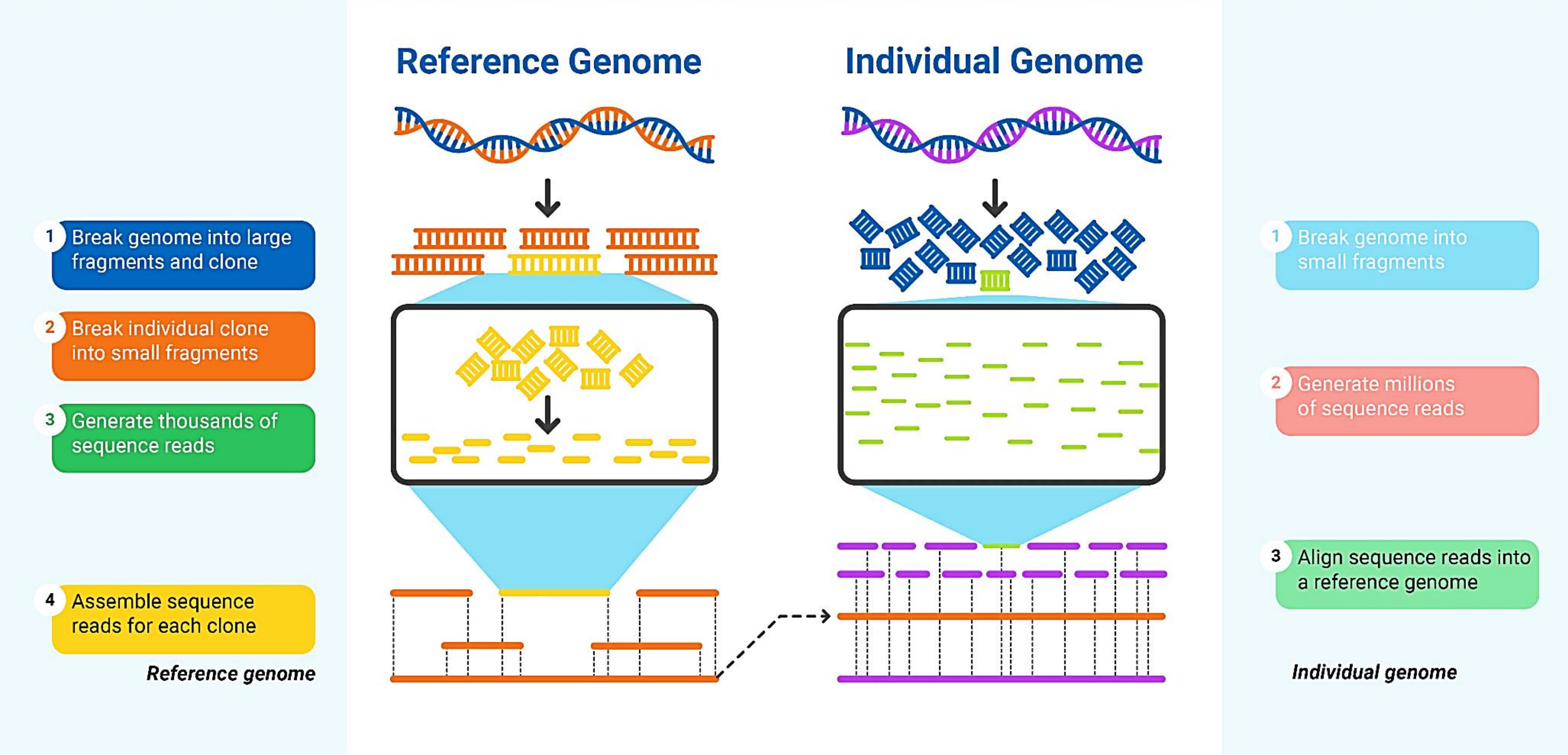
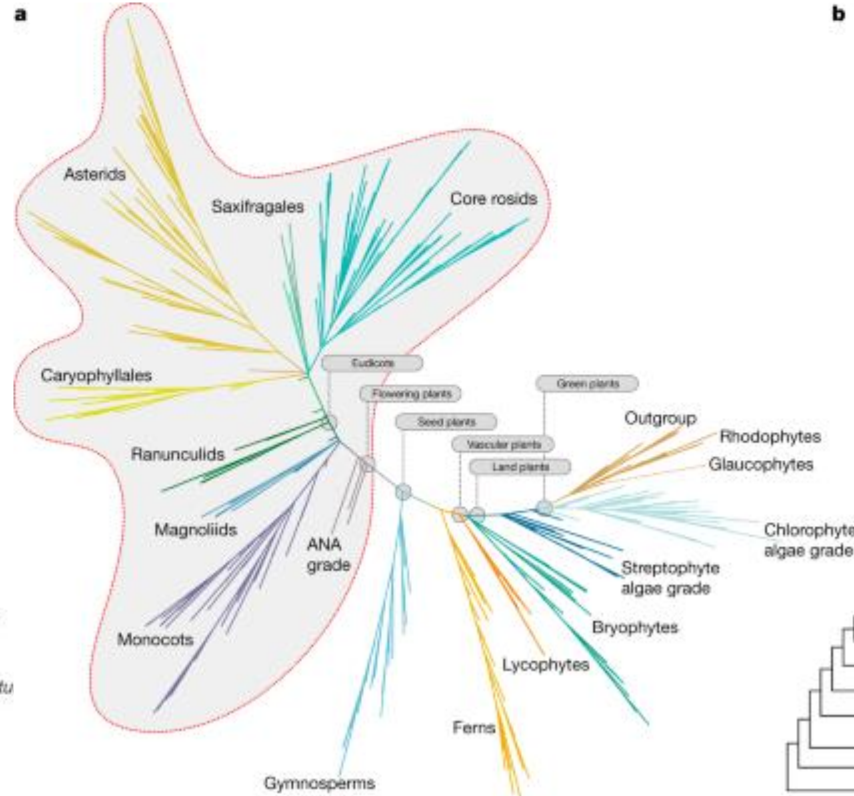
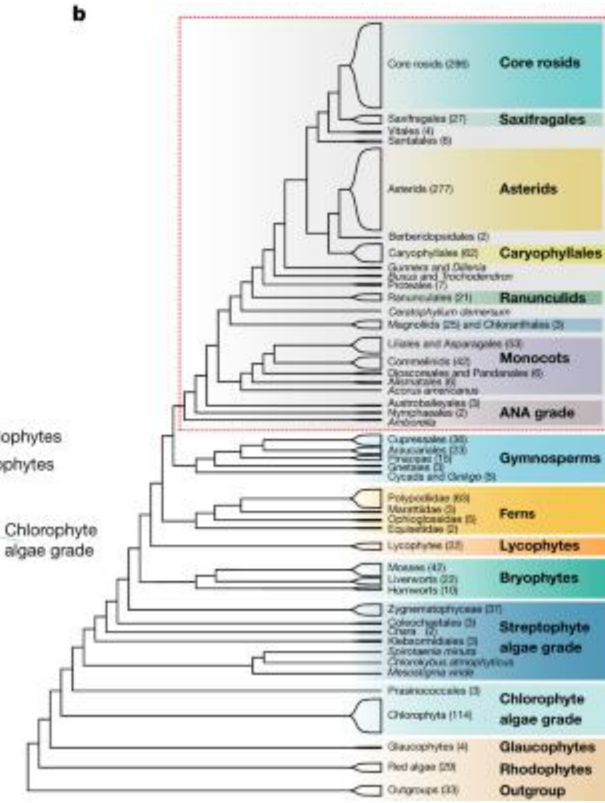
RECENT ADVANCES

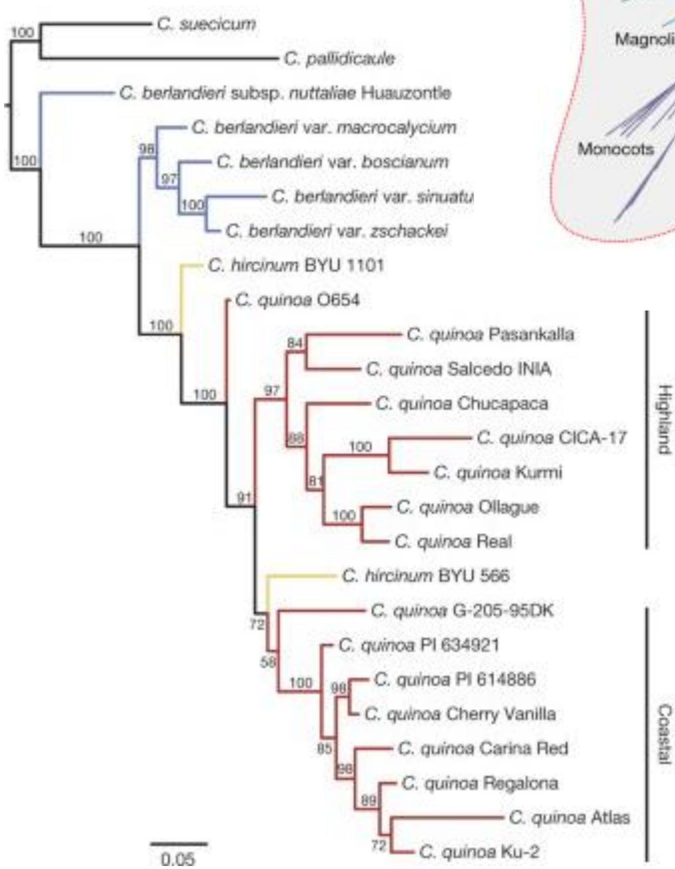
WHOLE GENOME SEQUENCING



Molecular phylogeny based on Genome data







Molecular phylogeny based on transcriptome data

Problems in Evolutionary Taxonomy

Introduction

Evolutionary taxonomy aims to classify organisms based on evolutionary history and degrees of evolutionary divergence.

While it represents a significant advancement, this approach has encountered several challenges.

Key Problems in Evolutionary Taxonomy

Subjectivity in Classification

Evolutionary taxonomy often involves subjective judgments about the relative importance of traits.

Example: Disputes over whether specific features indicate major evolutionary divergence or minor variation.

Results in inconsistent classifications between taxonomists.

Weighting of Traits

Evolutionary taxonomy requires assigning importance (weight) to different traits (morphological, genetic, ecological).

Disagreement over which traits are most significant leads to variability in classifications.

Homoplasy

Definition: Convergent or parallel evolution results in similar traits in unrelated species.

Problem: Misleading similarities can obscure true evolutionary relationships.

Example: Wings in bats and birds are analogous, not homologous.

Lack of Clear Criteria

No universally accepted criteria for determining evolutionary significance or degree of divergence.

Difficulty in distinguishing between **ancestral traits (plesiomorphies)** and **derived traits (apomorphies).**

Hybridization and Horizontal Gene Transfer

Hybridization between species complicates the construction of clear evolutionary lineages.

Horizontal gene transfer (especially in prokaryotes) challenges traditional tree-like models of evolution.

Challenges of Fossil Evidence

Fossil records are often incomplete or ambiguous.

Evolutionary relationships based on morphology in fossils can be speculative without genetic data.

Rapid Evolution and Speciation

Rapid adaptive radiations can make it difficult to determine clear relationships between species.

Example: Darwin's finches in the Galápagos.

Integration of Molecular and Morphological Data

Conflicts can arise between classifications based on traditional morphological traits and modern molecular data.

Example: Genetic studies sometimes reveal cryptic species or previously unrecognized relationships.

Deducing Phylogenetic Relationships: The Concept of Primitive and Advanced Traits in Plants

Introduction

Phylogenetic relationships are determined by comparing traits among organisms to infer their evolutionary history.

Primitive (Ancestral) Traits and **Advanced (Derived) Traits** are key concepts used to construct phylogenies in plants.

1. Primitive (Ancestral) Traits

Definition: Traits inherited from a common ancestor and shared across a wide group of organisms.

Characteristics:

- Present in both the ancestor and its descendants.
- Retain original structure and function with little modification.

Examples:

- **Presence of vascular tissue in plants**: Vascular tissue (xylem and phloem) is found in both non-flowering plants (like ferns) and flowering plants, inherited from a common ancestor.
- **Simple leaf structure**: Simple leaves (without complex structures like flowers or specialized tissues) are found in basal plant groups like mosses and ferns.

Significance:

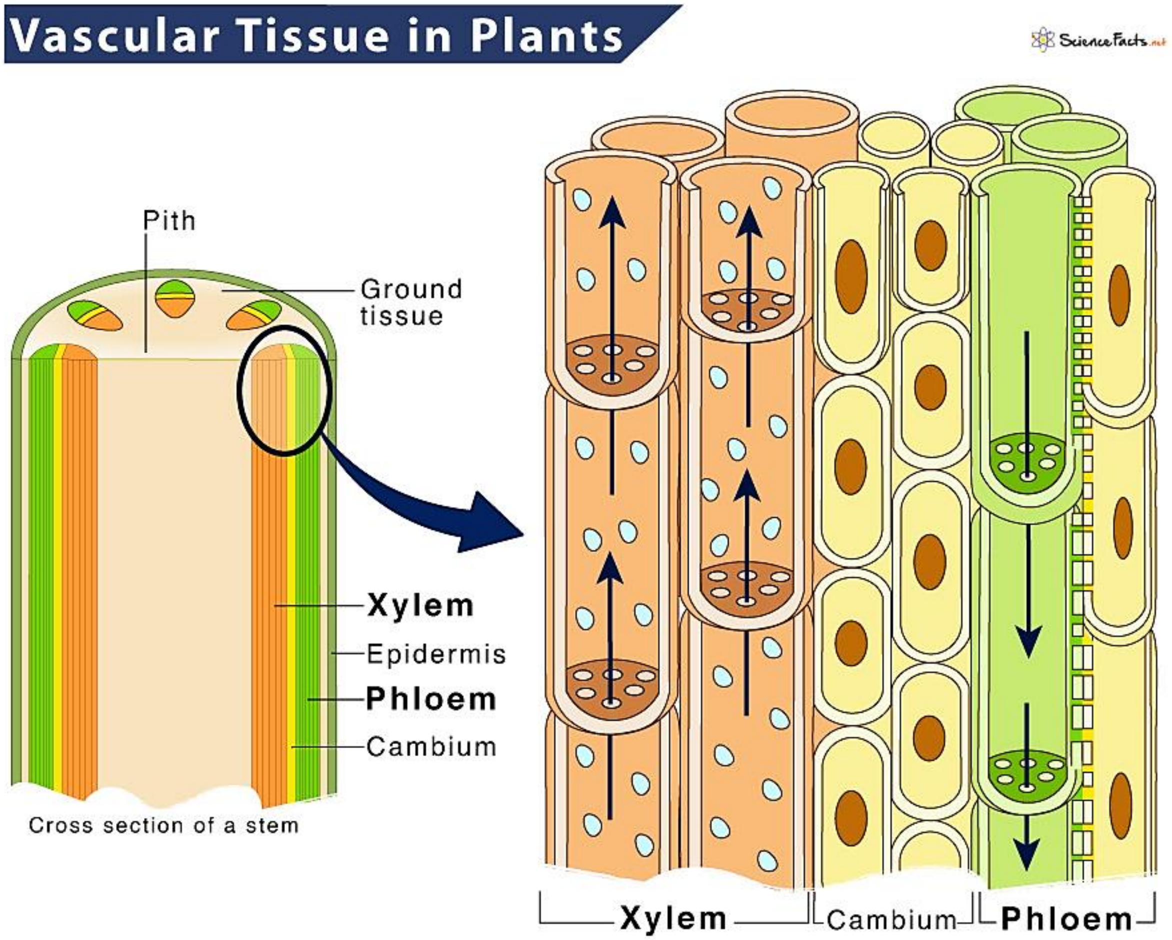
- Helps identify the evolutionary starting point of a plant lineage.
- **Vascular tissue** helped early plants transition from aquatic to terrestrial environments.

Advanced (Derived) Traits

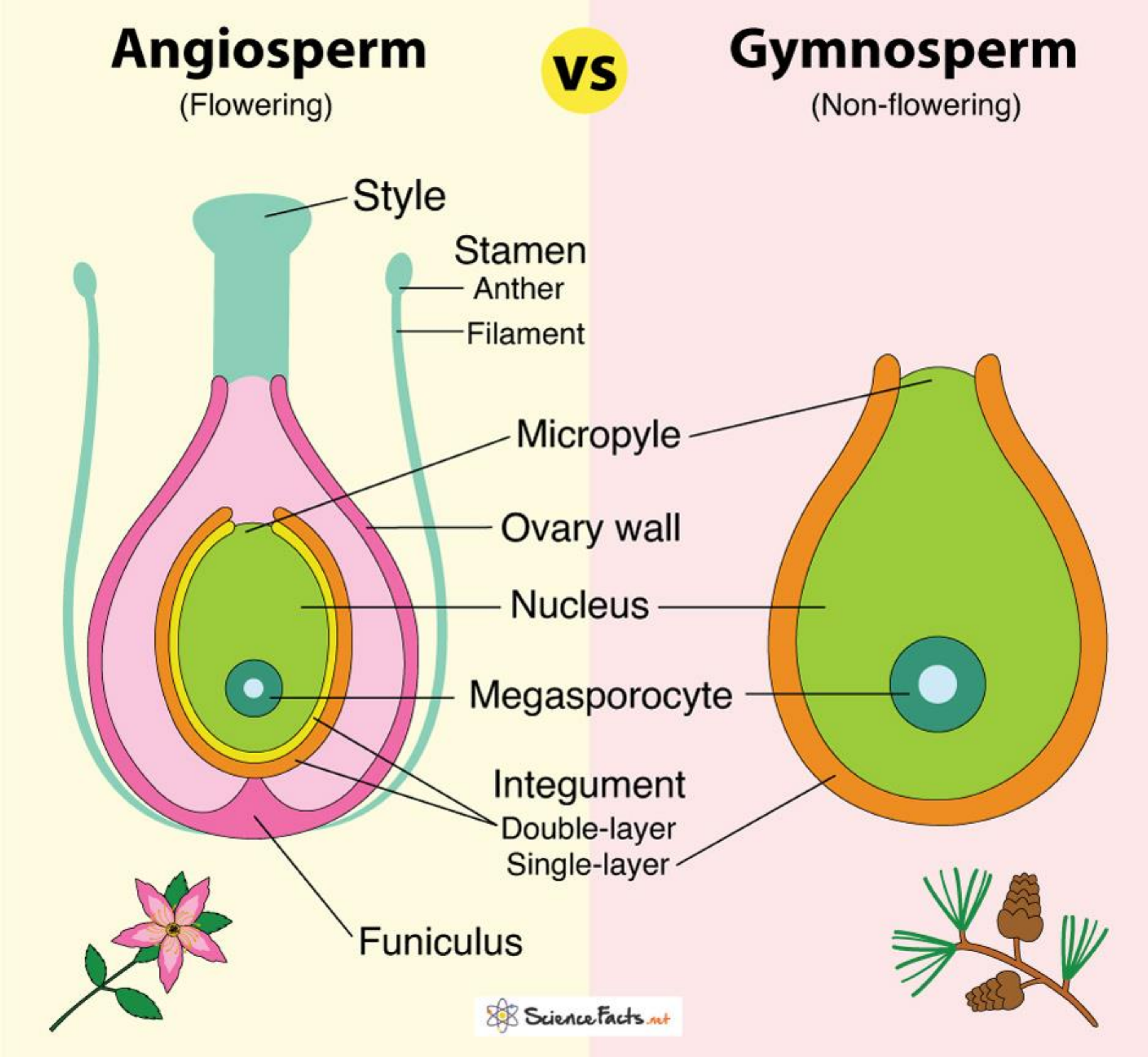
Definition: Traits that have evolved and are unique to specific lineages, not present in the common ancestor.

Characteristics:

Indicate evolutionary modifications. Often adapted for specific environmental or functional needs.



Simple leaf structure- ferns



Angiosperm
(Flowering)
vs
Gymnosperm
(Non-flowering)
Style
Stamen
Anther
Filament
Micropyle
Ovary wall
Nucleus
Megasporocyte
Integument
Double-layer
Single-layer
Funiculus
ScienceFacts.net

Challenges

Misidentification of traits:

Homoplasy: Similar traits that evolved independently.

Example: **Succulent leaves** in both cacti and agaves, which evolved independently in response to arid environments, even though the plants are from different families.

Reversals: Advanced traits reverting to ancestral forms.

Example: **Simple leaves** appearing in some angiosperms like certain species of **Amborella**, which have reverted to a more primitive leaf form.

Subjectivity in deciding which traits are primitive or derived:

It can be difficult to draw clear lines between primitive and derived traits, especially when plants show a mixture of features from different evolutionary periods.

Succulent leaves in both cacti and agaves

Monophyly and Polyphyly

Introduction

In plant taxonomy, phylogenetic groupings are classified based on shared ancestry. **Monophyly** and **Polyphyly** are crucial concepts used to describe plant groupings in phylogenetic trees.

1. Monophyly

Definition: A group consisting of a common ancestor and **all** its descendants.

Key Features:

Represents a natural, evolutionarily cohesive lineage.

Based on shared derived traits (**synapomorphies**).

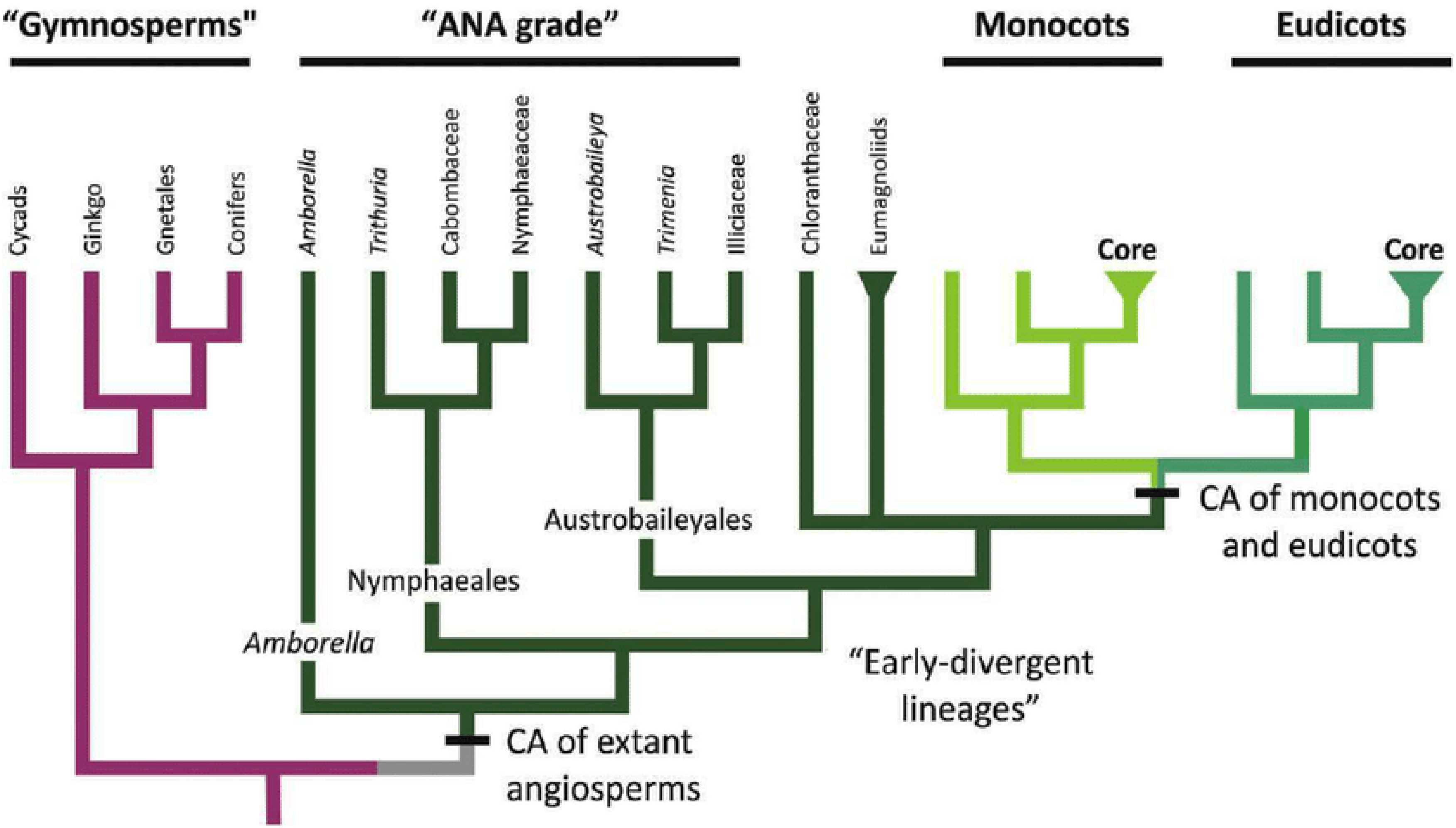
Plant Examples:

Angiosperms (flowering plants): A monophyletic group that includes all plants with flowers and fruits, sharing a common ancestor.

Gymnosperms: A monophyletic group including conifers, cycads, ginkgo, and gnetophytes, all descended from a single common ancestor.

Significance:

Monophyletic groups (or clades) are the foundation of modern plant phylogenetics.



"Gymnosperms"
"ANA grade"
Monocots
Eudicots
Cycads
Ginkgo
Gnetales
Conifers
Amborella
Trithuria
Cabombaceae
Nymphaeaceae
Austrobaileya
Trimenia
Illiciaceae
Chloranthaceae
Eumagnoliids
Core
Core
CA of monocots
and eudicots
Austrobaileyales
Nymphaeales
Amborella
"Early-divergent
lineages"
CA of extant
angiosperms

Polyphyly

Definition: A group that does **not** include the most recent common ancestor of its members.

Key Features:

- Formed based on convergent evolution or superficial similarities (**homoplasies**).
- Does not represent an evolutionary lineage.

Plant Examples:

- **C4 Photosynthetic Plants**: Includes plants like maize (Zea mays), sugarcane (Saccharum officinarum), and crabgrass (Digitaria sp.), but these traits evolved independently in unrelated lineages.
- **Succulents**: Aloe, cacti, and agave, grouped by their water-storing adaptations, but derived from different ancestors.

Significance:

- Highlights the importance of distinguishing between shared ancestry and convergent evolution in plant classification.

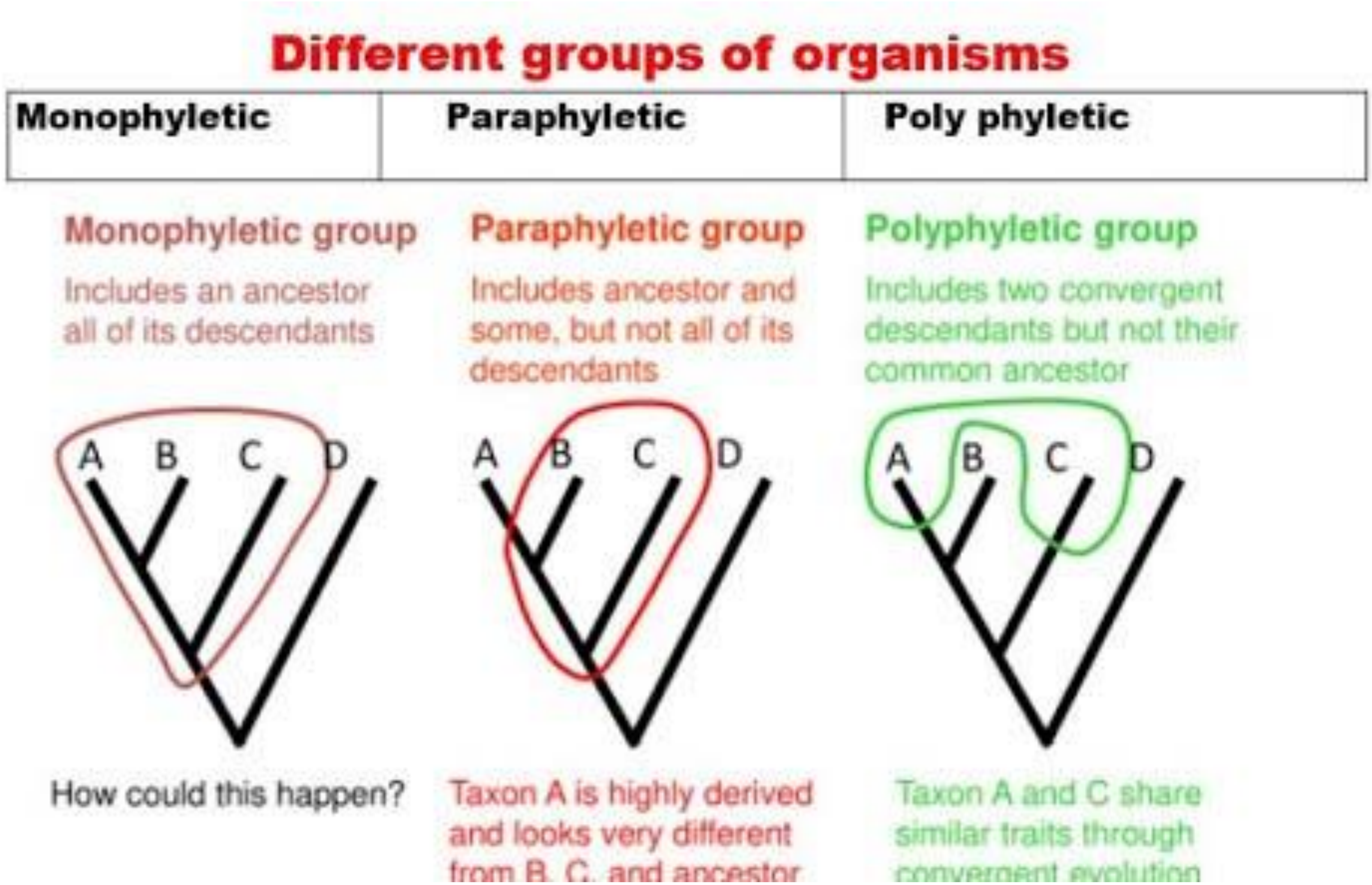
Comparison of Monophyly and Polyphyly in Plants

Aspect	Monophyly	Polyphyly
Definition	Includes common ancestor and all descendants	Excludes the common ancestor
Trait Basis	Shared derived traits (synapomorphies)	Superficial or convergent traits
Evolutionary Validity	Reflects evolutionary lineage	Artificial grouping
Plant Examples	Angiosperms, gymnosperms	C4 plants, succulents

Importance in Plant Phylogenetics

Monophyletic groups: The goal of plant taxonomy is to identify clades that represent true evolutionary relationships.

Polyphyletic groups: Highlight the need for careful analysis to avoid artificial groupings based on convergent traits.



Parallelism and Convergence

Introduction

Both parallelism and convergence describe the independent evolution of similar traits in different species.

These concepts are key to understanding evolutionary patterns in plants.

1. Parallelism

Definition: The independent evolution of similar traits in closely related species due to similar genetic or developmental pathways.

Key Features:

- Occurs in organisms with a shared evolutionary background.
- Similar traits evolve due to shared genetic predispositions.

Plant Examples:

- **C4 Photosynthesis in Grasses**:
  - C4 photosynthesis independently evolved in closely related grass species like maize (*Zea mays*), sugarcane (*Saccharum officinarum*), and sorghum (*Sorghum bicolor*).
  - These species share a genetic predisposition for this adaptation.
- **Leaf Shape in Oak Species**:
  - Similar lobed leaves evolved in different oak species (*Quercus* spp.) that are closely related.

3. Comparison of Parallelism and Convergence

Aspect	Parallelism	Convergence
Definition	Similar traits evolve in closely related species	Similar traits evolve in distantly related species
Key Drivers	Shared genetic/developmental pathways	Similar environmental pressures
Plant Examples	C4 photosynthesis in grasses, oak leaf shapes	Succulence in cacti and euphorbias, climbing vines

4. Importance in Plant Evolution

Parallelism: Highlights the role of shared ancestry in shaping evolutionary outcomes.

Convergence: Demonstrates the power of environmental pressures to shape unrelated species in similar ways.

Both processes complicate the identification of true phylogenetic relationships in plants.

Homology vs Analogy in Plants

Homology

Definition: Similar traits due to shared ancestry.

Examples:

- **Roots in all plants**: Evolved from a common ancestor for water and nut absorption.
- **Leaf structure**: Dicot leaves (broad, net-like veins) vs monocot leaves (long, narrow, parallel veins).

Analogy

Definition: Similar traits due to similar environmental pressures, not shared ancestry.

Examples:

- **Cactus spines vs holly leaves**: Both minimize water loss in dry environments but evolved independently.
- **Water storage in succulents vs Baobab trees**: Both store water but evolved in different plant families.

Key Differences

Aspect	Homology	Analogy
Origin	Shared ancestry	Independent evolution due to similar needs
Example	Leaf structure in dicots vs monocots	Cactus spines vs holly leaves

Theoretical Basis of Plant Classification: A Critical Evaluation

What is Plant Classification?

Plant Classification is the process of grouping plants based on shared characteristics, both structural and genetic.

Theoretical Foundations:

Linnaean System (Carl Linnaeus):

- **Basis**: Hierarchical classification based on observable traits.
- **Key Concepts**:
  - **Binomial Nomenclature**: Two-part naming system (Genus species).
  - **Taxonomic Ranks**: Kingdom, Phylum, Class, Order, Family, Genus, Species.
- **Strengths**: Simple, widely accepted system.
- **Criticism**: Focuses mainly on morphology, doesn't always reflect evolutionary relationships.

Phylogenetic System (Evolutionary Relationships):

- **Basis**: Classification based on common ancestry and evolutionary relationships.
- **Key Concept**: Cladistics, where species are grouped based on shared evolutionary traits.
- **Strengths**: Reflects true evolutionary history, emphasizes genetic data.
- **Criticism**: Requires extensive molecular data; sometimes ignores practical concerns like morphology.

Phenetic Classification (Numerical Taxonomy):

Basis: Grouping plants based on overall similarity, using statistical methods to compare traits.

Key Concept: All observable traits are equally weighted.

Strengths: Uses quantitative data, can classify a large number of species.

Criticism: May group organisms together without reflecting evolutionary relationships.

Modern Molecular Methods (DNA Barcoding, Genomic Data):

Basis: Using molecular markers (DNA sequences) to determine evolutionary relationships.

Key Concept: More accurate, reflects genetic distances between species.

Strengths: High precision, resolves ambiguities in traditional methods.

Criticism: Expensive, requires specialized equipment, and data interpretation can be complex.

Critical Evaluation:

Traditional vs. Modern Methods:

Traditional systems (Linnaean, Phenetic) rely heavily on observable traits, which may not fully represent evolutionary history.

Modern molecular methods provide more accurate evolutionary insights but are more resource-intensive.

Evolutionary Relationships:

Phylogenetic classification, which is based on genetic relationships, is seen as more accurate than morphology-based approaches.

However, some groups may not be easily classified using molecular data alone.

Practical Use in Fieldwork:

Linnaean classification remains the standard due to its simplicity and ease of use in identifying plants in the field.

Molecular methods are valuable in research and taxonomy but less practical for daily use.

QUESTIONS FOR PRACTICE

Multiple Choice Questions (MCQs)

1. **Who developed the Engler and Prantl system of classification?**
   a) Charles Darwin
   b) Adolf Engler and Karl Prantl
   c) Arthur Cronquist
   d) John Hutchinson
   Answer: b) Adolf Engler and Karl Prantl

2. **In the Engler and Prantl system, which plant group is considered more primitive than angiosperms?**
   a) Gymnosperms
   b) Monocots
   c) Eudicots
   d) Cryptogams
   Answer: a) Gymnosperms

3. **Which group of plants did Bessey consider the most primitive?**
   a) Monocots
   b) Dicotyledons
   c) Ranales
   d) Orchids
   Answer: c) Ranales

Multiple Choice Questions (MCQs)

1. **According to Hutchinson's system, what did he consider the more primitive group of angiosperms?**
   a) Monocots
   b) Dicotyledons
   c) Herbaceous plants
   d) Ranales
   Answer: b) Dicotyledons
2. **What did Takhtajan's classification system emphasize?**
   a) Fossil records
   b) Phylogenetic relationships
   c) Pollen morphology
   d) Artificial groupings
   Answer: b) Phylogenetic relationships
3. **Which of these systems emphasized the importance of biogeography in plant classification?**
   a) Takhtajan’s System
   b) Cronquist’s System
   c) Dahlgren’s System
   d) APG System
   Answer: a) Takhtajan’s System

Multiple Choice Questions (MCQs)

1. **Which system of classification emphasized the concept of "superorders"?**
   a) Engler and Prantl System
   b) Thorne’s System
   c) Dahlgren’s System
   d) Cronquist’s System
   Answer: c) Dahlgren’s System
2. **Which of these classification systems used floral structures to determine evolutionary relationships?**
   a) Engler and Prantl System
   b) Bessey’s Cactus System
   c) Hutchinson’s System
   d) Takhtajan’s System
   Answer: b) Bessey’s Cactus System
3. **Which system proposed the division of dicots into Lignosae and Herbaceae?**
   a) Takhtajan’s System
   b) Hutchinson’s System
   c) Engler and Prantl System
   d) Cronquist’s System
   Answer: b) Hutchinson’s System
   4.The APG system is based on which type of data?
   a) Morphological data
   b) Fossil records
   c) Molecular phylogenetic data
   d) Pollen morphology **Answer:** c) Molecular phylogenetic data

Fill in the Blanks

1. The Engler and Prantl system was published in the work titled "Die _______ Pflanzenfamilien".
   Answer: Natürlichen

2. Bessey's Cactus System was based on _______ principles.
   Answer: Darwinian

3. Takhtajan's classification system was first proposed in the year _______.
   Answer: 1954

4. In Hutchinson's system, dicots were considered more _______ than monocots.
   Answer: primitive

5. Cronquist's system divided angiosperms into two classes: _______ and Liliopsida.
   Answer: Magnoliopsida

6. The APG system is based on _______ phylogenetics.
   Answer: molecular

7. The APG system divided angiosperms into major clades like Basal Angiosperms, _______ and Eudicots.
   Answer: Monocots

8. Dahlgren's system emphasized the importance of _______ traits, such as alkaloids and flavonoids.
   Answer: chemical

9. Thorne's system introduced the concept of _______ to better represent evolutionary lineages.
   Answer: superorders

10. Bessey's Cactus system emphasized the evolution of _______ flowers.
    Answer: primitive

Short Answer Questions

1. **Who were the developers of the Engler and Prantl system?**
   Answer: Adolf Engler and Karl Prantl

2. **What was the key feature of Bessey's Cactus system?**
   Answer: Bessey's Cactus system was based on Darwinian evolutionary principles and used a cactus-like diagram to show evolutionary relationships.

3. **What is the main difference between monocots and dicots in the classification systems?**
   Answer: Monocots were generally considered more primitive than dicots in earlier systems like Engler and Prantl's, though this view has since been revised.

4. **What evolutionary concept did Takhtajan emphasize in his classification system?**
   Answer: Takhtajan emphasized phylogenetic relationships, integrating morphology, anatomy, and biogeography.

5. **What major grouping did Hutchinson's system use in dicots?**
   Answer: Hutchinson divided dicots into Lignosae (woody) and Herbaceae (herbaceous) groups.

6. **Which system was one of the first to integrate molecular phylogenetics into classification?**
   Answer: The APG system was one of the first to use molecular phylogenetics for classification.

7. **In Dahlgren's system, what additional taxonomic rank was introduced?**
   Answer: Dahlgren introduced the rank of "superorders" to classify plants.
8. **What was the main feature of Cronquist's system?**
   Answer: Cronquist's system emphasized traditional morphological traits such as vascular systems and leaf venation.
9. **How did the APG system classify plants differently from traditional systems?**
   Answer: The APG system classified plants into monophyletic clades based on DNA analysis, rejecting traditional hierarchical ranks.
10. **What is a major strength of Takhtajan's system?**
    Answer: Takhtajan's system is one of the most detailed phylogenetic classifications, incorporating morphology, anatomy, and biogeography.

True or False

1. **The Engler and Prantl system considered gymnosperms to be more advanced than angiosperms.**
   Answer: False

2. **Bessey's Cactus System emphasized the evolution of monocots over dicots.**
   Answer: False

3. **Hutchinson's system divided dicots into two groups: Lignosae and Herbaceae.**
   Answer: True

4. **Takhtajan's system was the first to use molecular data in plant classification.**
   Answer: False

5. **The APG system rejected artificial and traditional morphological classifications in favor of molecular data.**
   Answer: True

6. **The APG system divides angiosperms into fixed hierarchical ranks.**
   Answer: False

7. **Bessey's system considered Ranales as the ancestral angiosperms.**
   Answer: True

8. **Cronquist's system is heavily based on molecular data.**
   Answer: False

9. **Thorne's system used superorders to classify plant groups.**
   Answer: True

10. **Dahlgren's system was widely accepted globally.**
    Answer: False

Match the Following

Column A	Column B
1. Engler and Prantl	b) Based on molecular phylogenetic data
2. Bessey's Cactus System	d) Introduced superorders for plant classification
3. Hutchinson's System	e) Considered gymnosperms more primitive than angiosperms
4. Takhtajan's System	c) Proposed the Ranales group as ancestral angiosperms
APG System	a) Recognized dicots as more primitive than monocots

Answers:

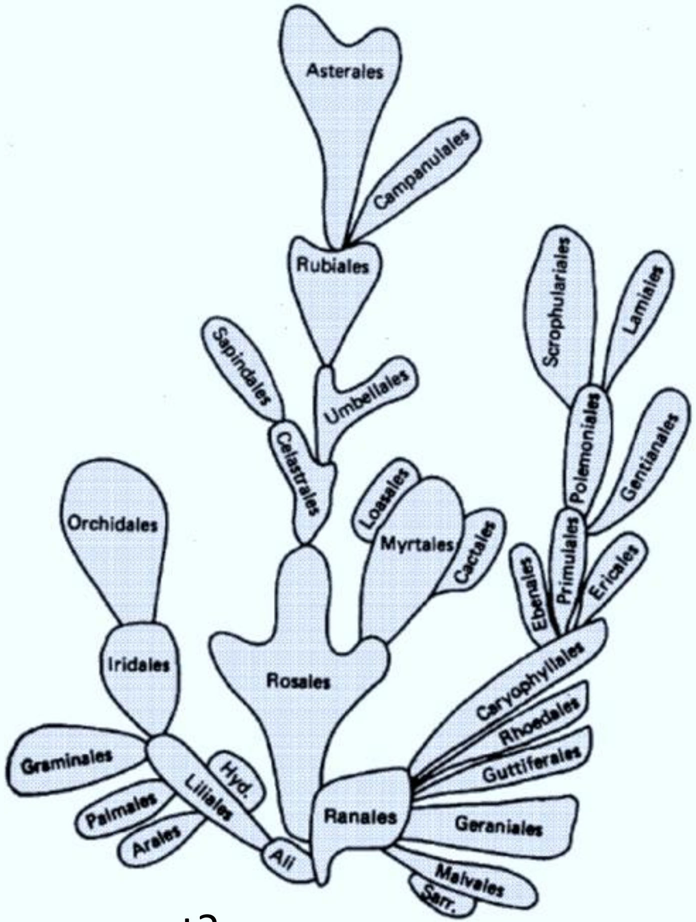
1 - e) Considered gymnosperms more primitive than angiosperms

2 - c) Proposed the Ranales group as ancestral angiosperms

3 - a) Recognized dicots as more primitive than monocots

4 - d) Introduced superorders for plant classification

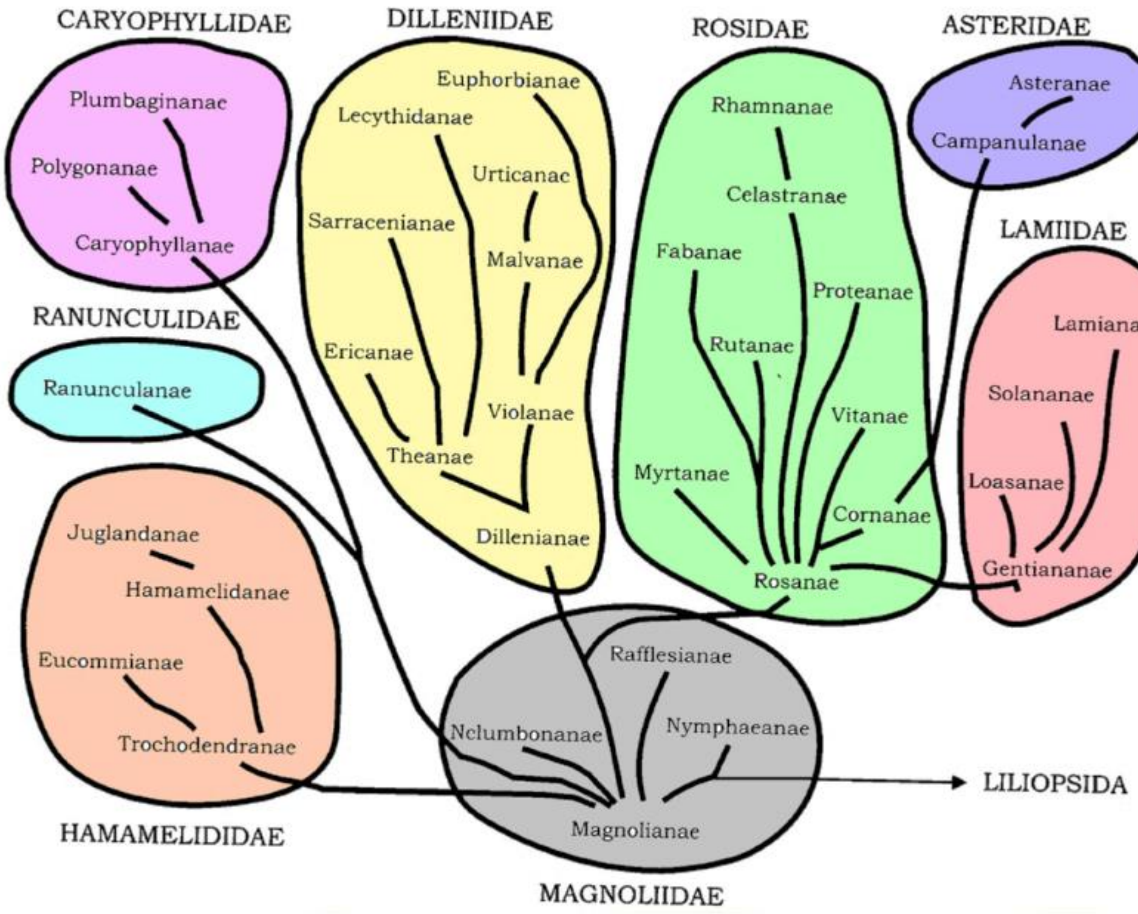
5 - b) Based on molecular phylogenetic data



Question: What does this diagram represent?

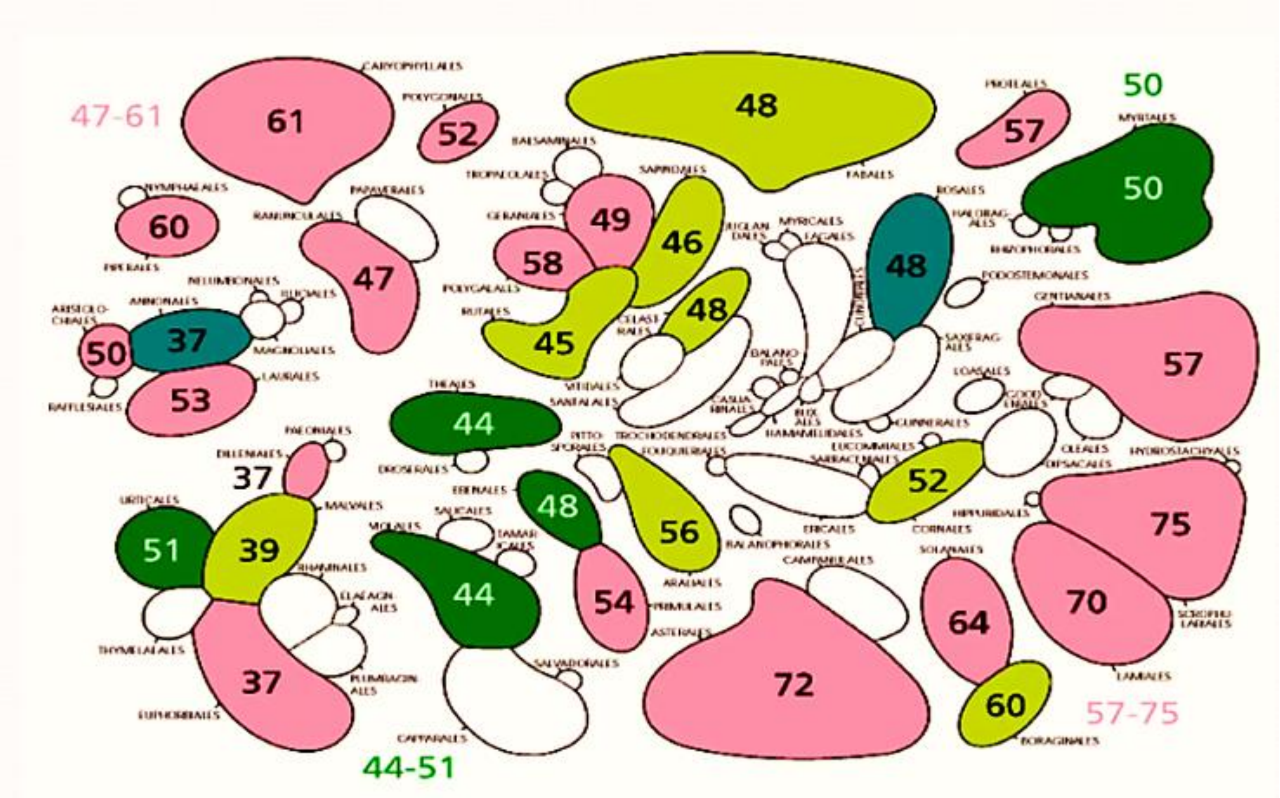
Answer: Bessey's Cactus

Image-Based Questions



Question: What does this diagram represent?

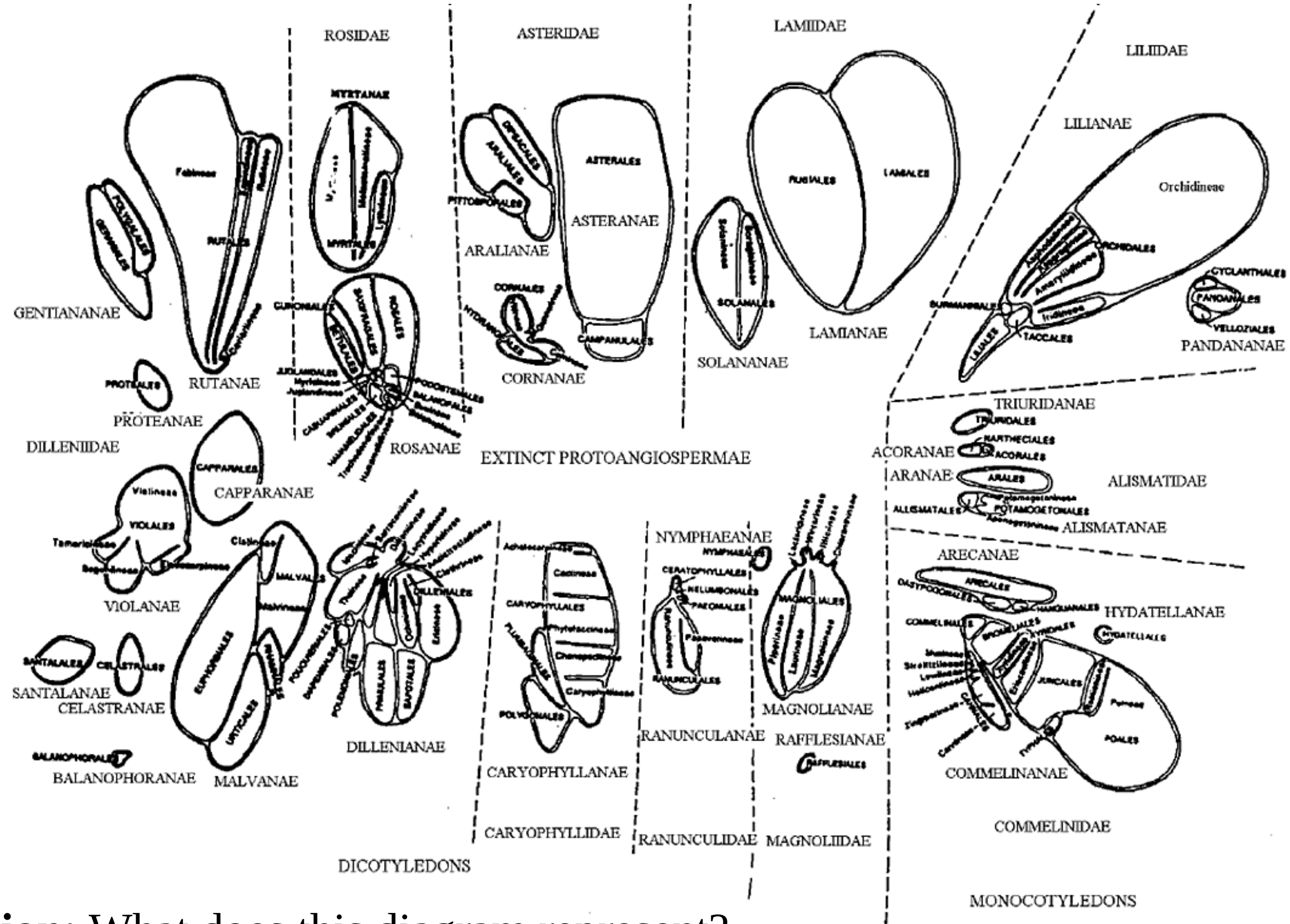
Answer: Bubble diagram of Takhtajan



Question: What does this diagram represent?

Answer: angiosperm classification by **Dahlgren**

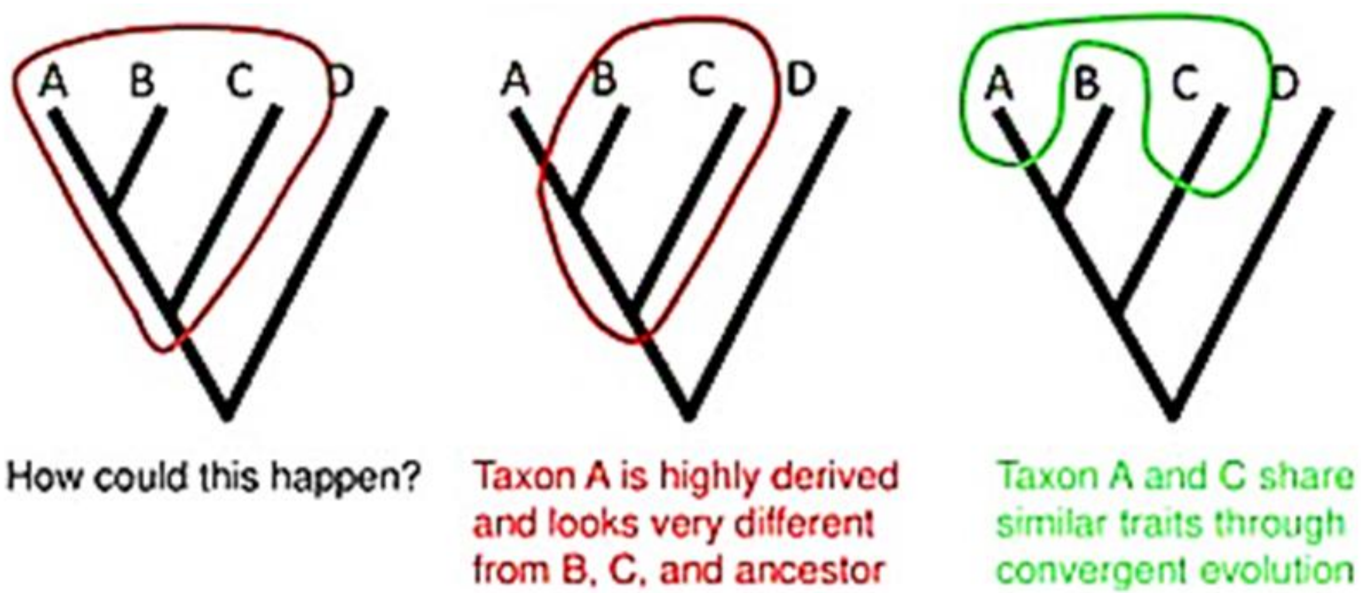
Image-Based Questions



Question: What does this diagram represent?

Answer: Thorne’s Phylogenetic shrub of Angiospermae

Image-Based Questions



Question: What does first clade represent ABC taxa?

Answer: Monophyletic group

Multiple Choice Questions (MCQs)

1.Who is considered the "Father of Botany"? a) Aristotle
b) Linnaeus
c) Theophrastus
d) Darwin
Answer: c) Theophrastus

2.Which book did Theophrastus write that is considered the first scientific botanical study? a) Historia Plantarum
b) De Causis Plantarum
c) Kitab al-Nabat
d) Physica
Answer: a) Historia Plantarum

3.Who was the first to introduce binomial nomenclature for naming plants? a) John Ray
b) Joseph Pitton de Tournefort
c) Carolus Linnaeus
d) Augustin Pyramus de Candolle
Answer: c) Carolus Linnaeus

4.What does the system of binomial nomenclature include? a) Genus and order
b) Kingdom and species
c) Genus and species
d) Class and genus
Answer: c) Genus and species

Multiple Choice Questions (MCQs)

1.In the classification system of Bentham and Hooker, how are dicotyledons subdivided? a) By habitat
b) By seed structure
c) By floral characteristics
d) By reproductive organs
Answer: c) By floral characteristics

2.Which of the following plants would be classified as a monocot? a) Rose
b) Pine tree
c) Wheat
d) Maple tree
Answer: c) Wheat

3.Which scholar wrote the influential work 'Kitab al-Nabat' in Islamic botany? a) Ibn al-Baitar
b) Al-Dinawari
c) Al-Razi
d) Avicenna
Answer: b) Al-Dinawari

4.What characteristic was NOT used by Theophrastus in his plant classification system? a) Morphological features
b) Reproductive structures
c) Evolutionary relationships
d) Growth habits
Answer: c) Evolutionary relationships

5.What significant concept did John Ray introduce in plant classification? a) Natural classification system
b) Concept of species
c) Binomial nomenclature
d) Flower morphology
Answer: b) Concept of species

6.Which of the following systems focused on plant structure and function for classification, and was later used widely in herbaria? a) Linnaean system
b) Bentham & Hooker system
c) Jussieu system
d) Ray system
Answer: b) Bentham & Hooker system

Fill in the Blanks

1. Theophrastus is known as the "______ of Botany."
   Answer: Father

2. Linnaeus introduced the system of _______ nomenclature in the 18th century.
   Answer: binomial

3. The book "Historia Plantarum" was written by _______.
   Answer: Theophrastus

4. The study of plant life in the Islamic Golden Age was heavily influenced by _______ and Greek botanical texts.
   Answer: translations

5. The concept of "species" was first defined by _______.
   Answer: John Ray

6. The Bentham & Hooker system classified plants into three major groups: monocotyledons, dicotyledons, and _______.
   Answer: gymnosperms

7. In the classification of plants, the genus name is always written in _______ letters.
   Answer: capital

8. Theophrastus classified plants based on their _______ and growth habits.
   Answer: morphology

9. _______ was a famous Islamic botanist who wrote "Kitab al-Nabat."
   Answer: Al-Dinawari

10. The Bentham & Hooker system was published in the book _______.
    Answer: Genera Plantarum

Short Answer Questions

1. **Who was Theophrastus, and what were his contributions to plant classification? Answer:** Theophrastus was a Greek philosopher and the "Father of Botany." His major contributions include classifying plants based on morphology and growth habits, and writing "Historia Plantarum," the first scientific botanical study.

2. **What is the importance of binomial nomenclature in modern plant classification? Answer:** Binomial nomenclature standardizes plant naming by using a two-part Latin name (genus + species), providing universal consistency and reducing confusion caused by regional or descriptive names.

3. **How did Islamic scholars contribute to botany during the Islamic Golden Age? Answer:** Islamic scholars preserved and expanded on Greek and Roman botanical knowledge, developed systematic plant classifications, and made advancements in medicinal botany and agricultural techniques.

4. **What is the difference between monocots and dicots in plant classification? Answer:** Monocots have one seed leaf (cotyledon), while dicots have two seed leaves. Monocots include grasses and lilies, while dicots include roses and beans.

5. **What was the significance of John Ray’s work in plant classification? Answer:** John Ray introduced the concept of species, which helped define plants as organisms that reproduce their own kind, laying the groundwork for modern taxonomy.

Short Answer Questions

1. **Explain the difference between the Linnaean and Bentham & Hooker classification systems. Answer:** The Linnaean system primarily uses floral structure and reproductive organs for classification, while Bentham & Hooker focused on a natural classification system based on overall plant characteristics, grouping them into families.

2. **What are the main categories in Theophrastus' plant classification? Answer:** Theophrastus classified plants into trees, shrubs, herbs, and undershrubs based on morphological characteristics and growth habits.

3. **What role did monastic gardens play in medieval botany? Answer:** Monastic gardens were centers of botanical knowledge, where monks cultivated and documented plants, often for medicinal purposes, preserving botanical studies during the medieval period.

4. **How did Joseph Pitton de Tournefort influence modern plant classification? Answer:** Pitton de Tournefort introduced the concept of "genera" and grouped plants based on their floral structures, influencing later classifications by Linnaeus.

5. **What is the importance of the "Historia Plantarum" in the history of botany? Answer:** "Historia Plantarum" is considered the first systematic classification of plants, and its detailed descriptions of plant species influenced later botanical studies.

True and False Questions

1. Theophrastus is known for his contribution to medicinal botany.
   Answer: True

2. Islamic botanists did not contribute significantly to plant classification.
   Answer: False

3. Binomial nomenclature was introduced by Antoine Laurent de Jussieu.
   Answer: False

4. The Bentham & Hooker system classified plants into three main groups: monocots, dicots, and gymnosperms.
   Answer: True

5. John Ray classified plants primarily by their reproductive structures.
   Answer: False

6. Medieval botany was primarily concerned with plant classification rather than medicinal uses.
   Answer: False

7. Theophrastus classified plants based on their size, shape, and utility.
   Answer: True

8. Carolus Linnaeus is known for his work in animal classification, not plant classification.
   Answer: False

9. Augustin Pyramus de Candolle introduced the term "taxonomy."
   Answer: True

10. The concept of species was first defined by Carolus Linnaeus.
    Answer: False

Match the Following

A	B
Theophrastus	Defined species as organisms that reproduce their own kind
John Ray	Father of Botany
Linnaeus	Preserved and expanded Greek botanical knowledge
Islamic Golden Age	Classified plants into three major groups in "Genera Plantarum"
Bentham & Hooker	Developed binomial nomenclature

Answer:

1. **Theophrastus -** a) Father of Botany
2. **John Ray -** b) Defined species as organisms that reproduce their own kind
3. **Linnaeus -** c) Developed binomial nomenclature
4. **Islamic Golden Age -** d) Preserved and expanded Greek botanical knowledge
5. **Bentham & Hooker -** e) Classified plants into three major groups in "Genera Plantarum"

Image-Based Questions

Which corolla structure is visible in the image?

Answer: Gamopetalous corolla

Who was the author of the book?

Answer: Theophrastus

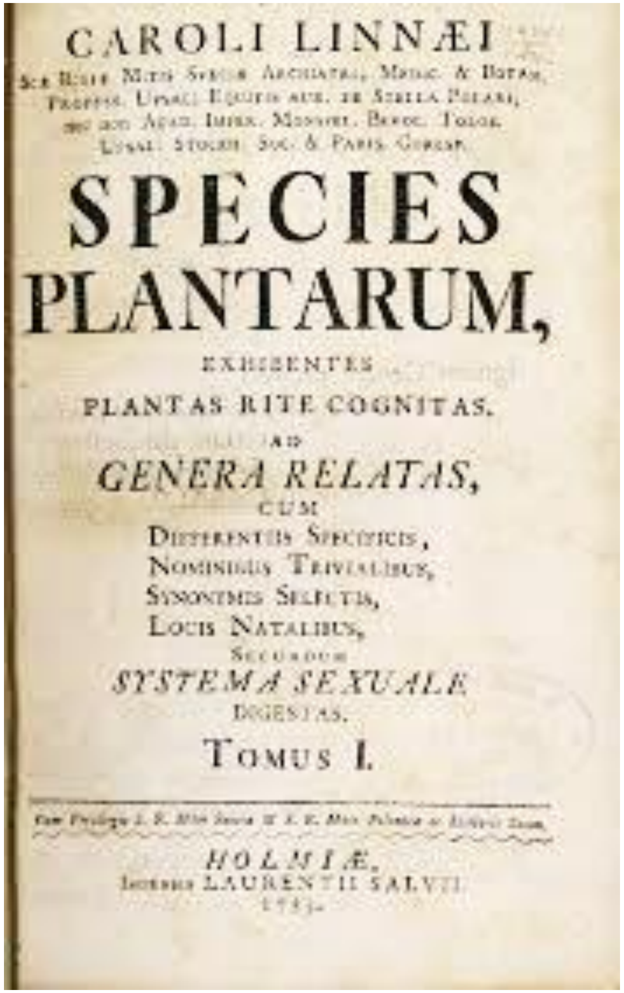
Image-Based Questions

Identify the person in the photo?

Answer: Ibn Sina

Image-Based Questions

Who was the author of the book?



Answer: Carl Linnaeus

QUESTIONS FOR PRACTICE

Multiple-Choice Questions (MCQs)

1.Who is considered the father of binomial nomenclature?
a) Charles Darwin
b) Willi Hennig
c) Carl Linnaeus
d) Ernst Haeckel
Answer: c) Carl Linnaeus

2.What is the primary focus of evolutionary classification?
a) Morphological similarities
b) Evolutionary history and common ancestry
c) Theological beliefs
d) Random categorization
Answer: b) Evolutionary history and common ancestry

3.Which of the following is an example of a primitive (ancestral) trait in plants?
a) Flowers in angiosperms
b) Presence of vascular tissue
c) Seed coat in gymnosperms
d) Specialized leaf structures in carnivorous plants
Answer: b) Presence of vascular tissue

4.Who introduced cladistics (phylogenetic systematics)?
a) Charles Darwin
b) Willi Hennig
c) Robert Sokal
d) George Gaylord Simpson
Answer: b) Willi Hennig

5.What is **homoplasy** in evolutionary taxonomy?
a) Traits inherited from a common ancestor
b) Convergent evolution resulting in similar traits in unrelated species
c) Traits unique to one species only
d) Traits that do not evolve
Answer: b) Convergent evolution resulting in similar traits in unrelated species

5. What is the primary tool used in modern phylogenetic systematics?
a) Binomial nomenclature
b) Phylogenetic trees (cladograms)
c) Nominalism
d) Scala Naturae
Answer: b) Phylogenetic trees (cladograms)

6. Which scientist proposed the **Theory of Inheritance of Acquired Characteristics**?
a) Carl Linnaeus
b) Jean-Baptiste Lamarck
c) Charles Darwin
d) Ernst Haeckel
Answer: b) Jean-Baptiste Lamarck

7. Which type of evolutionary relationship does **parallelism** describe?
a) Similar traits evolving in distantly related species
b) Traits evolving in closely related species due to shared genetic predisposition
c) Traits arising from mutations in a single individual
d) Traits that remain unchanged over time
Answer: b) Traits evolving in closely related species due to shared genetic predisposition

9. What is an example of convergent evolution in plants?
a) C4 photosynthesis in related grasses
b) Succulence in cacti and euphorbias
c) Vascular tissue in ferns and mosses
d) Flowers in angiosperms
Answer: b) Succulence in cacti and euphorbias

10. Which type of classification method uses **mathematical algorithms to group organisms** based on overall similarity?
a) Cladistics
b) Phenetics (Numerical Taxonomy)
c) Essentialism
d) Evolutionary systematics
Answer: b) Phenetics (Numerical Taxonomy)

Fill in the Blanks

1.____________Carl Linnaeus-------- developed the binomial nomenclature system.

2.The study of classifying organisms is known as _________**taxonomy----------**.

3.The ________**Scala Naturae--------** was an early classification system proposed by Aristotle.

4.___________Phylogenetic trees (cladograms)------------- are used to depict evolutionary relationships.

5.____________Homology-------------- refers to traits inherited from a common ancestor.

6.The **Theory of Evolution by Natural Selection** was proposed by ___________**Charles Darwin----------**

7.____________DNA sequencing------------------ is a modern technique used in molecular systematics.

8._______________Convergent evolution----------------- leads to the development of similar traits in unrelated species.

9.The classification system that assigns importance to traits based on evolutionary divergence is called ________**evolutionary systematics------**.

10.____________Fossil records-------- provide evidence of ancient species and their evolutionary changes.

Short Answer Questions

1. **Define evolutionary classification.**
   Answer: Evolutionary classification organizes organisms based on their evolutionary history and common ancestry.

2. **What is the main difference between homology and analogy?**
   Answer: Homology refers to traits inherited from a common ancestor, while analogy refers to similar traits that evolved independently due to similar environmental pressures.

3. **What is a cladogram?**
   Answer: A cladogram is a diagram that shows evolutionary relationships between organisms based on shared derived traits.

4. **Give an example of a derived trait in plants.**
   Answer: Flowers in angiosperms are an example of a derived trait.

5. **What is the main limitation of fossil evidence in evolutionary taxonomy?**
   Answer: Fossil records are often incomplete, making it difficult to determine precise evolutionary relationships.

6. **What is parallel evolution?**
   Answer: Parallel evolution occurs when closely related species develop similar traits independently due to shared genetic predispositions.

7. **Who developed the concept of phylogenetic systematics?**
   Answer: Willi Hennig.

8. **What is the significance of molecular systematics?**
   Answer: It uses genetic data to determine evolutionary relationships with greater accuracy.

9. **What role does bioinformatics play in modern taxonomy?**
   Answer: It helps analyze large-scale genomic data for constructing accurate phylogenetic trees.

10. **What is numerical taxonomy?**
    Answer: A classification system that groups organisms based on overall similarity using mathematical algorithms.

True or False

1. **Cladistics classifies organisms based on overall similarity.** (False)
2. Binomial nomenclature assigns a two-part scientific name to organisms. (True)
3. **Primitive traits indicate the evolutionary starting point of a lineage.** (True)
4. **Linnaeus believed that species could evolve over time.** (False)
5. **Homoplasy can mislead evolutionary classification.** (True)
6. **Horizontal gene transfer occurs only in plants.** (False)
7. **Fossil records are a perfect representation of evolutionary history.** (False)
8. **Parallel evolution occurs in distantly related species.** (False)
9. **Convergent evolution leads to analogous structures.** (True)
10. **DNA sequencing has improved the accuracy of evolutionary classification.** (True)

Match the Following

A	B
1. Binomial nomenclature	a. Carl Linnaeus
2. Evolutionary Systematics	b. George Gaylord Simpson
3. Phylogenetic Systematics	c. Willi Hennig
4. Parallel Evolution	d. C4 photosynthesis in grasses
5. Convergent Evolution	e. Succulence in cacti and euphorbias

Answers:

1 → a

2 → b

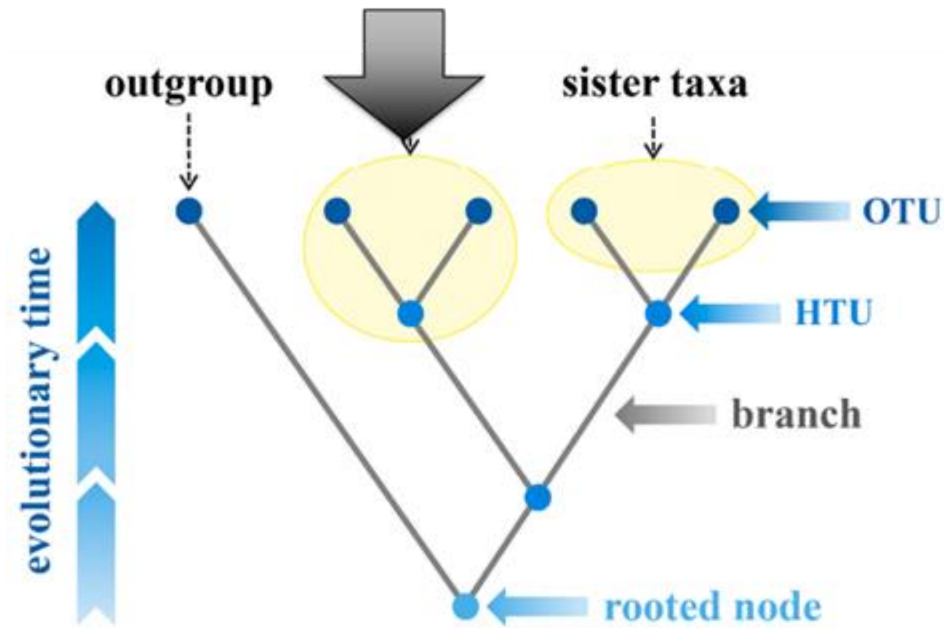
3 → c

4 → d

5 → e

Image-Based Questions

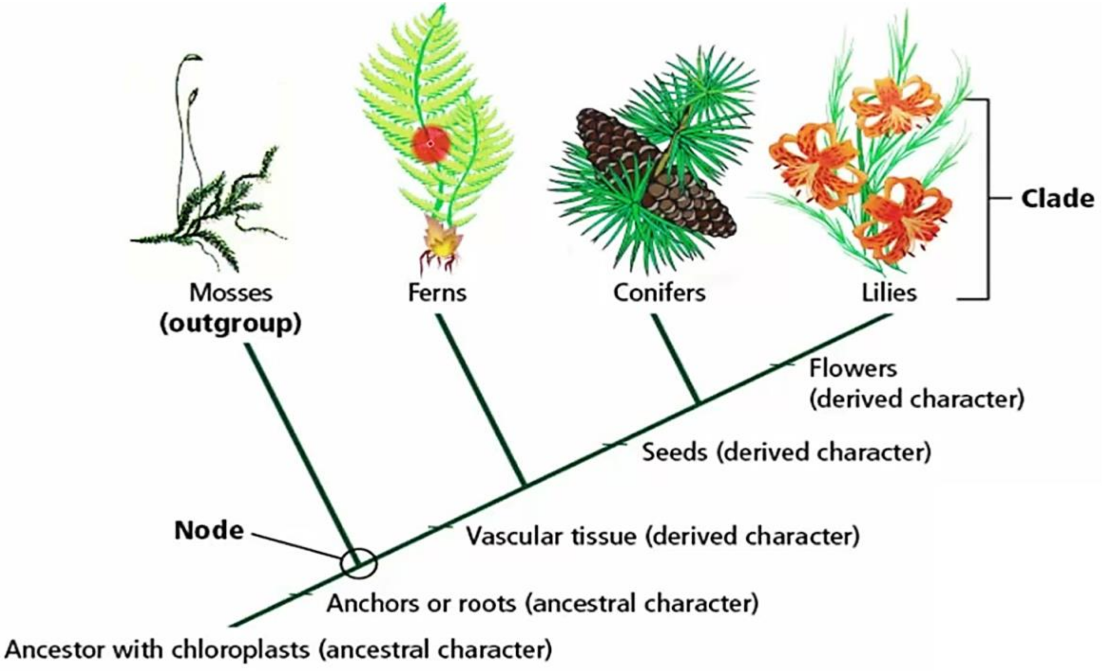
Identify the arrow mark in evolutionary relationship shown in the given cladogram



Answer: Clade

Image-Based Questions

Identify the ancestral and derived traits in the provided images of ferns and angiosperms.



Answer: Vascular tissue is ancestral; flowers in angiosperms are derived.

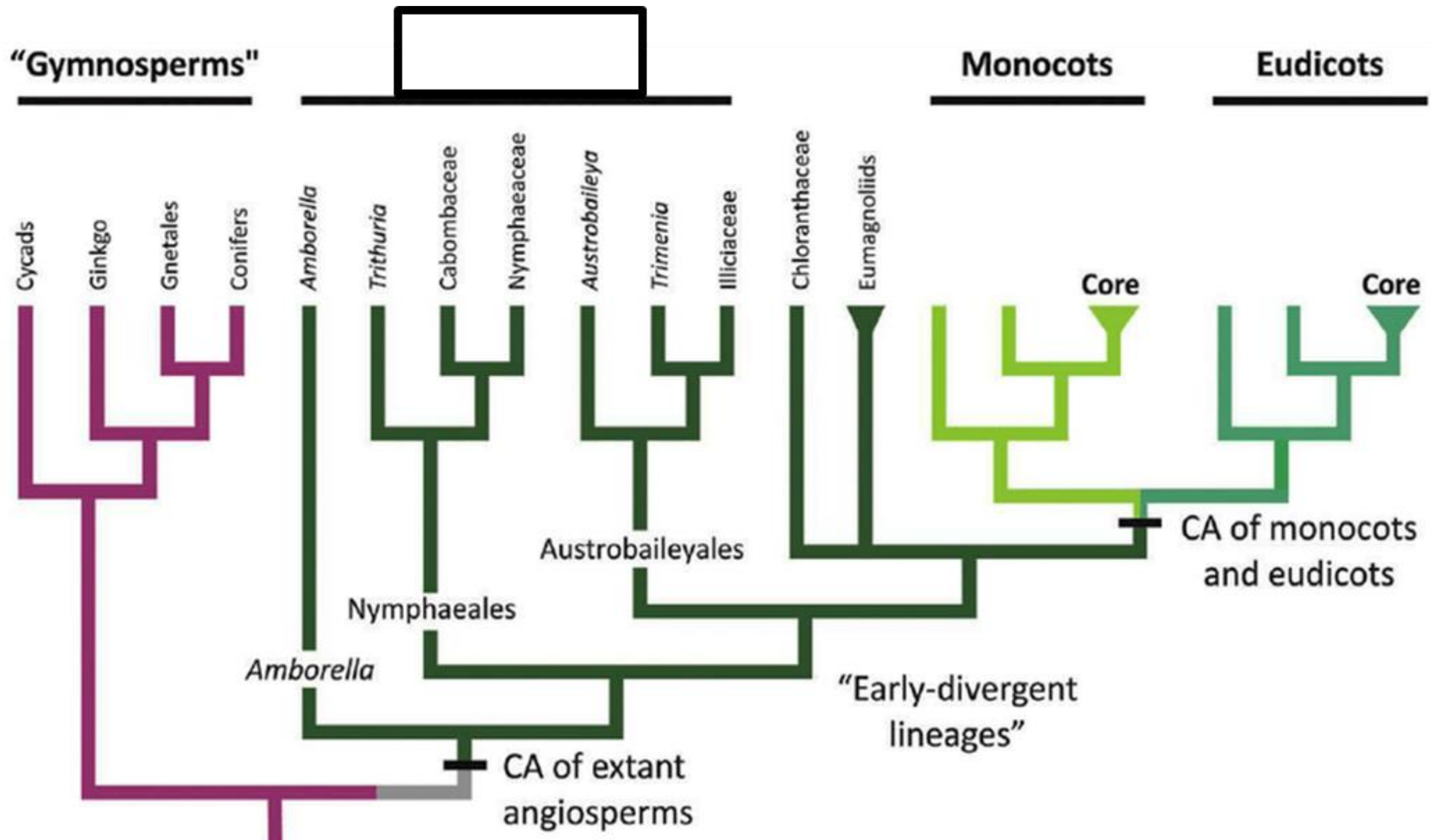
Image-Based Questions

Identify the image?

Answer: Carnivory (Nepenthes)

Image-Based Questions

Identify the rectangle box in the clade in the given below



Answer: ANA Grade

WEEK-5

FIRST MID TERM EXAM (From Slide Week 1 to 4)

BOT 222 First Term MODEL Question

Total 10 marks

Each question one marks

4 MCQ

2 fill in the blanks,

2 true false,

1 figure based question,

i short answer question.

BOT 222 PRINCIPLES OF PLANT TAXONOMY

THEORY EXAMS (First Term 10 Marks, Second Term 10 Marks, Final 40 Marks= Total 60 MARKS)

FIRST TERM

Full marks: 10, Time 30 minutes

- Multiple choice question (each question possess one marks) (1 X 4 =4 marks)
- Fill in the blanks (each question possess one marks) (1 X 2 =2 marks)
- Mark the True / False (each question possess one marks) (1 X 2 =2 marks)
- Figure based question (each question possess one marks) (1 X 1 =1 marks)
- Short answer question (each question possess one marks) (1 X 1 =1 marks)

SECOND TERM

Full marks: 10, Time 30 minutes

- Multiple choice question (each question possess one marks) (1 X 4 =4 marks)
- Fill in the blanks (each question possess one marks) (1 X 2 =2 marks)
- Mark the True / False (each question possess one marks) (1 X 2 =2 marks)
- Figure based question (each question possess one marks) (1 X 1 =1 marks)
- Short answer question (each question possess one marks) (1 X 1 =1 marks)

FINAL EXAM

Full marks: 40, Time 2 hours

- Multiple choice question (each question possess one marks) (1 X 10 =10 marks)
- Fill in the blanks (each question possess one marks) (1 X 7 =7 marks)
- Mark the True / False (each question possess one marks) (1 X 8 =8 marks)
- Figure based question (each question possess one marks) (1 X 7 =7 marks)
- Match the following (each question possess one marks) (1 X 6 =6 marks)
- Short answer question (each question possess one marks) (1 X 2 =2 marks)

BOT 222 First Term model Question

Multiple choice question (each question possess one marks)

1. **Which of the following is NOT a vegetative part of a plant?**
   a) Root
   b) Stem
   c) Flower
   d) Leaves
   Answer: c) Flower

2. **Which part of the plant is responsible for reproduction?**
   a) Leaves
   b) Stem
   c) Roots
   d) Flower
   Answer: d) Flower

3. **Which of the following is a vegetative part of the plant?**
   a) Seed
   b) Fruit
   c) Leaf
   d) Flower
   Answer: c) Leaf

4. **Flowers with both male and female reproductive parts are termed as:**
   a) Unisexual
   b) Bisexual
   c) Incomplete
   d) Sessile
   Answer: b) Bisexual

BOT 222 First Term model Question

5. What is an example of convergent evolution in plants?
a) C4 photosynthesis in related grasses
b) Succulence in cacti and euphorbias
c) Vascular tissue in ferns and mosses
d) Flowers in angiosperms
Answer: b) Succulence in cacti and euphorbias

6. Which type of classification method uses mathematical algorithms to group organisms based on overall similarity?
a) Cladistics
b) Phenetics (Numerical Taxonomy)
c) Essentialism
d) Evolutionary systematics
Answer: b) Phenetics (Numerical Taxonomy)

7. What is homoplasy in evolutionary taxonomy?
a) Traits inherited from a common ancestor
b) Convergent evolution resulting in similar traits in unrelated species
c) Traits unique to one species only
d) Traits that do not evolve
Answer: b) Convergent evolution resulting in similar traits in unrelated species

8. What is the primary focus of evolutionary classification?
a) Morphological similarities
b) Evolutionary history and common ancestry
c) Theological beliefs
d) Random categorization
Answer: b) Evolutionary history and common ancestry

BOT 222 First Term model Question

Fill in the blanks (each question possess one marks)

The ______ of the flower contains the male structures that produce pollen.
Answer: Androecium

The female part of the flower is the ______, which contains the ovary, style, and stigma.
Answer: Gynoecium

The **Theory of Evolution by Natural Selection** was proposed by_______
Answer: Charles Darwin.

___________ is a modern technique used in molecular systematics.
Answer: DNA sequencing

BOT 222 First Term model Question

Mark the True / False (each question possess one marks)

1. Seeds are formed in the stamens of the flower.
   Answer: False

2. Leaves are vegetative parts responsible for photosynthesis.
   Answer: True

3. Fossil records are a perfect representation of evolutionary history.
   Answer: False

4. Parallel evolution occurs in distantly related species.
   Answer: False

BOT 222 First Term model Question

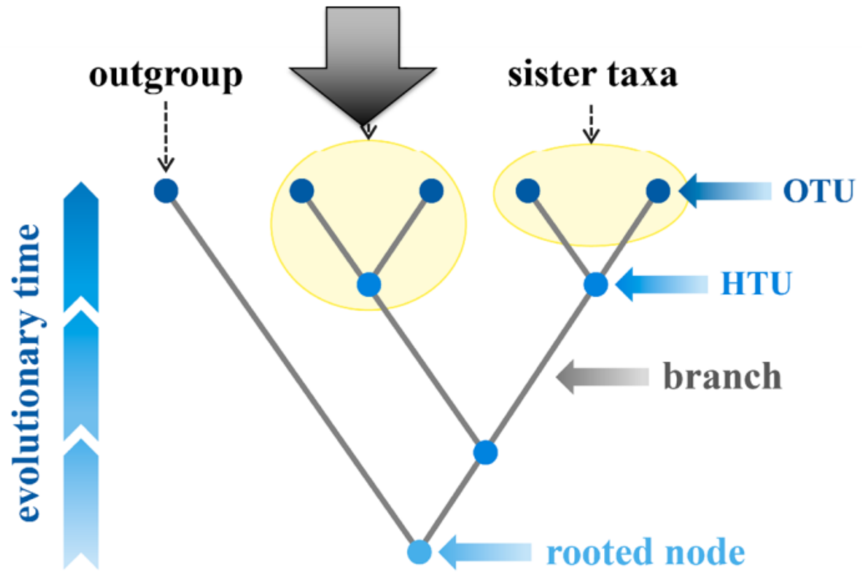
Figure based question (each question possess one marks)

Question: What type of aestivation is shown in this image?

Answer: Valvate.

BOT 222 First Term model Question

Figure based question (each question possess one marks)



Question: Identify the arrow mark in evolutionary relationship shown in the given cladogram

Answer: Clade

BOT 222 First Term model Question

Short answer question (each question possess one marks)

1. What part of the plant develops into fruit?
Answer: The ovary of the flower.

2. What is the significance of molecular systematics?
Answer: It uses genetic data to determine evolutionary relationships with greater accuracy.