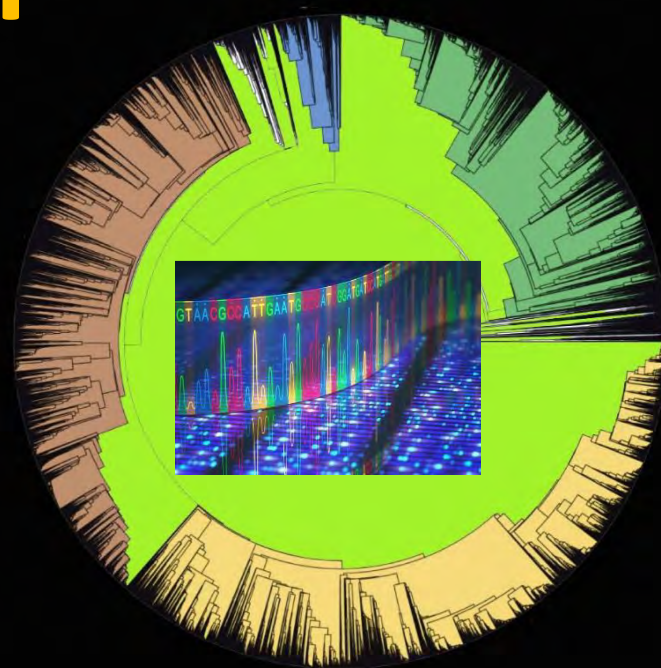
EXPERIMENTAL TAXONOMY

(BOT 322)



Professor (Dr.) Mohammad Ajmal Ali
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Riyadh-11451, Saudi Arabia

WEEK 1

هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

2023
TP-153

Course Specification
(Bachelor)

Course Title:	EXPERIMENTAL TAXONOMY
Course Code:	BOT322
Program:	BOTANY
Department:	BOTANY AND MICROBIOLOGY
College:	SCIENCE
Institution:	KING SAUD UNIVERSITY
Version:	4TH
Last Revision Date:	2024

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A. General information about the course:

1. Course Identification

1. Credit hours:

2 (1+1)

2. Course type

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

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

4. Course General Description:

The use of comparative experimental methods in taxonomy units. Eco-geographical distribution and its taxonomic importance. Natural hybridization. Anatomical, cytological, and chemical differences and their taxonomic value. Fertility and its significance

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

None

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

None

7. Course Main Objective(s):

1. **Using empirical taxonomic evidence to identify plant species**
2. **Using statistical programs to find out the percentage of similarities and differences between plant species**
3. **The influence of environmental factors on the emergence of plant diversity**

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	1/ week	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	Lectures	16
2.	Laboratory/Studio	24
3.	Field	
4.	Tutorial	
5.	Others (specify)	
Total		40

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

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	The student will be able to list the different taxonomic evidences used to identify plants	K1	Lecture- Practical lessons	Mid-Term exams- Lab exams- Discussions during the lectures
1.2	The student will be able to define different taxonomic categories	K2	Lecture- Practical lessons	Mid-Term exams- Final Exam -Lab exams- Discussions during the lectures
1.3	The student will be able to explain the role of taxonomic evidences in changing the taxonomic position of some plant species	K3	Lecture- Practical lessons- Presentations by students	Mid-Term exams- Final Exam - Lab exams- Discussions during the lectures
2.0	Skills			
2.1	The student will be able to use a light microscope to examine the fine structures of plant samples (stomata - trichomes - chromosomes ..... etc.)	S1	Practical lessons- Presentations by students- Internet contacts	Lab quizzes

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
2.2	The student will be able to use the botanical keys to identify the unknown plant	S2	Lecture- Practical lessons- Presentations by students- Internet contacts	Mid-Term exams- Final Exam - Lab exams
2.3	The student will be able to use the Excel program to record the plant traits in preparation for their numerical analysis	S3	Lecture- Practical lessons- Presentations by students- Internet contacts	Discussions during the lectures
2.4	The student will be able to use the various scientific research vessels to conduct searches for scientific papers	S3	Lecture- Practical lessons- Presentations by students- Internet contacts	Discussions during the lectures
3.0	**Values, autonomy, and responsibility**			
3.1	The student will be able to join a team	V2	Practical lessons- Internet contacts- Presentations by students	Discussions during the lectures-
3.2	The student will be able to lead a team	V2	Practical lessons- Internet contacts- Presentations by students	Presentations by students- Discussions after the report of the Practical field
...	The student will be able to do the homework by himself or share with his colleagues without problems	V1	Practical lessons- Internet contacts- Presentations by students	Discussions during the lectures-

C. Course Content

No	List of Topics	Contact Hours
1.	**Introduction**	**1**
2.	**experimental methods in taxonomy**	**1**
3.	**The use of comparative experimental methods in taxonomy**	**2**
4.	**Taxonomic evidences**	**1**
5.	**Plant structure as evidence taxonomy**	**1**
6.	**Plant anatomy as evidence taxonomy**	**2**
7.	**Phytochemistry**	**2**
8.	**Eco-geographical distribution and its taxonomic importance**	**2**

9.	Natural hybridization	2
10.	Cytological and chemical differences and their taxonomic value.	1
11.	Fertility and its significance.	1
	Total	16

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	First Mid-term Exam	7th	10/100
2.	Second Mid-term Exam	13th	10/100
3.	Seminar and project discussion	14th	10/100
4.	Practical lab Exam	16th	30/100
5.	Final Exam	18th	40/100

*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	- Farhan, A. Fahad, Al-Hemaid & Hassan, H.M. 1999 Arabic translation of C.A. Stace "Plant Taxonomy & Biosystematics" King Saud University, Riyadh. - Sharma, O.P. 1993. Plant Taxonomy, Tata Mc. Grank Hill Company Limited, New Delhi, India
Supportive References	
Electronic Materials	http://www.botnik.univie.ac.at/iapt/index_layer.php http://www.bgbm.org/iapt/nomeclature/code/saintlous/0000St.Luistitle.htm
Other Learning Materials	

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classrooms, laboratories
Technology equipment (projector, smart board, software)	data show, Smart Board
Other equipment (depending on the nature of the specialty)	

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	**Students & Peer Reviewers**	**Indirect**
Effectiveness of Students assessment	**Instructors**	Direct/ **Indirect**
Quality of learning resources	**Students& Instructors**	**Indirect**
The extent to which CLOs have been achieved	**Instructors**	Direct
Other		

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

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	**DEVELOPMENT AND QUALITY COMMITTEE**
REFERENCE NO.	
DATE	**SEPTEMBER 16, 2024**

هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA

Key Learning Outcomes for General Botany Programs

2024

S.No.	Topic	Domain	Course Learning Outcome	Teaching Strategies	KLO Alignment (Full Statement)	GKU & SKU Alignment (Full Statement)	EKU-6 (General Biology SLO)	EKU-7 (Research Skills SLO)	EKU-8 (Interpersonal Skills SLO)	Specialized SKU Alignment
1	Introduction	Knowledge	CLO 1.1, 1.2	Lecture, discussion	KLO1: Identify, describe, and define basic terminology, concepts, methodologies, and theories used within plant sciences.	GKU Plant Biology – SKU 1.1: Plant Science and Systems	SLO 2: State different taxa in the tree of life and their features.	SLO 1: Find and combine data from literature.	SLO 1: State fundamentals of communication.	SKU1.1 SLO1: Clarify and interpret factual claims in plant science.
2	Experimental methods in taxonomy	Skills	CLO 2.1, 2.4	Lab practical, demo	KLO6: Plan and perform plant-focused experiments.	GKU Plant Biology – SKU 1.3: Plant Form and Function	SLO 3: Perform experimental techniques to analyze evolution.	SLO 2: Create a thorough experiment design.	SLO 2: Identify types of verbal communication.	SKU1.3 SLO3: Conduct experiments and describe limitations.
3	Comparative experimental methods in taxonomy	Skills	CLO 2.1, 2.3	Comparative lab work	KLO7: Use digital technology and computer skills to analyze botanical data.	GKU Genetics & Molecular Biology – SKU 2.3: Plant Genetics	SLO 3: Experimental and computational evolutionary analysis.	SLO 3: Gather and analyze qualitative & quantitative data.	SLO 3: Discuss non-verbal communication.	SKU2.3 SLO4: Apply protocols in genetic analysis.
4	Taxonomic evidences	Knowledge	CLO 1.1, 1.3	Lecture, case studies	KLO3: Demonstrate cumulative knowledge in botany at phenotypic, structural, evolutionary levels.	GKU Plant Evolution – SKU5.1: Introductory Plant Diversity & Evolution	SLO 1: Identify evolutionary diversification.	SLO 4: Interpret data patterns conceptually.	SLO 4: Recall factors influencing communication.	SKU5.1 SLO4: Explain Darwinian evolution principles.
5	Plant structure as taxonomic evidence	Knowledge	CLO 1.1	Microscopy, slides	KLO4: Apply practical and field skills in botany.	GKU Plant Biology – SKU 1.5: Basic Plant Anatomy	SLO 2: Analytical methods for taxa relationships.	SLO 3: Data gathering and evaluation.	SLO 1: Communication fundamentals.	SKU1.5 SLO3: Identify forms, function, evolutionary diversity.
6	Plant anatomy as taxonomic evidence	Knowledge/Skills	CLO 1.1, 2.1	Lab practical	KLO2: Recognize methods and techniques in microscopy.	GKU Plant Cell Biology – SKU 1.4	SLO 3: Experimental evolutionary techniques.	SLO 2: Experimental design.	SLO 2: Verbal communication.	SKU1.4 SLO6: Identify cells using microscopy.
7	Phytochemistry	Knowledge	CLO 1.1, 1.3	Lecture, case study	KLO3: In-depth cumulative botanical knowledge.	GKU Plant Physiology – SKU4.1	SLO 1: Evolutionary diversification basis.	SLO 4: Conceptual interpretation.	SLO 4: Factors influencing communication.	SKU4.1 SLO2: Energy influence on biological processes.
8	Eco-geographical distribution	Knowledge	CLO 1.1, 1.3	GIS demo, discussion	KLO8: Evaluate botany's role in environmental problems.	GKU Plant Ecology – SKU3.3	SLO 4: Societal evolutionary concerns.	SLO 1: Literature synthesis.	SLO 3: Non-verbal communication.	SKU3.3 SLO1: Describe ecological system hierarchy.
9	Natural hybridization	Skills	CLO 2.2	Field study	KLO5: Propose scientific hypotheses.	GKU Genetics – SKU2.5: Population Genetics	SLO 3: Micro- and macro-evolution analysis.	SLO 2: Research design.	SLO 1: Communication fundamentals.	SKU2.5 SLO1: Explain genetic mechanisms affecting populations.
10	Cytological & chemical differences	Knowledge/Skills	CLO 1.3, 2.1	Cytology lab	KLO6: Plan and perform experiments.	GKU Plant Cell Biology – SKU 1.4	SLO 3: Experimental techniques.	SLO 3: Data analysis & statistics.	SLO 2: Verbal communication.	SKU1.4 SLO7: Utilize laboratory techniques.
11	Fertility and its significance	Knowledge/Values	CLO 1.3, 3.3	Seminar, teamwork	KLO10: Demonstrate integrity and teamwork.	GKU Plant Evolution – SKU5.1	SLO 1: Evolutionary diversification.	SLO 5: Scientific argument presentation.	SLO 4: Factors influencing communication.	SKU5.1 SLO3: Relate plant life cycles.

BOT 322: Experimental Taxonomy
Description
First Term 10 Marks
Second Term 10 Marks
Final 40 Marks
Total = 60 MARKS

Details

Full marks: 10

Time: 30 minutes

FIRST MID TERM

Question Type	Description	Marks Distribution
Multiple choice question	each question possess one marks	$(1 \times 4 = 4$ marks)
Fill in the blanks	each question possess one marks	$(1 \times 2 = 2$ marks)
Mark the True / False	each question possess one marks	$(1 \times 2 = 2$ marks)
Figure based question	each question possess one marks	$(1 \times 1 = 1$ marks)
Short answer question	each question possess one marks	$(1 \times 1 = 1$ marks)

Subject to change

Details

Full marks: 10

Time: 30 minutes

SECOND MID TERM

Question Type	Description	Marks Distribution
Multiple choice question	each question possess one marks	$(1 \times 4 = 4$ marks)
Fill in the blanks	each question possess one marks	$(1 \times 2 = 2$ marks)
Mark the True / False	each question possess one marks	$(1 \times 2 = 2$ marks)
Figure based question	each question possess one marks	$(1 \times 1 = 1$ marks)
Short answer question	each question possess one marks	$(1 \times 1 = 1$ marks)

Subject to change

Details

Full marks: 40

Time: 2 hours

FINAL EXAM

Question Type	Description	Marks Distribution
Multiple choice question	each question possess one marks	(1 × 10 = 10 marks)
Fill in the blanks	each question possess one marks	(1 × 7 = 7 marks)
Mark the True / False	each question possess one marks	(1 × 8 = 8 marks)
Figure based question	each question possess one marks	(1 × 7 = 7 marks)
Match the following	each question possess one marks	(1 × 6 = 6 marks)
Short answer question	each question possess one marks	(1 × 2 = 2 marks)

Subject to change

Details

Full marks: 40

Time:

PRACTICAL

Objective : The general course objective of the course advance experimental taxonomy is to introduce the students about the explanation of advances in tools and techniques, and relevance of molecular plant taxonomy in order to understand the principles of Plant taxonomy.

Essential References Materials

- American Journal of Botany (http://www.amjbot.org)
- Botanical Journal of the Linnaean Society (http://www.blackwellpublishing.com/jnl_default.asp)
- Molecular Biology & Evolution (http://mbe.oupjournals.org)
- Molecular Phylogenetics & Evolution (http://www.elsevier.com)
- Systematic Botany (http://www.sysbot.org/)
- Taxon (http://www.botanik.univie.ac.at/iapt/s_taxon.php)
- Website: http://www.plantsystematics.org/index.html

- Software: Molecular phylogenetic analysis software (BioEdit, ClustalX, MEGA4)

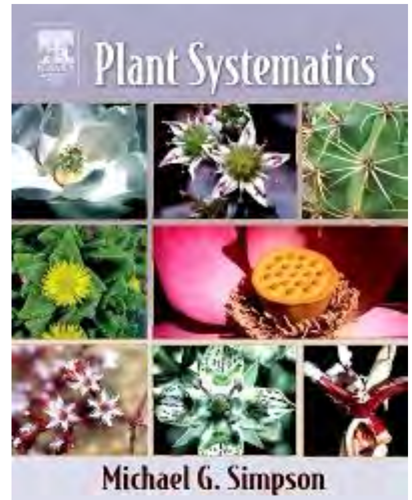
Course learning outcome

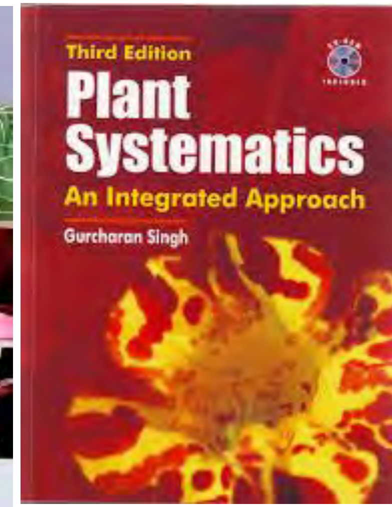
Knowledge:

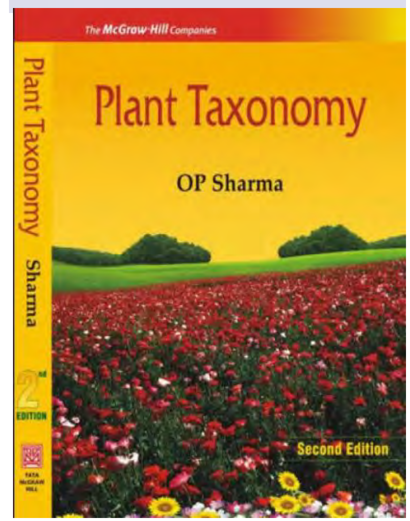
- **The student will be able to relate the origin of the taxonomic questions.**
- **The student will be able to relate the tools and techniques used to gather taxonomic evidences to resolve the taxonomic questions.**

Cognitive:

- **The student will be able to relate the relevance of plant molecular taxonomy in order to understand the principles of Plant taxonomy.**







- Michael G. Simpson (2010) Plant Systematics. Elsevier Science Publishing Co Inc, San Diego, United States (ISBN10 012374380X).

- Gurcharan Singh (2010) Plant Systematics: An Integrated Approach, Third Edition, CRC Press (ISBN 9781578086689).

- O.P. Sharma (2009)
- Plant Taxonomy, second edition, Tata McGraw-Hill Education Pvt. Ltd.,
- ISBN 10: 0070141592

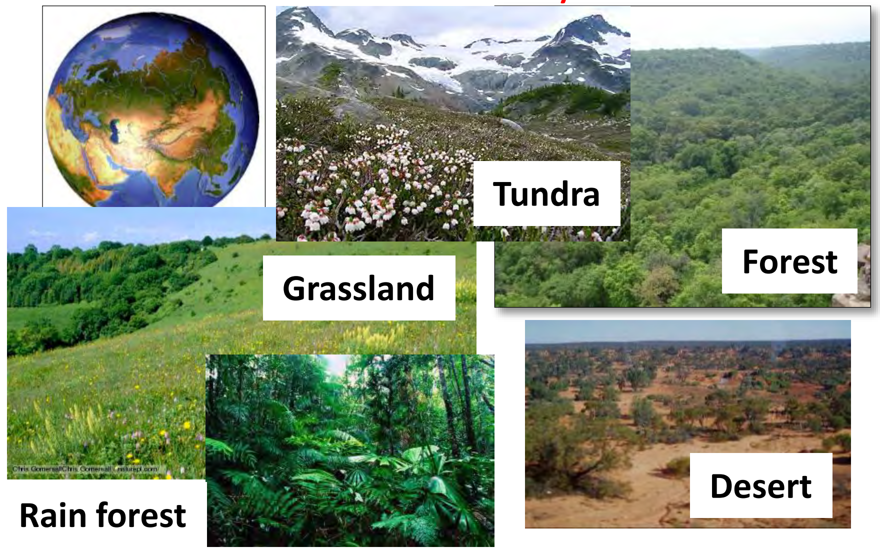
- Why experimental taxonomy needed ?

Introduction about Plant Taxonomy / Systematics

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**

Plant Biodiversity



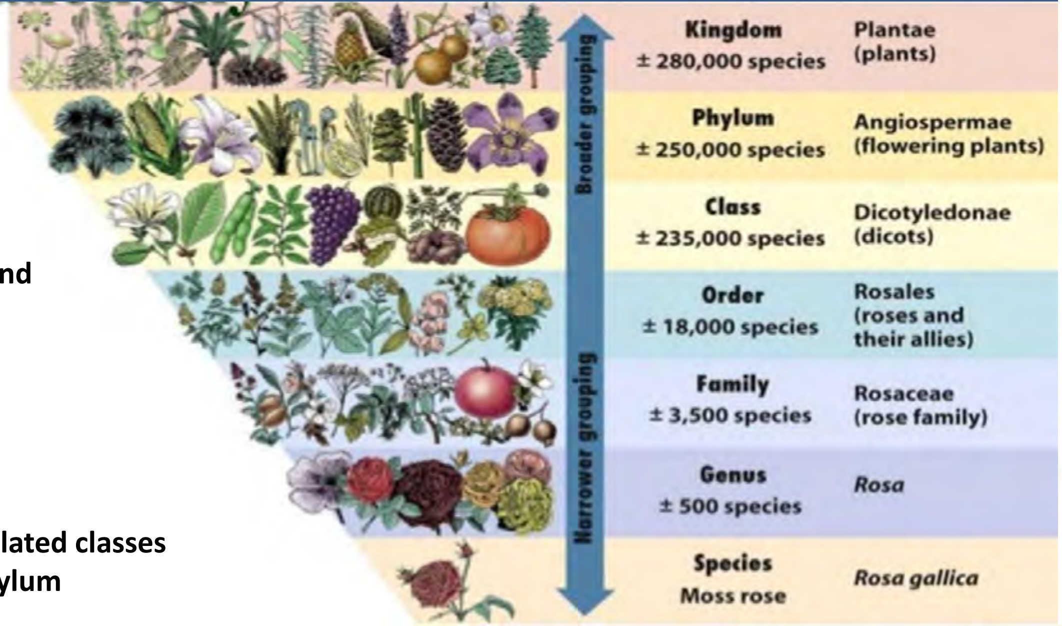
We study plants because:

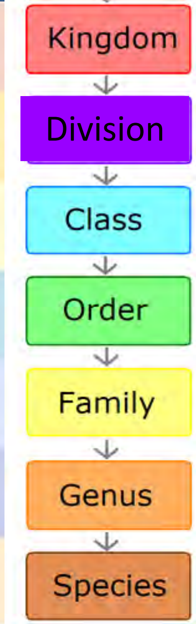
- ❑ Plants produce oxygen. We breathe oxygen. We cannot live without oxygen.
- ❑ Plants convert Carbon dioxide gas into sugars through the process of photosynthesis.
- ❑ Every things we eat comes directly or indirectly from plants.
- ❑ Plants provide fibres for paper or fabric.
- ❑ Many chemicals produced by the plants used as medicine.
- ❑ Study of plants science helps to conserve endangered plants.
- ❑ Plants can be a source of biofuels. Sugars, starches and cellulose can be fermented into ethanol. Ethanol is used as fuel.
- ❑ Study of plants science helps to learn more about the natural world

- Plant Biodiversity: diversity among and within plant and animal species in an environment
- We have millions of different kind of plants, animals and microorganism. There are about 15000 species of Mossess, 13000 species of fern plants, 900 species of Gymnosperms, 250000 species of angiosperms, 10000 species of algae, 5.1 million of fungi species. We need to scientifically identify, name and classify all the living organism.
- Taxonomy / Systematics is the branch of science deals with classification of organism.

TAXONOMIC HIERARCHY

- Carrolus Linnaeus first adopted the hierarchic system of taxonomy classification in 1753.
- The succession groups are as follow:
- **Species**: Organisms sharing a set of biological traits and reproducing only their exact kind.
- The lowest major group, representing plants and animals referred to as Species.
- Species is the fundamental unit in taxonomy
- **Genus**: Genus are the closely related species
- **Family** : Family is the closely related genera
- **Order** : Order is the closely related families
- **Class** : Class are the closely related order
- **Division / Phylum**: Division or Phylum is the related classes
- **Kingdom**: Kingdom is the related Division / Phylum





Objective / Goals / Aims of Plant Taxonomy

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

Scope of Taxonomy

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

Basic components (Principles) of Plant Taxonomy / Plant Systematics

- Plant collection, Preservation and Documentation
- Plant Structure (Taxonomic Terminology, Taxonomic description of external and internal morphology)
- Taxonomic Identification
- 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.
- Taxonomic Classification (History and Systems of Plant Classification)
- Taxonomic evidences / Source of data (Morphology, Anatomy, Embryology, palynology, Micromorphology, Chemistry, DNA etc.) in plant taxonomy

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

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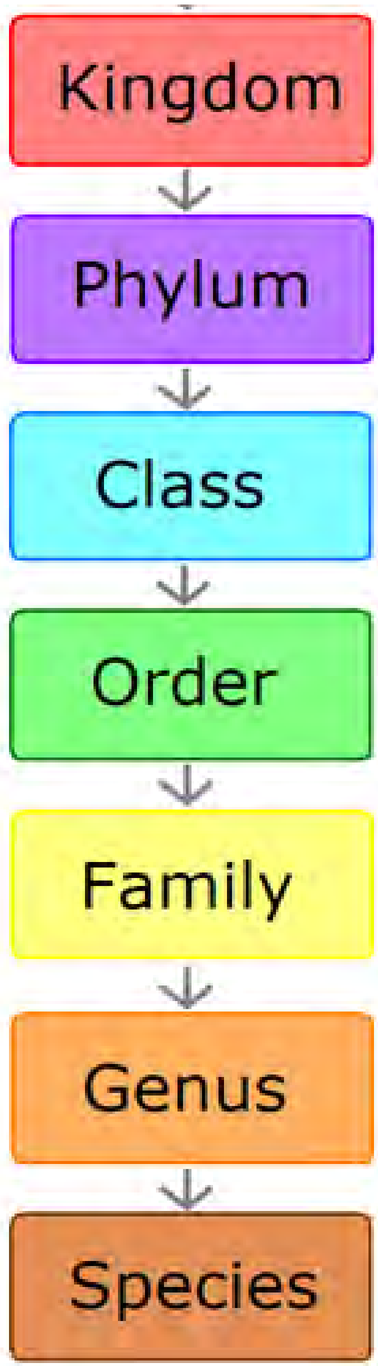
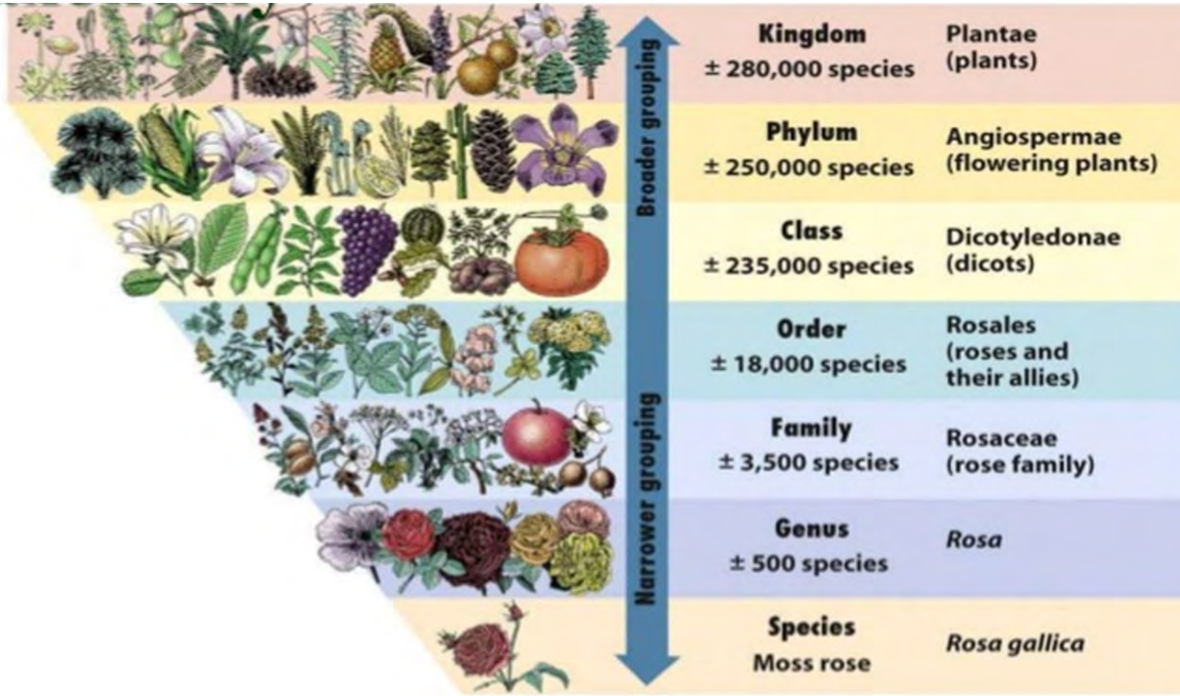
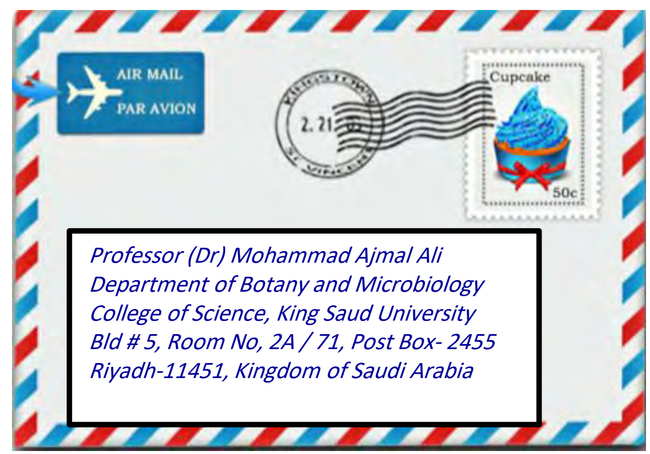
- **Kingdom**: Kingdom is the related Division / Phylum





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



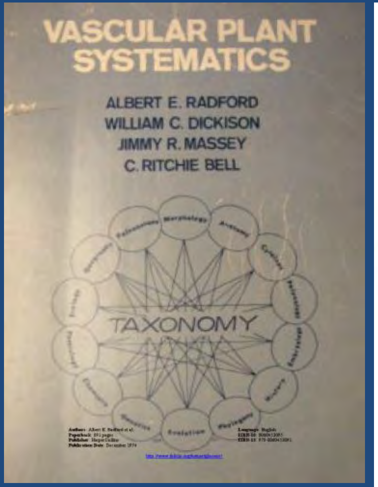
Types of Taxonomy / Taxonomic Studies / Plant Taxonomic Classification

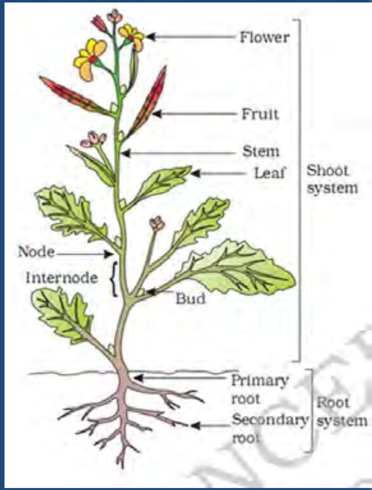
Alpha (α) Taxonomy / classical taxonomy:- It involves description and naming of organisms. It is the parent of other types of taxonomy.

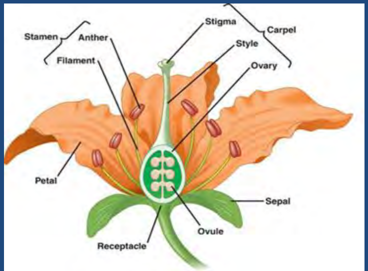
Omega (Ω) Taxonomy: - It is the modern experimental taxonomy in which the taxonomic activities have been enriched with data from ecology, phyto-chemistry, phyto-geography, cyto-genetics and physiology coupled with adequate computation.

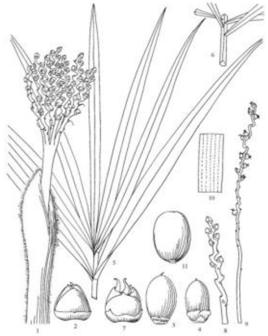
Herbarium: Plant collecting, Preservation and Documentation

- **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.**
- **Flora = it is the documentation of plants occurring in a particular region.**
- The FLORA is the main Resources of Taxonomic Information
- **A HERBARIUM is a collection of dried plants systematically named and arranged for ready reference and study.**

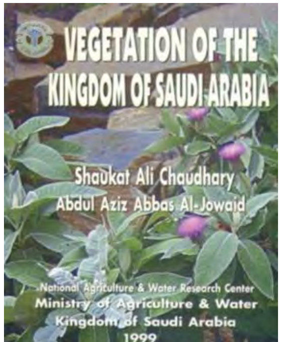








Phoenix dactylifera Linnaeus, Sp. Pl. 2: 1188. 1753.
Stems solitary or clustered and then with few shoots, to 30 m tall, to 50 cm in diam., rough with persistent, diamond-shaped leaf bases. Leaves 3-5 m; sheath and petiole to 1 m; rachis 1-2 m; acanthophylls many per side of rachis; pinnae to 200 per 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.



WEEK 2

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

- **Plant collection, Preservation and Documentation**

- **Plant Structure (Taxonomic Terminology, Taxonomic description of external and internal morphology)**
- **Taxonomic Identification**

- **Scientific Nomenclature / Botanical Nomenclature : 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.**

- **Taxonomic Classification (History and Systems of Plant Classification)**

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

Basic Components of Plant Taxonomy

Introduction to Plant Taxonomy

What is Plant Taxonomy?

- Science of naming, identifying, classifying, and describing plants.
- Organizes plant diversity into a structured system.
- Provides a universal naming system.
- Ensures proper communication in botany and agriculture.

Importance of Plant Taxonomy

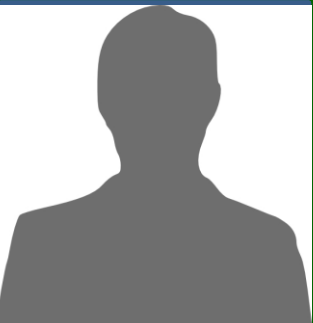
Biodiversity Conservation – Helps protect and categorize plant species.
Agriculture & Horticulture – Essential for crop breeding and pest control.
Medicinal Plant Research – Identifies plants with therapeutic value.
Ecology & Environmental Studies – Helps in habitat protection and restoration.
Standardized Naming – Avoids confusion in plant identification worldwide.

Relationship Between Taxonomy & Systematics
Plant Taxonomy
Focuses on naming, describing, and classifying plants.
Example: *Mangifera indica* (Mango) is classified under Genus *Mangifera*.
Plant Systematics
Studies evolutionary relationships among plants.
Uses molecular and genetic data for classification.

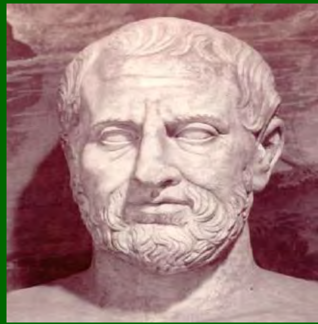
Species concept

Nomenclature

SYSTEM OF PLANT CLASSIFICATION



Preliterate Mankind / Folk taxonomies:



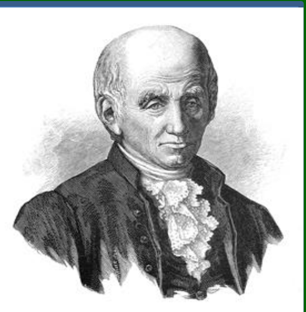
Theophrastus (372 BC to 287 BC):

Andrea Cesalpino (1519-1603)

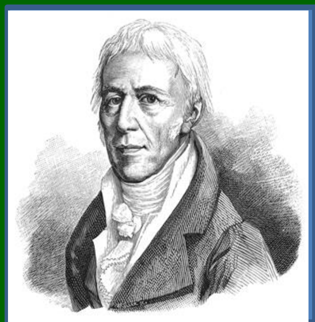
John Ray (1627-1705)

J. P. de Tournefort (1656-1708)

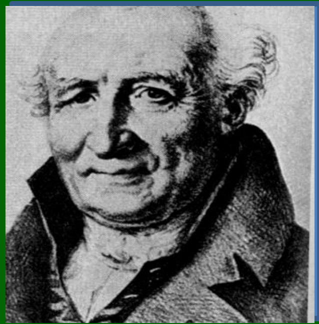
Carolus Linneaus (1753)



Michel Adanson (1727-1806)

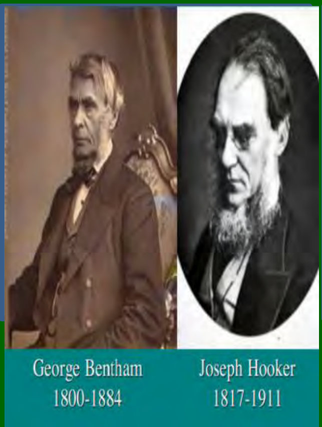


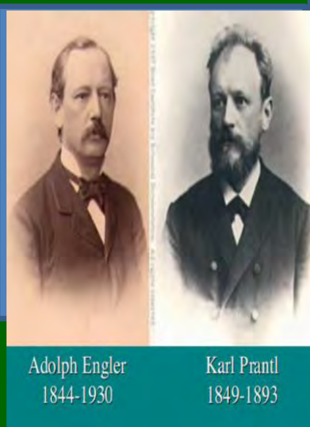
Jean B.P. Lamarck (1744-1829)

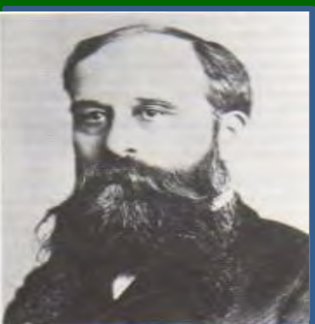


Antoine Laurent de Jussieu (1748-1836)

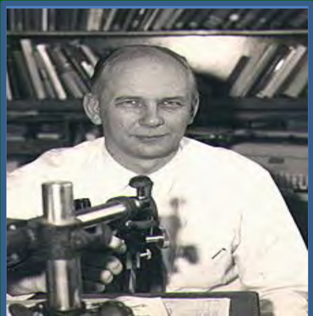
de Candolle (1778–1841)



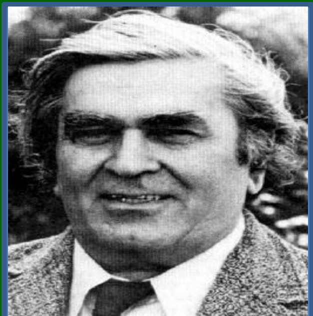




Charles E. Bessey (1845-1915)

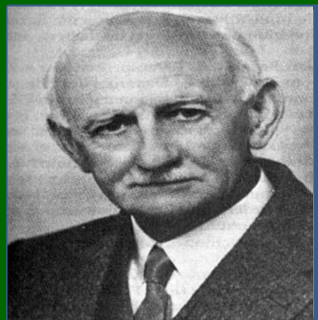


Auther Cronquist 1968

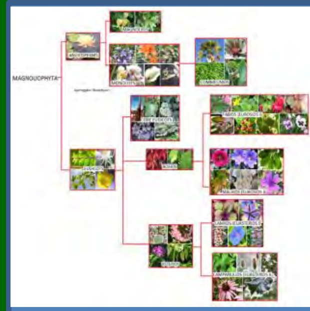


Armen Takhtajan 1969

Rolf Dahlgren (1932-87)



John Hutchinson (1884-1972)



APG Angiosperm Phylogeny Group (1998)

SCIENTIFIC NOMENCLATURE / BOTANICAL NOMENCLATE :

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

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

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

Species Concept

- **Species is the basic unit of classification**
- **Plants in the same species consistently produce plants of the same types**
- **The name of the plants must should be written in italics. For example Phoenix dactylifera**

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

- **Binomial Nomenclature and Carolus Linneaus System of Plant Classification**
- **Taxonomic Systems of Classification: Ideally our systems of classification should allow us to place similar species of plants together in the same category.**
- **There are two types of Classification Schemes:**

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

- **Carolus Linneaus was a Swedish botanist.**
- **Carolus Linneaus traveled to Lapland (Blue Lake, CA) and collected large number of plants.**
- **Carolus Linneaus introduced Binomial Nomenclature.**

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

- **Carolus Linneaus published the book 'Species Plantarum' in 1753.**
- **Carolus Linneaus classified the plants based on the plant's method of reproduction and structure of reproductive parts.**
- **Produced his sexual system of classification (Artificial classification)**

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

International Code of Botanical Nomenclature (ICBN)

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

The Code is divided into 3 divisions:

I. Principles

II. Rules and recommendations

III. Provisions for the governance of the Code

Principles of ICBN

- Botanical Nomenclature is independent of Zoological Nomenclature. The Code applies equally to the names of taxonomic groups treated as plants whether or not these groups were originally so treated.
- The application of names of taxonomic groups is determined by means of nomenclatural types / **TYPIFICATION**.
- Nomenclature of a taxonomic group is based upon **Priority Of Publication**.
- Each taxonomic group with a particular circumscription, position and rank can bear Only One Correct Name, the earliest that is in accordance with the rules.
- Scientific names of taxonomic groups are treated as LATIN, regardless of derivation.
- The rules of nomenclature are Retroactive, unless expressly limited.

- Generic Name: The Generic name is usually a noun and singular, which is spelled or written with a capital letter.
- Specific Epithet: The specific epithet is often an adjective and it is written with a small initial letter.
- In the hand written manner, both the generic names and specific epithet should be underlined, while if printed it should be in italics.

Synonyms and related terminology

- Synonyms: A name rejected due to misuse or difference in taxonomic judgement.
- Basionym:
  - The basionym is the first name ever given to a taxon. Further studies and revisions may reject the basionym as the most correct one, but it still is useful as a nomenclatural reference for that species.
  - Also, according to the priority rules of the ICBN, after a taxonomic revision that results in a species being reclassified in another genus, the specific epithet must remain the same as the one in the Basionym.
  - A short example: Linnaeus classified the Tea Plant as *Thea sinensis*. Some decades later, Sweet noticed that the genus *Thea* was not really different from the genus *Camellia*, and renamed all the *Theas* as *Camellias*. *Thea sinensis* became *Camellia sinensis*, because he had to keep the specific epithet the same as the original name (Basionym) for that species, given by Linnaeus.
- Homonym: A case in which two or more identical names are baed on different type , of which only one can be a legitimate name , is called as homonym.
- Tautonym: A case in which name of genus and the name of the species is the same.

Names of Taxa

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

Typification: Type Specimen is the one representative of the taxon.

- Holotype: A specimen designated by the author in the original publication (nomenclatural type).
- Isotype: A duplicate specimen of the holotype collected at the same time and place (may be in other herbarium).
- Lectotype: A specimen chosen from the author's original material when no holotype has been designated.
- Neotype: A specimen selected when all original specimens have been destroyed

Author Citation, Effective Publication and Principle of Priority

Author Citation

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

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

Ann. Bot. Fennici 53: 37–39 ISSN 0003-3847 (print) ISSN 1797-2442 (online)
Helsinki 4 January 2016

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

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

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

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

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

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

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

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

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

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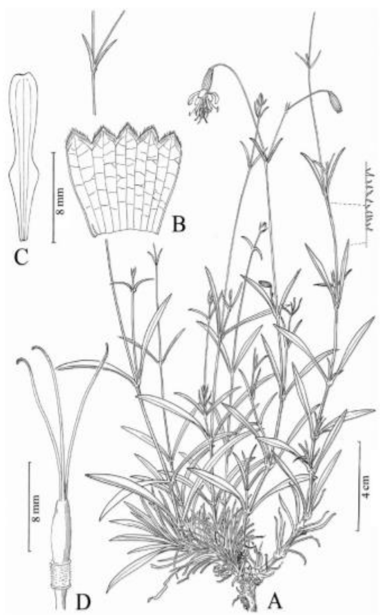

Fig. 1. *Silene langshanensis* (from the holotype, drawn by Ping Ma). — **A**: Habit. — **B**: Calyx. — **C**: Petal. — **D**: Pistil and carpophore.

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

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

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

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

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

Acknowledgements

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

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Effective publication in the journal, available to Botanist

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

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Abstract / Summary / Synopsis.

Previously it was required to write in Latin.

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

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Botanical name in Latin

Rank indicated

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

Type Specimen indicated

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

Specimens examined

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Taxonomic Description

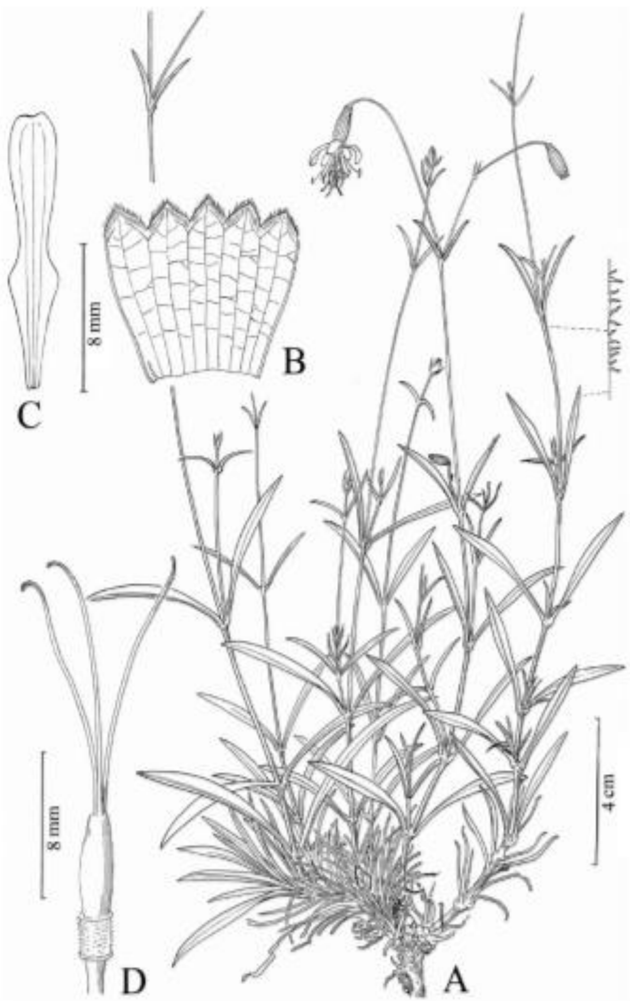

Fig. 1. *Silene langshanensis* (from the holotype, drawn by Ping Ma). — **A**: Habit. — **B**: Calyx. — **C**: Petal. — **D**: Pistil and carpophore.

Line drawing

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Basal leaves	oblanceolate, 20–60 × 2–6 mm	spatulate or lanceolate, 60–80 × 5–10 mm
Cyme	1-flowered (rarely 2)	multiflowered
Pedicel	20–60 mm long, glabrescent	5–10 mm long, sparsely pubescent
Calyx	narrowly campanulate, 10–13 × 4–5 mm, glabrous	tubular-clavate, 8–12 × 2–3 mm, glabrous or sparsely villous
Carpophore	shortly pubescent	glabrous
Petal	with obtuse auricles	without distinct auricles
Limbs	yellowish green	yellowish white

1. Leaves ovate-lanceolate, 15–30 mm wide .... *S. kungessana*
1. Leaves lanceolate or linear, 1.5–10 mm wide 2
2. Leaves linear, 10–30 × 1.5–3 mm .... *S. holopetala*
2. Leaves oblanceolate or lanceolate, 30–80 mm long, usually more than 4 mm wide 3
3. Stems usually not branched; calyx 6–9 mm; petals pinkish abaxially ....
3. Stems branched; calyx
or yellow
4. Stem
cyme
obvi
4. Ste

Taxonomic Key for Identification

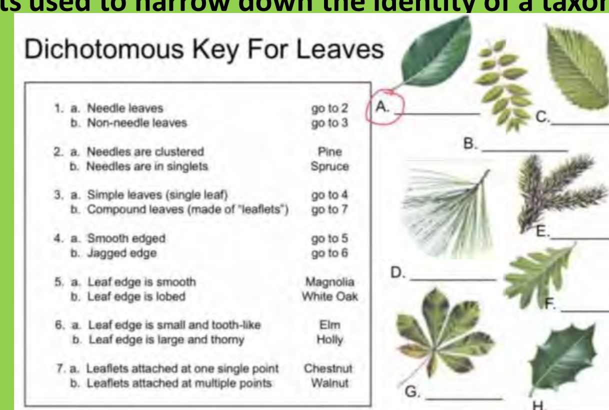
Acknowledgements

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

eferences

hkin B.K [Шишкин Б.К.] (ed.) 1936: [*Flora USSR*], vol. 6. — Izdatel'stvo Akademii Nauk USSR, Leningrad. [In ussian].
L.H., Wu Z.Y., Lidén M. & Oxelman B. 2001: *Silene*. — In: Wu Z.Y. & Raven P.H. (eds.), *Flora of China*, vol. 6: 66–100. Science Press, Beijing & Missouri Botanical Garden Press, Saint Louis.

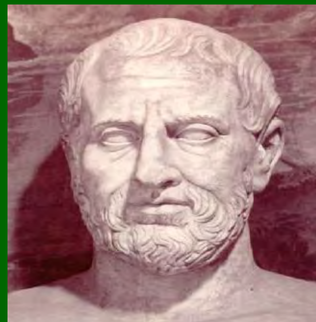
Taxonomic Key: An identification device, consisting of contrasting statements used to narrow down the identity of a taxon



WEEK 3

SYSTEM OF PLANT CLASSIFICATION

Preliterate Mankind / Folk taxonomies:



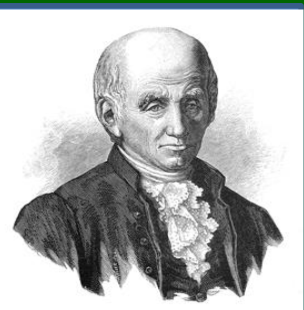
Theophrastus (372 BC to 287 BC):

Andrea Cesalpino (1519-1603)

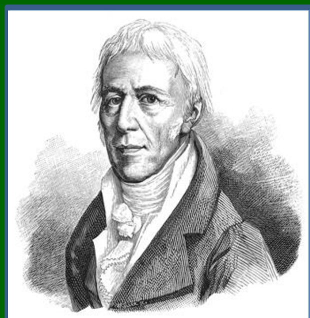
John Ray (1627-1705)

J. P. de Tournefort (1656-1708)

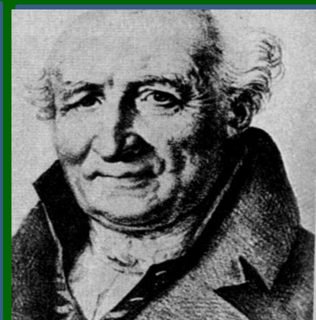
Carolus Linneaus (1753)



Michel Adanson (1727-1806)



Jean B.P. Lamarck (1744-1829)



Antoine Laurent de Jussieu (1748-1836)

de Candolle (1778–1841)

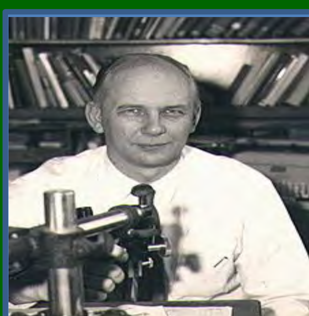
George Bentham 1800-1884

Joseph Hooker 1817-1911

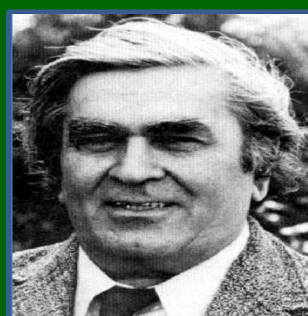
Adolph Engler 1844-1930

Karl Prantl 1849-1893

Charles E. Bessey (1845-1915)

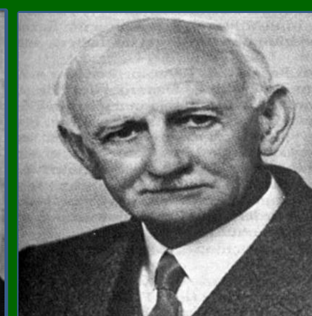


Auther Cronquist 1968



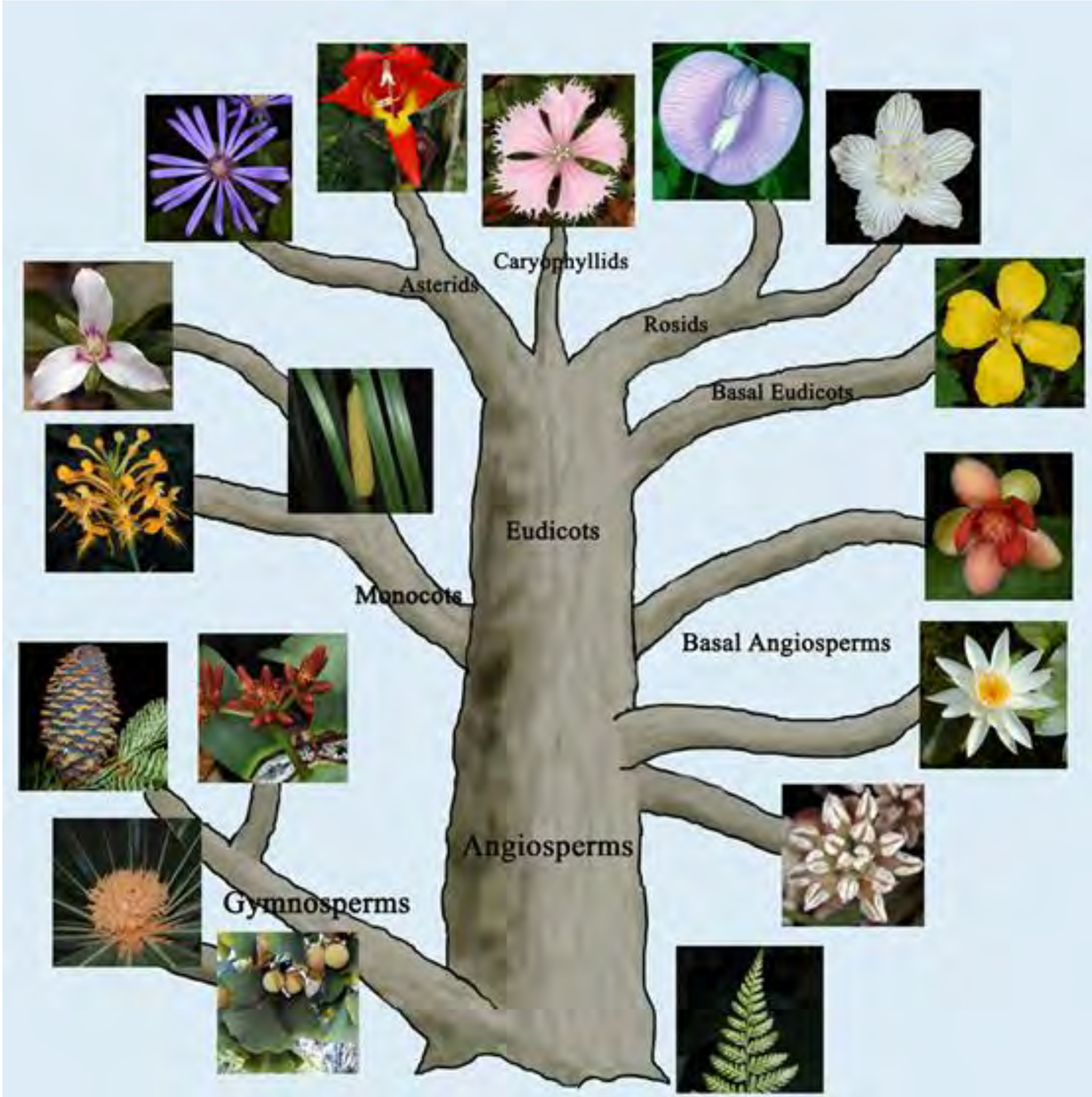
Armen Takhtajan 1969

Rolf Dahlgren (1932-87)



John Hutchinson (1884-1972)

APG Angiosperm Phylogeny Group (1998)


Caryophyllids
Asterids
Rosids
Basal Eudicots
Eudicots
Monocots
Basal Angiosperms
Angiosperms
Gymnosperms

Alpha (α) Taxonomy / classical taxonomy:

Plant collection, Preservation and Documentation

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.

Types of Taxonomy / Taxonomic Studies / Plant Taxonomic Classification

Alpha (α) Taxonomy / classical taxonomy:- It involves description and naming of organisms. It is the parent of other types of taxonomy.

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

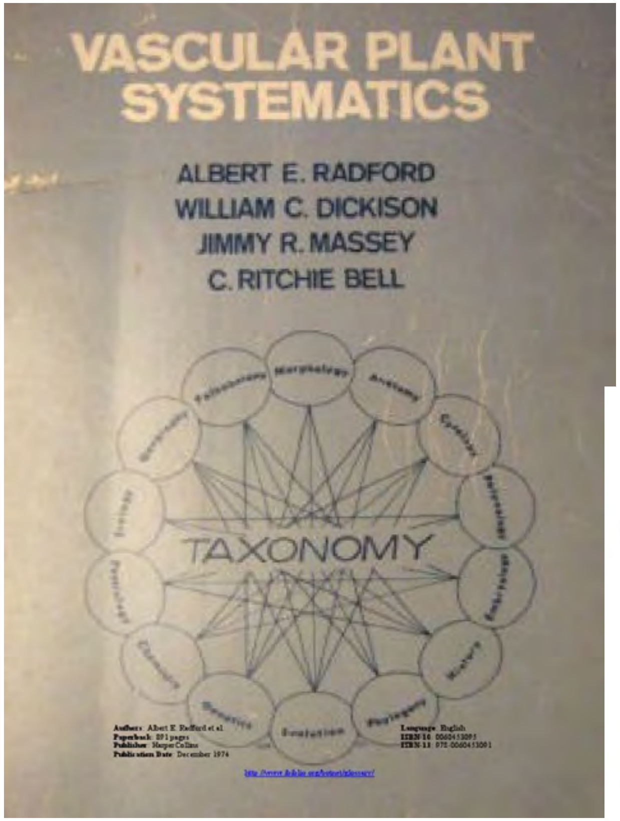
Herbarium: Plant collecting, Preservation and Documentation

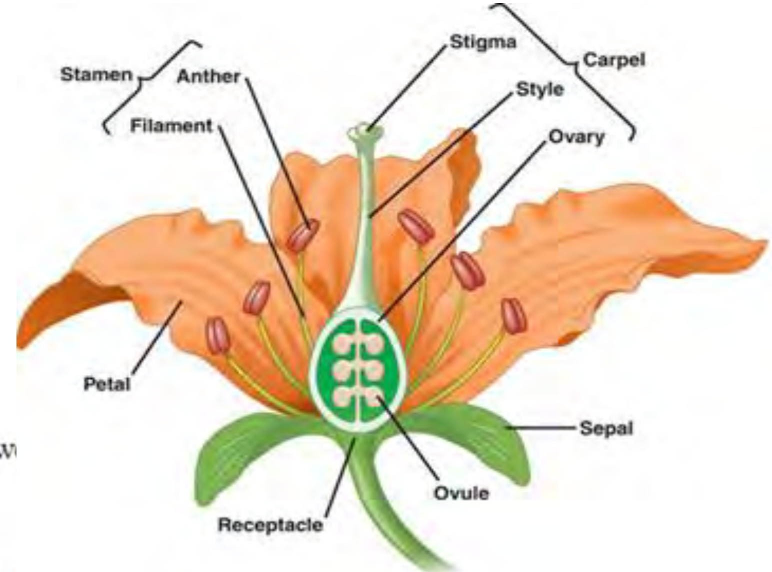
- **To make a herbarium specimen, the plant is collected, and notes are made about it. The plant is then pressed until dry between blotters that absorb moisture and mounted onto a herbarium sheet with a suitable label, and stored in steel cabinet arranged into some system of classification.**
- **Herbarium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

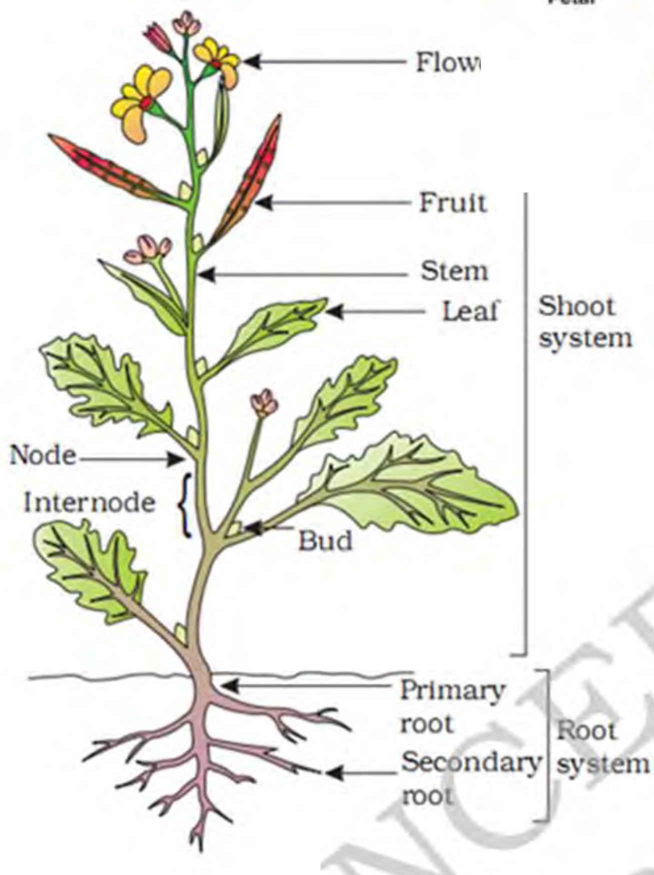
- **Flora = it is the documentation of plants occurring in a particular region.**

- The FLORA is the main Resources of Taxonomic Information

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


VASCULAR PLANT SYSTEMATICS
ALBERT E. RADFORD
WILLIAM C. DICKISON
JIMMY R. MASSEY
C. RITCHIE BELL
TAXONOMY
Authors: Albert E. Radford et al.
Paperback: 891 pages
Publisher: HarperCollins
Publication Date: December 1974
Language: English
ISBN-10: 0060453095
ISBN-13: 978-0060453091


Stamen
Anther
Filament
Stigma
Style
Carpel
Ovary
Petal
Sepal
Ovule
Receptacle


Flow
Fruit
Stem
Leaf
Shoot system
Node
Internode
Bud
Primary root
Secondary root
Root system

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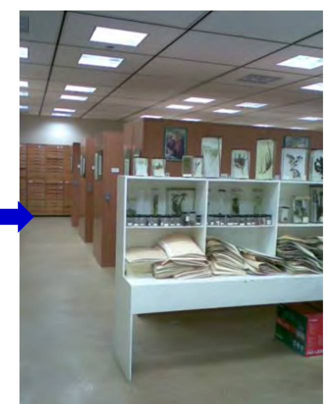


Herbarium Methodology

Ancient Practices:

Early civilizations like the **Egyptians** and **Greeks** preserved plants for medicinal and scientific purposes.

Plants were pressed and dried for **herbal medicine** documentation.

Middle Ages:

Herbals (illustrated books) described plants and their uses, but lacked physical specimens.

Focus was on artistic depictions rather than scientific accuracy.

Renaissance and the Birth of the Herbarium

Key Points:

Luca Ghini (1490–1556):

Italian physician and botanist credited with creating the **first herbarium**.

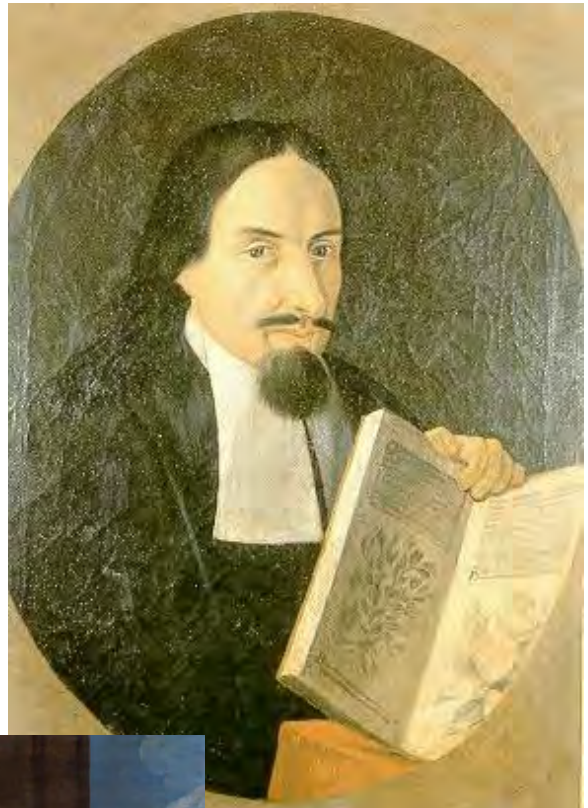
Developed the idea of pressing plants and mounting them on paper.

Herbariums were initially called "hortus siccus," meaning "dry garden."

Andrea Cesalpino (1519–1603):

Improved plant classification and established early taxonomic principles.

herbal manuscripts



The first recorded herbarium is credited to Luca Ghini, a professor of both medicine and botany at the University of Pisa, a site for the first university botanical garden in Europe.

Post-Linnaean Era

Key Points:

Carl Linnaeus (1707–1778):

Standardized plant classification with the **binomial nomenclature system**.

Emphasized the importance of herbarium collections in taxonomy.

Herbariums became central to plant identification and comparative studies.

Specimens were exchanged globally to expand botanical knowledge.

Expansion During the 18th and 19th Century

Key Points:

Colonial Exploration:

Expeditions to Asia, Africa, and the Americas brought a surge in plant specimen collection.

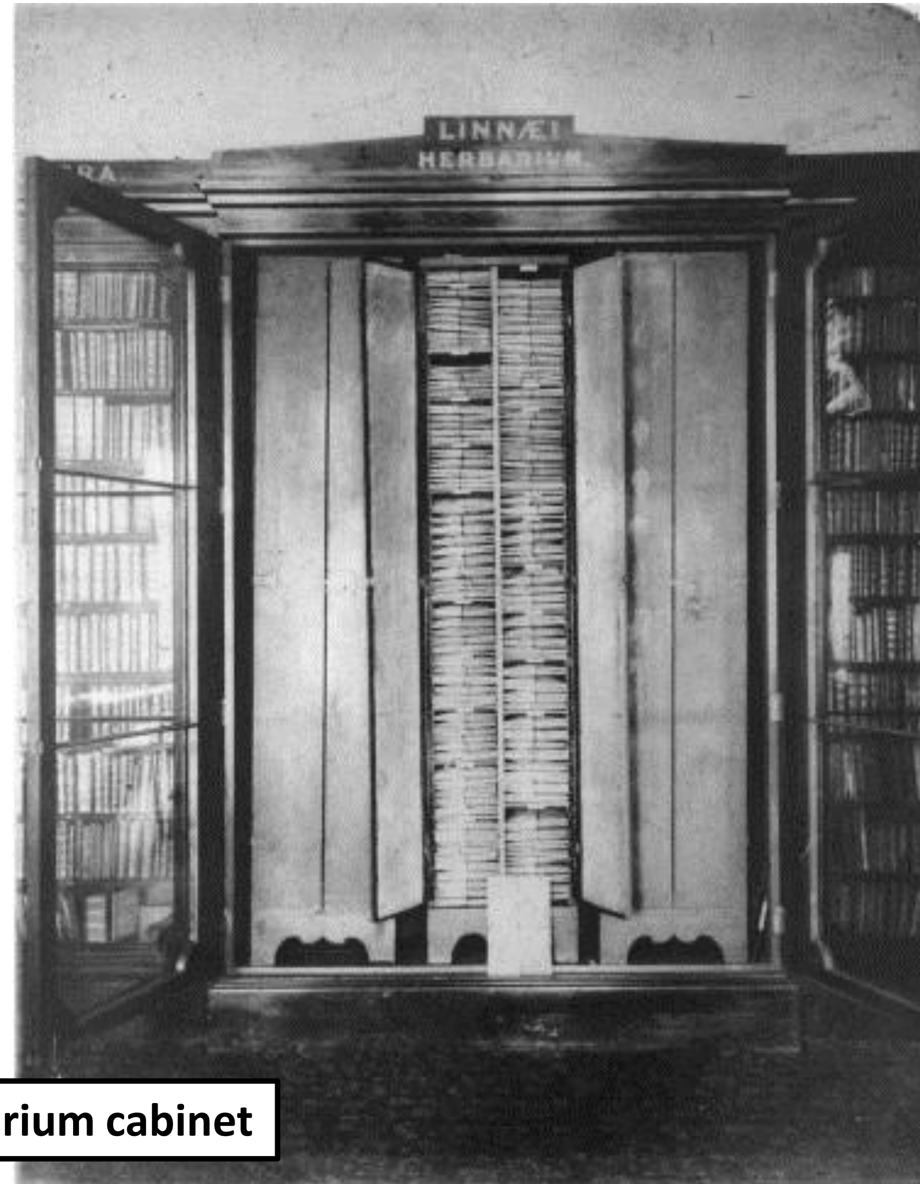
Famous herbaria were established in Europe, including the **Royal Botanic Gardens, Kew**.

Alexander von Humboldt:

Documented thousands of plant species during his explorations.

Standardized practices in herbarium methodology began to develop.

Linnaean Herbarium –
The Linnean Collections



Linnaeus' herbarium cabinet

The Role of Modern Herbaria

Key Points:

20th century:

Increased focus on **scientific precision** and preservation techniques.

Integration of **chemical treatments** to protect specimens.

Development of large-scale herbaria as repositories of global biodiversity.

Advances in taxonomy with contributions from herbarium studies.

Digitization and Global Access

Key Points:

21st century:

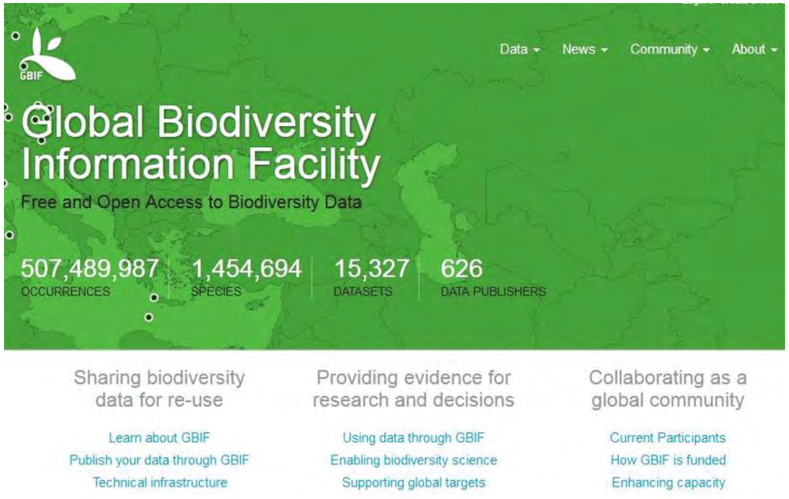
Herbarium specimens are being **digitized** to create online databases.

Initiatives like **GBIF (Global Biodiversity Information Facility)** and **JSTOR Global Plants** provide global access to herbarium data.

Digitization has revolutionized taxonomy, allowing easy comparison of specimens across the world.

A Typical Herbarium (KSU) in Saudi Arabia

The Herbarium at
King Saud University



Herbarium Methodology

Collection

Process:

Collect plant specimens from **fields, forests, or habitats**.

Choose **healthy specimens** with flowers, fruits, leaves, and other distinctive features.

Smaller Plants: Collect the entire plant, including roots.

Larger Plants: Take representative branches with leaves, flowers, or fruits.

Record **field data** such as:

- Location (with GPS coordinates).
- Collection date and time.
- Environmental conditions (soil type, associated flora, habitat).

Preparation

Process:

Protect specimens during transport by wrapping them in **newspaper** or **plastic bags**.

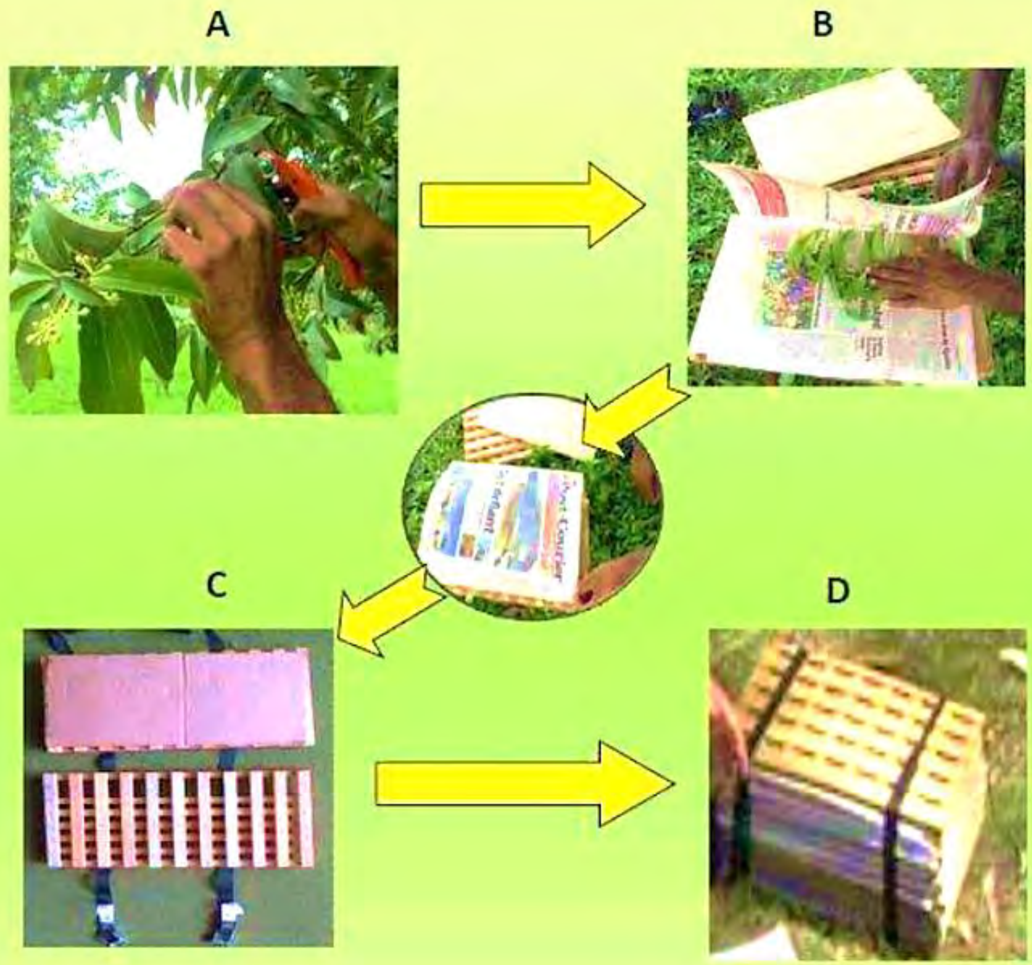
Ensure specimens remain **fresh** until pressed.

Use **moisture-retentive materials** if necessary for delicate specimens.

Tips:

Avoid crushing flowers or fragile parts.

Keep specimens shaded to prevent wilting.

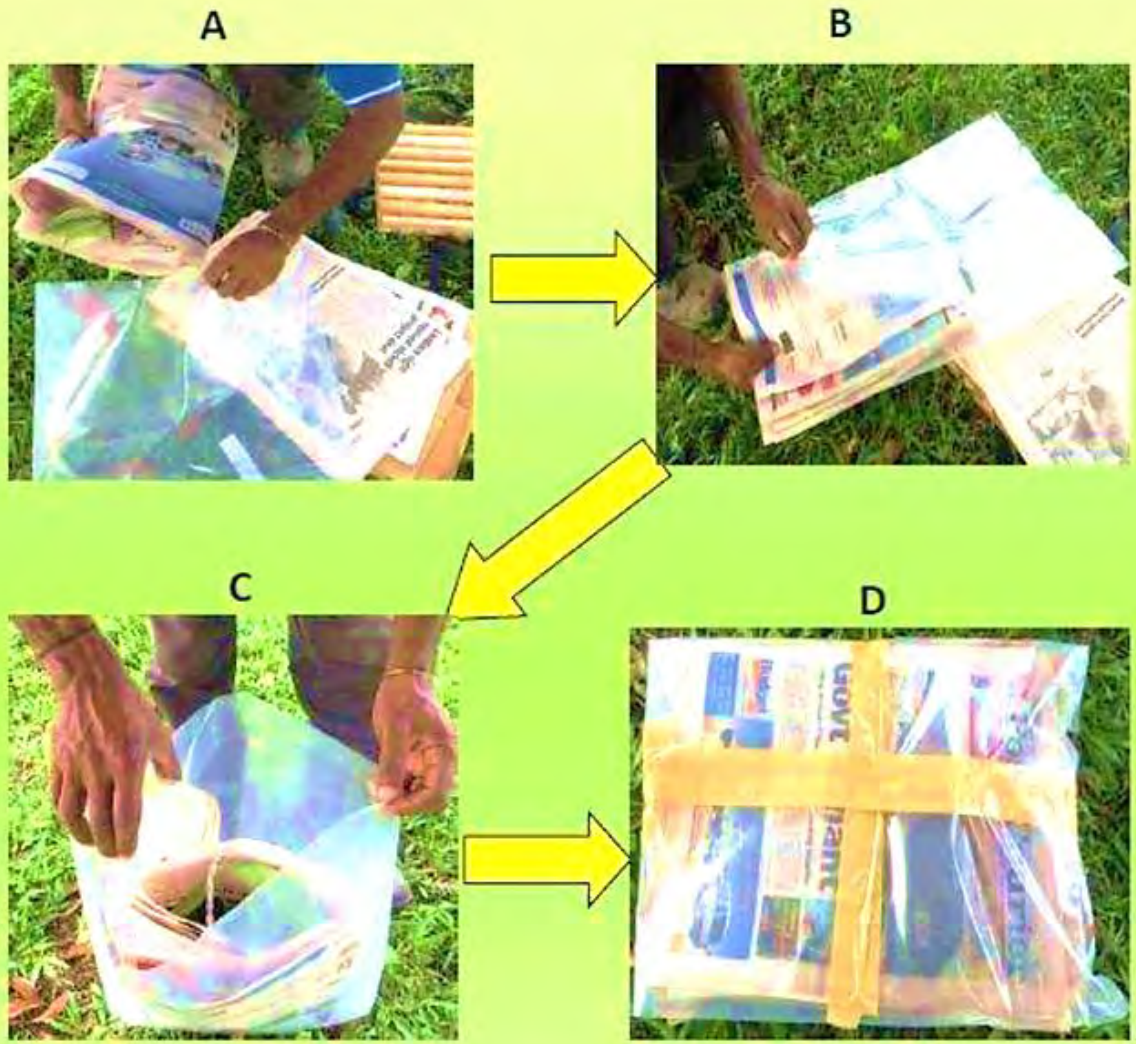


A. Flowering plant specimen cut using secateurs

B. Specimen placed between the news paper page

C. Card board & wooden frame for pressing specimens

D. Plant specimens pressed between wooden frames for 12 hours



A. & B Specimens in between newspapers placed into the plastic bags

C. Preservative poured on to the specimens in the plastic tubes

D. Plant specimens wrapped in plastic bags ready to be sent to Lae
Herbarium for further processing and identification.

Drying

Process:

Place specimens in a **plant press** with layers of blotting paper or newspaper.

Arrange plant parts to display diagnostic features clearly (e.g., flat leaves, open flowers).

Apply even pressure by tightening the press.

Replace blotting papers regularly to speed up drying.

Tips:

Dry in a warm, well-ventilated space or use a drying cabinet.

Drying takes **7–14 days**, depending on moisture content.

Poisoning

Process:

Treat dried specimens with **chemical preservatives** to prevent pest attacks.

Common chemicals:

- **Mercuric chloride** or **alcohol-based solutions** for poisoning.
- Safer alternatives like **camphor or thymol** can also be used.

Apply the solution lightly to avoid damaging the specimen.

Drying

Poisoning

Mounting

Process:

Mount the dried specimen on **acid-free archival paper** (standard size: 11.5 × 16.5 inches).

Arrange plant parts aesthetically and display essential features clearly.

Secure specimens using:

- **Glue**: For small, flat parts like leaves.
- **Strips or tape**: For thicker stems and flowers.

Stitching

Process:

Stitch larger plant parts (e.g., thick stems, fruits) to the archival paper using:

- **Fine thread** or **linen twine**.

Ensure stitching is firm but not damaging to the specimen.

Tips:

Use minimal stitching to avoid over-handling.

Focus on structural support.

Visual Suggestions:

Close-up image of stitched specimens.

Labeling

Process:

Attach a label to the bottom-right corner of the herbarium sheet.

Include the following information:

- **Scientific Name**: Genus and species, along with the authority citation.
- **Family Name**: Taxonomic family of the specimen.
- **Collector's Details**: Name, collection number, and date.
- **Location**: Habitat description and GPS coordinates.
- **Additional Notes**: Ecological and morphological details.

Deposition

Process:

Store mounted specimens in **acid-free folders** and organize them in **herbarium cabinets**.

Maintain a controlled environment:

- **Temperature**: 15–20°C.
- **Humidity**: 30–40%.

Use **pest prevention methods**, such as naphthalene balls, fumigation, or freeze storage.

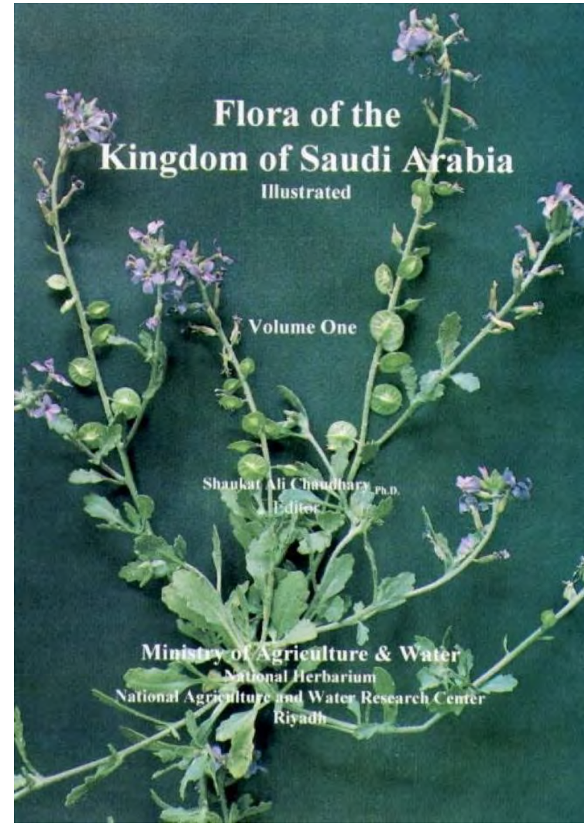
Identification

Process:

Identify the specimen's **scientific name** using:

- Floras, monographs, and taxonomic keys.
- Comparison with previously collected specimens.

Collaborate with **taxonomists or botanists** for verification.



Housing

Process:

Arrange specimens systematically in the **herbarium repository** based on:

- Taxonomic hierarchy (family, genus, species).
- Unique accession numbers for each specimen.

Ensure proper housing for long-term preservation.

Use digitization to make the collection accessible globally.

Housing

Applications of Herbarium

A **herbarium** is a collection of preserved plant specimens that are systematically arranged for study and reference. It plays a vital role in various scientific and practical applications.

1. Taxonomic Studies

Helps in the identification and classification of plants.

Acts as a reference for comparing newly discovered species.

2. Biodiversity Conservation

Provides a record of plant diversity in different regions.

Assists in monitoring endangered and extinct species.

3. Ecological and Environmental Studies

Helps in understanding plant distribution and habitat changes.

Aids in climate change research by analyzing historical plant records.

4. Ethnobotanical Research

Preserved specimens help study the medicinal and economic uses of plants by different cultures.

Supports traditional knowledge documentation.

5. Pharmaceutical and Medicinal Research

Provides reference material for the identification of medicinal plants.

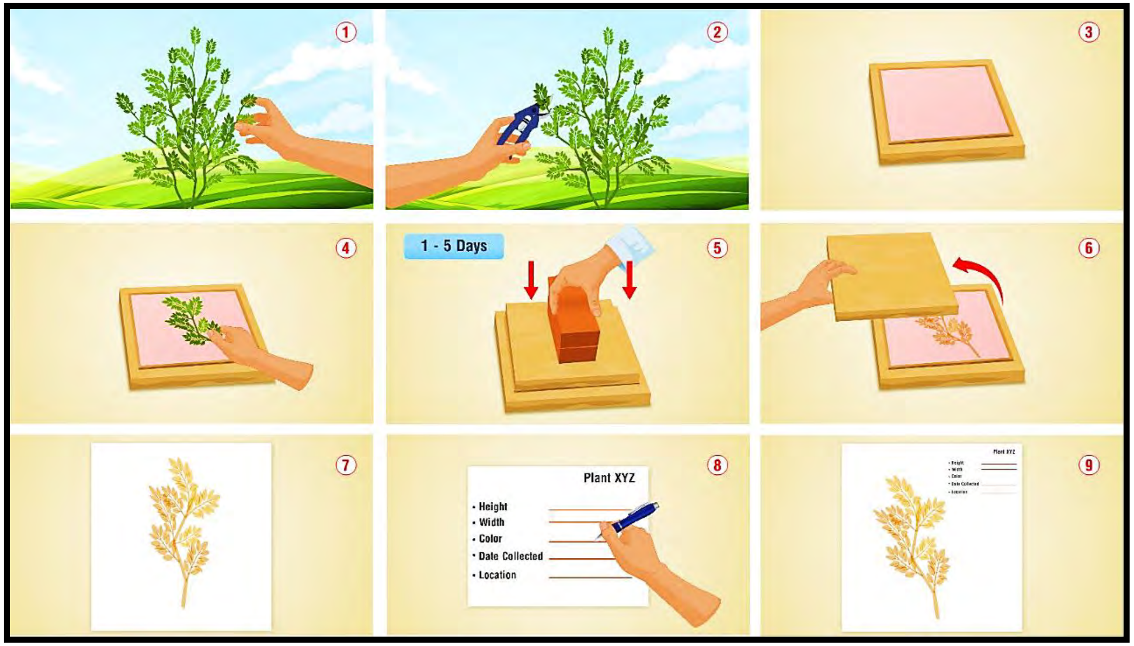
Assists in drug discovery and validation of herbal medicines.

6. Agricultural and Horticultural Development

Helps in improving crop varieties through comparative plant studies.

Assists in weed management and pest control studies.

7. Education and Research
Used as a teaching aid for botany, taxonomy, and ecology students.
Provides reference material for botanical research.
8. Legal and Forensic Investigations
Assists in verifying plant species involved in illegal trade.
Used in forensic botany to solve criminal cases.
9. Paleobotanical and Evolutionary Studies
Helps in studying plant evolution over time.
Provides insight into past climatic conditions through preserved specimens.
10. Biogeography and Climate Change Research
Helps track plant migration and distribution patterns.
Assists in studying the impact of climate change on vegetation.




HORTICULTURE AND AGRICULTURE


Biodiversity


Medicinal Plant Research


Ecology & Environmental Studies

Plant Identification Methods

Components of Taxonomy:

Characterization: Describing the observable features of a plant

Identification: Determining the correct name of a plant based on its characteristics

Nomenclature: System of assigning scientific names to plants (including the binomial system)

Classification: Arranging plants into hierarchical groups based on their relationships

Characterization

Definition: Describing the observable features of a plant.

Key Aspects:

Morphological traits – Leaf shape, flower color, fruit type.
Anatomical traits – Internal tissue structure, vascular arrangement.
Physiological traits – Growth patterns, photosynthesis type (C3, C4, CAM).
Chemical traits – Presence of alkaloids, flavonoids, essential oils.

Example: Roses are characterized by their thorny stems, compound leaves, and fragrant flowers.

Identification

Definition: Determining the correct name of a plant based on its characteristics.

Methods Used:

Morphological Key – Comparing features with known plants.

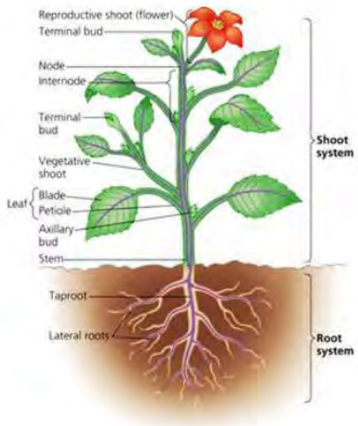
Flora Manuals – Reference books for plant identification.

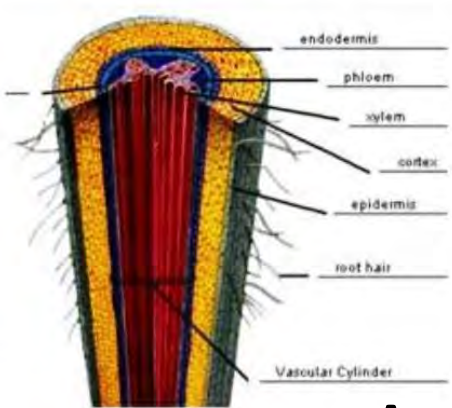
Herbaria – Preserved plant specimens for study.

Molecular Tools – DNA barcoding for precise identification.

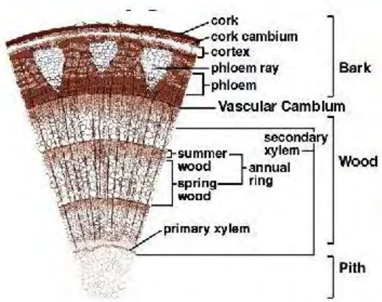
Example: A plant with yellow flowers and composite flower heads may be identified as a member of the **Asteraceae** family.

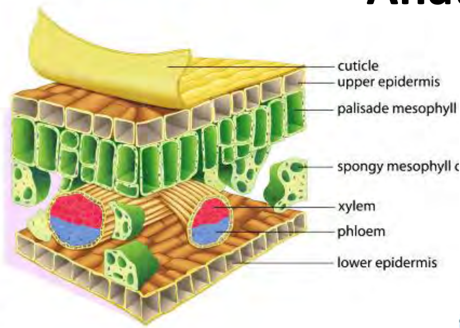
Morphological traits

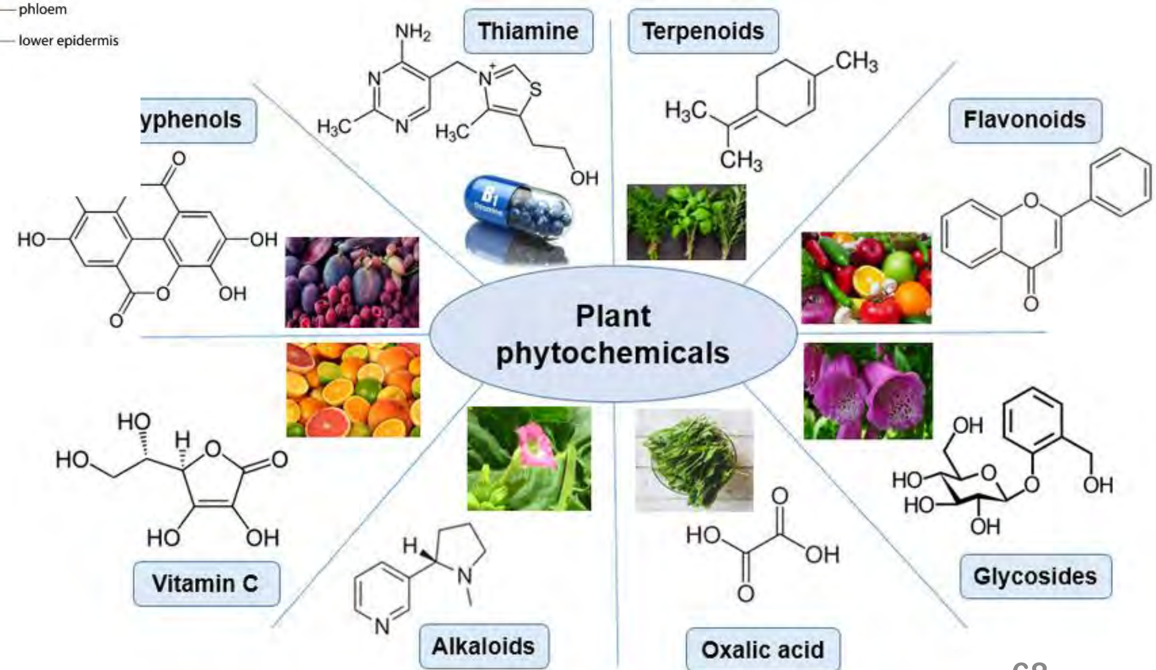




Anatomical traits

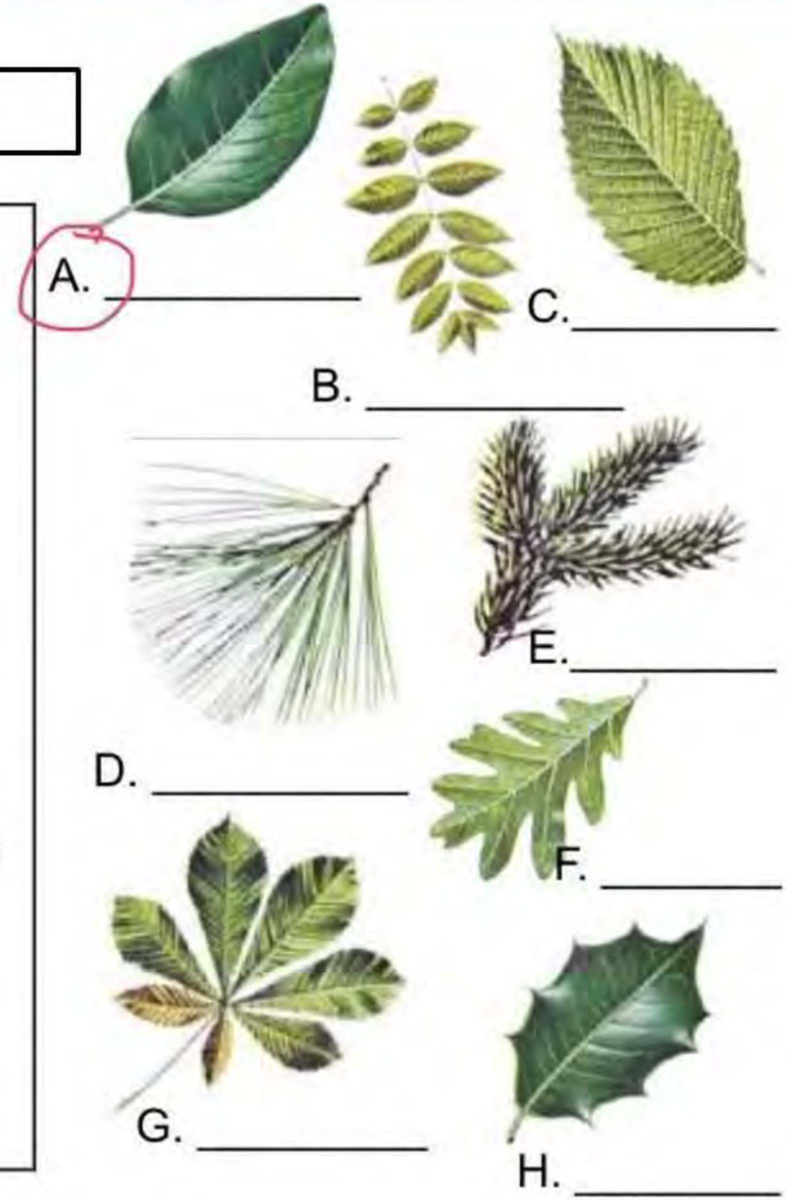






Morphological Key

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



Flora

Herbaria

Nomenclature

Definition: The system of assigning scientific names to plants.
Key Principles (ICN – International Code of Nomenclature):
Binomial System – Each plant has two names (Genus + species).
Universal Naming – Used globally to avoid confusion.
Priority Rule – The first validly published name is accepted.
Example: *Mangifera indica* (Mango), *Solanum tuberosum* (Potato).

Why is Nomenclature Important?

- Prevents duplication of names.
- Ensures scientific consistency.
- Helps in effective communication among botanists.

Classification

Definition: Arranging plants into hierarchical groups based on their relationships.
Hierarchy of Classification:
Kingdom → Division → Class → Order → Family → Genus → Species
Artificial System – Based on external characteristics (e.g., Linnaeus).
Natural System – Based on overall similarities (e.g., Bentham & Hooker).
Phylogenetic System – Based on evolutionary history (e.g., APG).

Example:
Kingdom – Plantae
Division – Angiosperms
Class – Monocotyledonae
Order – Arecales
Family – Arecaceae
Genus – *Phoenix* **Species** – *Phoenix dactylifera*

Taxonomic Hierarchy

Definition
The system of arranging plants into a hierarchical structure based on their relationships.
Helps in organizing plant diversity in a systematic way.

Hierarchy Levels (Broad to Specific)

Kingdom – The highest rank, includes all plants (*Plantae*).

Division (Phylum in zoology) – Groups based on major characteristics (e.g., *Angiosperms*, *Gymnosperms*).

Class – Further subdivision based on key traits (e.g., *Monocotyledonae*, *Dicotyledonae*).

Order – Groups families with similar characteristics (e.g., *Arecales*).

Family – Groups related genera (e.g., *Arecaceae*).

Genus – A group of closely related species (e.g., *Phoenix*).

Species – The basic unit of classification, includes individual plants with similar traits (e.g *Phoenix dactylifera)*

Importance of Taxonomic Hierarchy

Helps in identifying and classifying plants systematically.
Establishes evolutionary relationships between plants.
Provides a universal system for plant naming and study.
Essential for biodiversity conservation and ecological studies.

SCIENTIFIC NOMENCLATURE / BOTANICAL NOMENCLATE :

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

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

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

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

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

Species Concept

- Species is the basic unit of classification
- Plants in the same species consistently produce plants of the same types
- The name of the plants must should be written in italics. For example Phoenix dactylifera

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

Binomial Nomenclature and Carolus Linneaus System of Plant Classification

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

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

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

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

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

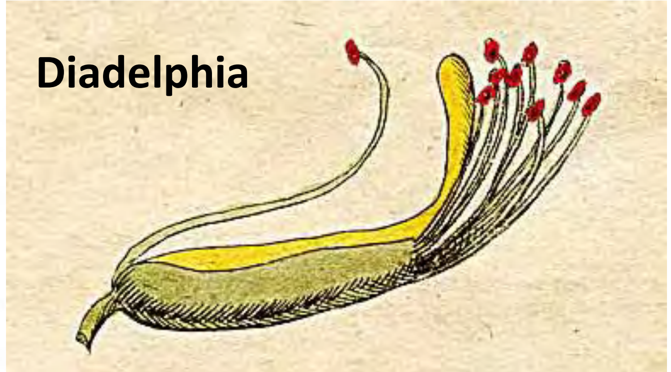
- **Carolus Linneaus introduced Binomial Nomenclature.**

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

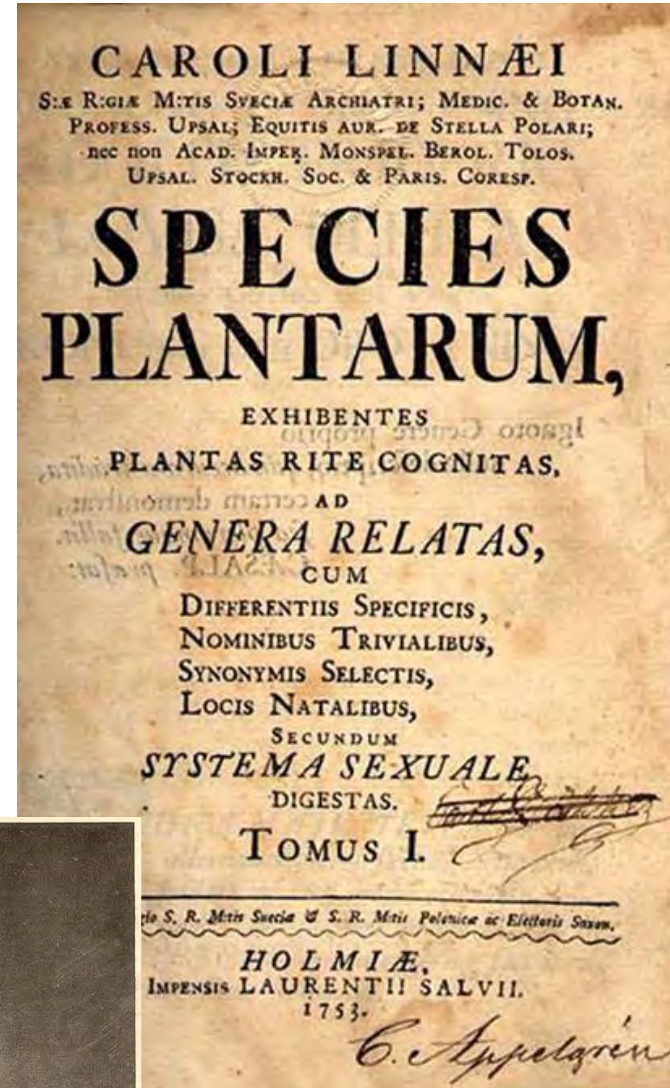
- **Carolus Linneaus published the book 'Species Plantarum' in 1753.**
- **Carolus Linneaus classified the plants based on the plant's method of reproduction and structure of reproductive parts.**
- **Produced his sexual system of classification (Artificial classification)**
- **Carolus Linneaus divided plants into 24 classes. The Classes in the Linneaus is based largely on the amount, union and length of stamens**

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



Diadelphia



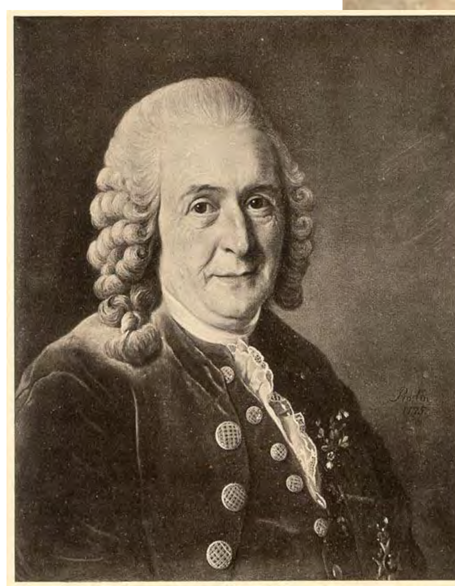
CAROLI LINNÆI
S:Æ R:GIÆ M:TIS SVECIÆ ARCHIATRI; MEDIC. & BOTAN.
PROFESS. UPSAL; EQUITIS AUR. DE STELLA POLARI;
nec non ACAD. IMPER. MONSPEL. BEROL. TOLOS.
UPSAL. STOCKH. SOC. & PARIS. CORESP.

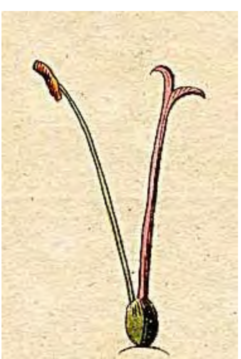
SPECIES
PLANTARUM,
EXHIBENTES
PLANTAS RITE COGNITAS,
AD
GENERA RELATAS,
CUM
DIFFERENTIIS SPECIFICIS,
NOMINIBUS TRIVIALIBUS,
SYNONYMIS SELECTIS,
LOCIS NATALIBUS,
SECUNDUM
SYSTEMA SEXUALE
DIGESTAS.
TOMUS I.

...io S. R. M:tis Sueciæ & S. R. M:tis Poloniæ ac Electoris Saxon.

HOLMIÆ,
IMPENSIS LAURENTII SALVII.
1753.

C. Appelgrén





Triandria

Monandria

International Code of Nomenclature (ICN)

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

The Code is divided into 3 divisions:

I. Principles

II. Rules and recommendations

III. Provisions for the governance of the Code

Principles of ICBN

- **Botanical Nomenclature is independent of Zoological Nomenclature. The Code applies equally to the names of taxonomic groups treated as plants whether or not these groups were originally so treated.**
- **The application of names of taxonomic groups is determined by means of nomenclatural types / TYPIFICATION.**
- **Nomenclature of a taxonomic group is based upon Priority Of Publication.**
- **Each taxonomic group with a particular circumscription, position and rank can bear Only One Correct Name, the earliest that is in accordance with the rules.**
- **Scientific names of taxonomic groups are treated as LATIN, regardless of derivation.**
- **The rules of nomenclature are Retroactive, unless expressly limited.**

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

- **Specific Epithet:** The specific epithet is often an adjective and it is written with a small initial letter.

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

Synonyms and related terminology

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

- **Basionym:**

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

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

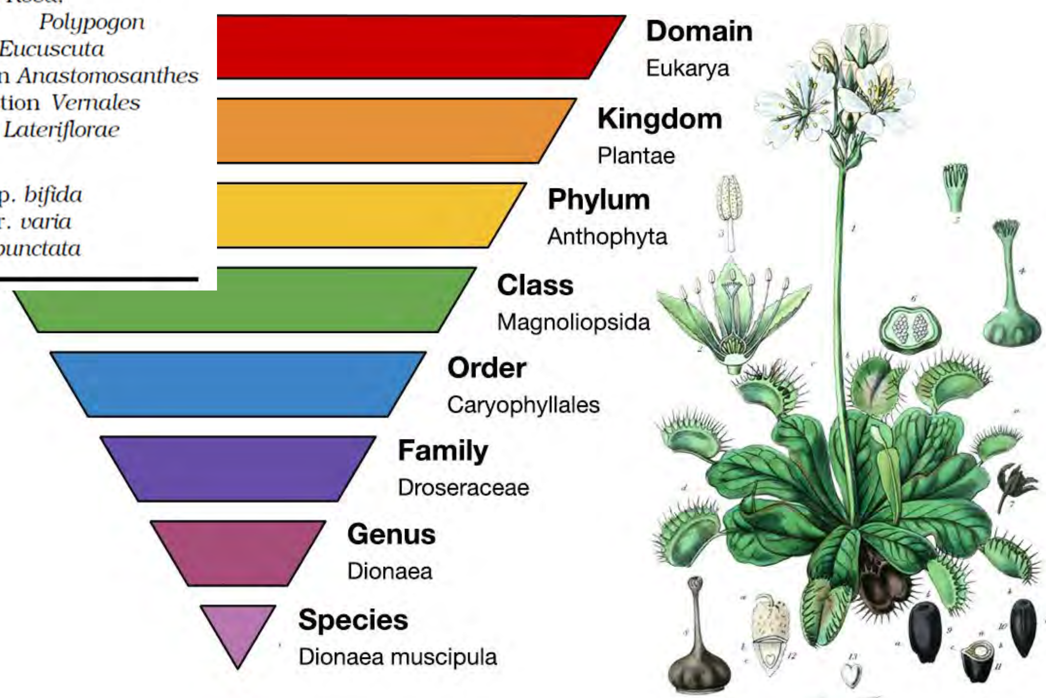
  - A short example: Linnaeus classified the Tea Plant as *Thea sinensis*. Some decades later, Sweet noticed that the genus *Thea* was not really different from the genus *Camellia*, and renamed all the *Theas* as *Camellias*. *Thea sinensis* became *Camellia sinensis*, because he had to keep the specific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

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

- **Tautonym:** A case in which name of genus and the name of the species is the same.

Names of Taxa

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



Typification: Type Specimen is the one representative of the taxon.

- **Holotype:** A specimen designated by the author in the original publication (nomenclatural type).

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

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

- **Neotype:** A specimen selected when all original specimens have been destroyed

Author Citation, Effective Publication and Principle of Priority

Author Citation

- **For a name to be complete, it should be accompanied by the name of the author or authors who first published the name validly. The names of the authors are commonly abbreviated, Example L. for Carolus Linnaeus**

- ***Aizoon canariense*** **L.**

- ***Tribulus macropterus*** **var*.*** ***arabicus*** **(Hosni) Al-Hemaid & J. Thomas**

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

Ann. Bot. Fennici 53: 37–39 ISSN 0003-3847 (print) ISSN 1797-2442 (online)
Helsinki 4 January 2016

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

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

[1] College of Life Science, Inner Mongolia University, Hohhot 010021, China (*corresponding author's e-mail: zhaolieniu@126.com)
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Silene langshanensis L.Q. Zhao, Y.Z. Zhao & Z.M. Xin *sp. nova* (Caryophyllaceae), is described and illustrated from Inner Mongolia, China. It appears to be most closely related to *S. scabrifolia* of *Silene* sect. *Holopetalae*. *Silene langshanensis* can be distinguished by the basally pubescent carpophore, petals with obtuse auricles, stems and leaves with dense, short hairs, and by the glabrous calyx.

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

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

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

HOLOTYPE: China. Inner Mongolia, Bayannaoer, Dengkou, Mt. Langshan, 40°13′58.4″N, 106°22′28.5″E, on stony mountain slopes, 1371 m a.s.l., 9 June 2014 *Li-Qing Zhao, Zhi-Ming Xin, Shuai Qin & Long Chen N14-001* (HIMC). — PARATYPES (all HIMC): Same location as holotype, 9 June 2014 *Li-Qing Zhao, Zhi-Ming Xin, Shuai Qin & Long Chen N14-002, N14-003, N14-004*; Mt. Langshan, 40°59′27.7″N, 106°23′14.1″E, on stony mountain slopes, alt. 1185 m a.s.l., 10 September 2008 *Li-Qing Zhao & Zhi-Ming Xin N08-001*.

Herbs perennial, 20–30 cm tall. Roots robust, lignified. Plants cespitose with erect stems, multi-branched or sparsely branched, pubescent, upper parts glabrescent. Basal leaves oblanceolate, 20–60 × 2–6 mm, both surfaces pubescent, margins ciliate, base attenuate into a long petiole, apex acute; cauline leaves 3–7 pairs, linear-oblanceolate or linear-lanceolate, with short, axillary sterile branches or sometimes elongated flowering axillary branches. Flowers in a raceme-like thyrse, cymes alternating (resulting from suppression of opposite cyme at same node) or opposite, 1 flowered (rarely 2), peduncles nearly equal or shorter than pedicels. Pedicel 2–6 cm, glabrescent, bracts ovate-lanceolate, ciliate, base connate, apex acuminate. Calyx tubular, green,

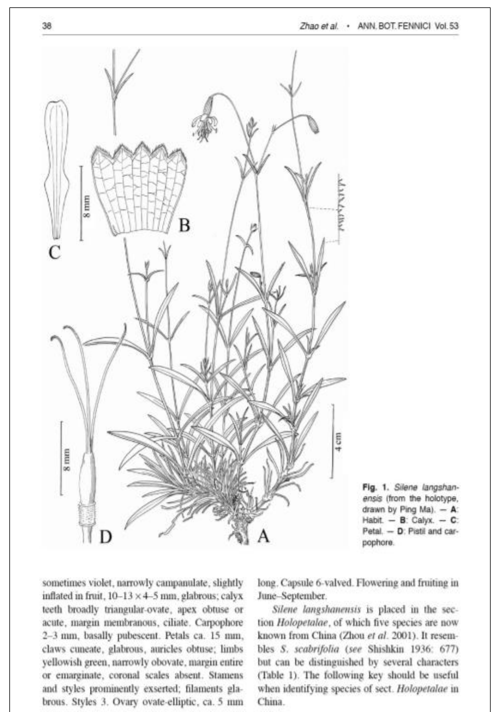

Fig. 1. *Silene langshanensis* (from the holotype, drawn by Ping Ma). — **A**: Habit. — **B**: Calyx. — **C**: Petal. — **D**: Pistil and carpophore.

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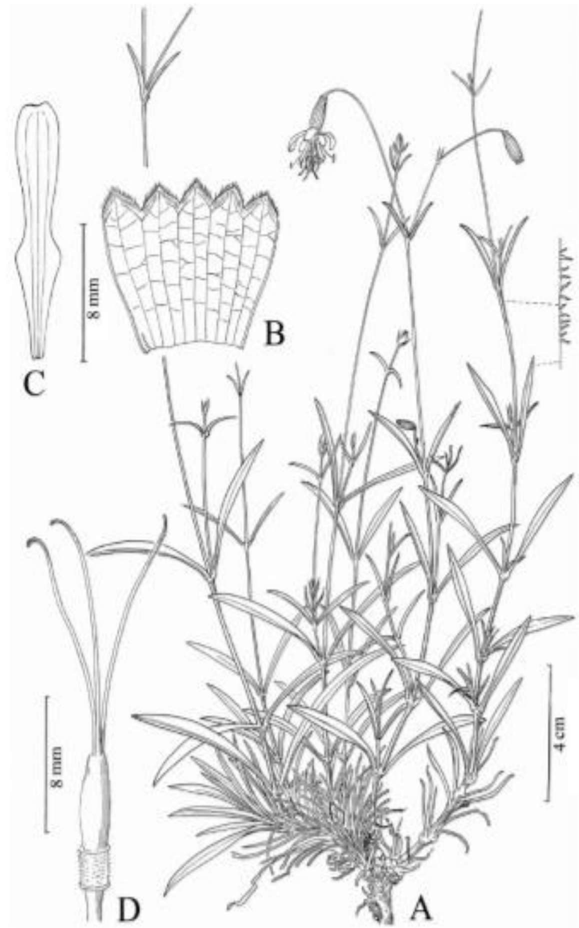

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Effective publication in the journal, available to Botanist

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

Abstract / Summary / Synopsis.

Previously it was required to write in Latin.

Botanical name in Latin

Rank indicated

Specimens examined

Taxonomic Description

Type Specimen indicated

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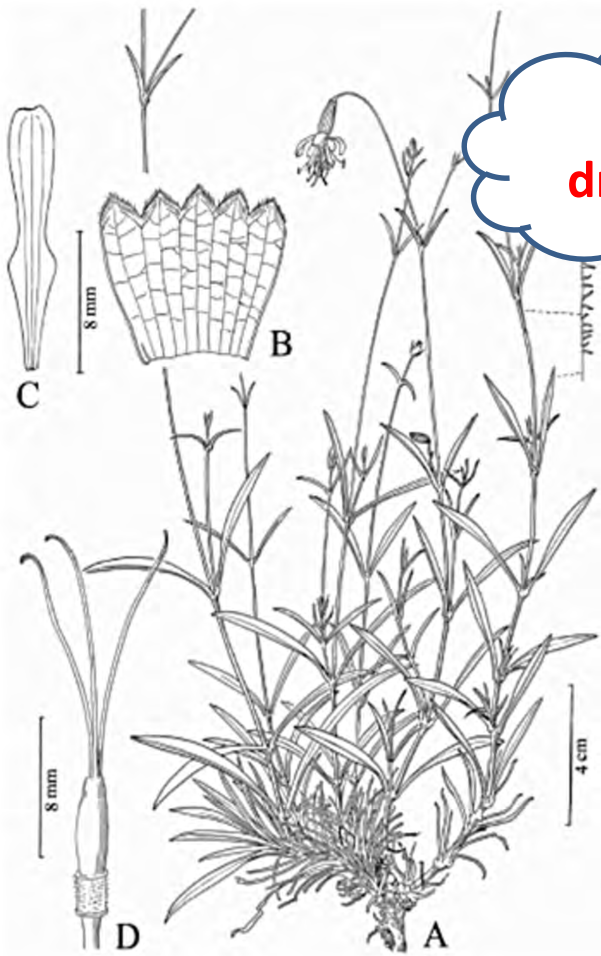

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Table 1. Main morphological differences between *Silene langshanensis* and *S. scabrifolia*.

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

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

Taxonomic Key for Identification

Acknowledgements

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

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Taxon	Grey Wolf	Date palm
Kingdom	Animalia	Plantae
Phylum	Chordata	Angiospermophyta
Class	Mammalia	Monocotyledoneae
Order	Carnivora	Palmales
Family	Canidae	Arecaceae
Genus	*Canis*	*Phoenix*
Species	*lupis*	*dactylifera*

Descriptive Terminology in Plant Taxonomy

Definition

Descriptive terminology refers to the **morphological features** used to identify and classify plants.
Based on **vegetative** and **reproductive** characteristics.

Morphological Features for Plant Identification

Leaf Characteristics – Shape (oval, lanceolate, lobed), arrangement (opposite, alternate), margin (serrated, smooth).
Stem Structure – Woody or herbaceous, branching pattern, presence of thorns.
Root System – Taproot (e.g., dicots) vs. Fibrous (e.g., monocots).
Flower Parts – Petal shape, symmetry (radial/bilateral), inflorescence type.
Fruit & Seed – Dry vs. fleshy, seed number, dispersal mechanism.

Vegetative vs. Reproductive Characteristics

Vegetative (Non-reproductive parts):

Leaves – Shape, venation, arrangement.
Stem – Growth habit (erect, creeping, climbing).
Roots – Type and structure.

Reproductive (Flower & fruit traits):

Flower Structure – Presence of sepals, petals, stamens, and pistils.
Pollination Mechanism – Wind, insect, bird-pollinated flowers.
Fruit Type – Simple, aggregate, or multiple fruits.

Importance of Descriptive Terminology

Essential for plant identification & classification.
Helps distinguish closely related species.
Used in floras, field guides, and herbarium studies.

Plant Identification Methods

Definition

Plant identification is the process of determining the correct name of a plant using morphological, anatomical, and molecular characteristics.

Various methods are used for accurate identification.

Taxonomic Keys (Dichotomous Keys)

Definition: A step-by-step tool that helps in identifying plants based on contrasting characteristics.

Types:

Dichotomous Key – Two contrasting choices at each step (e.g., "Leaves opposite" vs. "Leaves alternate").

Polyclave Key (Multiple-access key) – Uses multiple characteristics at once.

Example:

Step 1: Leaves simple → Go to Step 2

Step 2: Flowers yellow → Species A

Step 2: Flowers white → Species B

Dichotomous Key

1a. It has fur.................................**It belongs to the class Mammalia.**

1b. It does not have fur.................................**Go to number 2.**

2a. It cannot change locations (move) on its own.................................**Go to number 3.**

2b. It can change locations on its own.................................**Go to number 4.**

3a. It has a flower.................................**It belongs to the phylum Phanerogams (flowering plants).**

3b. It does not have a flower.................................**It belongs to the phylum Cryptogams (non-flowering plants).**

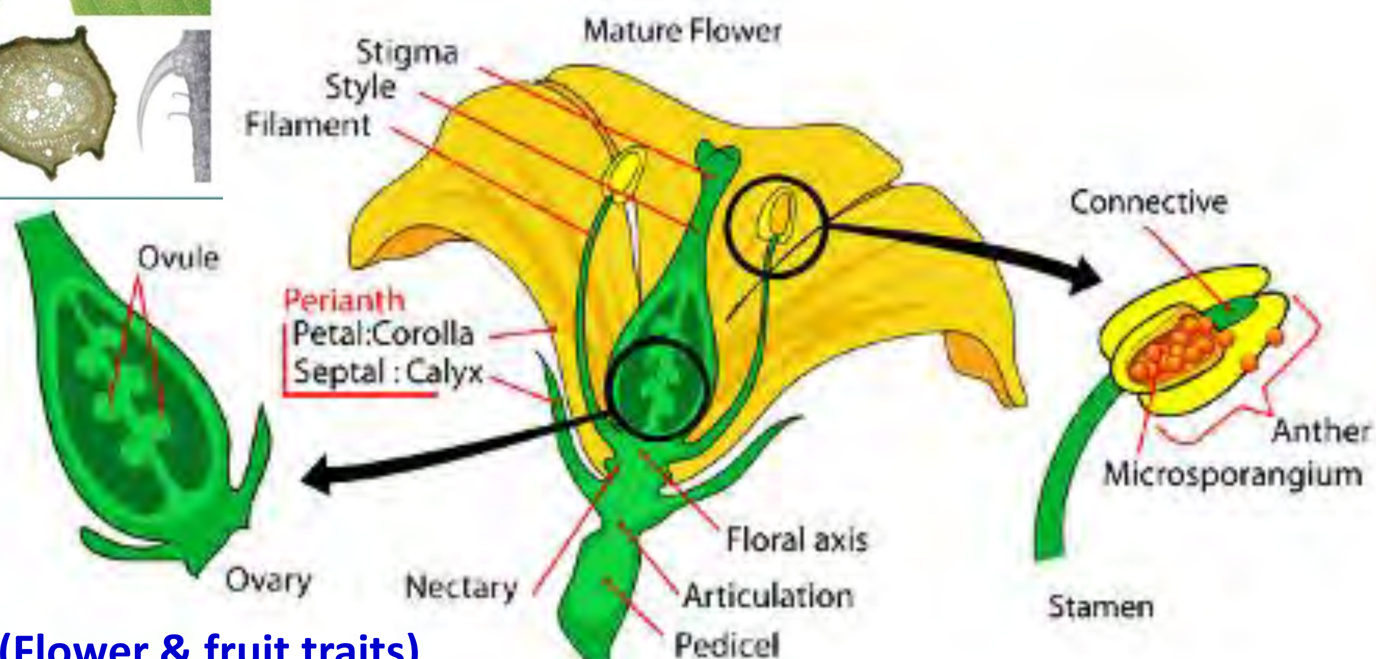
4a. It has feathers and can fly.................................**It belongs to the class Aves.**

4b. It cannot fly.................................**Go to number 5.**

5a. It does not have a backbone.................................**It belongs to the phylum Cnidaria.**

5b. It swims in water.................................**It belongs to the phylum Chondrichthyes.**

Vegetative (Non-reproductive parts)

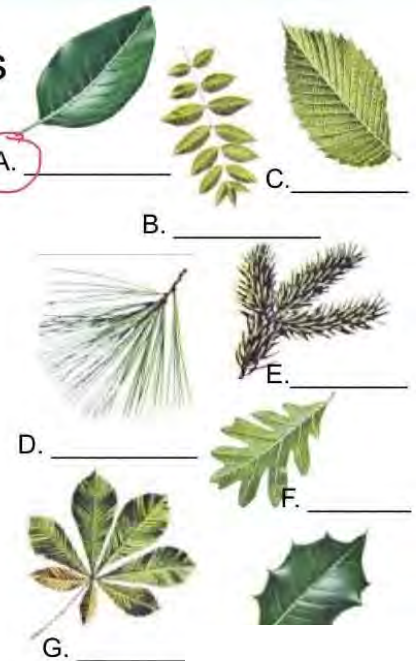


Reproductive (Flower & fruit traits)

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

Dichotomous Key For Leaves

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



Dichotomous Key

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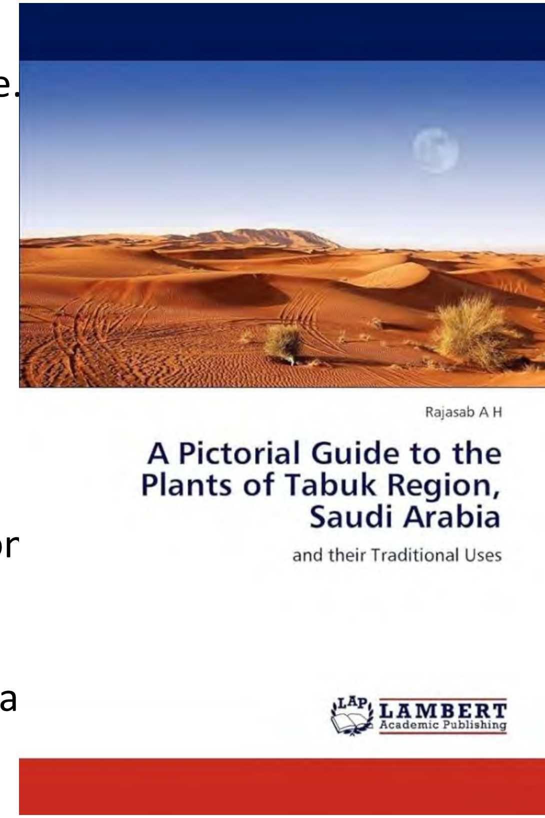
Herbarium Specimens

Definition: Dried, pressed plant samples preserved on sheets for reference.



Components of a Herbarium Sheet:

Plant specimen (leaf, flower, fruit, stem).

Label with scientific name, collector's name, date, and location.

Examples of Major Herbaria:

Kew Herbarium (UK)

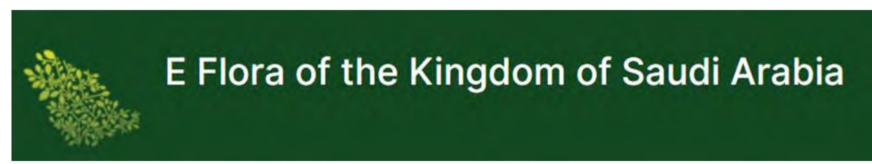
Indian Botanical Garden Herbarium

New York Botanical Garden Herbarium

Importance: Permanent record for plant study, taxonomy, and conservatior

Field Guides

Definition: Illustrated books/manuals used to identify plants in their natura habitat.



Features:

High-quality images or drawings.

Simple descriptions of plant features.

Information on habitat, flowering season, and distribution.

Examples:

"E Flora of the Kingdom of Saudi Arabia"

"Flora of the Kingdom of Saudi Arabia, Illustrated

Importance: Useful for botanists, ecologists, and nature enthusiasts for real-time plant identification.

QUESTIONS FOR PRACTICE

Multiple Choice Questions (MCQs)

Who is credited with creating the first herbarium? a) Carl Linnaeus
b) Luca Ghini
c) Andrea Cesalpino
d) Alexander von Humboldt

Answer: b) Luca Ghini
What was the initial name given to herbariums? a) Hortus Siccus
b) Plant Archive
c) Botanical Repository
d) Herbarium Garden

Answer: a) Hortus Siccus
Which chemical is commonly used to prevent pest attacks in herbarium specimens? a) Ethanol
b) Mercuric chloride
c) Sodium chloride
d) Hydrogen peroxide
Answer: b) Mercuric chloride

Fill in the Blanks

- The first herbarium was created by _______. **(Luca Ghini)**
- Herbarium sheets are usually ______ inches in size. **(11.5 x 16.5)**
- _______ is known for standardizing plant classification using binomial nomenclature. **(Carl Linnaeus)**
- The initial name for a herbarium was _______. **(Hortus Siccus)**
- The largest herbarium collection is found at _______. **(Royal Botanic Gardens, Kew)**
- The process of treating specimens with chemicals to prevent pest attacks is called _______. **(Poisoning)**
- _______ is an example of a modern online herbarium database. **(GBIF or JSTOR Global Plants)**
- The part of the herbarium sheet where scientific details are written is called the _______. **(Label)**
- The drying process for plant specimens typically takes ______ days. **(7-14)**
- The scientific study of plants is known as _______. **(Botany)**

Short Answer Questions

Q. What is a herbarium?
Ans. A herbarium is a collection of preserved plant specimens used for scientific study and reference.

Q. Name two chemicals used for poisoning herbarium specimens.
Ans. Mercuric chloride and thymol.

Q. What is the purpose of mounting plant specimens?
Ans. To preserve and display them systematically for study.

Q. Why are herbarium specimens labeled?
Ans. provide information on the plant's scientific name, collection details, and habitat.

Q. What does GBIF stand for?
Ans. Biodiversity Information Facility.

Q. Who introduced the concept of pressing and mounting plants for preservation?
Ans. Luca Ghini.

Q. What is the significance of herbariums in forensic science?
Ans. They help identify plant species involved in criminal investigations.

Q. What role did Alexander von Humboldt play in herbarium studies?
Ans. He documented thousands of plant species and helped standardize herbarium practices.

Q. How do modern herbaria contribute to climate change studies?
Ans. By providing historical records of plant distribution and changes over time.

Q. What is symplastic transport in plants?
Ans. The movement of substances through the cytoplasm of connected cells.

True or False

- The first herbarium was created by Carl Linnaeus. **(False)**
- Herbarium specimens help in biodiversity conservation. **(True)**
- Andrea Cesalpino developed the binomial nomenclature system. **(False)**
- Digitization of herbaria has improved global access to plant data. **(True)**
- Herbariums play no role in forensic science. **(False)**
- The standard herbarium sheet size is 11.5 x 16.5 inches. **(True)**
- Drying plant specimens takes 1-2 days. **(False)**
- Herbariums were initially called "dry gardens" or "hortus siccus." **(True)**
- A herbarium is only useful for taxonomy and has no practical applications. **(False)**

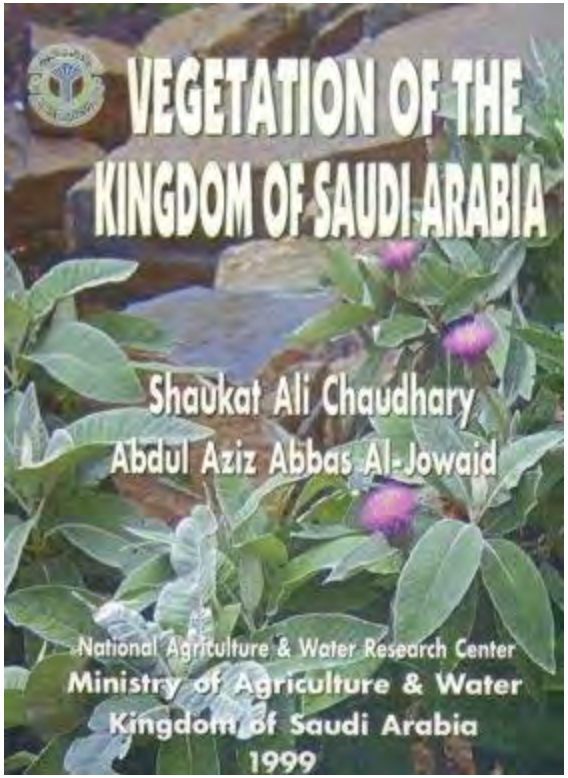
Match the Following

Column A	Column B
1. Botanic garden	a. First herbarium
2. Royal Botanic Gardens, Kew	b. Binomial nomenclature
3. The process of treating specimens with chemicals to prevent pest attacks	c. Standardized herbarium practices
4. Luca Ghini	d. Plant specimen storage
5. JSTOR Global Plants	e. Poisoning
6. Taxonomy	f. Chemical treatment for preservation
7. Herbarium Sheet	g. Digital herbarium database
8. Poisoning	h. Largest herbarium collection
9. Alexander von Humboldt	i. Classification of plants
10. Carl Linnaeus	j. conservation

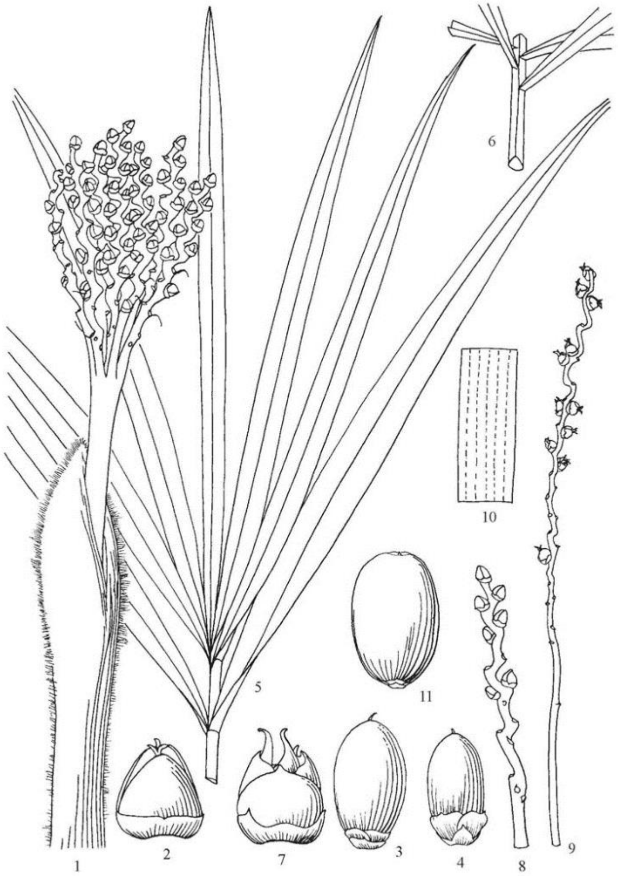
1→j, 2→h, 3→e, 4→a, 5→g, 6→i, 7→d, 8→f, 9→c, 10→b

WEEK 4

The FLORA is the main Resources of Taxonomic Information



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



Description of plant need taxonomic terminology

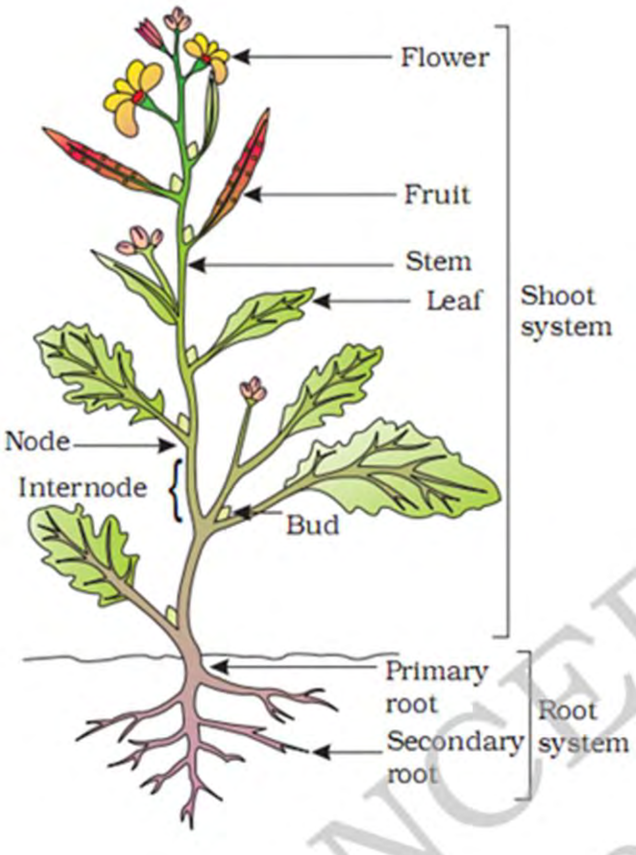
Phoenix dactylifera Linnaeus, Sp. Pl. 2: 1188. 1753.

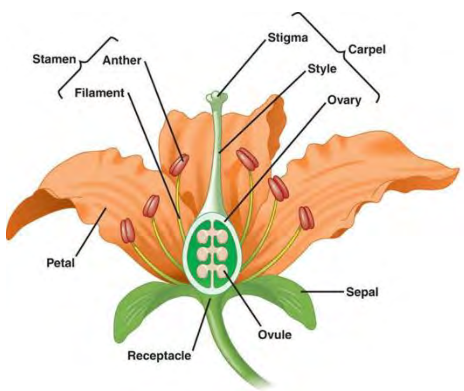
Stems solitary or clustered and then with few shoots, to 30 m tall, to 50 cm in diam., rough with persistent, diamond-shaped leaf bases. Leaves 3-5 m; sheath and petiole to 1 m; rachis 1-2 m; acanthophylls many per side of rachis; pinnae to 200 per side of rachis, linear, irregularly arranged and spreading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

PLANT STRUCTURE (MORPHOLOGY AND ANATOMY)

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

Vegetative and Reproductive Parts of Plants





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

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

❑ **Internodes :**
The internodes distance one node from another.

❑ **Stem:**
The main body or stalk of a plant or shrub, typically rising above ground.

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

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

❑ **Fruit:**
A fruit is the seed-bearing structure in flowering plants formed from the ovary after flowering

Habit of Plants

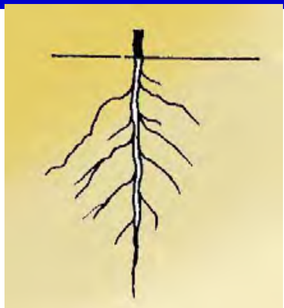
Herb. A usually low, soft or coarse plant with annual aboveground stems.
Shrub. A much-branched woody perennial plant usually without a single trunk.
Tree. A tall, woody perennial plant usually with a single trunk.
Vine *or* Liana. An elongate, weak-stemmed, often climbing annual or perennial plant,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

shrubs

Tree

Vines

Different Types of Roots



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

Adventitious Roots

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

Fibrous Root

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

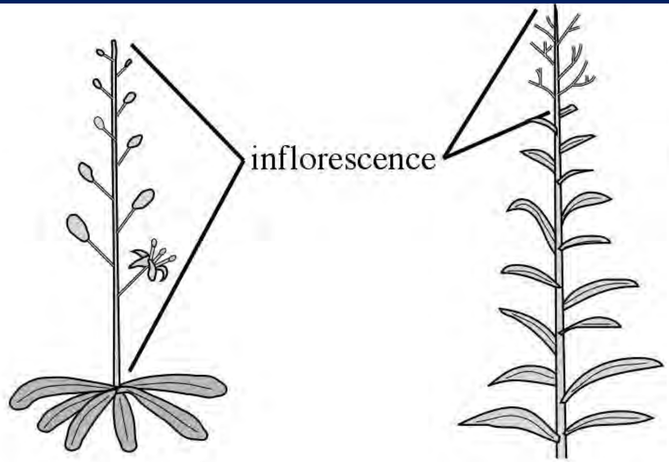
❖ Prop roots
The adventitious root when modified for aerial support, are called prop roots

Respiratory Roots:

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

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

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

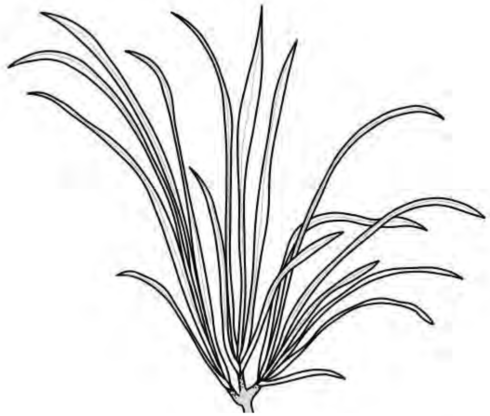


Acaulescent

❖ Apparently a stemless plant having very inconspicuous reduced stem

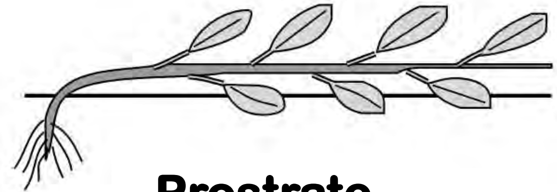
Caulescent

❖ With a distinct stem



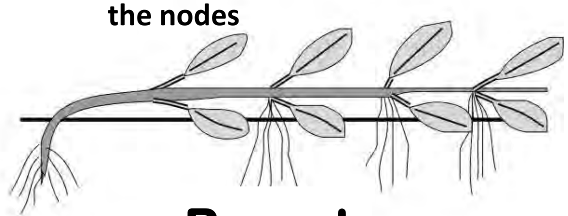
Cespitose

❖ Short, much-branched, plant forming a cushion



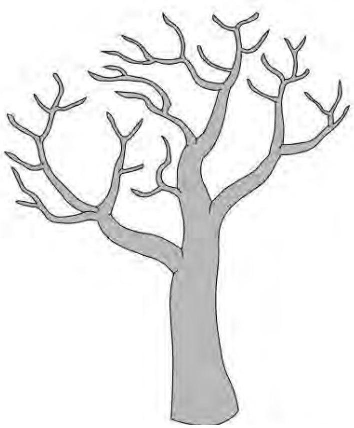
Prostrate

❖ Trailing or lying flat, not rooting at the nodes



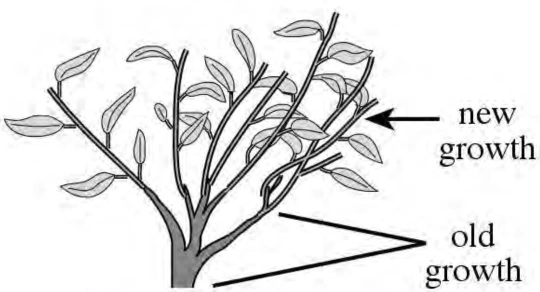
Repent

❖ Creeping or lying flat and rooting at the nodes



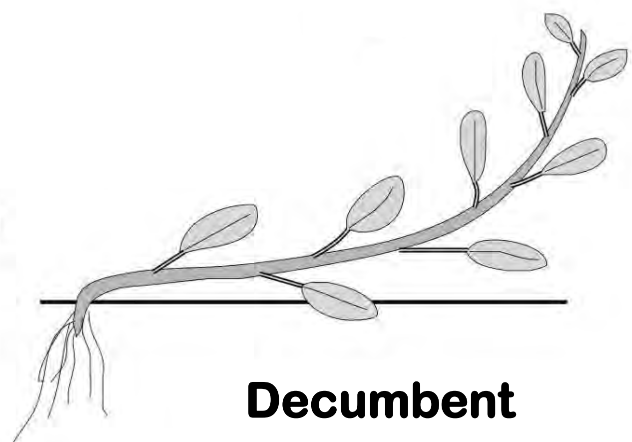
Arborescent

❖ Tree-like in appearance and size



Suffrutescent

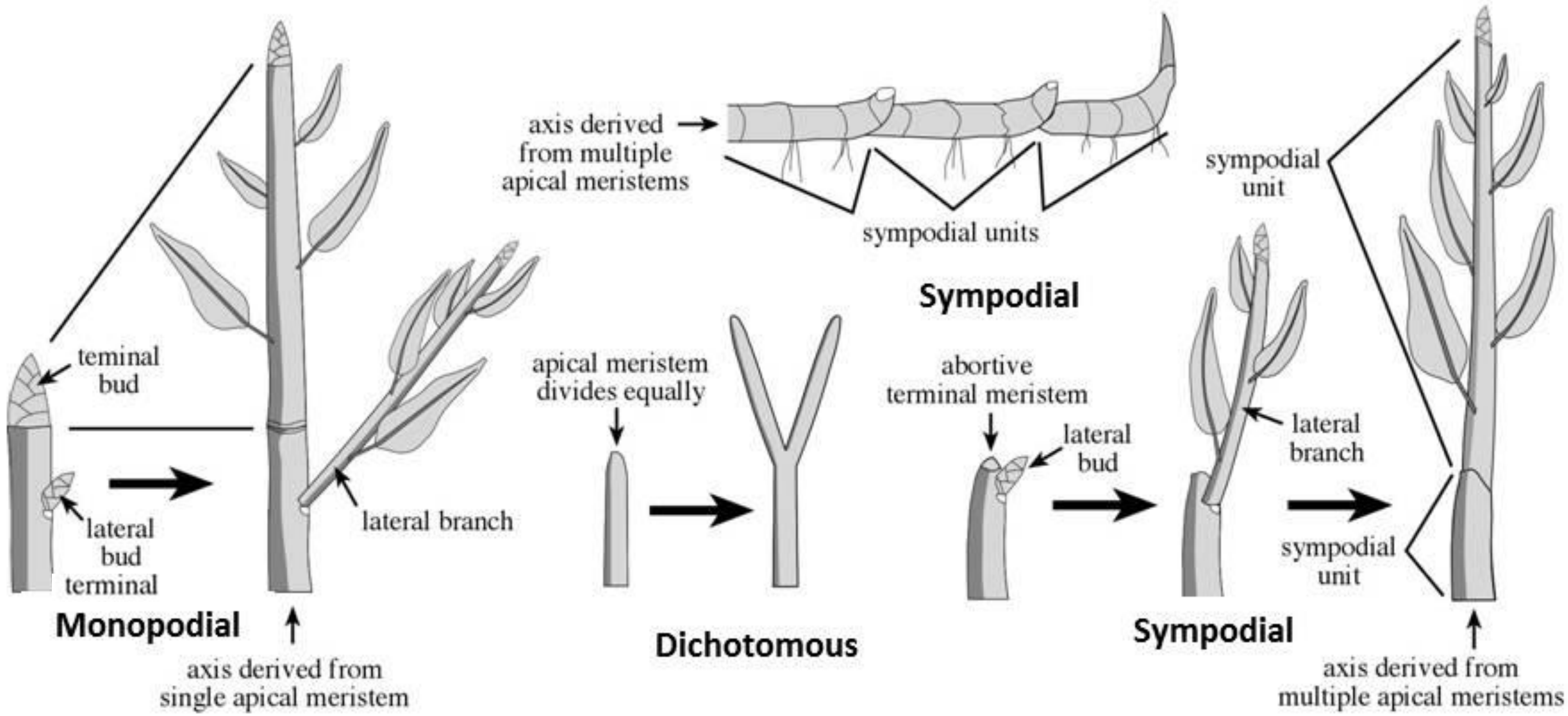
❖ Woody basally, herbaceous apically



Decumbent

❖ Lying on the ground with the tips ascending

Stem Branching



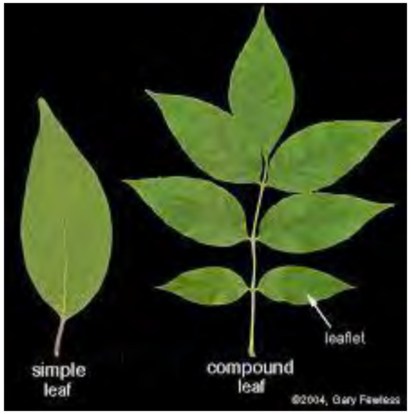
- **Monopodial:** Branching with a main axis and reduced or missing

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

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

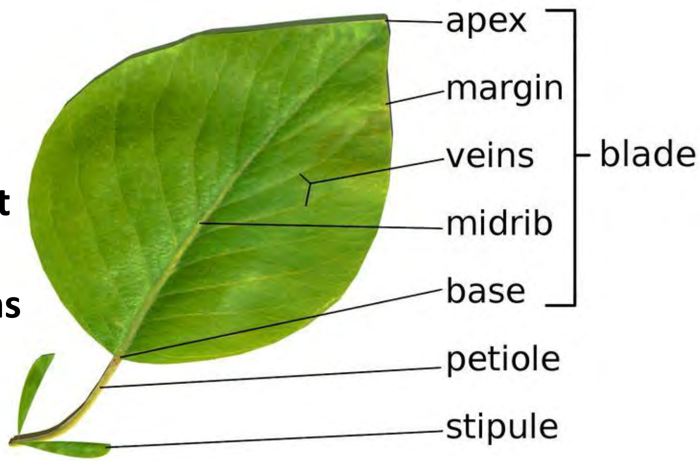
LEAVES

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



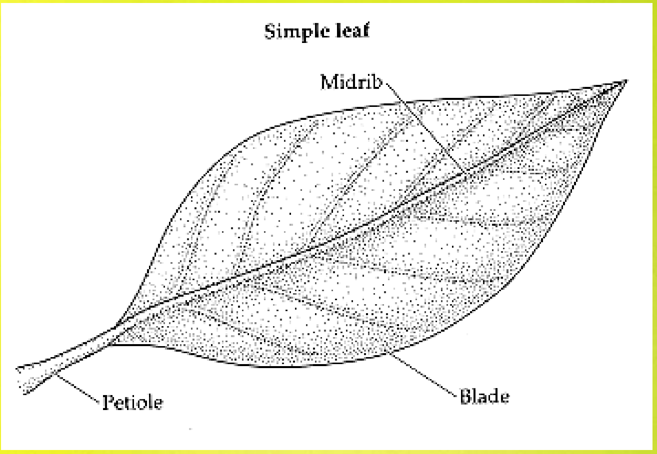
There are large number of terminology leaf based on:

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



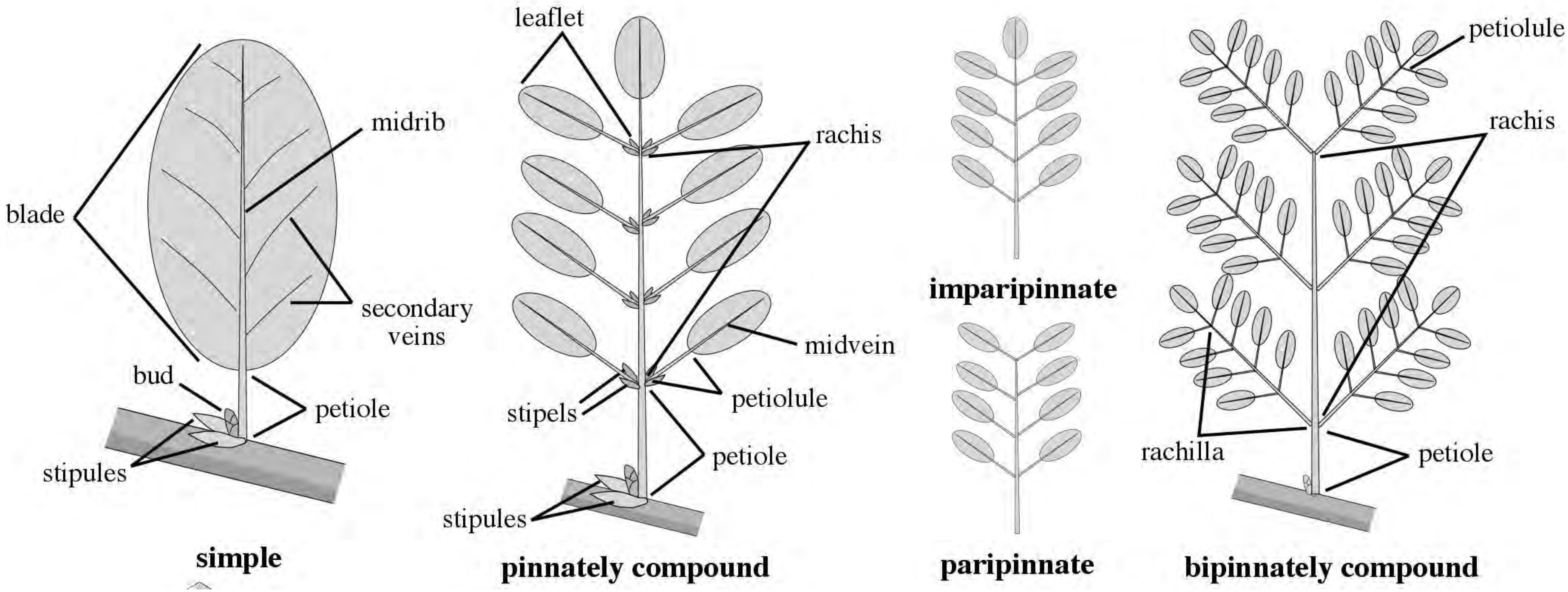
Leaves

External Parts of the Leaf:



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

Leaf Types

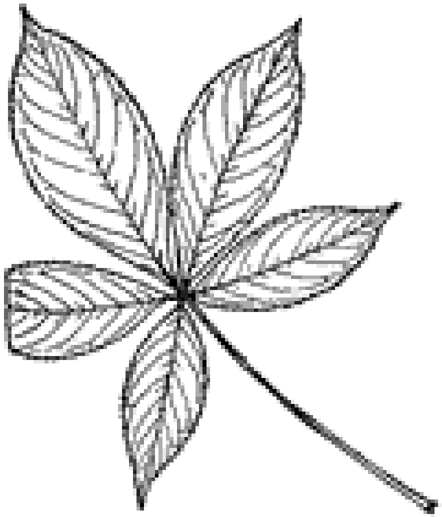


(a) Simple leaf. ورقة بسيطة A simple leaf is a single, undivided blade.

(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.

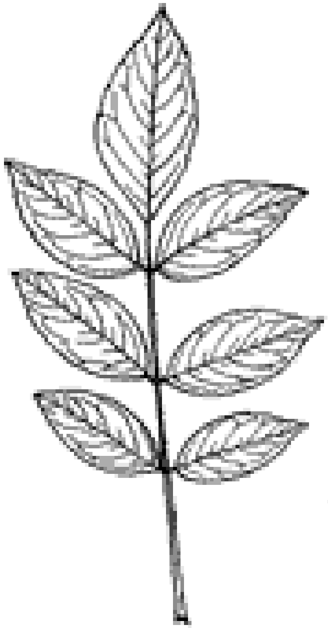
(c) Doubly compound leaf (Bipinnate). مركبة ريشية مزدوجة In a doubly compound leaf, each leaflet is divided into smaller leaflets.

Compound Leaves



palmately compound

- ❖ With leaflets from one point at end of petiole

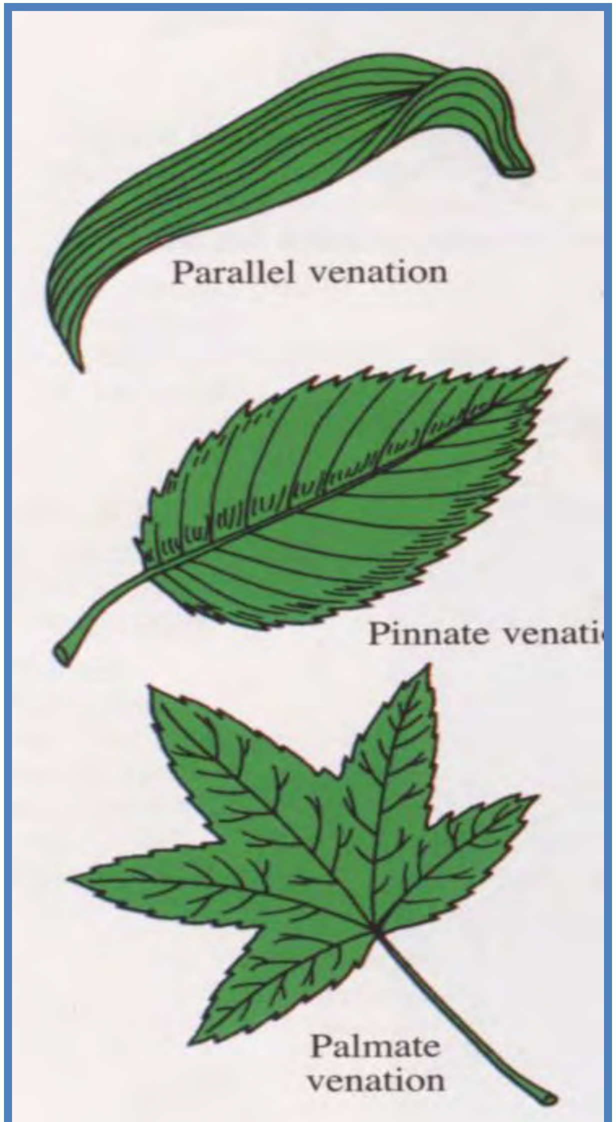


pinnately compound

- ❖ With leaflets arranged oppositely or alternately along a common axis

- ❖ With two orders of leaflets, each pinnately compound

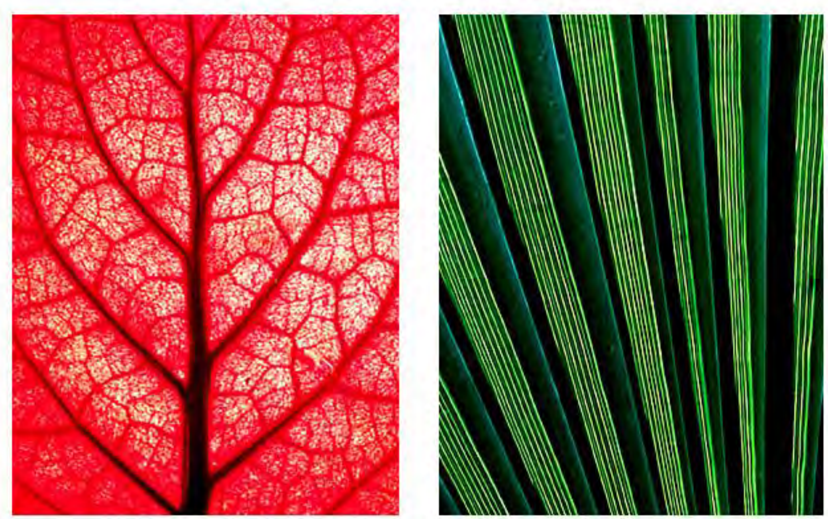
Leaf Venation



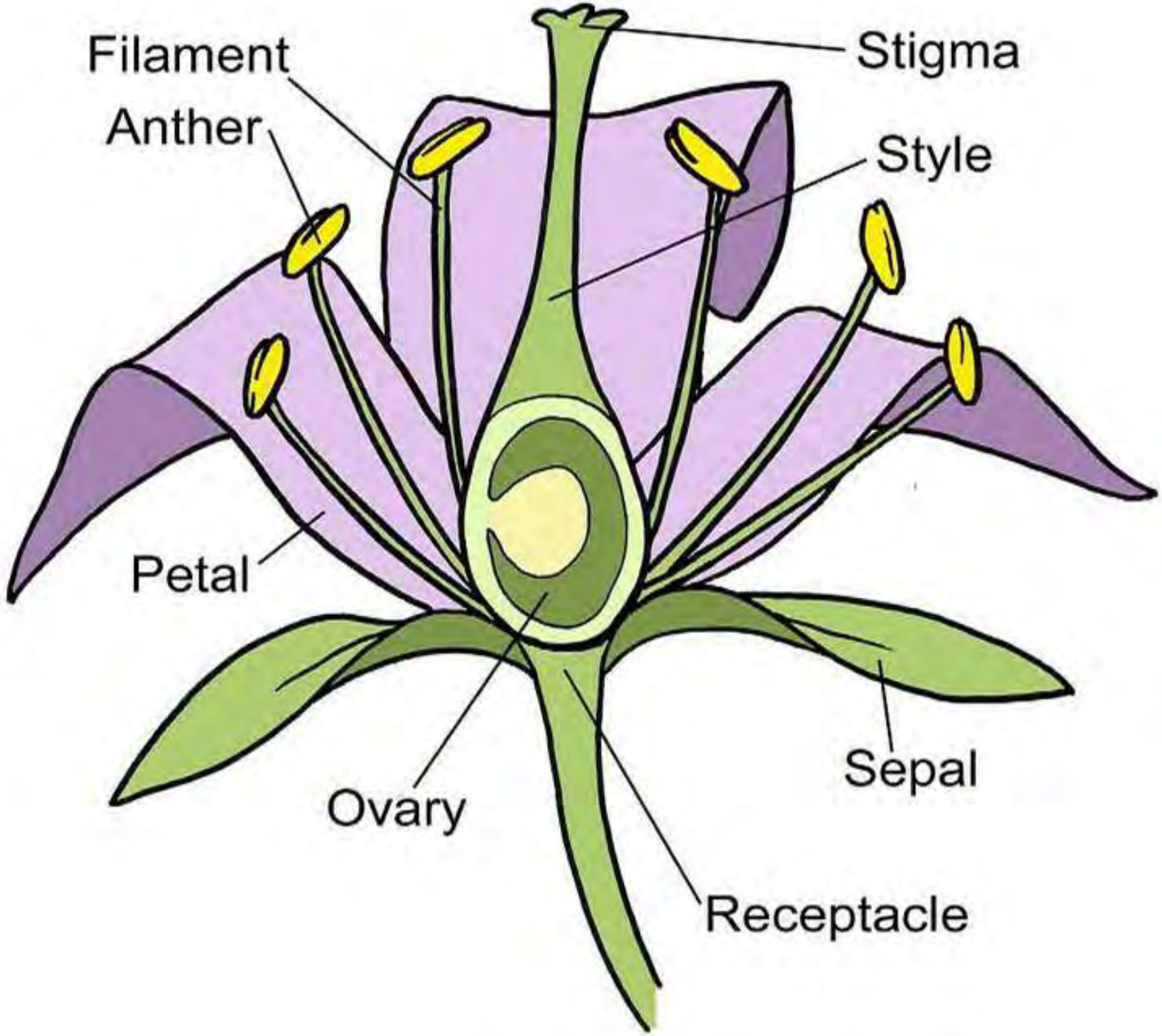
- **Parallel-** متوازي veins extend the entire length of the leaf with little or no cross-linking
- **Pinnate-** ريشي leaves have one major vein from which others branch
- **Palmate-** راحي leaves have several veins which branch

Dicot and Monocot Leaves

Reticulate
شبكي

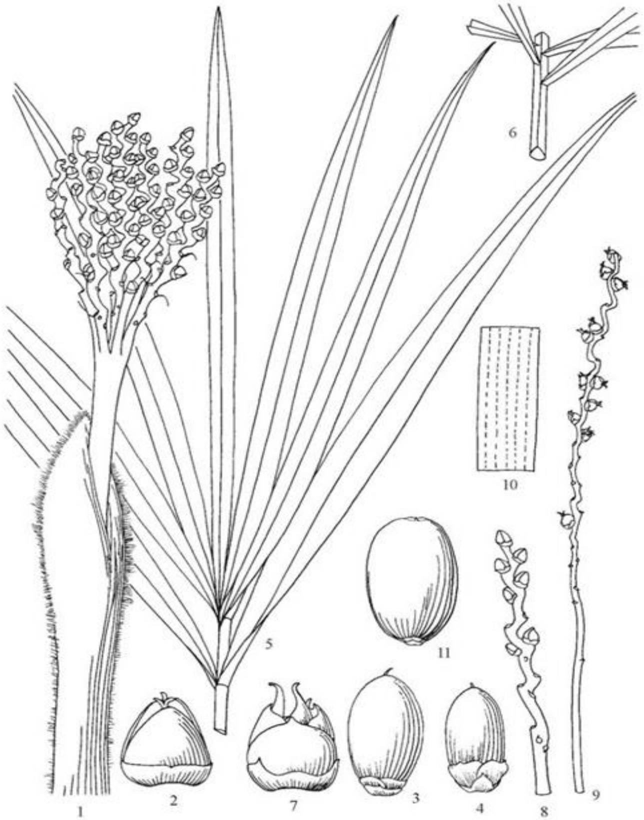


Parallel
متوازي



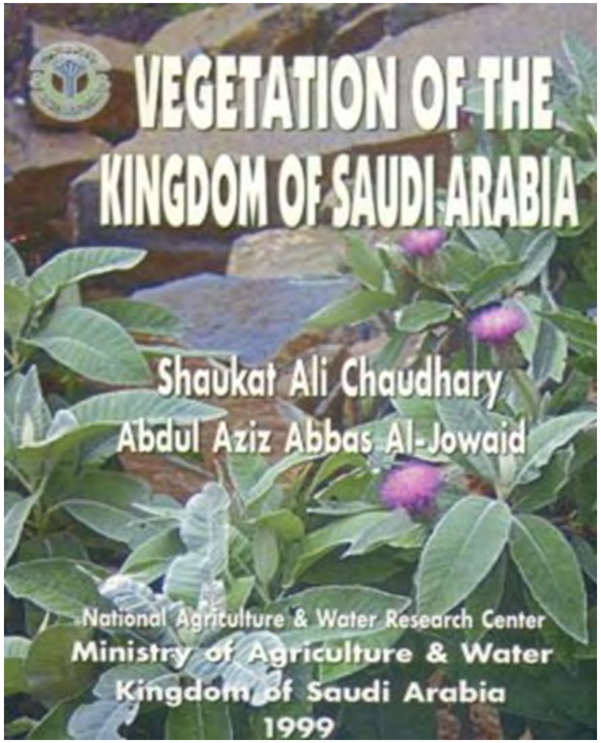
Filament + Anther = Stamen

Stigma + Style + Ovary = Carpel



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.



First mid Term Model question

First Term Model question

Multiple choice question

Binomial nomenclature consists of how many Latin words?

a) One
b) Two
c) Three
d) Four
Answer: b) Two

What is the lowest major taxonomic group in plant classification?

a) Order
b) Family
c) Genus
d) Species
Answer: d) Species

The scientific name of Mango is:

a) Mangifera indica
b) Musa paradisiaca
c) Oryza sativa
d) Phoenix dactylifera
Answer: a) Mangifera indica

First Term Model question

Multiple choice question

The study of plant diversity, relationships, and evolution is called:

a) Plant Morphology
b) Plant Anatomy
c) Plant Systematics
d) Plant Physiology
Answer: c) Plant Systematics

The **Index Kewensis** was published under the supervision of:

a) Bentham
b) Hooker
c) Linnaeus
d) APG
Answer: b) Hooker

The International Code of Nomenclature (ICN) is governed by:

a) UNESCO
b) WHO
c) IAPT
d) IUCN
Answer: c) IAPT

Which plant classification system divided plants into 24 classes based on reproductive parts?

a) Bentham and Hooker System
b) APG System
c) Linnaeus Sexual System
d) Natural System
Answer: c) Linnaeus Sexual System

How many species of angiosperms exist worldwide?

a) 10,000
b) 100,000
c) 250,000
d) 5.1 million
Answer: c) 250,000

First Term Model question

Fill in the blanks

1. ___________ introduced the binomial nomenclature system.
   Answer: Carl Linnaeus

2. The Bentham and Hooker system of classification is a _______ system.
   Answer: natural

3. The study of plant classification is called_________.
   Answer: taxonomy

4. The book **Species Plantarum** was published in ______.
   Answer: 1753

First Term Model question

Mark the True / False

1. Linnaeus classified plants based on their vegetative characteristics.
   Answer: False

2. The APG system is based on molecular phylogenetics.
   Answer: True

3. Species is the highest taxonomic rank.
   Answer: False

4. The herbarium technique includes steps such as drying, mounting, and labeling.
   Answer: True

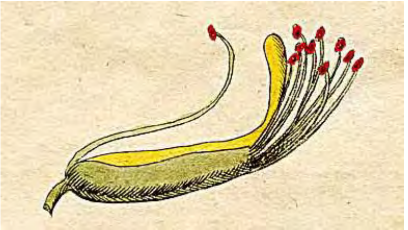
First Term Model question

Figure based question

1. Question: **Identify the condition based on Linnaean class?**

Answer: Triandria

2. Question: **Identify the condition based on Linnaean class?**



Answer: Diadelphia

First Term Model question

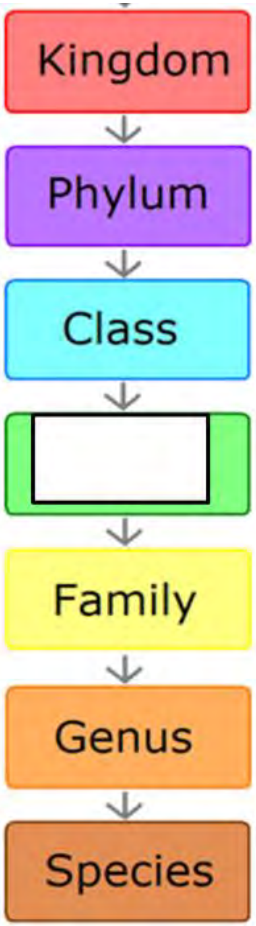
Short answer question

1. What are the principles of the International Code of Nomenclature (ICN)?
   Answer: The ICN is based on principles such as priority of publication, typification, and the rule that each taxonomic group has only one correct name.

2. Define herbarium.
   Answer: A herbarium is a collection of dried and pressed plant specimens systematically arranged for scientific study.

Image-Based Question

Question: fill the box given in the hierarchy **?**



Answer: Order

WEEK 5

First mid term exam (from Week 1-4)

WEEK 6

Applications of Plant Taxonomy

Plant taxonomy is essential in various scientific fields.
It helps in **biodiversity conservation, plant breeding, ecology, and evolutionary studies**.

Biodiversity Conservation

Definition: Protecting plant diversity by identifying and classifying species.

Role of Taxonomy:

Helps in documenting **endangered and rare species**.
Assists in **creating conservation strategies** (protected areas, seed banks).
Aids in monitoring **invasive species**.

Example:
Nepenthes rajah (Giant Pitcher Plant) classified as **endangered**, requiring conservation efforts.
Importance: Preserves plant genetic resources for future generations.

Plant Breeding Programs

Definition: Improving plant varieties for higher yield, disease resistance, and better quality.

Role of Taxonomy:
Helps in selecting **wild relatives** for crop improvement.
Identifies **genetic variations** between species.
Assists in hybridization programs.

Example:
Wheat Breeding – Hybridization of wild wheat species improved resistance to rust diseases.
Importance: Enhances food security and agricultural sustainability.

Volunteer Wildlife Conservation In Saudi Arabia

Improving plant varieties for higher yield

Ecological Studies

Definition: Understanding plant interactions with their environment.
Role of Taxonomy:
Identifies **indicator species** for climate and soil health.
Helps in studying **plant-pollinator relationships**.
Supports habitat restoration projects.
Example:
Mangrove Species Classification – Helps in coastal ecosystem restoration.
Importance: Aids in environmental protection and ecological balance.

Phylogenetic Analysis (Evolutionary Relationships)

Definition: Studying evolutionary links between plant species using **morphological and molecular data**.
Role of Taxonomy:
Uses **DNA sequencing** to trace plant ancestry.
Helps in reconstructing **evolutionary trees (phylogenies)**.
Explains how plants adapted over time.
Example:
Angiosperm Phylogeny Group (APG) – Modern classification of flowering plants based on DNA studies.
Importance: Provides insights into plant evolution and speciation.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QUESTIONS FOR PRACTICE

Multiple Choice Questions (MCQs)

What does plant taxonomy primarily deal with?
a) Chemical composition of plants
b) Naming, identifying, and classifying plants
c) Studying the photosynthesis process
d) None of the above
Answer: b) Naming, identifying, and classifying plants

Which level of the taxonomic hierarchy is the most specific?
a) Family
b) Order
c) Species
d) Genus
Answer: c) Species

What system assigns two names (Genus + Species) to plants?
a) Artificial system
b) Natural system
c) Binomial system
d) Phylogenetic system
Answer: c) Binomial system

Multiple Choice Questions (MCQs)

What is the lowest major taxonomic group in plant classification?
a) Order
b) Family
c) Genus
d) Species
Answer: d) Species

The scientific name of Mango is:
a) Mangifera indica
b) Musa paradisiaca
c) Oryza sativa
d) Phoenix dactylifera
Answer: a) Mangifera indica

The study of plant diversity, relationships, and evolution is called:
a) Plant Morphology
b) Plant Anatomy
c) Plant Systematics
d) Plant Physiology
Answer: c) Plant Systematics

Fill in the Blanks

Plant taxonomy provides a _______ naming system to avoid confusion worldwide.
Answer: universal

The basic unit of classification in taxonomy is _______.
Answer: species

Morphological keys are used to compare _______ with known plants for identification.
Answer: features

The scientific name of the mango plant is _______.
Answer: *Mangifera indica*

_______ taxonomy uses DNA analysis to determine plant relationships.
Answer: Molecular

Short Answer Questions

Question. Define plant taxonomy.
Answer: Plant taxonomy is the science of naming, identifying, classifying, and describing plants, organizing them into a structured system based on their characteristics and evolutionary relationships.

Question. What are the main components of taxonomy?
Answer: Characterization, Identification, Nomenclature, and Classification.

Question. Name any two modern approaches in plant taxonomy.
Answer: Molecular taxonomy and Chemotaxonomy.

Question. What is the significance of herbarium specimens?
Answer: Herbarium specimens serve as a permanent record for plant study, taxonomy, and conservation.

Question. What does the term "phylogenetic system" mean in taxonomy?
Answer: It refers to a classification system based on the evolutionary history and relationships among plants.

True or False

Taxonomy and systematics are completely unrelated fields.
Answer: False

Bentham and Hooker's system is an example of a natural system of classification.
Answer: True

The family Arecaceae belongs to the order Caryophyllales.
Answer: False

DNA barcoding is a tool used in chemotaxonomy.
Answer: False

The presence of alkaloids is a key feature used in chemotaxonomy.
Answer: True

Match the Following

Column A	Column B
1. Binomial System	a) Naming plants (Genus + Species)
2. Artificial Classification	b) Based on external traits
3. Molecular Taxonomy	c) Uses DNA sequencing
4. Nomenclature	d) Assigning scientific names
5. Herbarium	e) Preserved plant specimens

Answers:
1 → a, 2 → b, 3 → c, 4 → d, 5 → e

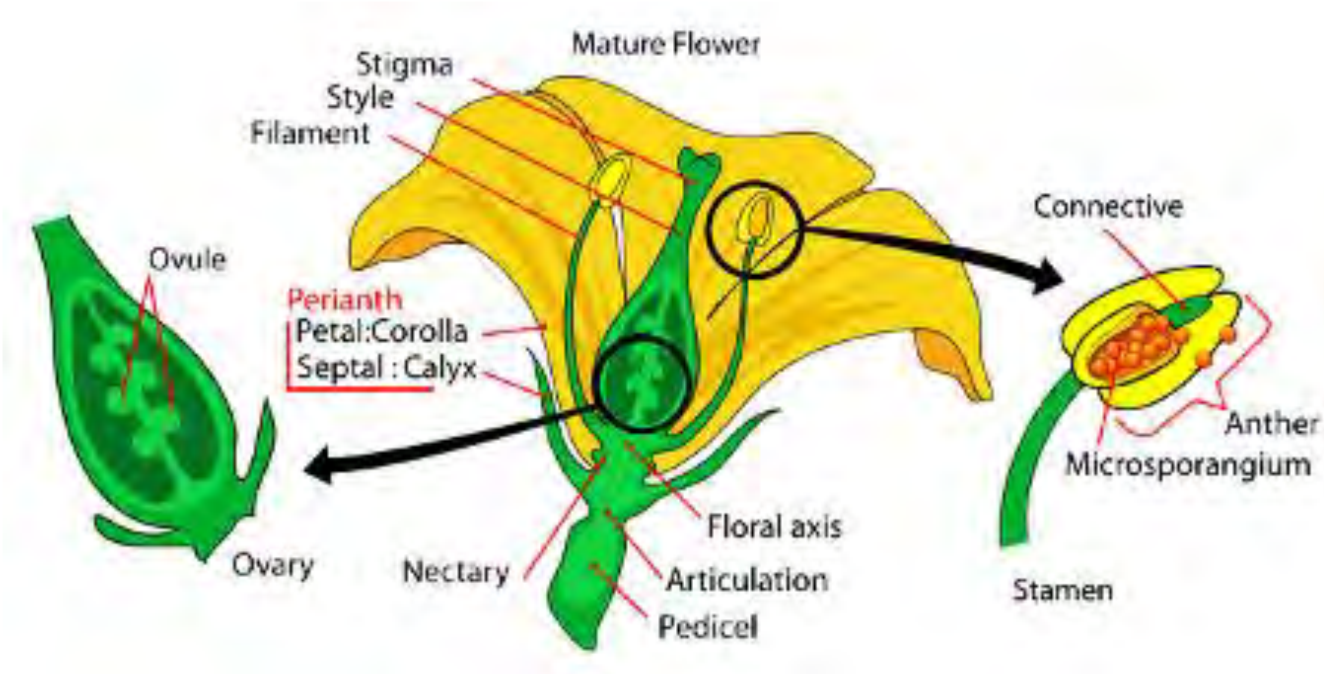
Image-Based Question

Question: Identify types of morphological features used in descriptive terminology:

Answer: Vegetative (Non-reproductive parts)

Image-Based Question

Question: Identify types of morphological features used in descriptive terminology:



Answer: Reproductive (Flower & fruit traits)

Image-Based Question

Question: Identify the matter in the image which used in the identification:

1a. It has fur...**It belongs to the class Mammalia**.

1b. It does not have fur..**Go to number 2**.

2a. It cannot change locations (move) on its own..**Go to number 3**.

2b. It can change locations on its own...**Go to number 4**.

3a. It has a flower..................................**It belongs to the phylum Phanerogams (flowering plants)**.

3b. It does not have a flower.............**It belongs to the phylum Cryptogams (non-flowering plants)**.

4a. It has feathers and can fly..**It belongs to the class Aves**.

4b. It cannot fly...**Go to number 5**.

5a. It does not have a backbone...**It belongs to the phylum Cnidaria**.

5b. It swims in water..**It belongs to the phylum Chondrichthyes**.

Answer: Taxonomic Keys (Dichotomous Keys)

WEEK 7

History and evolution of plant classification-taxonomic data set

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:

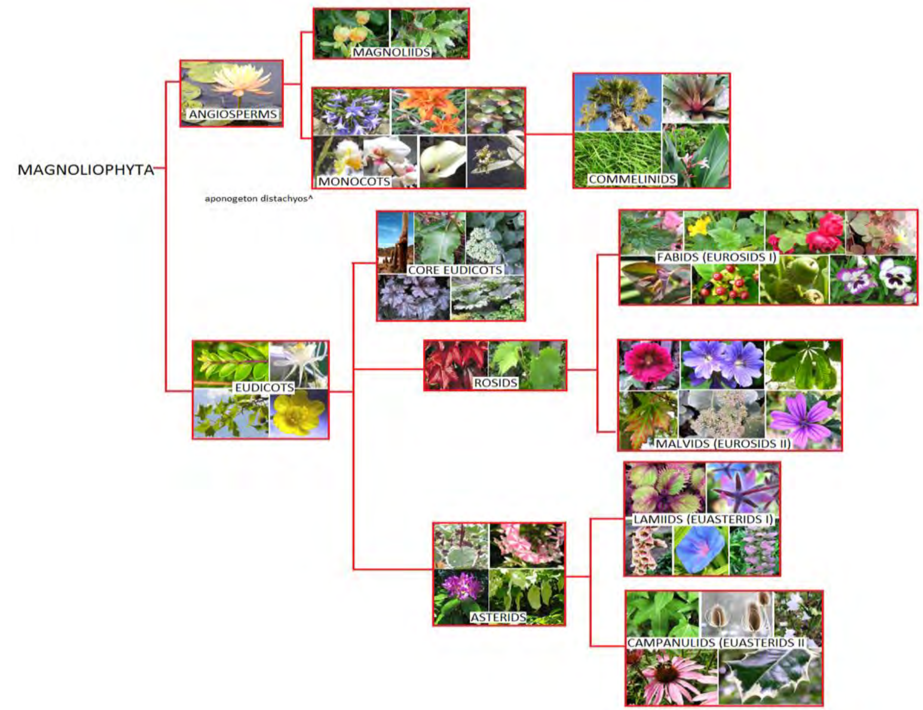
Class Dicotyledones:

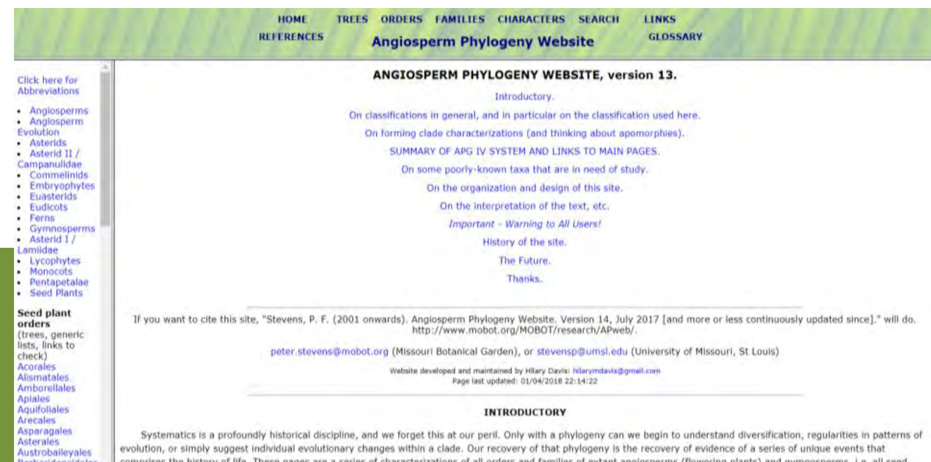
Subclass POLYPETALE with three series Series 1. THALAMIFLORÆ, Series 2. DISCIFLORÆ, Series 3. CALYCIFLORÆ;
Subclass DICOTYLEDONES (GAMOPETALÆ) with three series that is Series 1. INFERÆ, Series 2. HETEROMERÆ, Series 3. BICARPELLATÆ, and
Subclass DICOTYLEDONES MONOCHLAMIDEÆ.

Class Gymnospermeæ (Gymnosperms are placed between Dicotyledons and Monocotyledons)

Class Monocotyledones

❖ Angiosperm Phylogeny Group (APG)

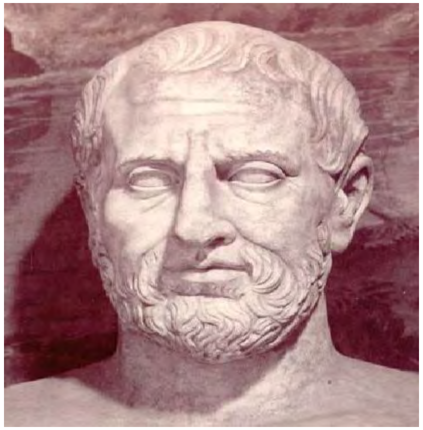




- ❖ The APG system of flowering plant classification is the modern, mostly molecular-based, system of plant taxonomy for flowering plants (angiosperms) being developed by the Angiosperm Phylogeny Group (APG).
- ❖ The APG was first published in 2008.
- ❖ Currently the APG IV system recognizes a total 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

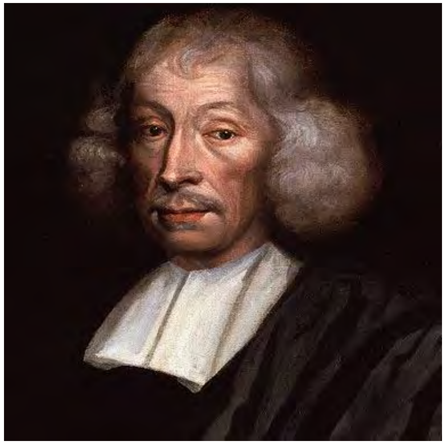
SYSTEM OF PLANT CLASSIFICATION

Preliterate Mankind / Folk taxonomies:



Theophrastus (372 BC to 287 BC):

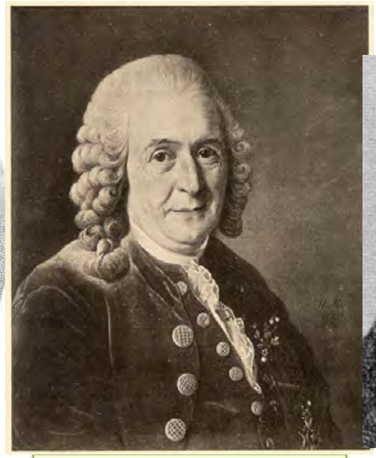
Andrea Cesalpino (1519-1603)



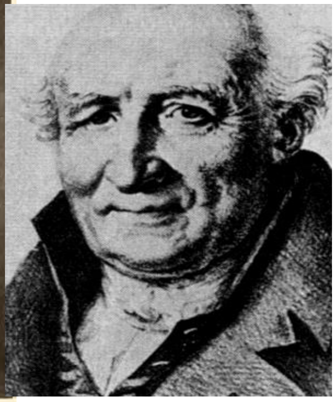
John Ray (1627-1705)

Michel Adanson (1727-1806)

J. P. de Tournefort (1656-1708)



Carolus Linneaus (1753)

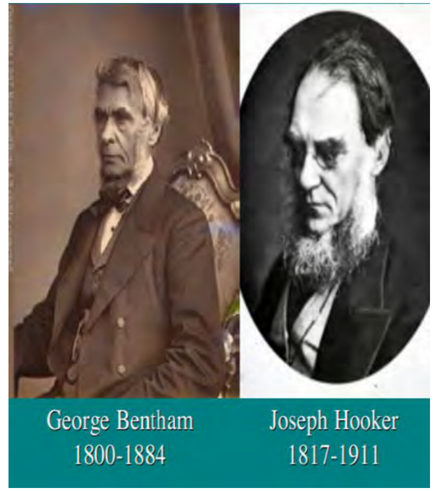


Antoine Laurent de Jussieu (1748-1836)

Jean B.P. Lamarck (1744-1829)

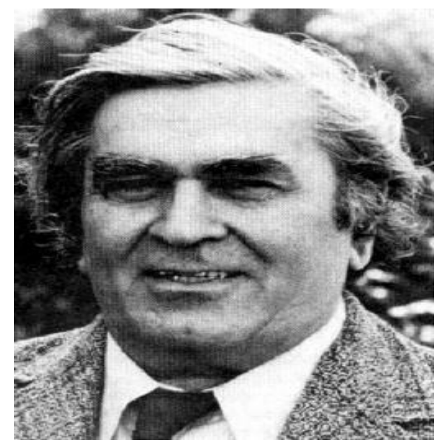
SYSTEM OF PLANT CLASSIFICATION

de Candolle
(1778–1841)



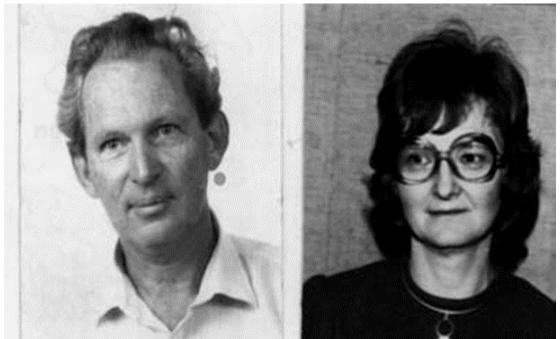
Charles E. Bessey
(1845-1915)

Auther Cronquist
1968

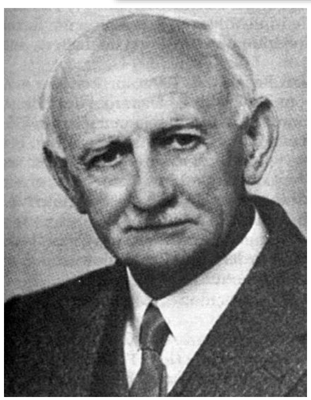


Armen Takhtajan
1969

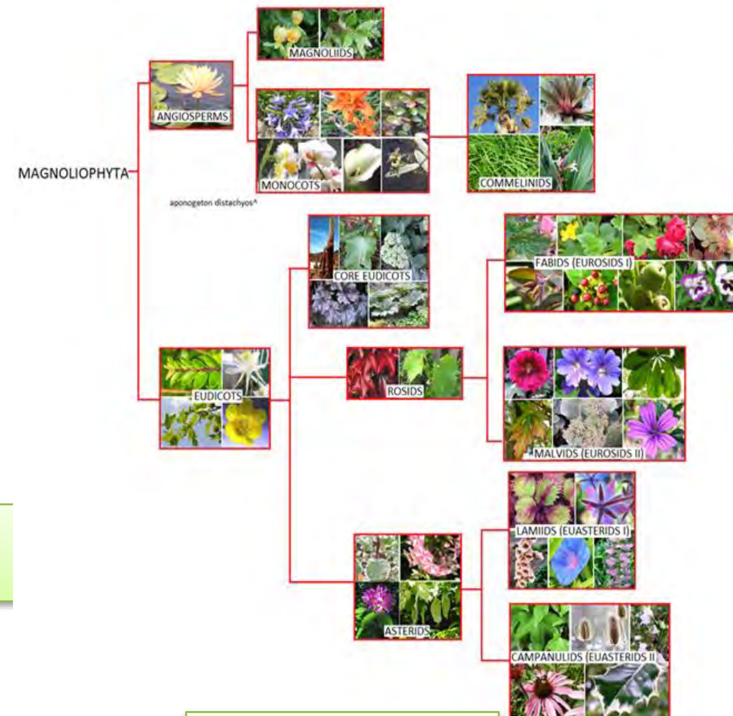
SYSTEM OF PLANT CLASSIFICATION



Rolf Dahlgren (1932-87)



John Hutchinson (1884-1972)



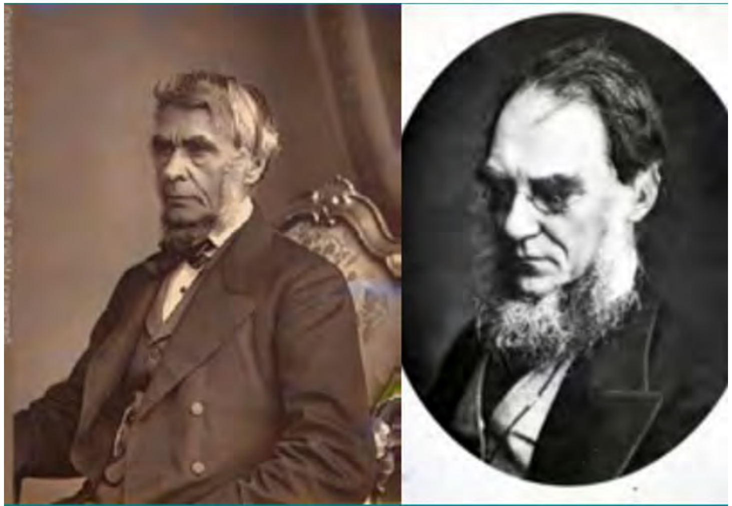
APG Angiosperm Phylogeny Group (1998)

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.



George Bentham 1800-1884

Joseph Hooker 1817-1911

❖ **Bentham and Hooker recognized three class:**

Class Dicotyledones:

Subclass POLYPETALE with three series

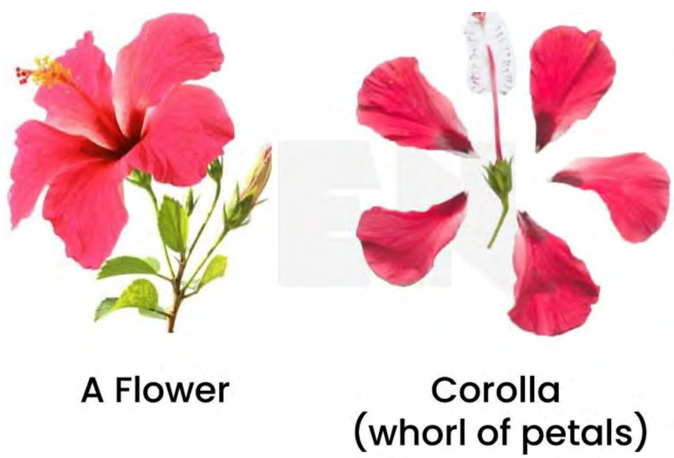
Series 1. THALAMIFLORÆ, Series 2. DISCIFLORÆ, Series 3. CALYCIFLORÆ;

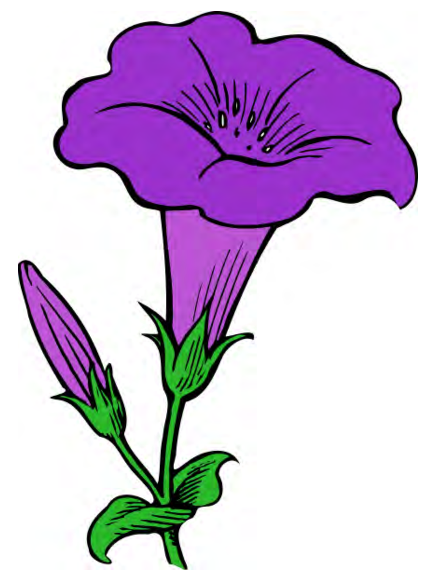
Subclass DICOTYLEDONES (GAMOPETALÆ) with three series that is Series 1. INFERÆ, Series 2. HETEROMERÆ, Series 3. BICARPELLATÆ, and

Subclass DICOTYLEDONES MONOCHLAMIDEÆ.

Class Gymnospermeæ (Gymnosperms are placed between Dicotyledons and Monocotyledons)

Class Monocotyledones





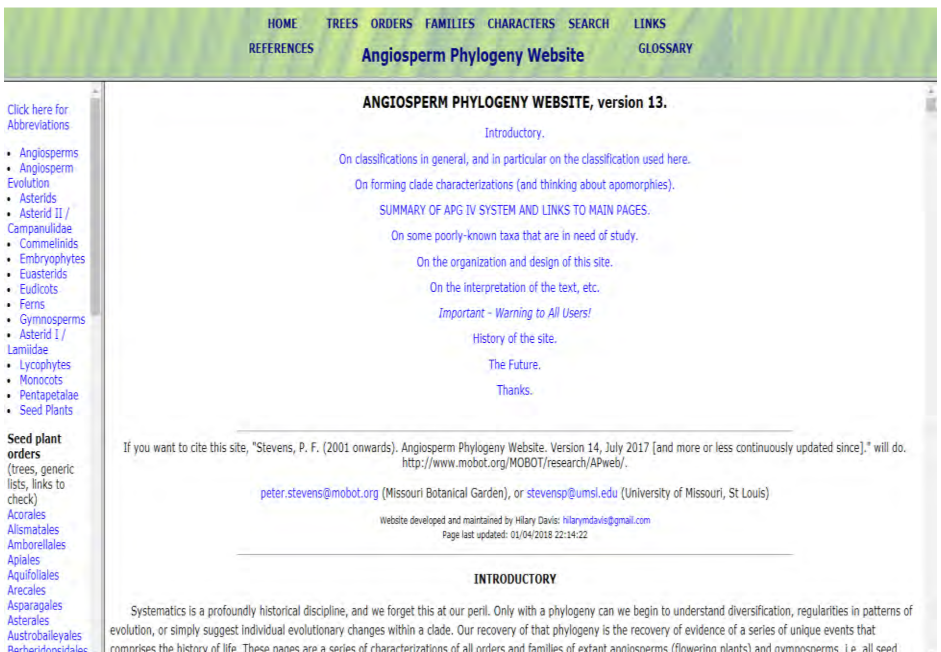
Angiosperm Phylogeny Group (APG)

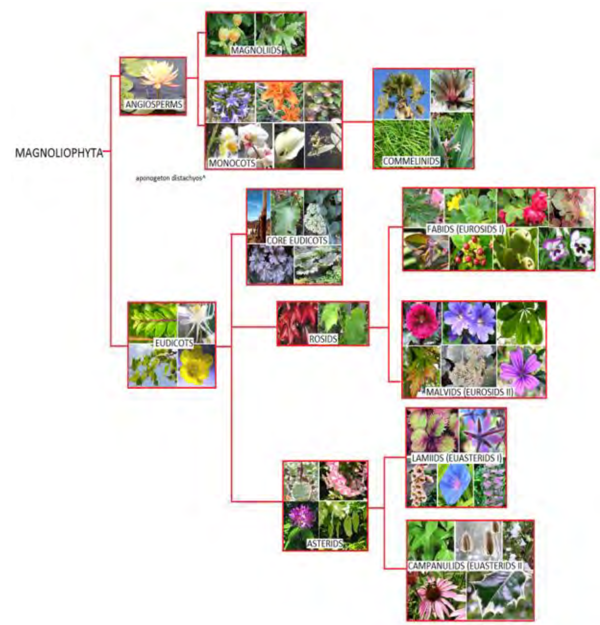
- **The APG system of flowering plant classification is the modern, mostly molecular-based, system of plant taxonomy for flowering plants (angiosperms) being developed by the Angiosperm Phylogeny Group (APG).**

- **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**





QUESTIONS FOR PRACTICE

Multiple Choice Questions (MCQs)

Who is known as the father of taxonomy?
a) Aristotle
b) Carl Linnaeus
c) Charles Darwin
d) Gregor Mendel
Answer: b) Carl Linnaeus

Which of the following plant classification systems is primarily molecular-based?
a) Bentham and Hooker System
b) Linnaean System
c) APG System
d) Artificial System
Answer: c) APG System

Binomial nomenclature consists of how many Latin words?
a) One
b) Two
c) Three
d) Four
Answer: b) Two

Multiple Choice Questions (MCQs)

What is the lowest major taxonomic group in plant classification?
a) Order
b) Family
c) Genus
d) Species
Answer: d) Species

The scientific name of Mango is:
a) Mangifera indica
b) Musa paradisiaca
c) Oryza sativa
d) Phoenix dactylifera
Answer: a) Mangifera indica

The study of plant diversity, relationships, and evolution is called:
a) Plant Morphology
b) Plant Anatomy
c) Plant Systematics
d) Plant Physiology
Answer: c) Plant Systematics

Multiple Choice Questions (MCQs)

The **Index Kewensis** was published under the supervision of:
a) Bentham
b) Hooker
c) Linnaeus
d) APG
Answer: b) Hooker

The International Code of Nomenclature (ICN) is governed by:
a) UNESCO
b) WHO
c) IAPT
d) IUCN
Answer: c) IAPT

Which plant classification system divided plants into 24 classes based on reproductive parts?
a) Bentham and Hooker System
b) APG System
c) Linnaeus Sexual System
d) Natural System
Answer: c) Linnaeus Sexual System

How many species of angiosperms exist worldwide?
a) 10,000
b) 100,000
c) 250,000
d) 5.1 million
Answer: c) 250,000

Fill in the Blanks

1. The fundamental unit in taxonomy is called the _______**species**.
2. The process of determining the correct name of a plant is called ____**identification**.
3. **Carl Linnaeus** _______introduced the binomial nomenclature system.
4. The Bentham and Hooker system of classification is a ________**natural** system.
5. The study of plant classification is called ______**taxonomy**.
6. The book __________**Species Plantarum** was published in **1753**.
7. The binomial nomenclature consists of two parts: ________**genus** and ______**species**.
8. The ________**herbarium** is a collection of preserved plant specimens.
9. The __________**APG IV system** recognizes 64 orders and 416 families of angiosperms.
10. Scientific names are treated as _______**Latin**, regardless of derivation.

Short Answer Questions

QUESTION. What is taxonomy?

Answer: Taxonomy is the science of naming, identifying, classifying, and organizing plants based on their similarities and evolutionary relationships.

QUESTION. What is binomial nomenclature?

Answer: Binomial nomenclature is a system of naming species using two Latin words: the first for the genus and the second for the species (e.g., *Mangifera indica*).

QUESTION. What are the principles of the International Code of Nomenclature (ICN)?

Answer: The ICN is based on principles such as priority of publication, typification, and the rule that each taxonomic group has only one correct name.

QUESTION. Define herbarium.

Answer: A herbarium is a collection of dried and pressed plant specimens systematically arranged for scientific study.

QUESTION. Name three sources of taxonomic evidence.

Answer: Morphology, DNA analysis, and phytochemistry.

True or False

1. Taxonomy is independent of zoological nomenclature. **(True)**
2. Linnaeus classified plants based on their vegetative characteristics. **(False)**
3. The APG system is based on molecular phylogenetics. **(True)**
4. Species is the highest taxonomic rank. **(False)**
5. The herbarium technique includes steps such as drying, mounting, and labeling. **(True)**

Match the Following

Column A	Column B
1. Herbarium	Collection of preserved plants
2. Linnaeus	Binomial nomenclature
3. Bentham and Hooker	Natural classification
4.APG System	Molecular-based classification
5. Species Plantarum	Book by Linnaeus

Answers:
1 → B, 2 → C, 3 → A, 4 → D, 5 → E

Image-Based Question

Question: What is the purpose of this tool?

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

Answer: A dichotomous key helps in the identification of plants by guiding users through a series of yes/no questions based on characteristics.

Image-Based Question

Question: What is this and why is it important in taxonomy

Answer: This is a herbarium specimen, used for plant identification, documentation, and reference in taxonomy.

Image-Based Question

Question: Identify the condition based on Linnaean class?

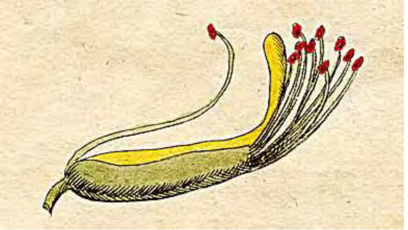
Answer: Monandria

Image-Based Question

Question: **Identify the condition based on Linnaean class?**

Answer: Triandria

Question: **Identify the condition based on Linnaean class?**



Answer: Diadelphia

WEEK 8

TAXONOMIC EVIDENCES: MORPHOLOGY

Taxonomic evidences

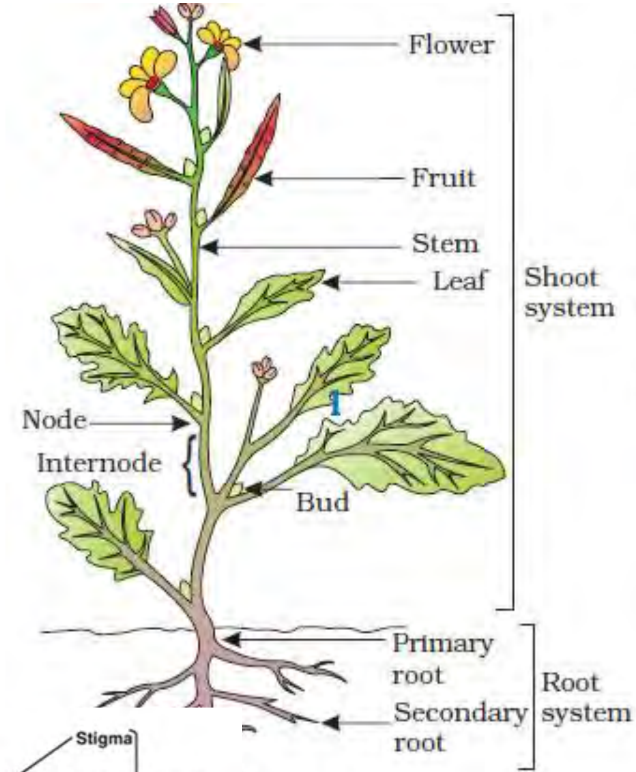
Source of Taxonomic Evidence: Vegetative & Floral Morphology

Vegetative Morphology

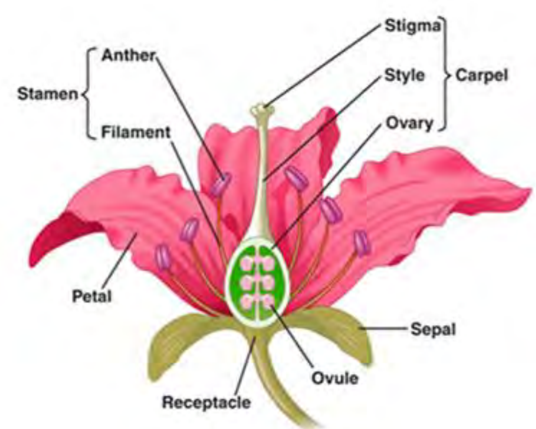
- Leaf shape, arrangement, venation
- Stem structure, bark texture
- Root type (taproot, fibrous, adventitious)

Floral Morphology

- Flower symmetry (actinomorphic, zygomorphic)
- Inflorescence type (raceme, panicle, spike)
- Floral parts (sepals, petals, stamens, carpels)
- Pollination adaptations (color, nectar guides)



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



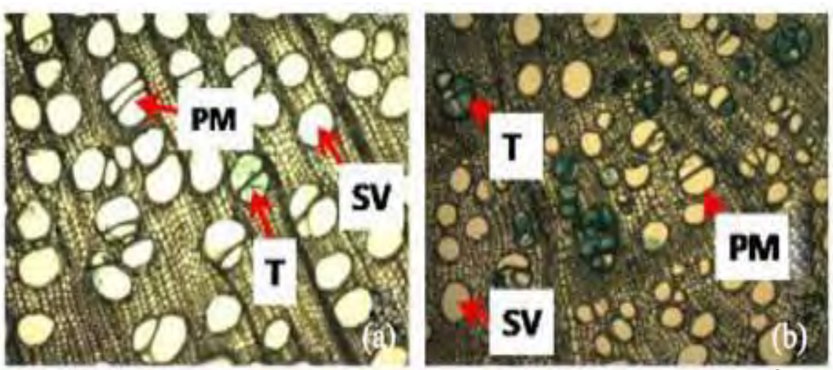
TAXONOMIC EVIDENCES: ANATOMY

Source of Taxonomic Evidence: Plant Anatomy & Physiology

1. Plant Anatomy (Internal Characteristics)

Vascular Tissues: Xylem (vessel elements vs. tracheids), phloem structure
Leaf Anatomy: Stomata type, epidermal patterns
Secretory Structures: Glandular trichomes, laticifers, resin ducts
Wood Anatomy: Growth rings, fiber arrangement

2. Plant Physiology in Taxonomy
Photosynthetic Pathways: C3, C4, CAM plants
Secondary Metabolites: Alkaloids, flavonoids, essential oils
Growth Responses: Photoperiodism, seed dormancy mechanisms



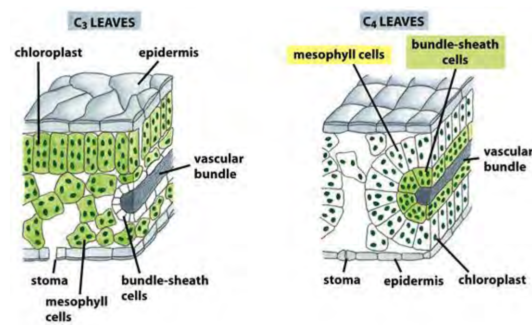
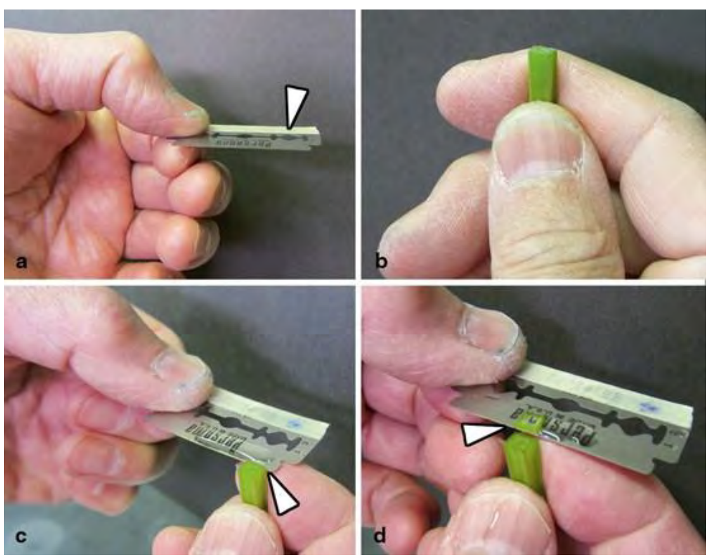
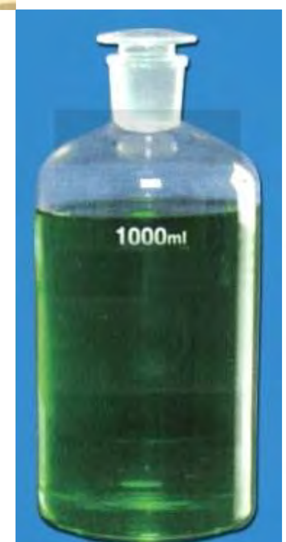


Figure: Transverse Sections of stem *Artocarpus atilis* (a) and *Artocarpus* communis (b). PM: Pore multiple, T=Tylose (Tyloses are outgrowths on parenchyma cells of xylem vessels of secondary heartwood, SV: Solitary vessel

Experimental Techniques:

- **Cutting of thin slices / section (Transverse section or Longitudinal section) of plant organs**
- **Preparation of temporary slides or permanent slides**
- **Observation under light compound microscope using tissue stain like safranin, fast green**





TAXONOMIC EVIDENCES: STOMATA

Systematic Significance of Stomata in Plant Taxonomy

Stomatal characteristics provide valuable taxonomic evidence for plant classification and evolutionary studies.

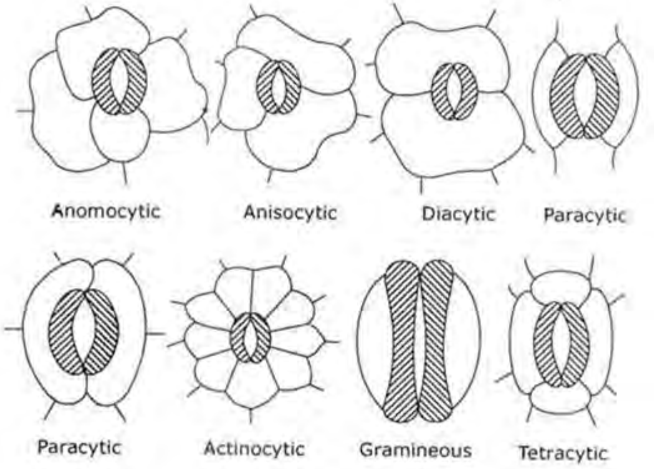
1. **Stomatal Types (Based on Structure & Development)**

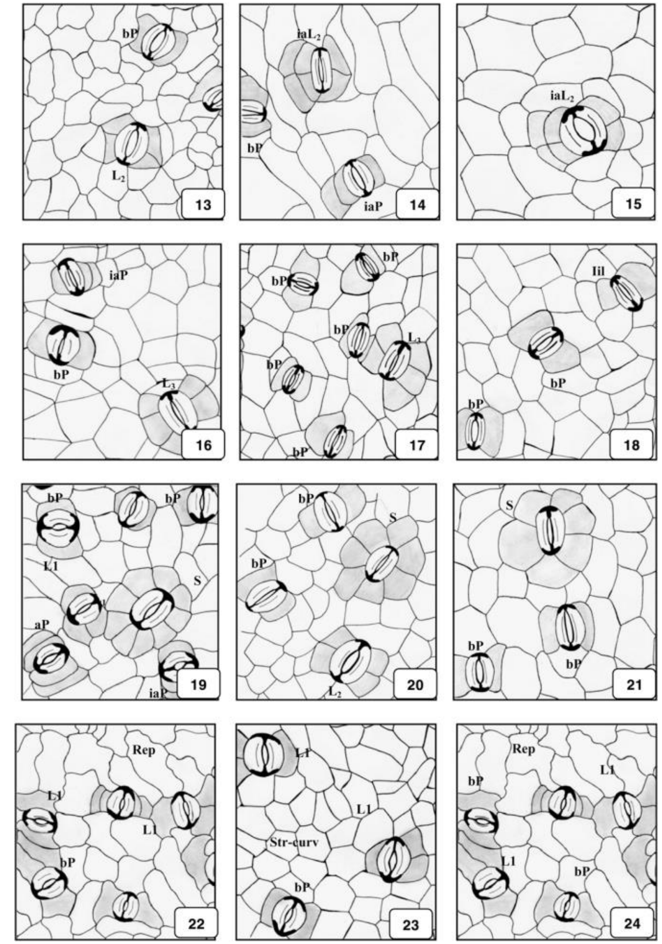
Anomocytic (Ranunculaceous): No distinct subsidiary cells (e.g., Ranunculaceae).
Paracytic (Rubiaceous): Two subsidiary cells parallel to the guard cells (e.g., Rubiaceae).
Diacytic (Caryophyllaceous): Two subsidiary cells at right angles to guard cells (e.g., Caryophyllaceae).
Anisocytic (Cruciferous): Three unequal subsidiary cells (e.g., Brassicaceae).
Actinocytic: Several radially arranged subsidiary cells.

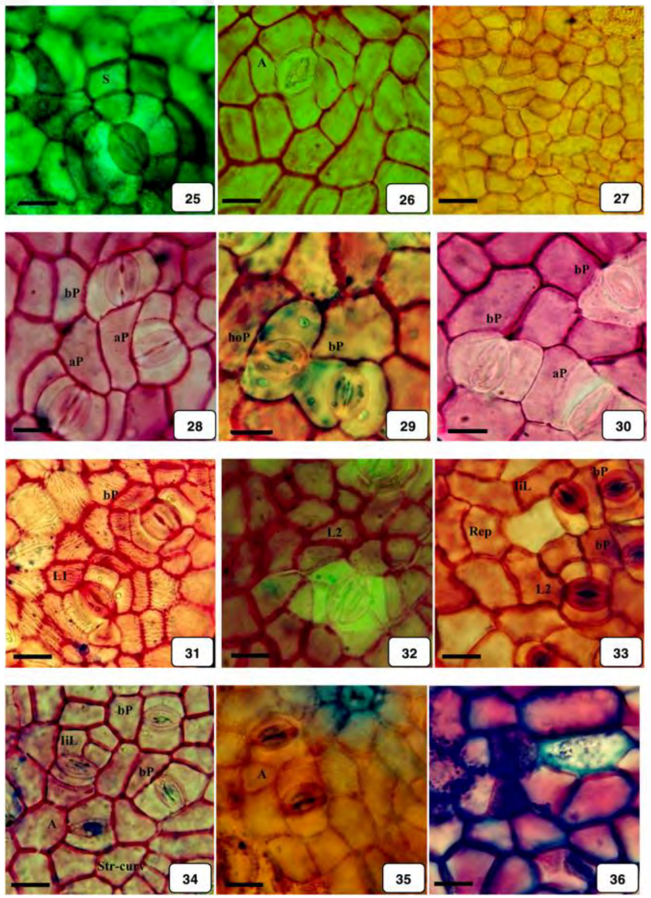
2. Stomatal Distribution Patterns

Amphistomatic: Stomata on both leaf surfaces (adapted to high light environments).
Hypostomatic: Stomata only on the lower surface (common in mesophytes).
Epistomatic: Stomata only on the upper surface (e.g., floating aquatic plants).

3. Evolutionary & Taxonomic Importance
Stomatal types are stable within families and genera, aiding classification.
Variations reflect adaptations to ecological conditions (xerophytes, hydrophytes).
Fossil stomata help in phylogenetic and paleoenvironmental reconstructions.



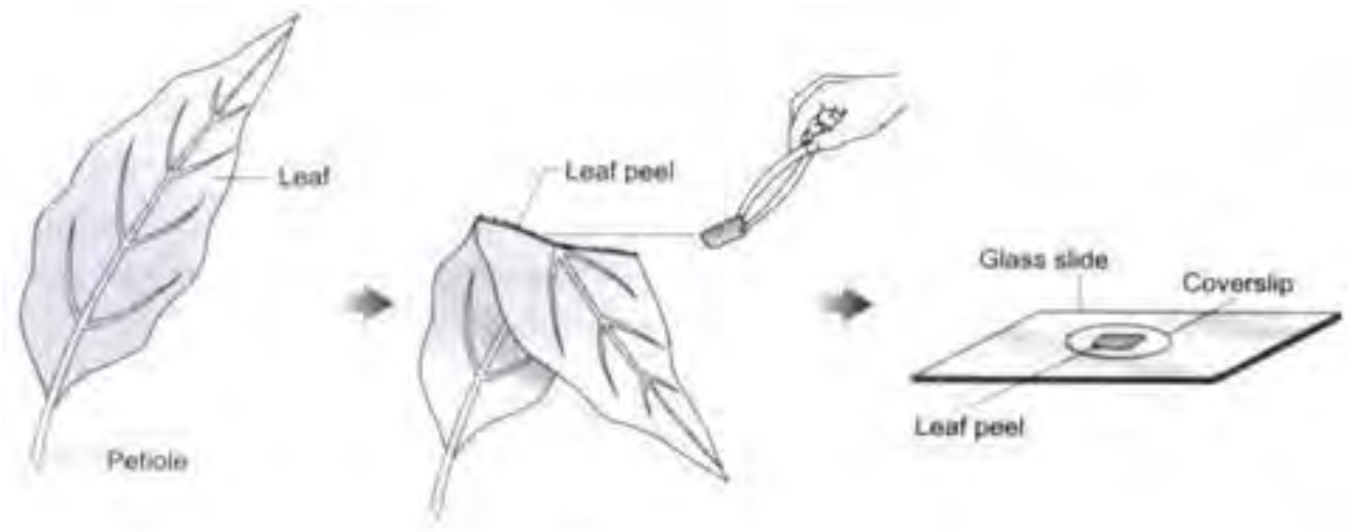




❖ **FARROKH et al., studies 32 *Salix speices of Salix* Species (Salicaceae) in order to find the systematic significance of trichomes in Angiosperms**

Experiment Techniques:

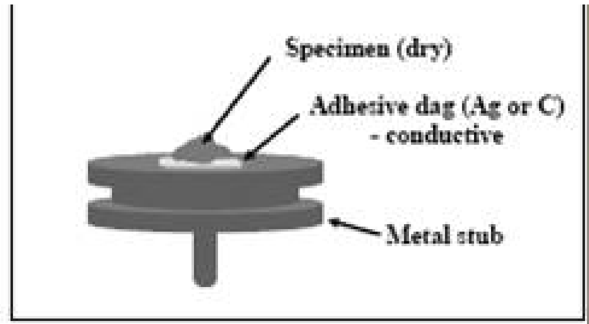
- **Usually peeling of leaves and observation under llight compound microscope (using tissue stain like safranin, fast green or without stain)**



(a)

TAXONOMIC EVIDENCES: MICOR MORPHOLOGY

SEM


Specimen (dry)
Adhesive dag (Ag or C)
- conductive
Metal stub


0.5 mm


HITACHI

Systematic Significance of Micromorphological Characters in Plant Taxonomy

Micromorphological features of the leaf surface, trichomes, and electron microscopy provide crucial taxonomic insights at the family, genus, and species levels.

1. Leaf Surface Micromorphology

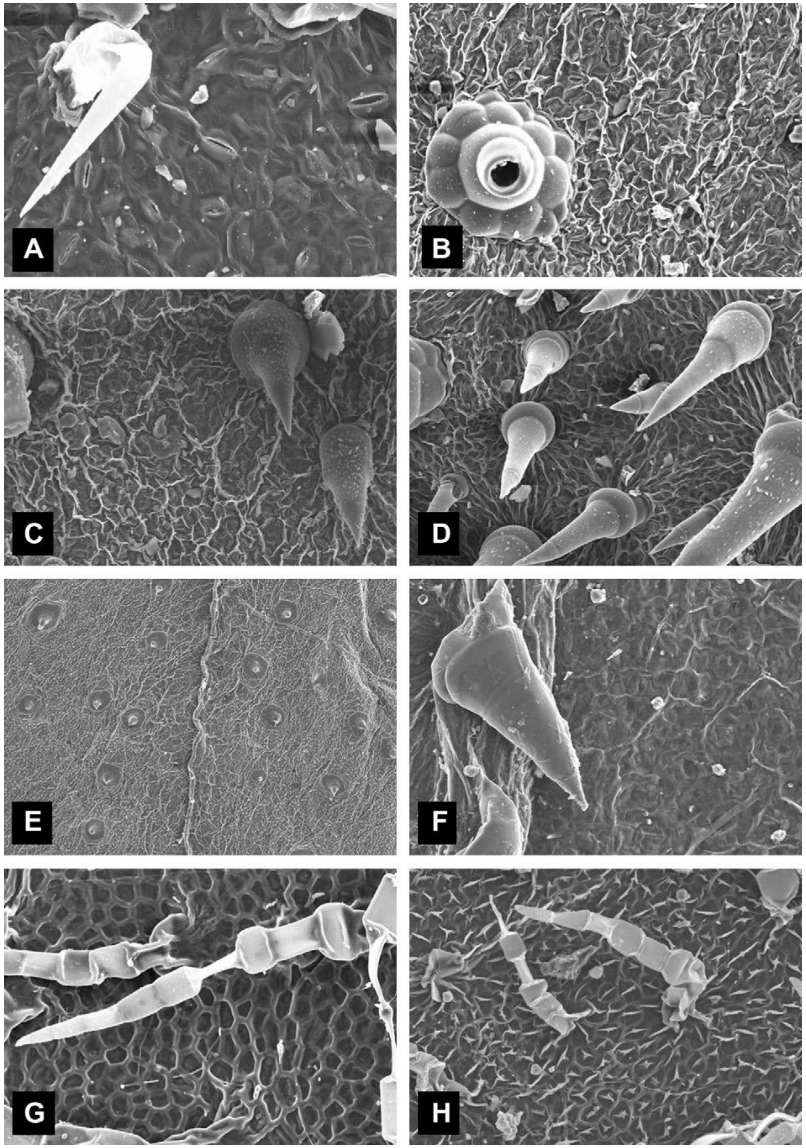
Cuticular Patterns: Thickness, ornamentation, and striations help distinguish taxa.
Epicuticular Wax: Crystals, plates, or rod-like structures vary across species.
Stomatal Complex: Arrangement and type aid in family-level classification.

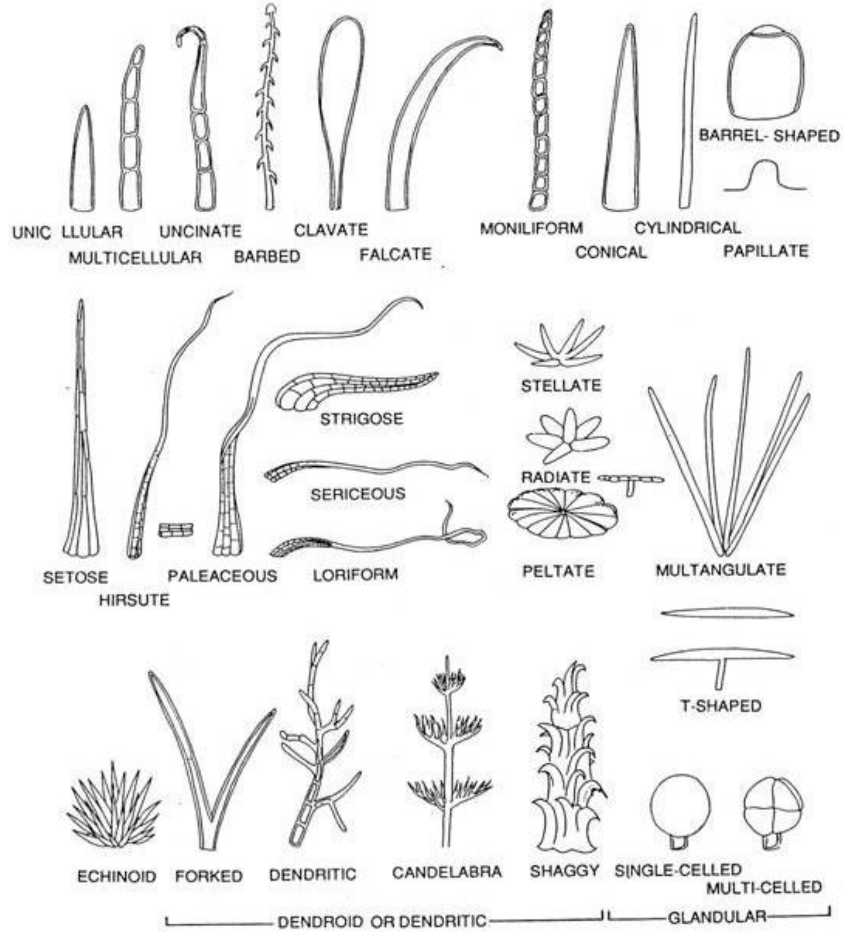
2. Trichomes (Hair-Like Structures)

Types: Glandular (secreting oils, resins) vs. non-glandular (unicellular, multicellular).
Distribution: Helps differentiate between closely related species.
Function: Adaptations to environmental stress (drought, herbivory, UV protection).

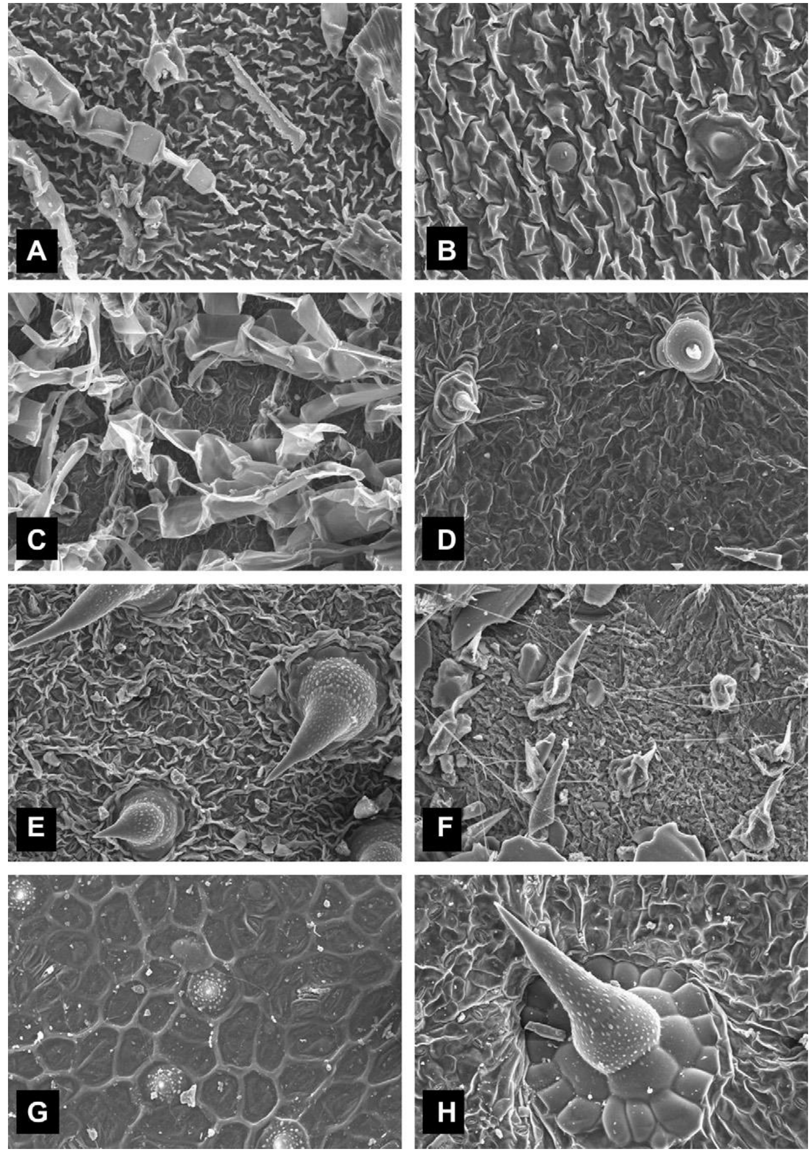
3. Electron Microscopy (Scanning & Transmission EM)

Ultrastructural Details: High-resolution imaging of cell walls, stomata, and glandular structures.
Palynology (Pollen Morphology): Shape, exine sculpturing used in classification.
Seed Coat Micromorphology: Unique textures help in species identification.



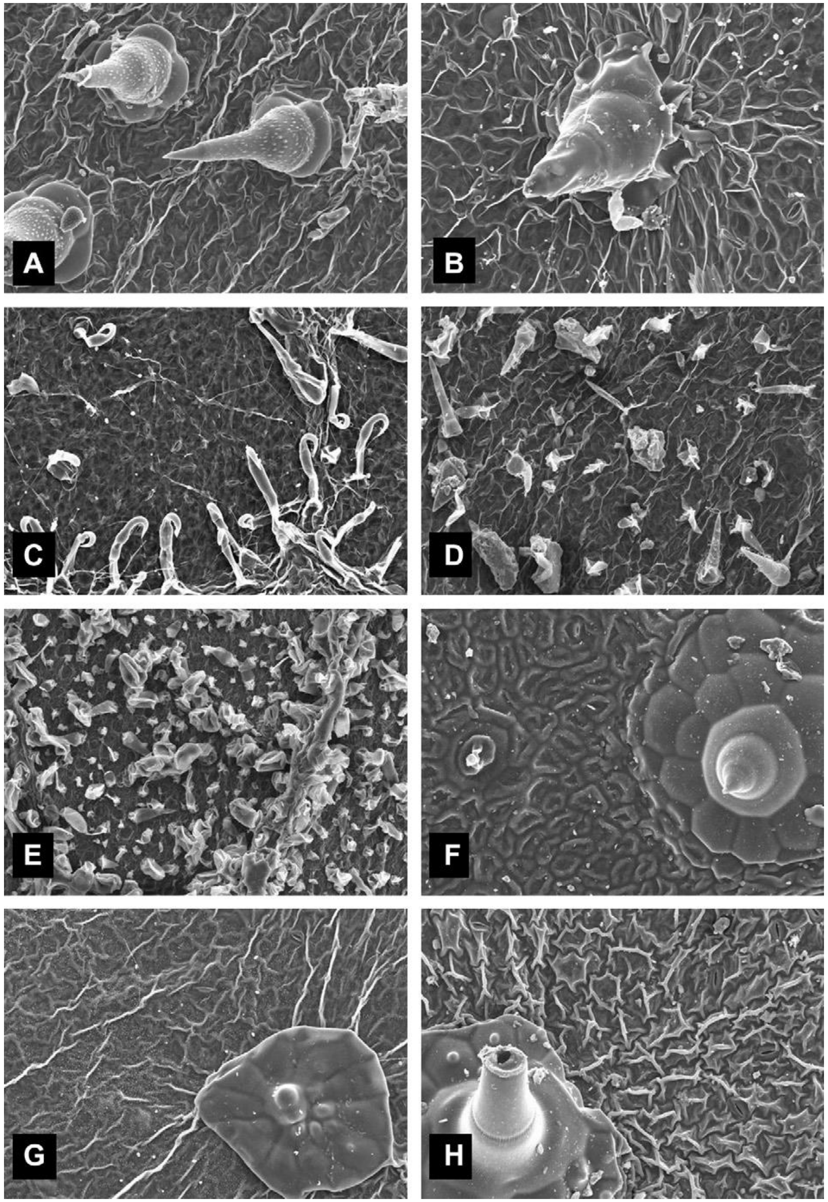


Trichomes morphology in Cucurbitaceae: (A) *Benincasa hispida* x300, (B) *Citrullus lanatus* x300, (C) *Cucumis melo* var. *agrestis* x300, (D) *C. sativus* x300, (E) *Diplocyclos palmatus* x50, (F) *Edgaria dargeelingensis* x300, (G) *Gynostemma burmanicum* x300, and (H) *G. pentaphyllum* x300.



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

- **Trichomes meaning "hair", are fine outgrowths or appendages on plants.**
- **Ali and Al-Hemaid (2011) studies trichomes of 23 species of the member of the family Cucurbitaceae using Electron Microscope in order to find the systematic significance of micromorphological characters of trichomes**



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

Systematic Significance of Seed Micromorphology & Electron Microscopy in Plant Taxonomy

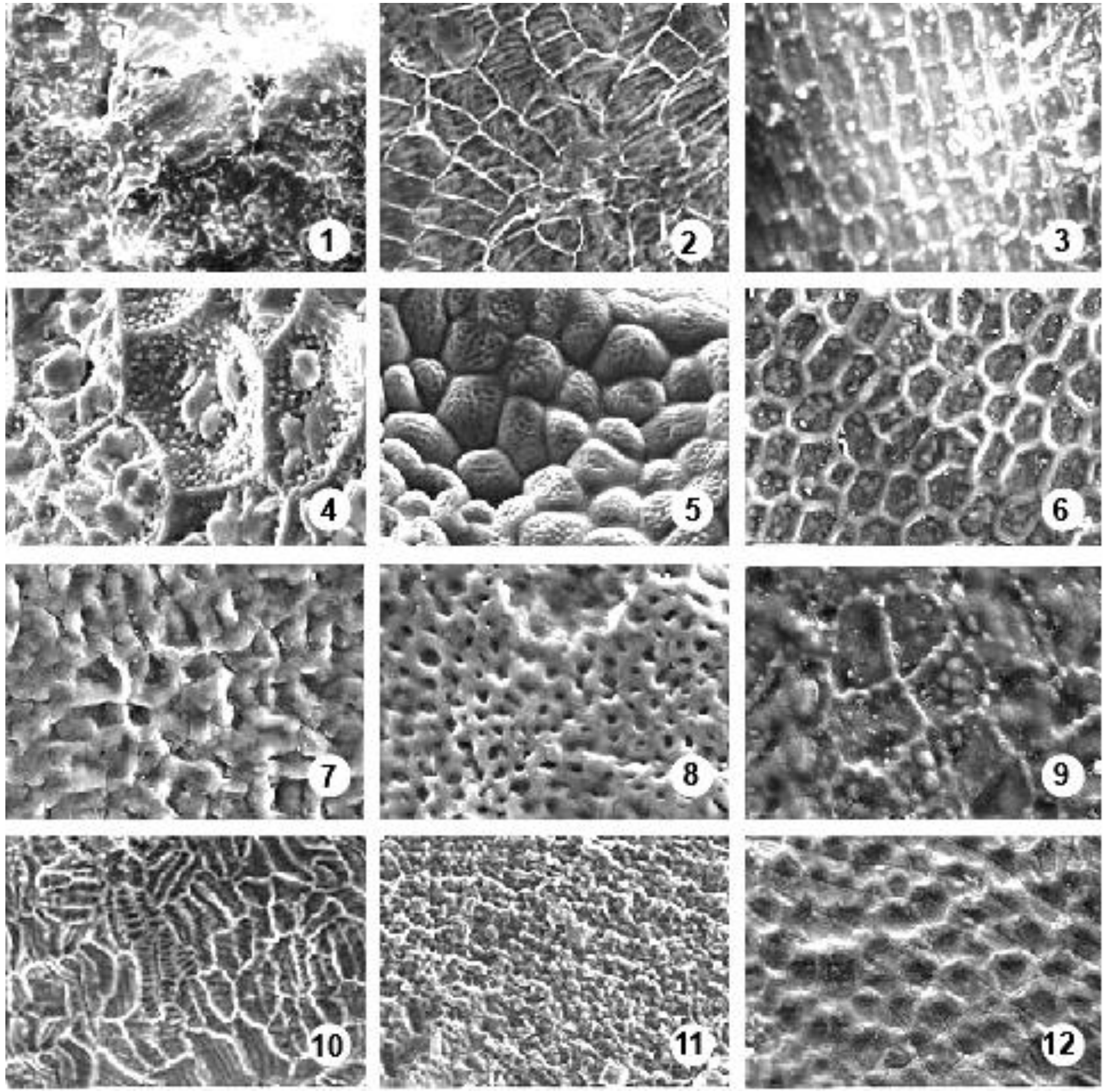
Seed micromorphology, especially observed through **scanning electron microscopy (SEM)**, provides valuable taxonomic and phylogenetic insights at different classification levels.

1. Key Micromorphological Seed Characters

Seed Coat Texture: Smooth, reticulate, striate, tuberculate (species-specific patterns).
Seed Shape & Size: Diagnostic at the genus or species level.
Hilum & Raphe Features: Position and structure help in taxonomic identification.
Epidermal Cell Structure: Unique cell wall ornamentation used for classification.

2. Electron Microscopy (SEM) in Seed Taxonomy

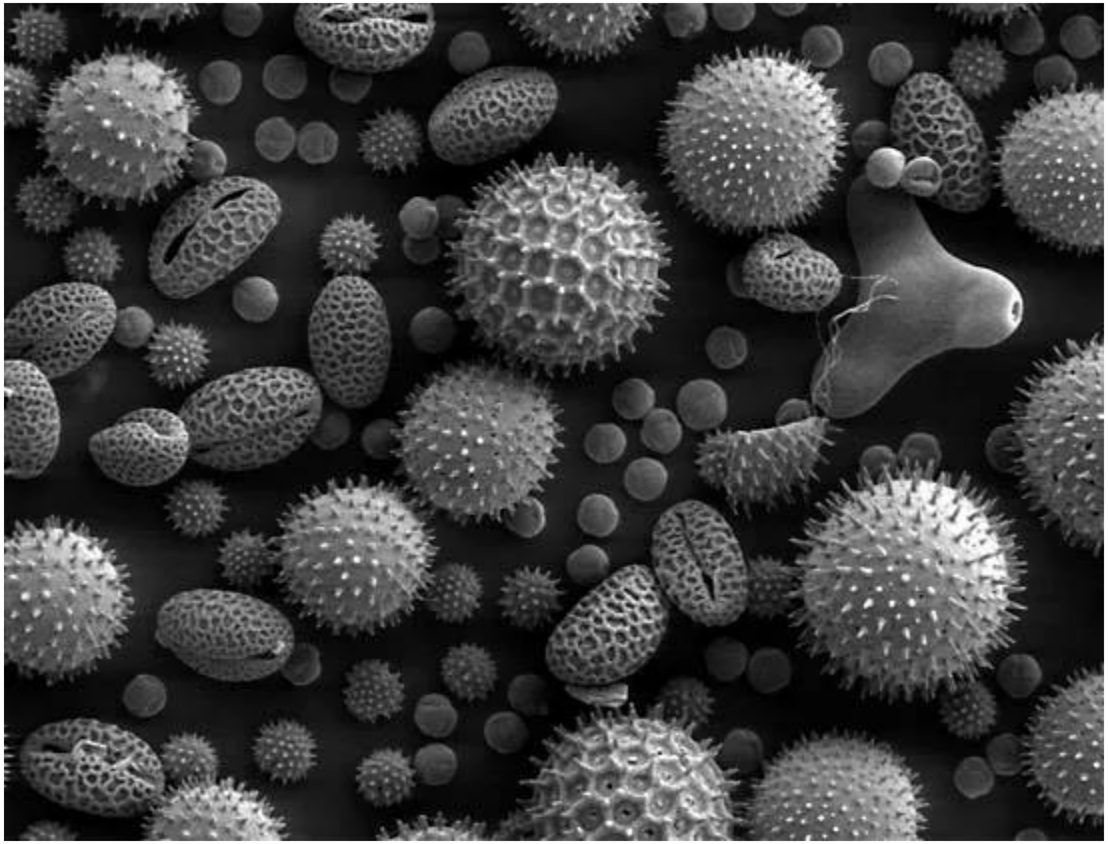
High-Resolution Surface Imaging: Identifies fine sculptural details not visible under light microscopy.
Pollen-Seeds Correlation: Helps in linking reproductive traits to taxonomic groups.
Comparative Studies: Differentiates closely related species or cultivars based on seed coat ultrastructure.



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

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

PALYNOLOGY



Systematic Significance of Palynology & Pollen Micromorphology in Plant Taxonomy

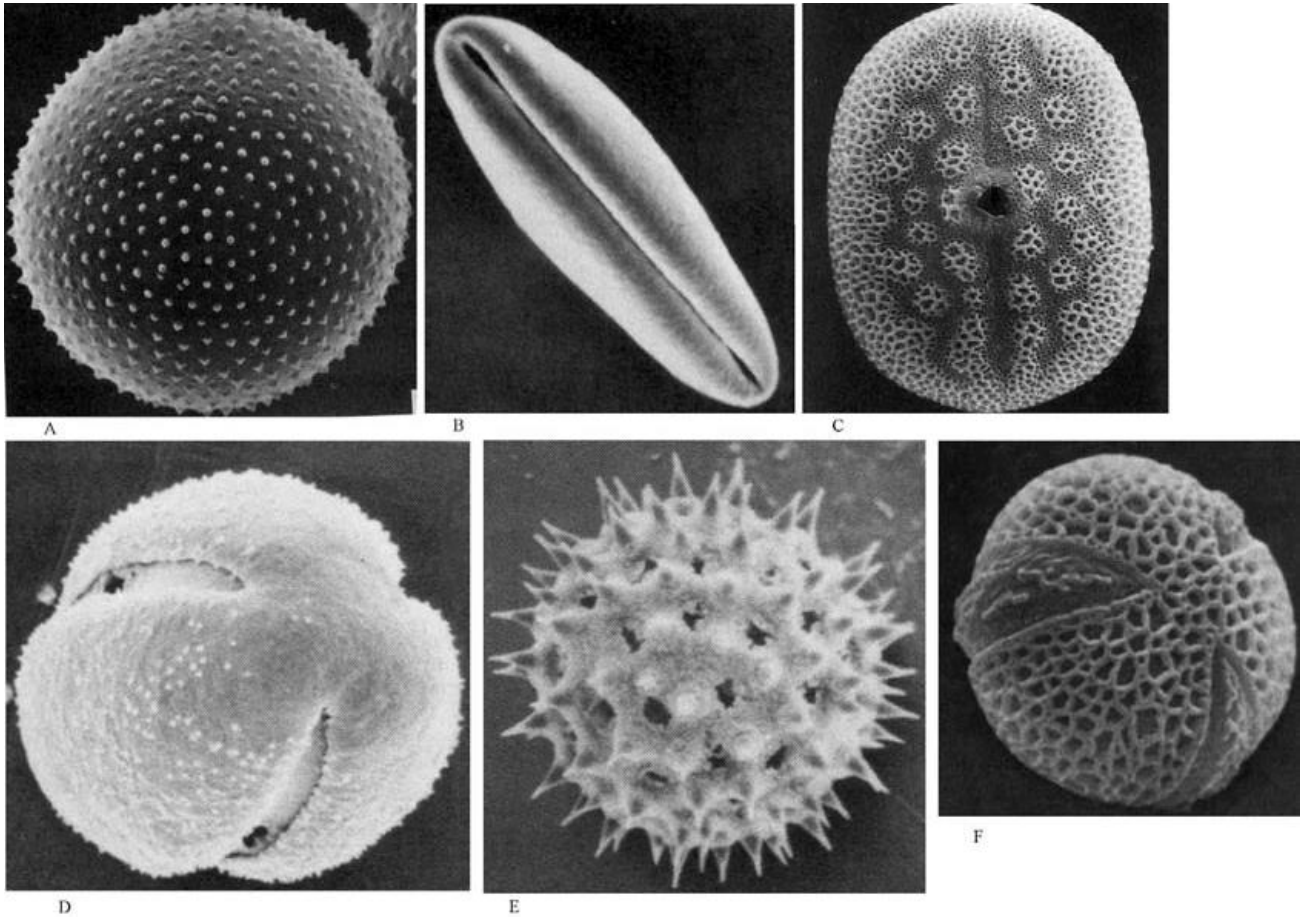
Palynology (study of pollen grains and spores) provides crucial taxonomic, phylogenetic, and evolutionary insights. **Scanning Electron Microscopy (SEM)** and **Transmission Electron Microscopy (TEM)** reveal pollen characteristics with high precision, aiding plant classification.

1. **Key Pollen Micromorphological Characters**

Pollen Shape & Size: Spherical, oblate, prolate (diagnostic at genus/species level).
Aperture Types:
- **Monocolpate:** Primitive type (Magnoliids, monocots).
- **Tricolpate:** Characteristic of eudicots.
- **Porate & Colporate:** Found in advanced taxa.

Exine Ornamentation: Reticulate, striate, spinate, psilate (family-specific patterns).

2. Electron Microscopy (SEM & TEM) in Pollen Studies
SEM: Reveals exine sculpturing, spines, and structural details.
TEM: Examines internal pollen wall layers, stratification, and ultrastructure.
Fossil Pollen Studies: Helps trace evolutionary lineages and ancient plant distributions.



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

- **Palynology is the study of plant pollen and spores.**
- **There are two pollen types: monosulcate and tricolpate**
- **Monosulcate pollen are boat shaped with one long furrow and one germinal aperture (associated with primitive docots and the majority of monocots, the cycads and ferns). Triculpate pollen are found and typically have 3 apertures and is characteristic of the more advanced dicots.**
- **Erdtman (1963) used the pollen charactersin solving the taxonomic problem of 105 family**

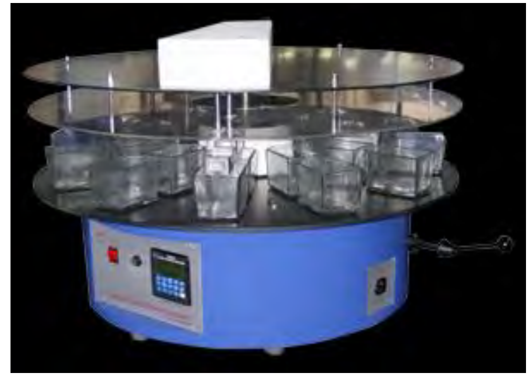
Experiment Techniques:

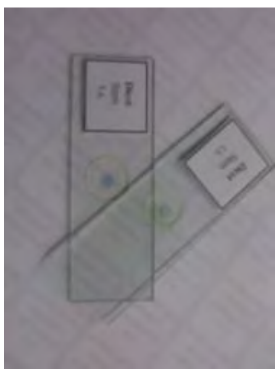
- **Today's strongest compound microscopes have magnifying powers of 1,000 to 2,000X.**
- **SEM (Scanning electron Microscope) or TEM (transmission electron Microscope) is required to study ultra structure.**
- **SEM and TEM is costly microscope (price in Million or Million plus Riyal).**
- **Magnification about 500,000 times.**
- **Material to be studies kept on aluminum stub, and then placed under vacuum condition (gold coating machine) for gold coating.**
- **Gold coated biological sample placed in SEM chamber.**
- **Specimen passed thru electron beam**
- **Images can be only observed at computer monitor.**

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

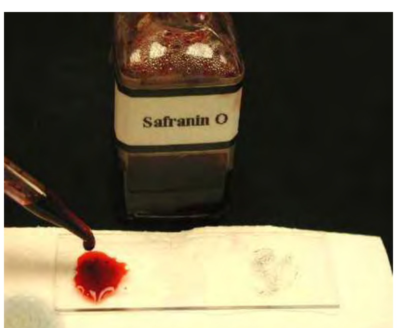
WEEK 9

TAXONOMIC EVIDENCES: EMBRYOLOGY





Station	Time (min)	Solution
1		Water
2	45	70% alcohol
3	45	80% alcohol
4	45	90% alcohol
5	45	100% alcohol
6	60	100% alcohol
7	60	100% alcohol
8	60	Clearing reagent (xylene or substitute)
9	60	Clearing reagent (xylene or substitute)
10	60	Paraffin 1
11	60	Paraffin 2
12	60	Paraffin 3



Systematic Significance of Embryology in Plant Taxonomy

Embryology (study of embryo development) provides valuable taxonomic evidence by revealing stable and conserved traits that help in plant classification and phylogenetic studies.

1. Key Embryological Characters in Taxonomy

Ovule Structure: Anatropous, orthotropous, campylotropous (helps distinguish families).
Embryo Type & Development: Variation in suspensor, cotyledon, and axis structure.
Endosperm Type: Nuclear, cellular, helobial (used to differentiate taxonomic groups).
Embryo Sac Development: Monosporic (Polygonum type), Bisporic, or Tetrasporic (variation across taxa).
Anther & Pollen Development: Tapetum type (glandular vs. amoeboid), pollen wall differentiation.

2. Systematic & Evolutionary Significance

Family-Level Differentiation:

Onagraceae (Endosperm absent) vs. Asteraceae (Cellular endosperm).
Solanaceae (Two-celled pollen) vs. Malvaceae (Three-celled pollen).

Phylogenetic Relationships: Conserved embryological traits indicate common ancestry.
Support for Classification Systems: Confirms or refines groupings based on external morphology.

- **Embryology is the branch of biology that studies the prenatal development of gametes (sex cells), fertilization, and development of embryos and seed coats.**

- **The major embryological character that separates the monocots from the dicots is the number of embryonic cotyledon leaves.**

- **Embryological features are normally constant at the family level and below.**

- **The genus *Paeonia* was earlier included under the family Ranunculaceae. But *Paeonia* differs from Ranunculaceae in chromosome number, vascular anatomy, floral anatomy.**

- **Worsdell (1908) suggested its removal to a distinct family, Paeoniaceae.**

- **The separation is supported by the embryological features: (i) centrifugal stamens (not centripetal); (ii) pollen with reticulately-pitted exine with a large generative cell (not granular, papillate and smooth, small generative cell); (iii) unique embryogeny in which early divisions are free nuclear forming a coenocytic stage, later only the peripheral part becomes cellular (not onagrad or solanad type); and (iv) seed arillate.**

Embryology

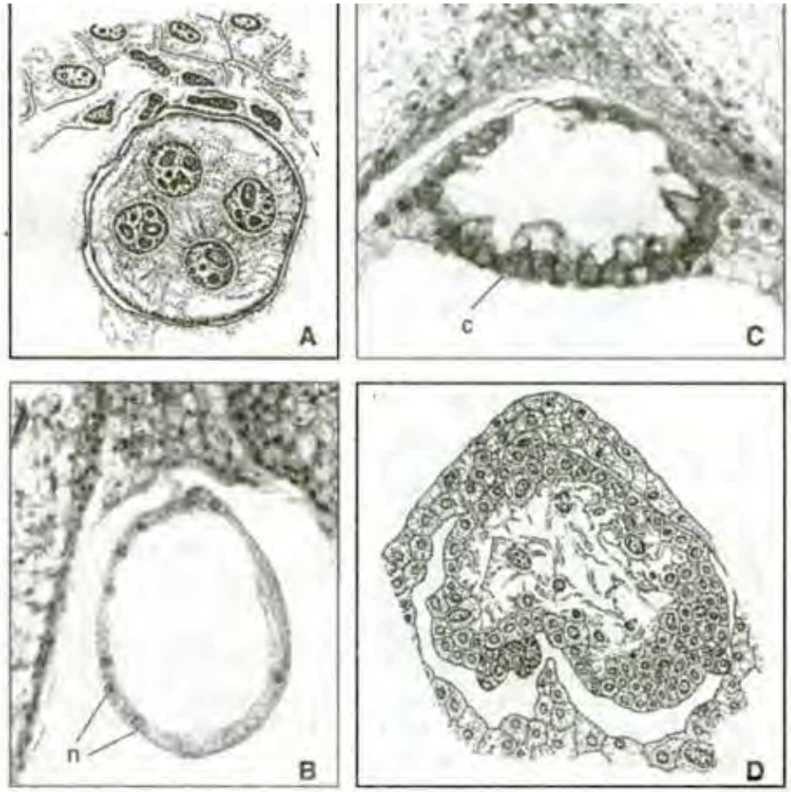


Fig. 12.14 Early stages of embryogenesis in *Paeonia* sp. **A**,**B**. Coenocytic embryo. **C**. Cellularization. **D**. Formation of embryos in the coenocytic-cellular stage. *n*, nuclei; *c*, cells (*from* Czapik and Izmailow, 2001)

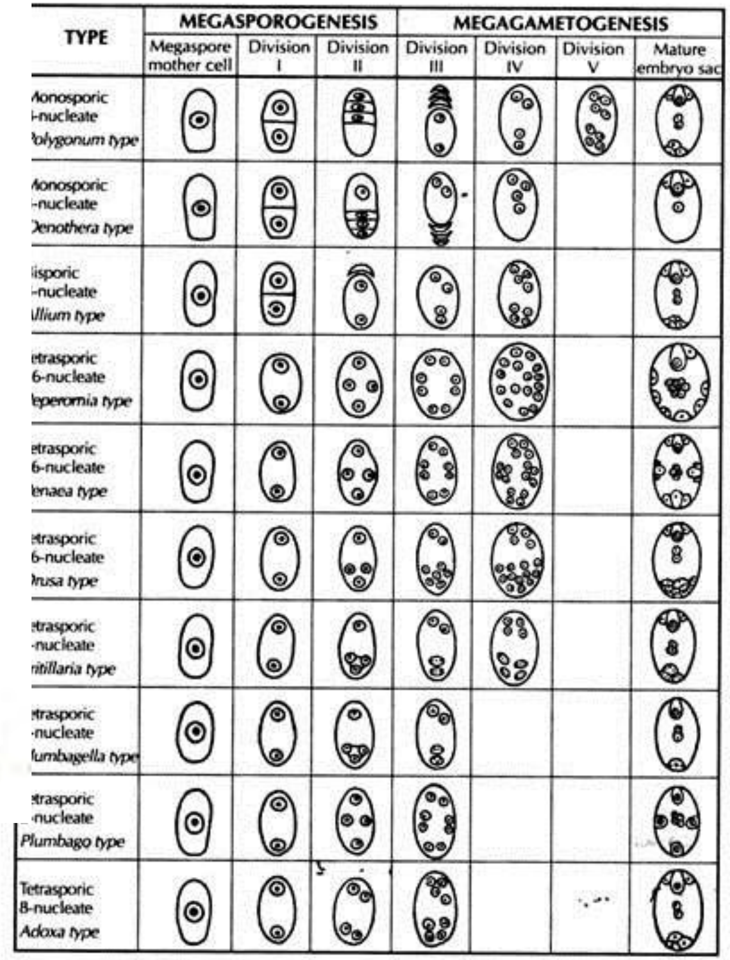


Fig. 3.8 : Development of different types of embryo sac in angiosperms (*after* Maheshwari) [Micropyle above in all illustrations]

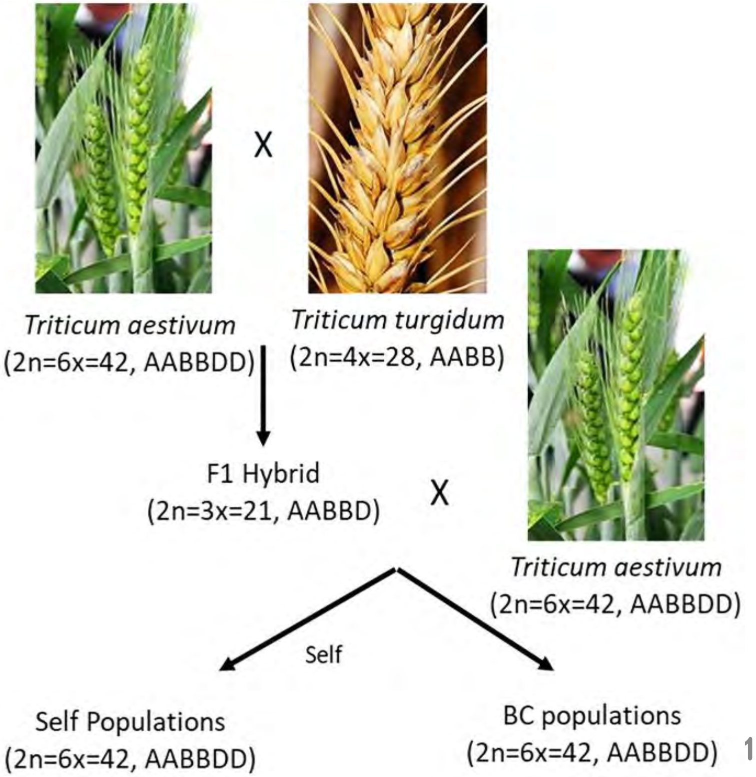
TAXONOMIC EVIDENCES: CYTOTAXONOMY

Cytotaxonomy (Chromosome Studies)

Definition: Study of **chromosome number, structure, and behavior** to classify plants.
Key Aspects:

Chromosome Number – Different species have specific numbers (e.g., *Triticum aestivum* has 42).

Karyotype Analysis – Examines chromosome shape and size.
Polyploidy Studies – Many plants evolve through genome duplication.
Example:
Wheat (*Triticum aestivum*) is an **allohexaploid** (6 sets of chromosomes).
Importance:
Helps in understanding **species evolution**.
Identifies **hybrid species** in plant breeding.
Useful in **crop improvement programs**.



Experiment Techniques:

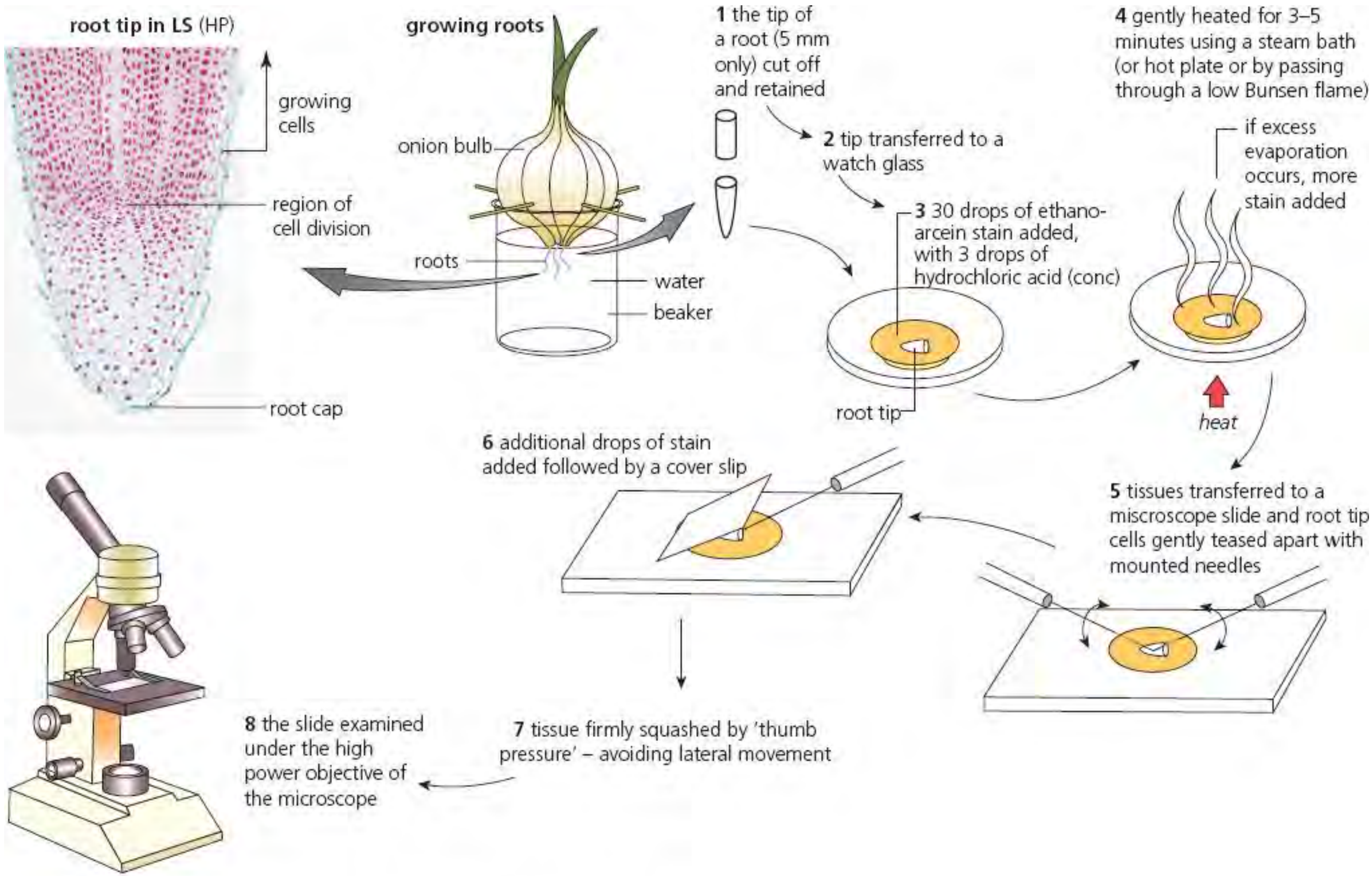


Figure 5.9 Preparing an onion root tip squash with ethano-orcein stain

Systematic Significance of Cytology in Plant Taxonomy

Cytology (study of chromosomes and cell structure) provides fundamental taxonomic evidence by revealing **chromosomal number, structure, and behavior**, which help in classifying and understanding plant relationships.

1. Key Cytological Characters in Taxonomy

Chromosome Number:

Stable numbers define taxa (e.g., **Brassicaceae: 2n = 14**, **Poaceae: 2n = 14, 20**).

Polyploidy (triploids, tetraploids) is common in evolution.

Chromosome Structure & Behavior:

Karyotype analysis (size, shape, banding patterns) distinguishes taxa.

Chromosomal rearrangements (inversions, translocations) provide evolutionary insights.

DNA Content & Genome Size:

Differences in genome size help in species differentiation.

Flow cytometry and sequencing assist in phylogenetic studies.

2. Systematic & Evolutionary Significance

Family & Genus Classification: Chromosomal variations help in plant differentiation (e.g., Asteraceae, Fabaceae).

Hybridization & Polyploidy:

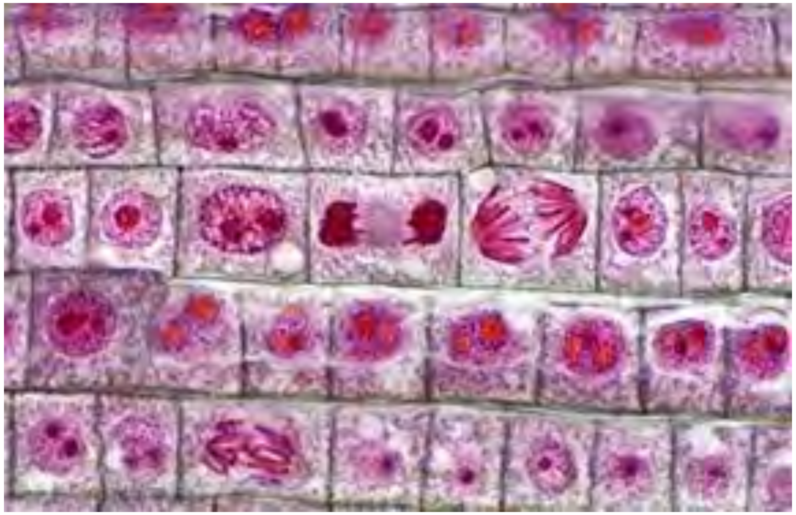
Explains speciation and adaptive evolution.

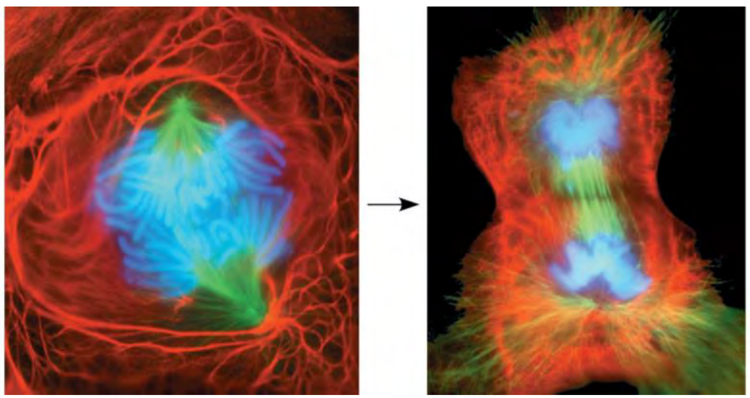
Many crop plants (wheat, cotton) evolved via polyploidy.

Phylogenetic Insights: Chromosomal changes reflect evolutionary history and plant lineage divergence.

- **Chromosome Set:**

- **Number of chromosome can be counted in the metaphase stage of cell division.**
- **One copy of each of the different chromosomes in the nucleus containing one copy of each different gene.**
- **Haploid Number (n): The number of chromosomes comprising one set.**
- **Diploid Number (2n): The number of chromosomes in a cell containing two sets.**
- **Human Haploid (n)= 23, Diploid (2n)=46**
- **Dates Haploid (n)= 14, Diploid (2n)=28**
- **In plants, only information about chromosome number, shape or pairing at meiosis is used for classification purposes.**
- **The term karyotype is used for the phenotypic appearance for the somatic chromosomes.**
- **The diagrammatic representation of the karyotype is termed as idiogram.**
- **The characteristic of chromosome having taxonomic values are: chromosome number, chromosome size, chromosome morphology, and chromosome behavior during meiosis.**
- **The genus *Yucca* had long been treated as a member if Liliaceae because of the superior ovary. Hutchinson shifted *Yucca* to the family Agavaceae because the genus *Yucca* possess 25 small and 5 large chromosome which is similar to the member of family Agavaceae**





Yucca carnerosana

TAXONOMIC EVIDENCES: CHEMOTAXONOMY

Chemotaxonomy (Chemical Analysis)

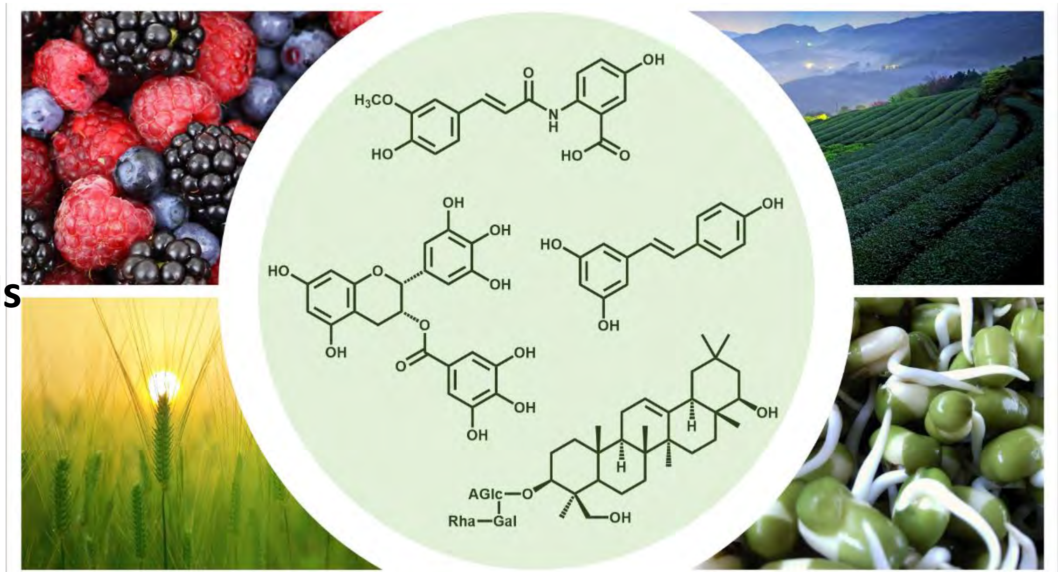
Definition: Uses **chemical compounds** (secondary metabolites) for classification.

Key Chemical Markers:

Alkaloids – Found in medicinal plants (*Papaver somniferum* - Opium poppy).
Flavonoids – Pigments help classify plant families (*Caryophyllales produce Betalains*).
Essential Oils – Common in aromatic plants (*Lamiaceae - Mint family*).
Example:
Betalains vs. Anthocyanins – Used to distinguish **Caryophyllales from Polygonales**.

Importance:
Helps in **medicinal plant classification**.
Differentiates plants with **similar morphology**.
Useful in **pharmaceutical and agricultural research**.

Phytochemicals



Systematic Significance of Chemotaxonomy in Plant Taxonomy

Chemotaxonomy uses **chemical compounds** (secondary metabolites) to differentiate plants at various taxonomic levels. These biochemical markers provide critical insights into plant relationships, classification, and evolutionary processes.

1. Key Chemical Characters in Taxonomy

Secondary Metabolites:

Alkaloids, flavonoids, terpenoids, and phenolics are commonly used for classification.
Terpenoids: Diagnostic in families like Lamiaceae and Rutaceae.
Flavonoids: Found in family-level distinctions like Rosaceae and Fabaceae.

Essential Oils:

Plant species produce distinct volatile oils (e.g., in mint, lavender) used to identify species and genera.

Amino Acids & Fatty Acids:

Unique amino acid compositions assist in distinguishing plant families.

Proteins & Enzymes:

Specific proteins (e.g., Rubisco) and enzymes can be used for genetic relationships (e.g., peroxidases).

2. Systematic & Evolutionary Significance

Family & Genus Differentiation:

Chemical profiles (e.g., alkaloid presence) help define family boundaries (e.g., Papaveraceae, Solanaceae).

Some compounds are specific to certain lineages, providing strong taxonomic markers.

Evolutionary Insights:

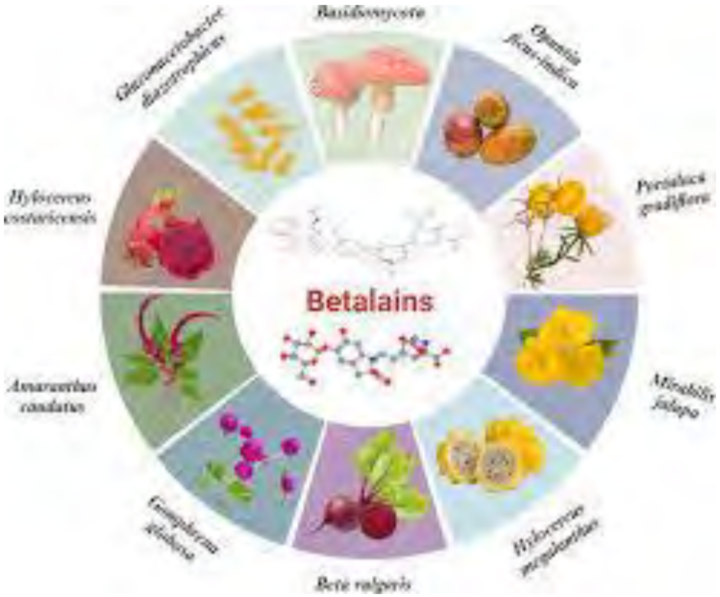
Similarities in chemical composition can indicate common ancestry.

Evolutionary patterns are reflected in the presence or absence of certain metabolites.

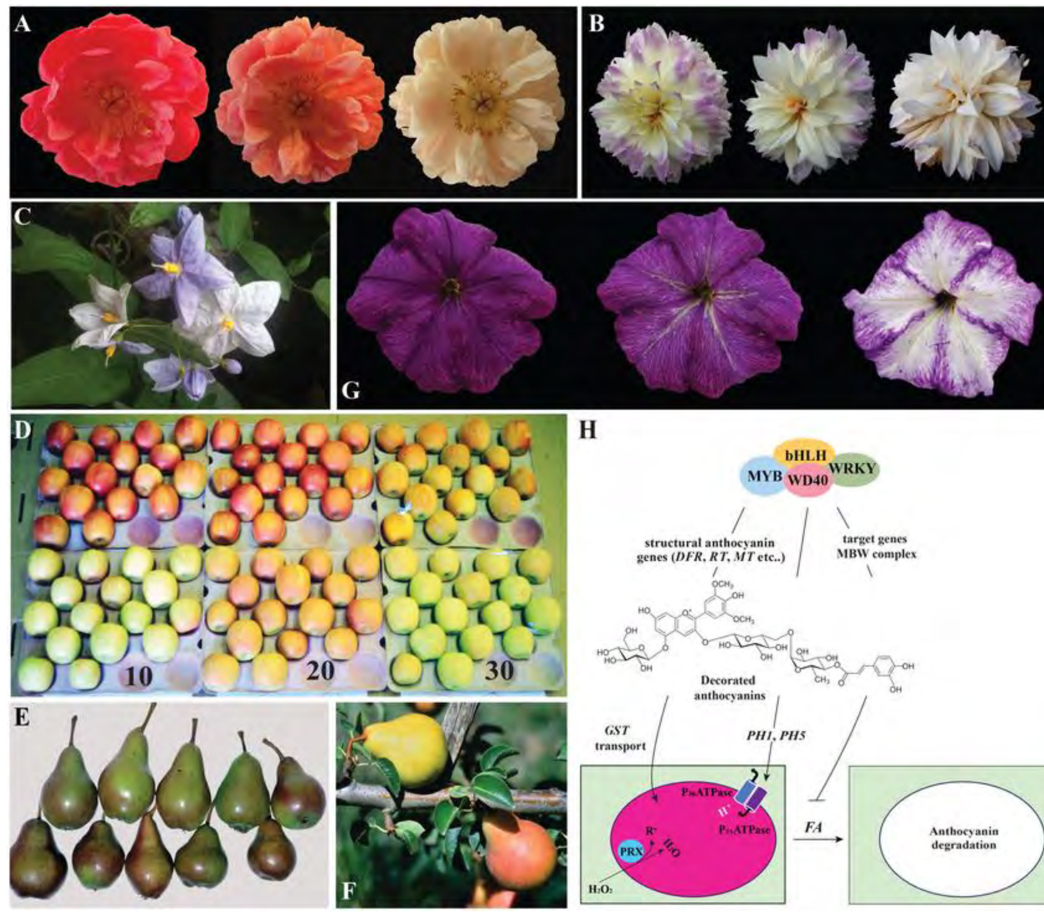
Ecological Adaptations:

Chemical compounds often relate to plant's defense mechanisms or ecological roles (e.g., phenolic compounds in drought tolerance).

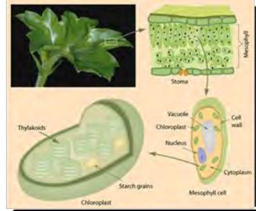
- **Caryophyllales** produce **Betalins** (instead of anthocyanins).
- **Polygonales** produce **anthocyanins** (instead of Betalins).
- **Lamiaceae** are known for producing **highly aromatic compounds**.

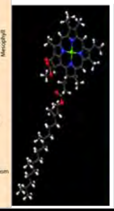


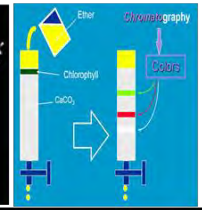
Caryophyllales

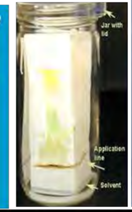


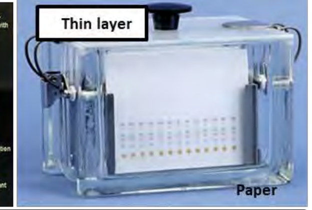
Polygonales







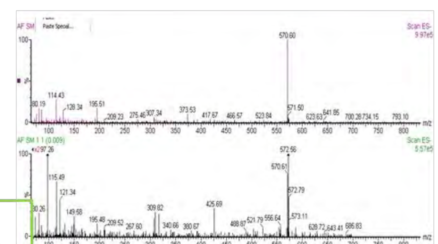


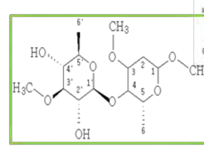


Chromatography is used to separate mixtures of substances into their components. All forms of chromatography work on the same principle. They all have a stationary phase (a solid, or a liquid supported on a solid) and a mobile phase (a liquid or a gas).

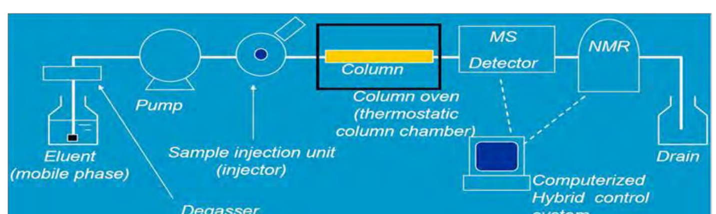
Mass spectrometry

Mass spectrometry (MS) is an analytical technique that ionizes chemicals and measures the masses within a sample.





Al-Allah et al., 2018 identified as methyl β-lilacinobioside islated from *Caralluma retrospiciens*



TAXONOMIC EVIDENCES: ECOLOGY

Systematic Significance of Ecology in Plant Taxonomy

Ecological factors play a significant role in **plant classification** and help clarify species relationships. The **environmental context** influences plant adaptation, distribution, and behavior, which can be used to classify plants and understand their evolutionary histories.

1. Ecological Characteristics in Taxonomy

Habitat Type:

Terrestrial (e.g., forests, grasslands) vs. **Aquatic** habitats can differentiate families (e.g., **Alismataceae** for aquatic plants, **Poaceae** for grasslands).

Ecological specialization helps define species' niche and their evolutionary adaptations.

Climatic Adaptations:

Plants may be classified based on their **response to temperature, moisture, and light** conditions (e.g., **xerophytes** in dry environments like Cactaceae).

Soil Preferences:

Soil pH, fertility, and mineral composition affect plant distribution (e.g., **calciphiles** vs. **acidophiles**).

Growth Form & Phenology:

Annuals vs. Perennials, **deciduous vs. evergreen** trees help differentiate families and genera.

Pollination Ecology:

Pollinators (wind, insect, bird) influence flower morphology and plant groupings (e.g., **Orchidaceae** and **Lamiaceae** have distinct pollination mechanisms).

Symbiotic Relationships:

Symbiosis with fungi, bacteria, or animals (e.g., **mycorrhizal fungi**) provides key insights into plant taxonomy and evolutionary adaptation.

2. Systematic & Evolutionary Significance

Ecological Divergence & Speciation:

Plants adapting to different ecological niches can undergo **ecological speciation**, which leads to divergence in species (e.g., alpine plants, coastal plants).

Ecology-Driven Classification:

Taxonomy can be informed by ecological patterns like **climate zones** or **biogeographical regions** (e.g., tropical vs. temperate plant families).

Evolution of Adaptations:

Ecological pressures influence **adaptive radiation** and **phylogenetic relationships** (e.g., Cactaceae evolved unique adaptations for desert life).

Erect form of *Euphorbia hira*

Prostrate form of *Euphorbia hira*

QUESTION FOR PRACTICE

Second Term Exam model questions

Multiple choice question

What does plant taxonomy primarily deal with?
a) Chemical composition of plants
b) Naming, identifying, and classifying plants
c) Studying the photosynthesis process
d) None of the above
Answer: b) Naming, identifying, and classifying plants

Which level of the taxonomic hierarchy is the most specific?
a) Family
b) Order
c) Species
d) Genus
Answer: c) Species

Which family is known for producing Betalains instead of Anthocyanins?
a) Polygonaceae
b) Caryophyllaceae
c) Lamiaceae
d) Solanaceae
Answer: b) Caryophyllaceae

Second Term Exam model questions

Multiple choice question

Which level of the taxonomic hierarchy is the most specific?
a) Family
b) Order
c) Species
d) Genus
Answer: c) Species

What system assigns two names (Genus + Species) to plants?
a) Artificial system
b) Natural system
c) Binomial system
d) Phylogenetic system
Answer: c) Binomial system

Which chemical compound is commonly used in chemotaxonomy for classification?
a) DNA
b) Alkaloids
c) Proteins
d) Lipids
Answer: b) Alkaloids

Second Term Exam model questions

Fill in the blanks

1. The basic unit of classification in taxonomy is _______.
   Answer: species

2. Morphological keys are used to compare _______ with known plants for identification.
   Answer: features

3. The nucleus is surrounded by a double membrane called the ______.
   Answer: nuclear envelope

4. The powerhouse of the cell is the ______.
   Answer: mitochondria

5. Plant taxonomy provides a _______ naming system to avoid confusion worldwide.
Answer: universal

6. The rigid outer layer of a plant cell is called the ______.
Answer: cell wall

Second Term Exam model questions

Mark the True / False

Taxonomy and systematics are completely unrelated fields.
Answer: False

The cell membrane is fully permeable.
Answer: False

Bentham and Hooker's system is an example of a natural system of classification.
Answer: True

DNA barcoding is a tool used in chemotaxonomy.
Answer: False

The nucleus contains chromatin, which is made up of DNA and proteins.
Answer: True

Mitochondria are present only in animal cells.
Answer: False

Second Term Exam model questions

Short answer question

Define plant taxonomy.
Answer: Plant taxonomy is the science of naming, identifying, classifying, and describing plants, organizing them into a structured system based on their characteristics and evolutionary relationships.

Name any two modern approaches in plant taxonomy.
Answer: Molecular taxonomy and Chemotaxonomy.

What are the two main types of cells?
Answer: Prokaryotic cells and Eukaryotic cells.

Second Term Exam model questions

Figure based question

1 Question: Identify types of morphological features used in descriptive terminology:

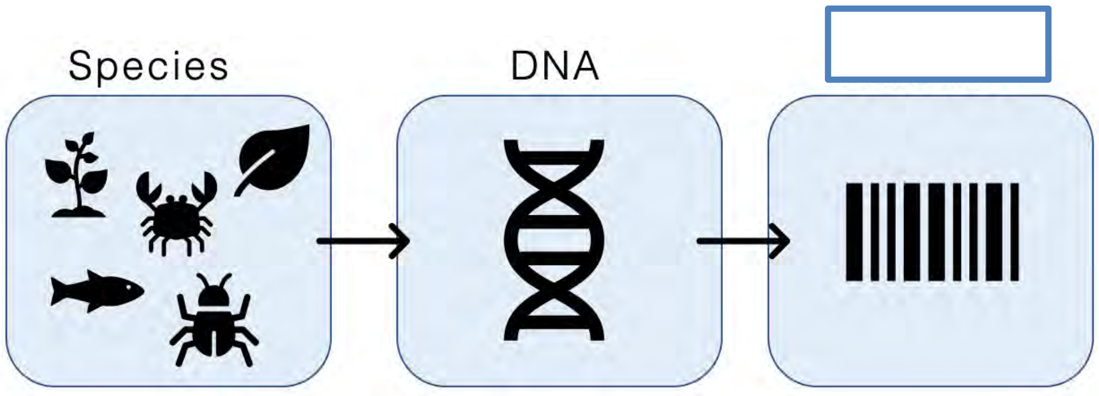
Answer: Vegetative (Non-reproductive parts)

Second Term Exam model questions

Figure based question

Look at the image of a herbarium sheet with a pressed plant specimen. Which part of the specimen is the most important for identification?

1. Observe the image given and fill the blue box which used in the molecular taxonomy:



Answer: Barcode

WEEK 10

Second mid term exam

WEEK 11

TAXONOMIC EVIDENCES: MOLECULAR TAXONOMY

Advanced Experimental Approaches in Plant Taxonomy

Introduction
Traditional taxonomy relied on **morphological features**, but modern techniques provide **greater accuracy** in plant classification.
Advanced methods include **Molecular Taxonomy, Cytotaxonomy, and Chemotaxonomy**.

Molecular Taxonomy (DNA Analysis)

Definition: Uses **DNA sequencing** to study genetic relationships between plants.
Techniques:
DNA Barcoding – Uses short DNA sequences to identify species.
RFLP (Restriction Fragment Length Polymorphism) – Identifies genetic differences.
PCR (Polymerase Chain Reaction) – Amplifies DNA for analysis.
Example:
Arabidopsis thaliana genome sequencing helped in plant evolutionary studies.
Importance:
Provides **precise plant identification**.
Helps in studying **evolutionary relationships**.
Useful for identifying **cryptic species** (visually similar but genetically different).

Molecular Systematics (brief)

Definition: Molecular systematics uses genetic data (DNA, RNA, proteins) to classify organisms and study their evolutionary relationships.

Objective Approach: Provides more accurate classifications compared to traditional morphology-based taxonomy.

Key Molecular Markers: Uses chloroplast DNA (*rbcL, matK*), nuclear DNA (*ITS*), and mitochondrial DNA.

Techniques Used: PCR amplification, DNA sequencing, and phylogenetic tree construction.

Significance: Helps in species identification, evolutionary studies, and biodiversity conservation.

Molecular systematics

- **Molecular systematics deals the utilization of nucleic acid data. As DNA sequence of a gene is constant in a species, hence advantage over morphological data for taxonomic studies.**

- **Taxonomist use molecular data from three different locations within a plant cell: chloroplast, mitochondrion and the nucleus.**

- **Molecular systematics involves following steps: (1) Sample collection, (2) DNA extraction, (3) Amplification using PCR –Polymerase chain Reaction, (4) DNA / Gene Sequencing, (5) Analysis of Sequence data.**
- **DNA barcoding can speed up identification of species. DNA barcoding helps in Wild plant identification / Medicinal plant authentication**

- **A DNA barcode is a short gene sequence taken from standardized portions of the genome, used to identify species**

DNA (Deoxyribo Nucleic Acid)

- The Cell is the basic structural, functional and biological unit of all known living organisms. The Nucleus is enclosed in an envelope which is a double membrane structure. The nucleus of each eukaryotic cell contains Deoxyribonucleic Acid (DNA). The Nucleus contains DNA in the form of loose threads called chromatin / Chromosomes.

- The chromosomes are the thread-like structure of nucleic acids and protein found in the nucleus of the living cells, carrying genetic information in the form of gene.

- The DNA is tightly packed into structures called chromosomes, which consist of long chains of DNA and associated proteins. Chromosome is the physical basis of heredity while DNA is the chemical basis of hereditary material.

- The DNA located in the nucleus of the cell called as nuclear DNA, but a small amount of DNA can also be found in the mitochondria (mitochondrial DNA or mtDNA) or chloroplast (chloroplast DNA or plastid DNA or cpDNA).

- **Genes passes genetic information from one generation to another generation. Genes lies on Chromosomes. Genes are made up of DNA. There are large number of genes occurs in each cell on each chromosomes.**

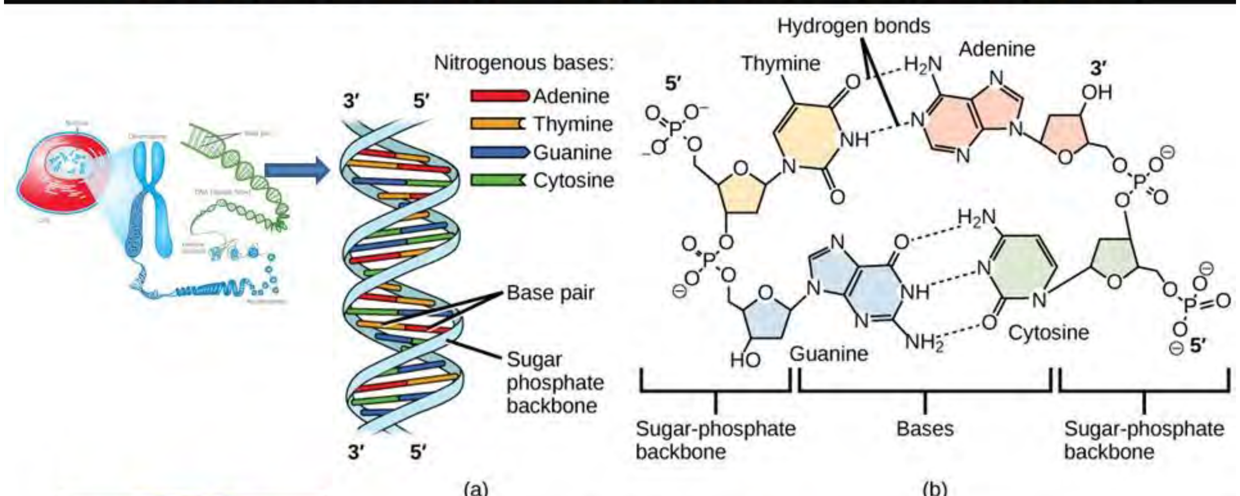
- **The model of DNA was given by James Watson and Francis Crick in 1962.**

- **An important property of DNA is that it can replicate, or make copies of itself. Each strand of DNA in the double helix can serve as a pattern for duplicating the sequence of bases.**

- **DNA is the molecule that carries the genetic information in all cellular forms of life. It belongs to a class of molecules called the nucleic acids, which are polynucleotides - that is, long chains of nucleotides. The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). The order, or sequence, of these bases determines the information available for building and maintaining an organism, similar to the way in which letters of the alphabet appear in a certain order to form words and sentences. DNA bases pair up with each other, A with T and C with G, to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the ladder's and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.**

- Gene expression is the process of converting information from gene to cellular product. Protein synthesis is the main function of the gene. DNA transcribed in to RNA (called as Transcription), and then RNA translated into Amino Acids (called as Translation). There are 20 different types of amino acids. Several amino acids in a fixed sequenced forms protein. Several protein in a fixed sequenced forms Enzymes. The enzymes participate in the biochemical reaction of the cell. There are many biochemical simultaneously occurring in a cell. Proper biochemical reactions of cell ensure the life.

Watson and Crick's DNA double helical model



In 1962 Nobel prize for medicine

Wilkins

Franklin

James Watson and Francis Crick

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

- The Cell is the basic structural, functional and biological unit of all known living organisms. The Nucleus is enclosed in an envelope which is a double membrane structure. The Nucleus contains DNA in the form of loose threads called chromatin / Chromosomes

- The chromosomes are the thread-like structure of nucleic acids and protein found in the nucleus of the living cells, carrying genetic information in the form of gene.

- Genes passes genetic information from one generation to another generation. Genes lies on Chromosomes. Genes are made up of DNA. There are large number of genes occurs in each cell on each chromosomes.

- DNA (Deoxyribo Nucleic Acid) the genetic materials of living organism. The model of DNA was given by James Watson and Francis Crick in 1962.

- Protein synthesis is the main function of the gene. DNA transcribed in to RNA (called as Transcription), and then RNA translated into Amino Acids (called as Translation). There are 20 different types of amino acids. Several amino acids in a fixed sequenced forms protein.
- Gene expression is the process of converting information from gene to cellular product.

Key Molecular Data in Taxonomy

DNA Sequencing:

rDNA (ribosomal DNA): 18S, 5.8S, 28S rDNA regions provide species- and genus-level identification.

Chloroplast DNA: matK, **rbcL**, and **trnL** regions are often used for plant family and genus classification.

Mitochondrial DNA: Markers like **COX1** and **ATP synthase genes** reveal evolutionary relationships within certain plant groups.

Molecular Markers:

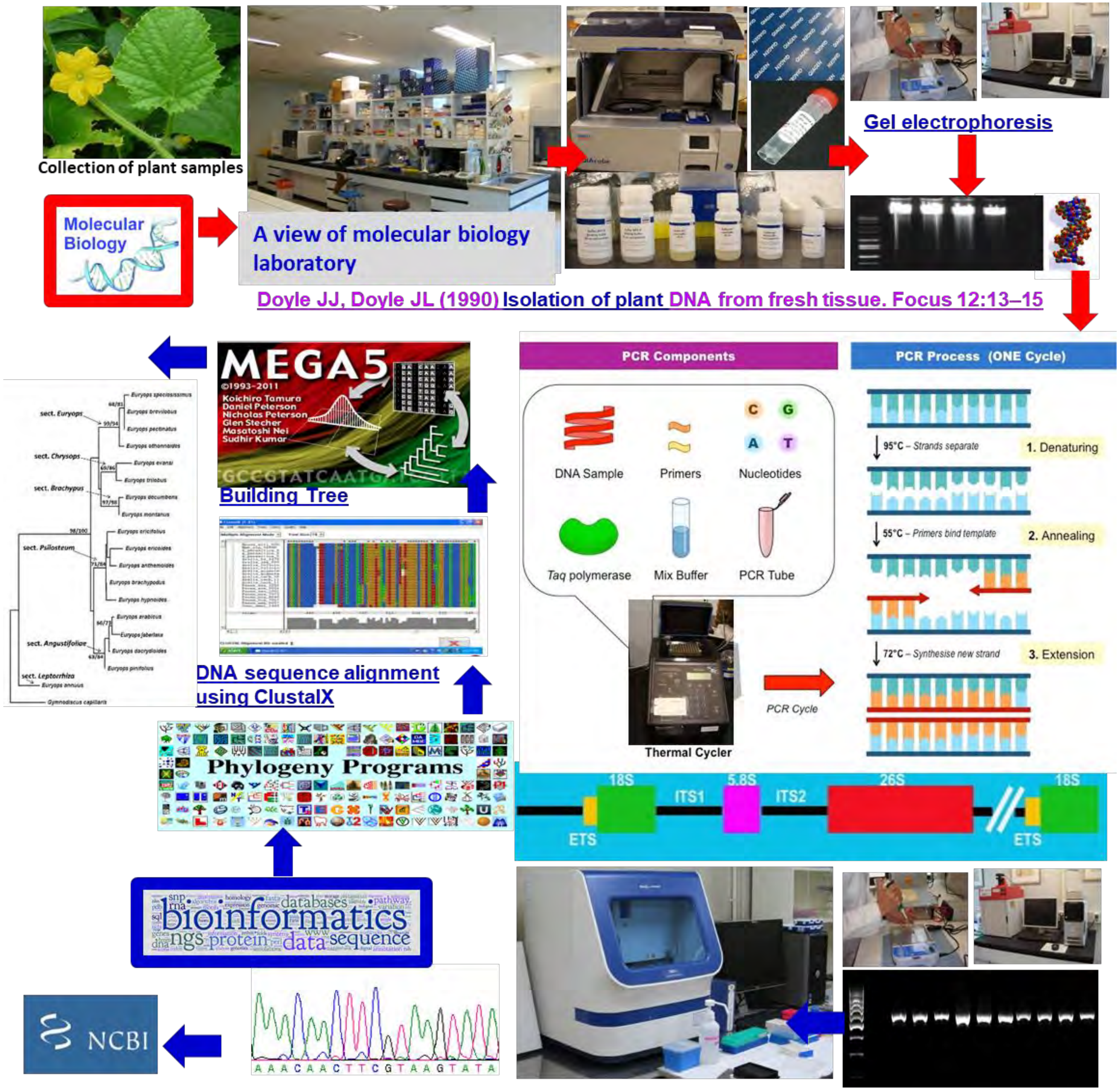
SSR (Simple Sequence Repeats): Highly polymorphic markers for species identification.

AFLP (Amplified Fragment Length Polymorphism): Used to assess genetic diversity and phylogenetic relationships.

SNPs (Single Nucleotide Polymorphisms): Help refine species boundaries and reveal population-level diversity.

Genome Sequencing:

Full **genome sequencing** provides the most comprehensive taxonomic data, revealing gene family expansions, genome size, and synteny between species.


Collection of plant samples
Molecular Biology
A view of molecular biology laboratory
Gel electrophoresis
Doyle JJ, Doyle JL (1990) Isolation of plant DNA from fresh tissue. Focus 12:13–15
MEGA5
©1993-2011
Koichiro Tamura
Daniel Peterson
Nicholas Peterson
Glen Stecher
Masatoshi Nei
Sudhir Kumar
Building Tree
DNA sequence alignment using ClustalX
Phylogeny Programs
bioinformatics
databases
pathway
ngs
protein
data
sequence
NCBI
A A A C A A C T T C G T A A G T A T A
PCR Components
PCR Process (ONE Cycle)
DNA Sample
Primers
Nucleotides
C G A T
Taq polymerase
Mix Buffer
PCR Tube
Thermal Cycler
PCR Cycle
95°C – Strands separate
1. Denaturing
55°C – Primers bind template
2. Annealing
72°C – Synthesise new strand
3. Extension
18S
ITS1
5.8S
ITS2
26S
18S
ETS
ETS

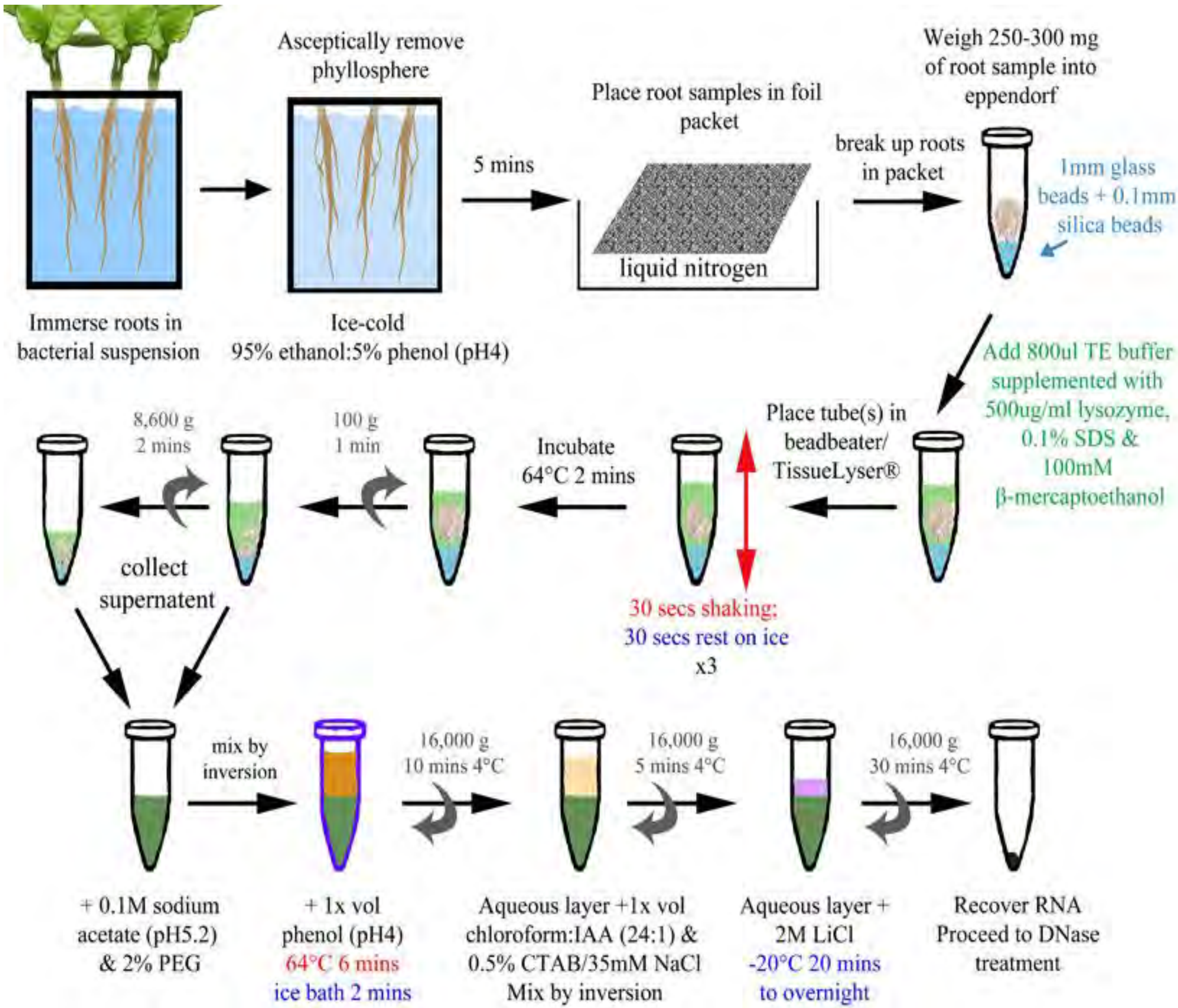
Sampling of leaf material for the molecular taxonomic study and DNA extraction

- **Doyle and Doyle (1990) is widely used protocol for DNA Extraction from plant tissue. But it involves preparation of several buffer manually. It takes long times. This method atleast take more than one day preparation and about whole day in DNA extraction. It also involves several times centrifugation. This method requires large amount of fresh leaves (10 gram or even more).**

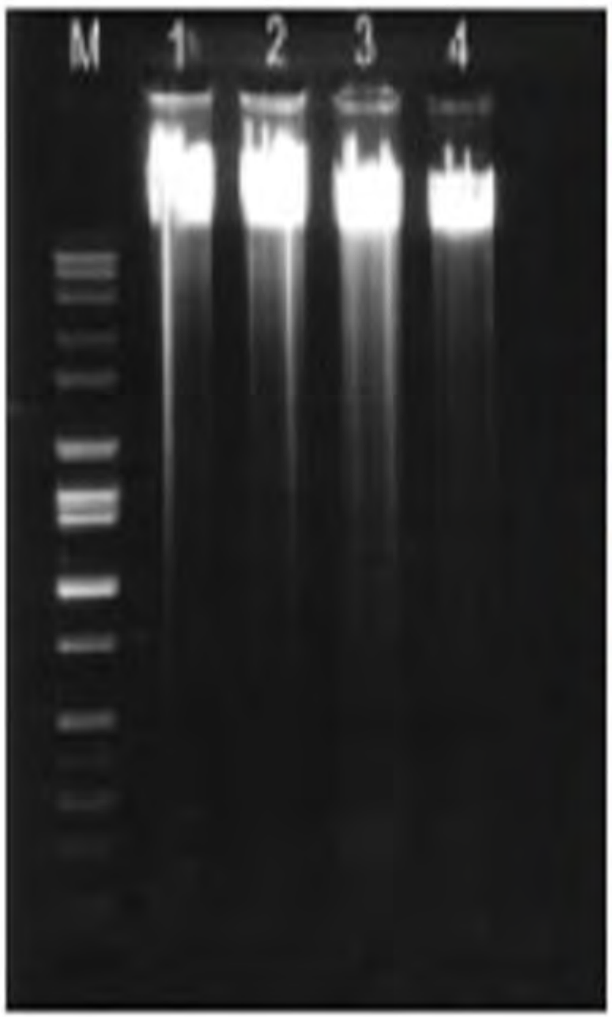
- **Doyle JJ, Doyle JL (1990) Isolation of plant DNA from fresh tissue. Focus 12:13–15**

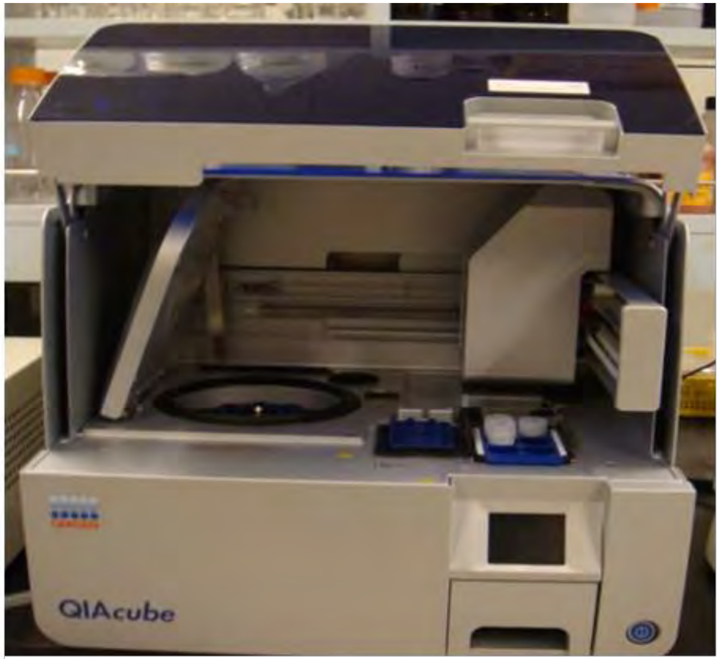
- **In contrast to manual method, there are several DNA extraction kit and automated DNA extraction machine is available like Qiagen automated DNA extraction machine, and Qiagen DNA extraction Kit.**

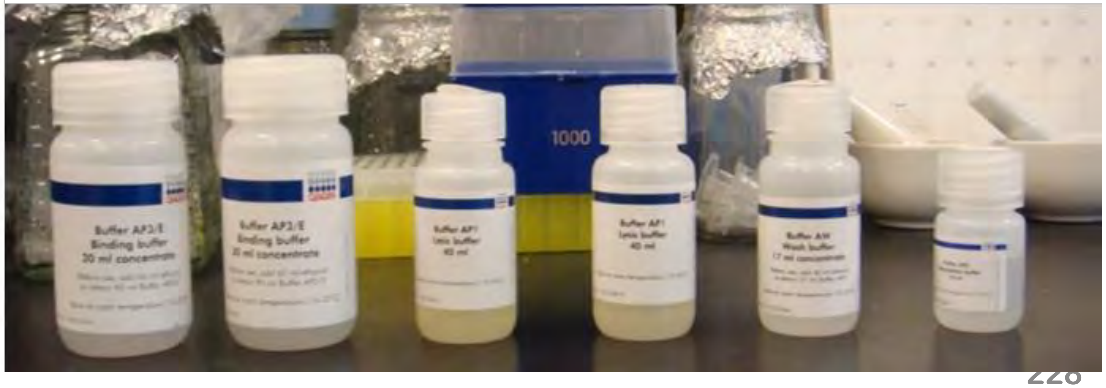
- **In Qiagen DNA extraction all the buffer are provided and ready to use. DNA can be extracted from small amount of 20 mg l dried leaf tissue or from very small piece of leaf collected from even old herbarium specimens. By using Qiagen DNA can be extracted in 3 hours. It do not required centrifugation manually.**

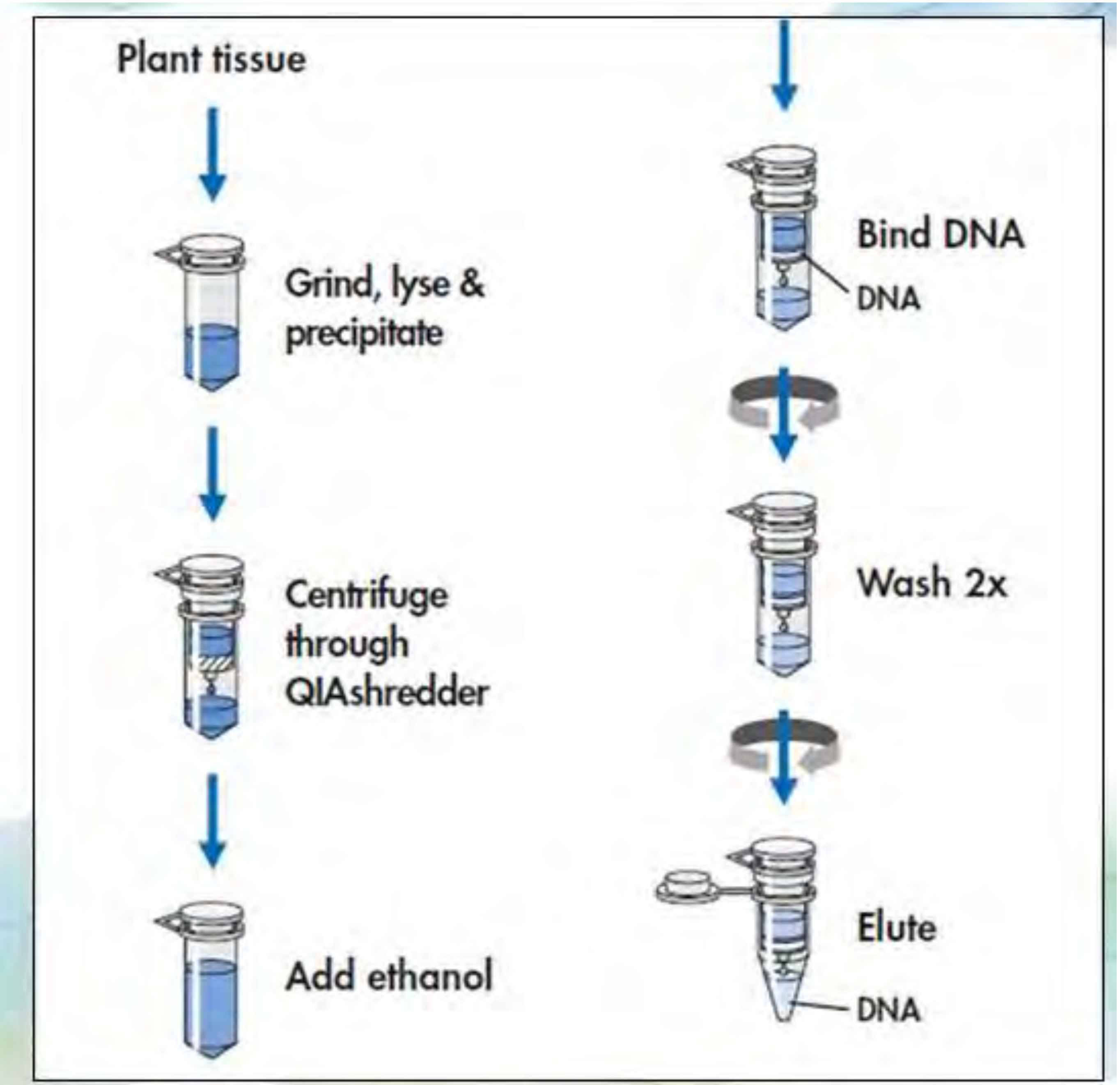

Asceptically remove phyllosphere
Place root samples in foil packet
Weigh 250-300 mg of root sample into eppendorf
5 mins
break up roots in packet
1mm glass beads + 0.1mm silica beads
liquid nitrogen
Immerse roots in bacterial suspension
Ice-cold 95% ethanol:5% phenol (pH4)
Add 800ul TE buffer supplemented with 500ug/ml lysozyme, 0.1% SDS & 100mM β-mercaptoethanol
Place tube(s) in beadbeater/ TissueLyser®
Incubate 64°C 2 mins
100 g 1 min
8,600 g 2 mins
collect supernatent
30 secs shaking; 30 secs rest on ice x3
mix by inversion
16,000 g 10 mins 4°C
16,000 g 5 mins 4°C
16,000 g 30 mins 4°C
+ 0.1M sodium acetate (pH5.2) & 2% PEG
+ 1x vol phenol (pH4) 64°C 6 mins ice bath 2 mins
Aqueous layer +1x vol chloroform:IAA (24:1) & 0.5% CTAB/35mM NaCl Mix by inversion
Aqueous layer + 2M LiCl -20°C 20 mins to overnight
Recover RNA Proceed to DNase treatment

QIAGEN automated DNA extraction method








Plant tissue
Grind, lyse & precipitate
Centrifuge through QIAshredder
Add ethanol
Bind DNA
DNA
Wash 2x
Elute
DNA

Agarose Gel Electrophoresis

- **The main purpose of agarose gel electrophoresis is to determine the presence or absence of genomic DNA or PCR products and quantify the size (length of the DNA molecule).**

- **Agarose gel electrophoresis is a widely used technique for the preparation and analysis of DNA. Electrophoresis is a method of separating DNA based on the rate of movement while under the influence of an electric field.**

- **Agarose is a polysaccharide purified from seaweed.**

- **An agarose gel is created by suspending dry agarose in a buffer solution, boiling until the solution becomes clear, and then pouring it into a casting tray and allowing it to cool. During electrophoresis, the gel is submersed in a chamber containing a buffer solution and a positive and negative electrode.**

- **The DNA to be analyzed is forced through the pores of the gel by the electrical current.**
- **Under an electrical field, DNA moves to the positive electrode (red) and away from the negative electrode (black).**

- **DNA itself is not visible within an agarose gel.**

- **The DNA visualized by the use of dye that binds to DNA.**


MED 2.05
AGAROSE
5gm

TAE 50X

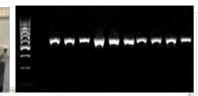
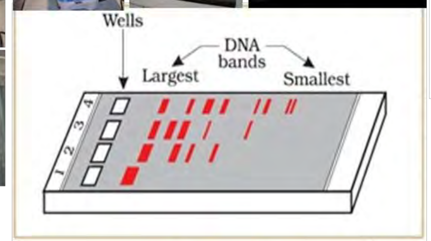
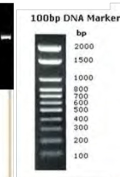
Agarose

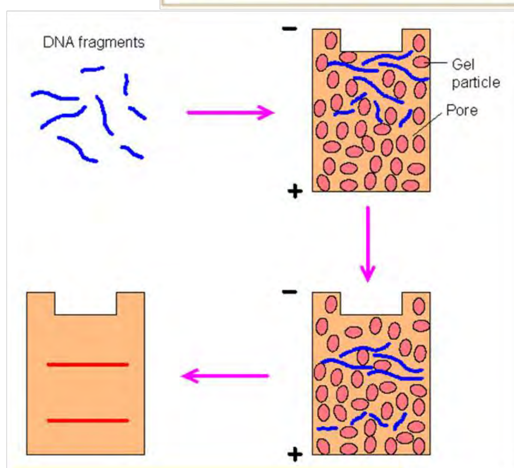
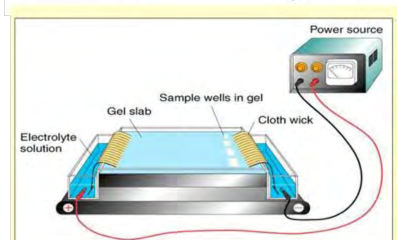
Buffer Solution



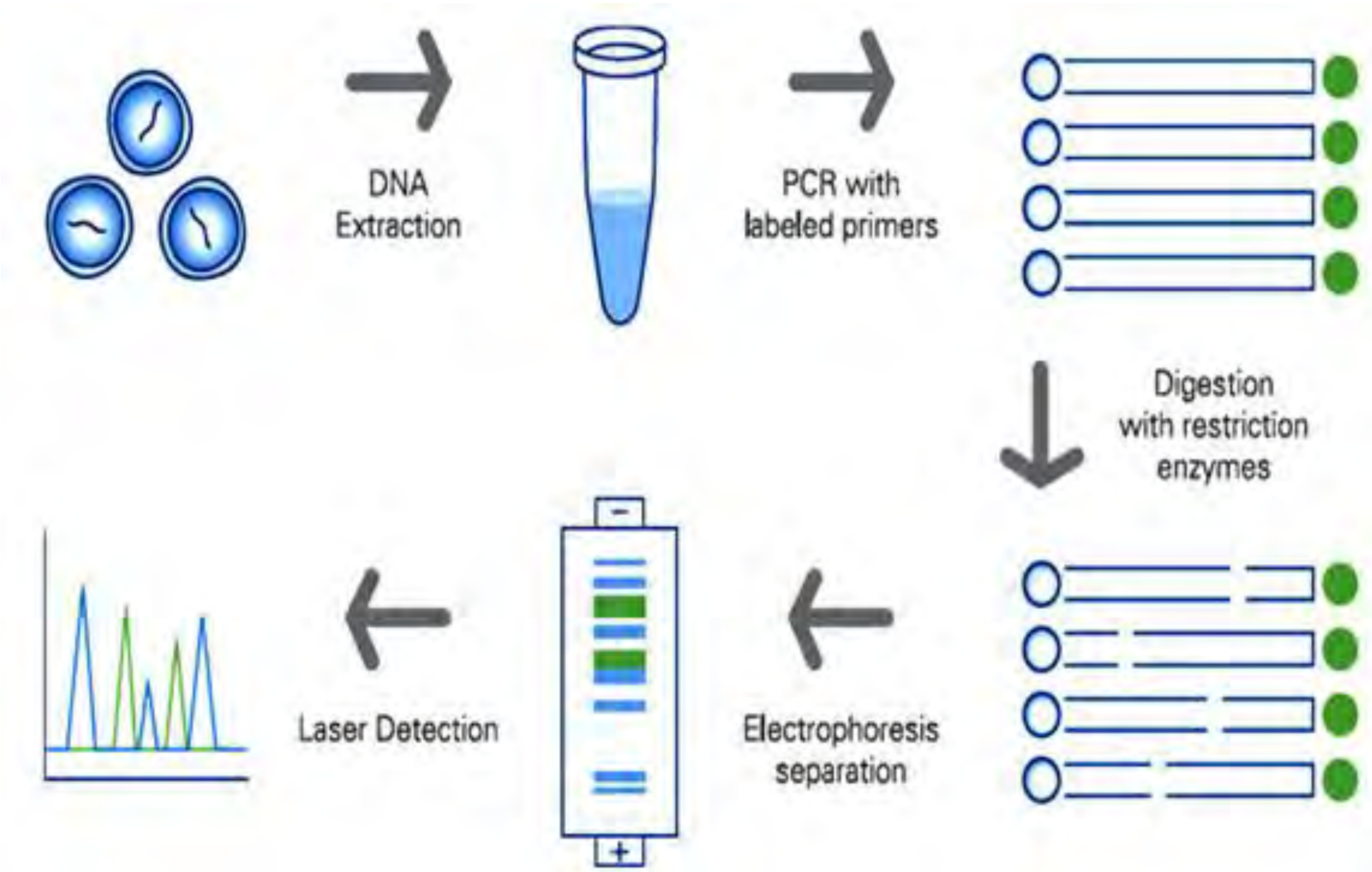






Wells
DNA bands
Largest
Smallest
1
2
3
4

100bp DNA Marker
bp
2000
1500
1000
800
700
600
500
400
300
200
100


100 bp DNA Ladder

DNA fragments
−
+
Gel particle
Pore
−
+

Power source
Sample wells in gel
Gel slab
Cloth wick
Electrolyte solution

MOLECULAR MARKERS



Key Molecular Markers in Molecular Systematics

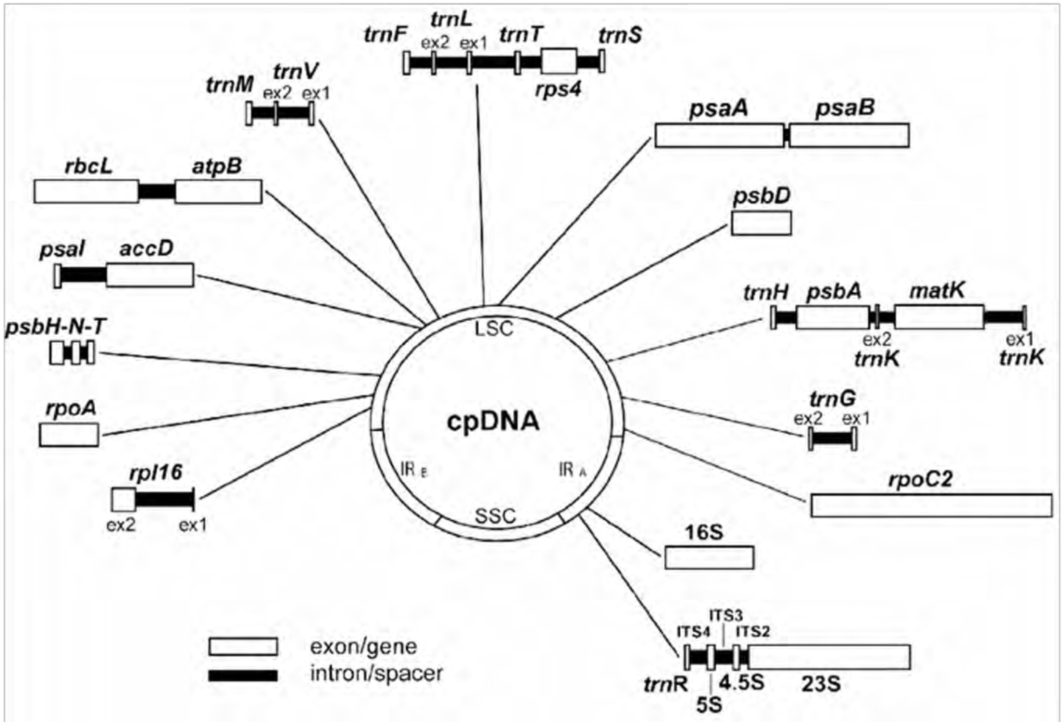
1. Chloroplast DNA (cpDNA)

Found in plant chloroplasts and maternally inherited in most angiosperms.
Highly conserved, making it useful for studying evolutionary relationships.
Commonly used **cpDNA markers:**

rbcL (*Ribulose-1,5-bisphosphate carboxylase/oxygenase large subunit*): Used in DNA barcoding and phylogenetics.

matK (*Maturase K*): Highly variable, useful for resolving species-level relationships.

trnL-F spacer, psbA-trnH, atpB-rbcL: Used in phylogenetic and population studies.



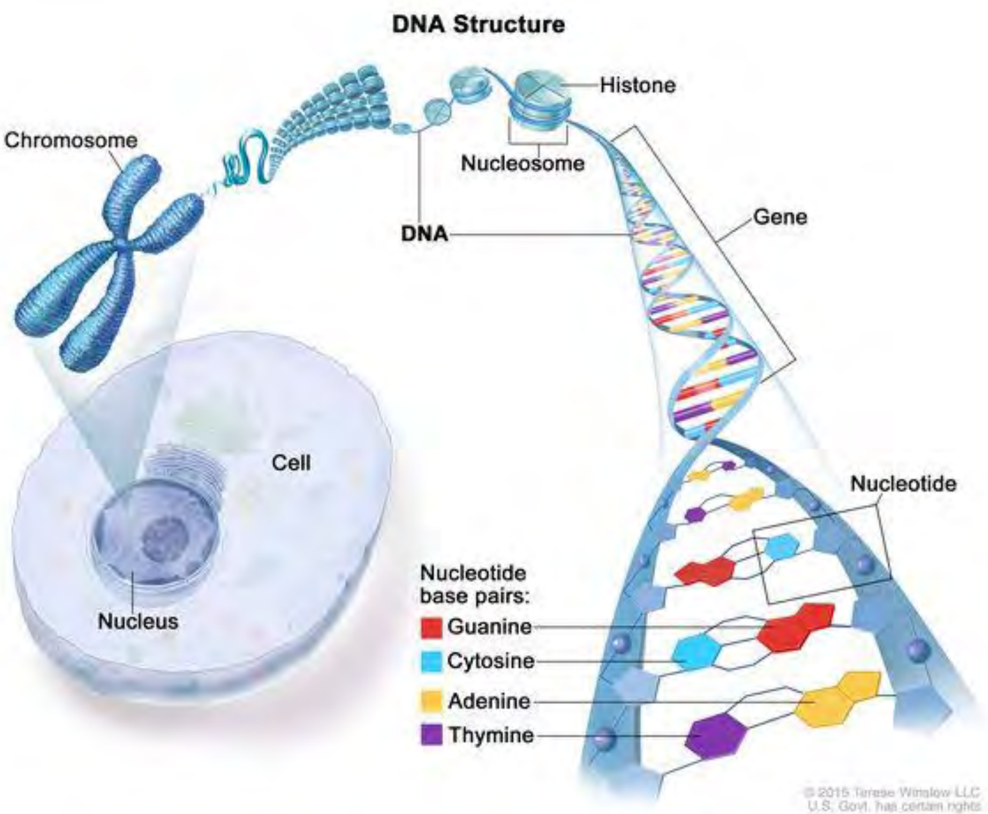
2. Nuclear DNA (nDNA)

Found in the nucleus and inherited biparentally.

Provides high-resolution data for species differentiation and hybrid detection.

Commonly used **nuclear DNA markers:**

- **ITS (Internal Transcribed Spacer) regions (ITS1 & ITS2):** Widely used for species-level phylogenetics.
- **18S rRNA, 26S rRNA:** Used in deep phylogenetic studies.
- **Single-Copy Nuclear Genes:** Provide additional resolution for evolutionary studies.



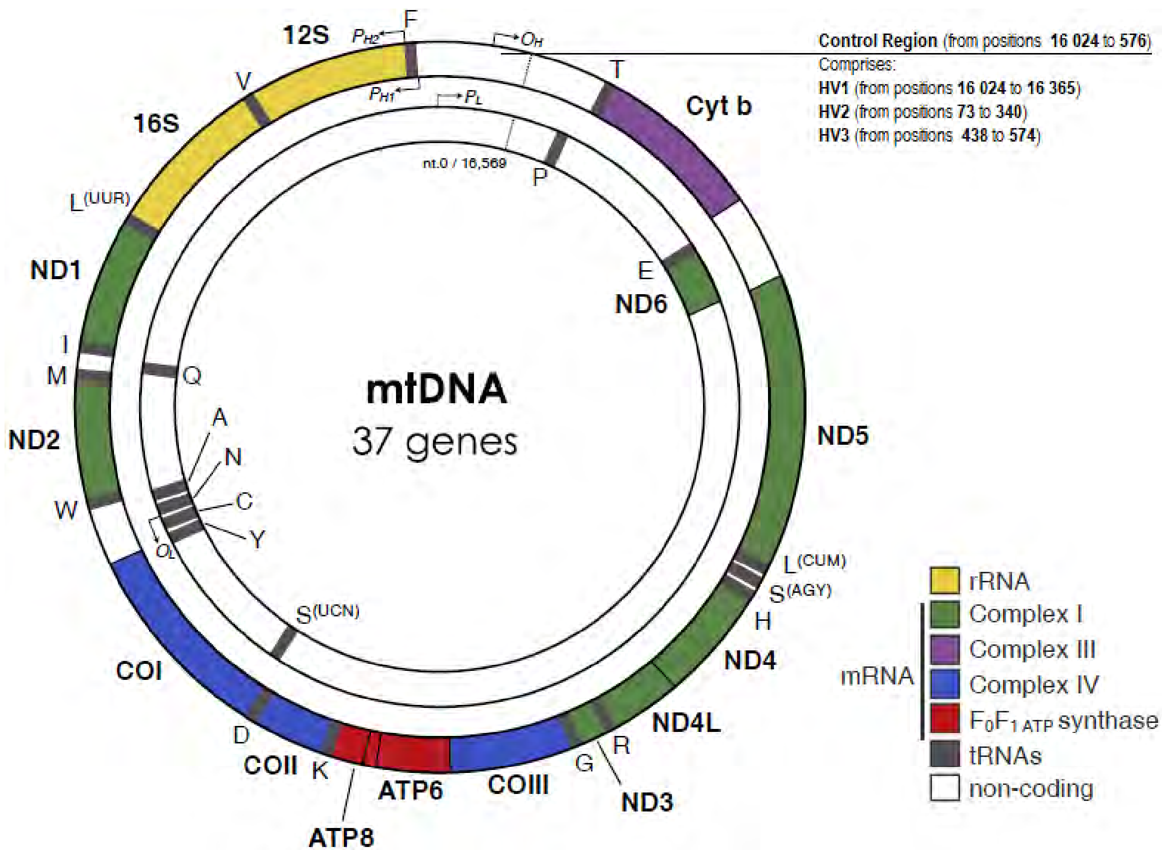
3. Mitochondrial DNA (mtDNA)

Found in plant mitochondria and typically maternally inherited.

Has a **high recombination rate** in plants, making it less useful than cpDNA for phylogenetic studies.

Commonly used **mtDNA markers:**

- **cox1 (Cytochrome c oxidase subunit 1):** Used in some plant phylogenetic studies.
- **nad1, nad2:** Useful in specific plant groups but less consistent.



Choosing molecular marker, and application of PCR in plant molecular taxonomy / DNA taxonomy

- In DNA sequencing method based practice of plant molecular taxonomy required DNA sequences.

- To obtain DNA sequence of a taxon required extraction of whole genomic DNA first. And then amplification of gene of interest. The amplification using gene interest is achieved by the polymerase chain reaction (PCR). The PCR results into billions of copies of gene of interest which can be observed in a gel under UV light. The amplified DNA later used for the purpose of DNA sequencing. So, for the cloning of the gene of interest using PCR requires primer. The primers are also called as molecular markers. To begin plant molecular taxonomy, selection of molecular marker is very critical and important.

- The most commonly used molecular marker in molecular taxonomy are ITS, rbcL, matK, psb, ndhF, trn gene.
- The molecular marker gene could be coding gene or non coding gene.

- Properties of ideal marker genes

➢ A single-copy gene may be more useful than multiple-copy gene
➢ The substitution rate should be optimum so as to provide enough informative sites and alignment should be easy.
➢ Primers should be available to selectively amplify the marker gene

- **The nuclear ribosomal locus coding for the large subunit is represented in tandem arrays in the plant genome.**

- **ITS is located between the 18 and 26S rRNA genes.**

- **The 5.8S region on the other hand is only about 160 bp long and highly conserved within major organism groups.**

- **The ITS region consists of three parts: the ITS1 and ITS2 and the highly conserved 5.8S rDNA exon located in between. The total length of this region varies between 500 and 750 bp in angiosperms while in other seed plants it can be much longer, up to 1,500–3,500 bp.**

- **Spacer DNA is a region of non-coding DNA between genes.**

- **In contrast to the coding regions, spacers evolve more quickly, like the internal transcribed spacer (ITS) region, which is extensively used as a marker for phylogenetic reconstruction at different levels.**

- **The ITS is present in virtually all organisms. The advantages of this region are: (1) easy PCR amplification, with several universal primers available for a various kind of organisms; (2) multicopy structure; (3) moderate size allowing easy sequencing; and (4) it has a high degree of variation even between closely related species.,**

- **variability is due to frequently occurring nucleotide polymorphisms or to common insertions/deletions in the sequence.**

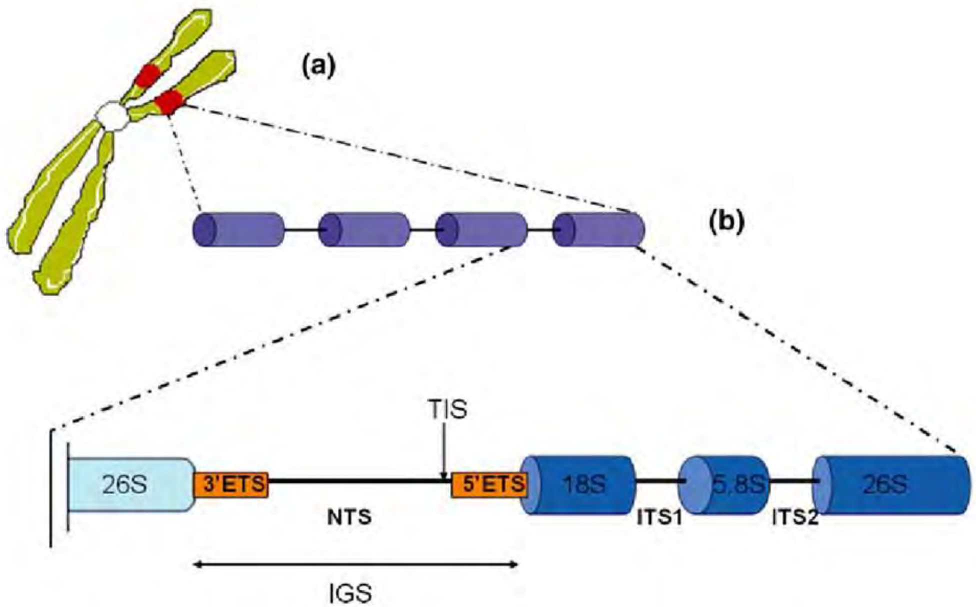
- **As DNA of ITS regions is removed and it is not part of the mature RNA molecule, they are considered noncoding regions of the genome**

A fascinating feature of biological life is the common use of the DNA genetic code and its subsequent processing into functional units of protein through the intermediate RNA molecule.

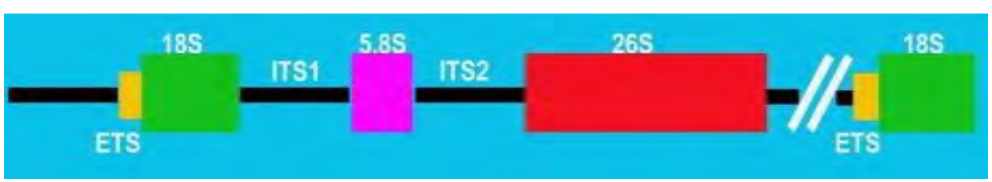
The transcription of DNA into RNA and translation of RNA into protein are both highly regulated and compartmentalized in all living organisms.

The cellular factory responsible for the production of protein is the ribosome. As the essential functions of ribosomes are critical for survival, their physical parameters have been conserved in all forms of life.

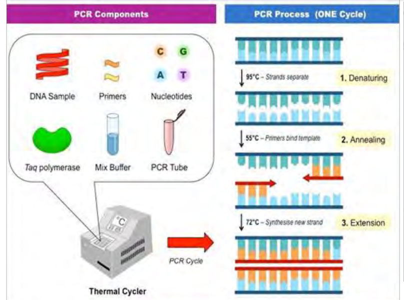
Some components within the ribosomal factories have, however, changed sometimes. These similarities, as well as the changes within genetic material can be used as tools for the identification of organisms

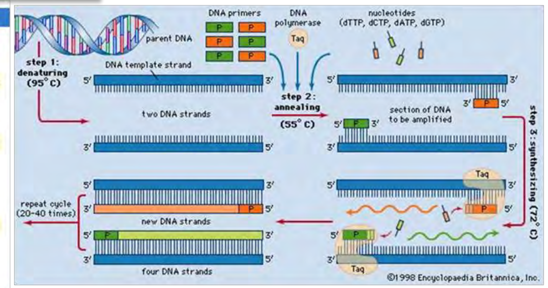


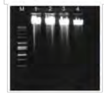
MARKER	SEQUENCE	REFERENCE
ITS1 F	TCCGTAGGTGAACCTGCGG	White et al. (1990)
ITS4 R	TCCTCCGCTTATTGATATGC	White et al. (1990)
rbcLa F	ATGTCACCACAAACAGAGACTAAAGC	Levin (2003)
rbcLa R	GTAAAATCAAGTCCACCRCG	Kress and Erickson (2007)
MatK 390 F	CGATCTATTCATTCAATATTTC	Cuenoud et al. (2002)
MatK 1326 R	TCTAGCACACGAAAGTCGAAGT	Cuenoud et al. (2002)
psbA-trnH F	GTTATGCATGAACGTAATGCTC	Sang et al. (1997)
psbA-trnH R	CGCGCATGGTGGATTCACAATCC	Tate and Simpson (2003)
trn L-F R	GGTTCAAGTCCCTCTATCCC	Taberlet et al. (1991)
trn L-F F	ATTTGAACTGGTGACACGAG	Taberlet et al. (1991)



PCR (Polymerase Chain Reaction)







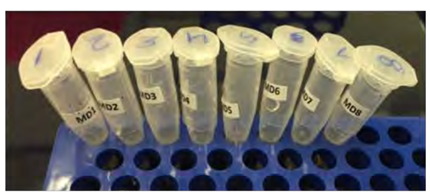
MARKER	SEQUENCE	REFERENCE
ITS1 F	TCCGTAGGTGAACCTGCGG	White et al. (1990)
ITS4 R	TCCTCCGCTTATTGATATGC	White et al. (1990)
rbcLa F	ATGTCACCACAAACAGAGACTAAAG C	Levin (2003)
rbcLa R	GTAAAATCAAGTCCACCRCG	Kress and Erickson (2007)
MatK 390 F	CGATCTATTCATTCAATATTTC	Cuenoud et al. (2002)
MatK 1326 R	TCTAGCACACGAAAGTCGAAGT	Cuenoud et al. (2002)
psbA-trnH F	GTTATGCATGAACGTAATGCTC	Sang et al. (1997)
psbA-trnH R	CGCGCATGGTGGATTCACAATCC	Tate and Simpson (2003)
trn L-F R	GGTTCAAGTCCCTCTATCCC	Taberlet et al. (1991)
trn L-F F	ATTTGAACTGGTGACACGAG	Taberlet et al. (1991)

Contents of HF PCR premix Reaction size (20 µl reaction): 1. DNA polymerase 1µl, 2. Each dNTP (dATP, dCTP, dGTP, dTTP) 250 µM, 3. 10X reaction buffer Stabilizer and tracking dye2µl

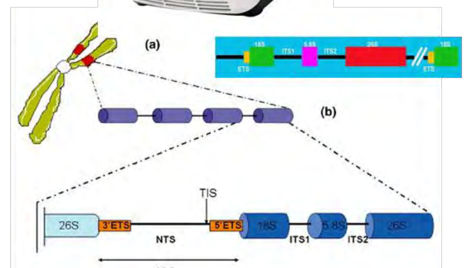
Template DNA (1µl ~ 100 ng), Primer (1µl each of F and R, 5 ~20 pmole)

No	Oligo Name	Sequence(5'-3')	Size	Synthesis scale	Purification	OD	ug	nmols	Volume for 100 pmoles/ul	Mw	Tm (°C)	GC%
1/2	ITS1	GTC CAC TGA ACC TTA TCA TTT AG	23	0.05	desalting	4.5	134.0	18.3	182.9	6973.6	57.1	39.1
2/2	ITS4	TCC TCC GCT TAT TGA TAT GC	20	0.05	desalting	4.5	142.6	22.5	224.9	6034.0	55.2	45.0

1/10th genomic DNA dilution: Add 10 µl total genomic DNA in 90 µl molecular grade distilled water.
Dilution of primer for stock solution (100 pmoles/ µl): nmols X 10 Distilled water (ddH_2O) = 100 pmoles/ µl (Stock)



PCR Parameters			
1	Initial Denaturation	94 °C for 5 minutes	
	Denaturation	94 °C for 1minute	
2	Annealing	49 °C for 1minute	Number of cycles: 40
	Extension	72 °C for 1minute	
3	Final extension	72 °C for 5 minutes	
4	Hold	4 °C	∞



Agarose Gel Electrophoresis

- **The main purpose of agarose gel electrophoresis is to determine the presence or absence of genomic DNA or PCR products and quantify the size (length of the DNA molecule).**

- **Agarose gel electrophoresis is a widely used technique for the preparation and analysis of DNA. Electrophoresis is a method of separating DNA based on the rate of movement while under the influence of an electric field.**

- **Agarose is a polysaccharide purified from seaweed.**

- **An agarose gel is created by suspending dry agarose in a buffer solution, boiling until the solution becomes clear, and then pouring it into a casting tray and allowing it to cool. During electrophoresis, the gel is submersed in a chamber containing a buffer solution and a positive and negative electrode.**

- **The DNA to be analyzed is forced through the pores of the gel by the electrical current.**
- **Under an electrical field, DNA moves to the positive electrode (red) and away from the negative electrode (black).**

- **DNA itself is not visible within an agarose gel.**

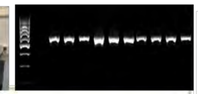
- **The DNA visualized by the use of dye that binds to DNA.**

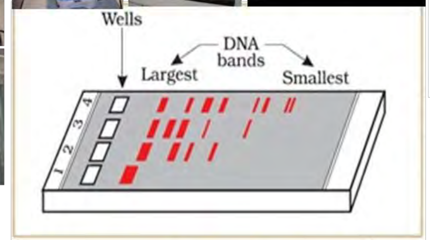

MED 2.05
AGAROSE
5gm

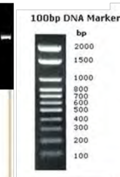

TAE 50X

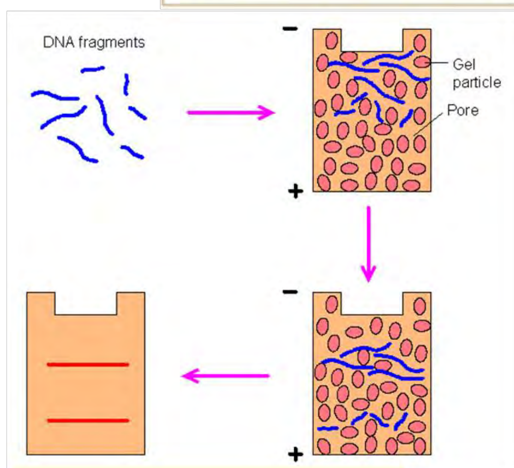

Agarose

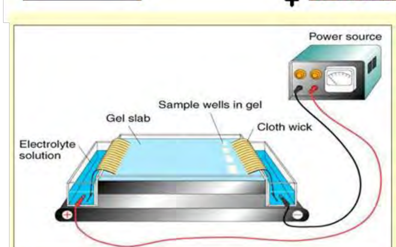

Buffer Solution




Wells
DNA
bands
Largest
Smallest
1
2
3
4


100bp DNA Marker
bp
2000
1500
1000
800
700
600
500
400
300
200
100


DNA fragments
−
Gel
particle
Pore
+
−
+


Power source
Sample wells in gel
Gel slab
Cloth wick
Electrolyte
solution

DNA sequencing

- DNA sequencing is the process of determining the sequence of nucleotides (A, T, C, and G) in a piece of DNA.

- In Sanger sequencing, the target DNA is copied many times, making fragments of different lengths. Fluorescent "chain terminator" nucleotides mark the ends of the fragments and allow the sequence to be determined.

- Next-generation sequencing techniques are new, large-scale approaches that increase the speed and reduce the cost of DNA sequencing.

- Sanger sequencing: The chain termination method

- Regions of DNA up to about 900 base pairs in length are routinely sequenced using a method called Sanger sequencing or the chain termination method.

- Ingredients for Sanger sequencing

- Sanger sequencing involves making many copies of a target DNA region. Its ingredients are similar to those needed for DNA replication in an organism, or for polymerase chain reaction (PCR), which copies DNA *in vitro*. They include:

- A DNA polymerase enzyme

- A primer, which is a short piece of single-stranded DNA that binds to the template DNA and acts as a "starter" for the polymerase

- The four DNA nucleotides (dATP, dTTP, dCTP, dGTP)

- The template DNA to be sequenced

- However, a Sanger sequencing reaction also contains a unique ingredient:

- **Dideoxy, or chain-terminating, versions of all four nucleotides (ddATP, ddTTP, ddCTP, ddGTP), each labeled with a different color of dye**

- **Dideoxy nucleotides are similar to regular, or deoxy, nucleotides, but with one key difference: they lack a hydroxyl group on the 3’ carbon of the sugar ring. In a regular nucleotide, the 3’ hydroxyl group acts as a “hook," allowing a new nucleotide to be added to an existing chain.**

- **Once a dideoxy nucleotide has been added to the chain, there is no hydroxyl available and no further nucleotides can be added. The chain ends with the dideoxy nucleotide, which is marked with a particular color of dye depending on the base (A, T, C or G) that it carries.**

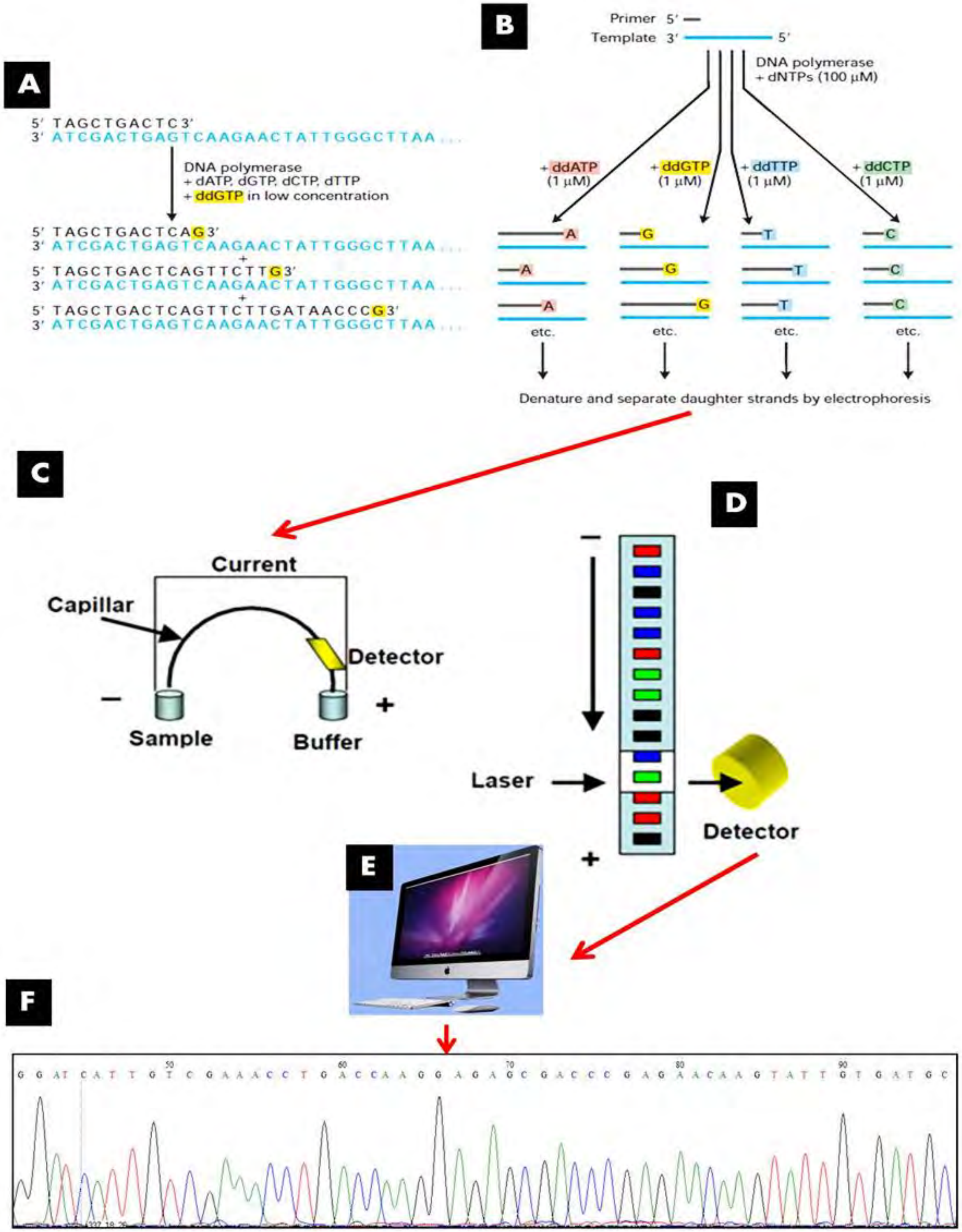
- **The DNA sample to be sequenced is combined in a tube with primer, DNA polymerase, and DNA nucleotides (dATP, dTTP, dGTP, and dCTP). The four dye-labeled, chain-terminating dideoxy nucleotides are added as well, but in much smaller amounts than the ordinary nucleotides.**

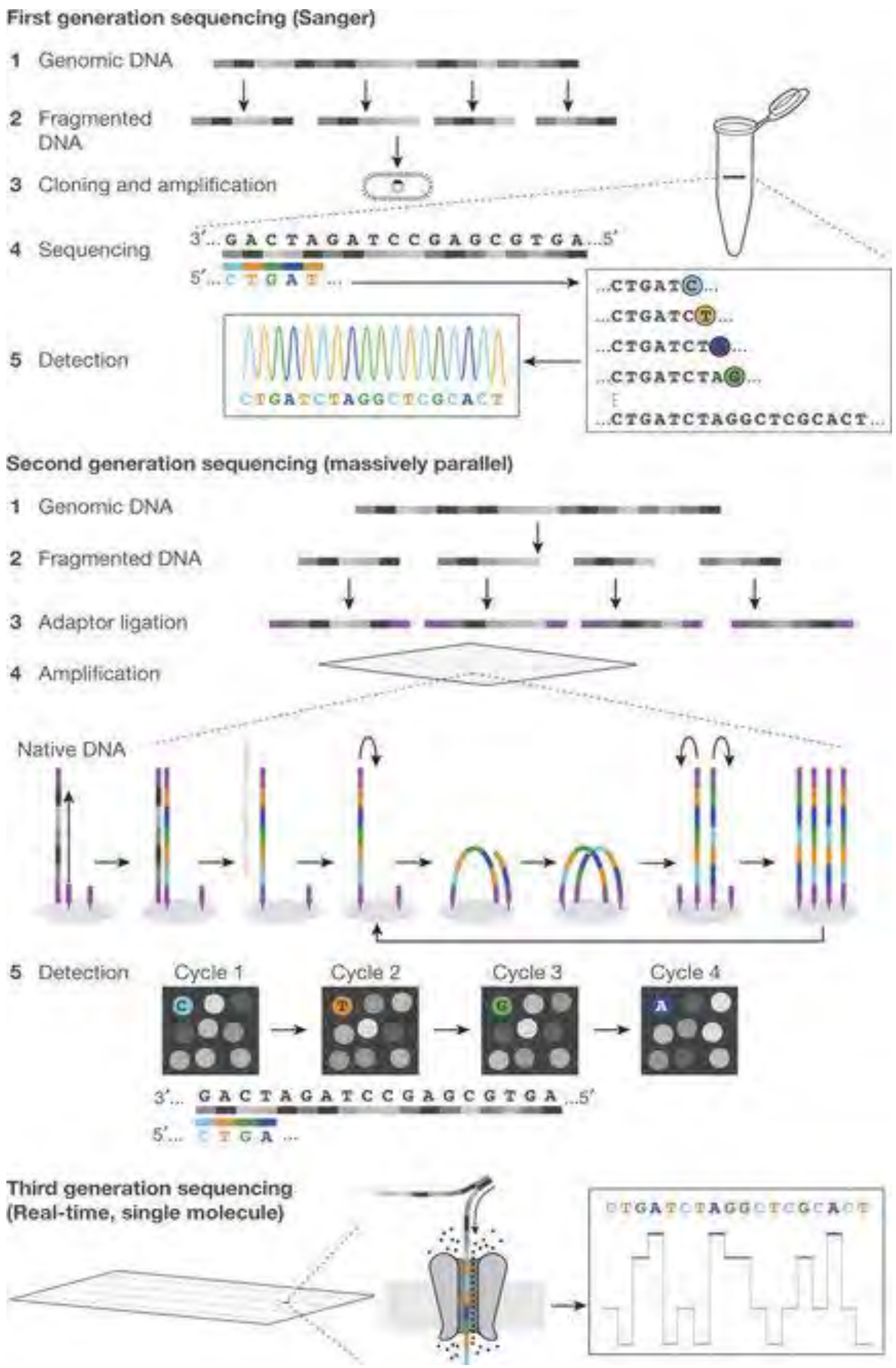
- **The mixture is first heated to denature the template DNA (separate the strands), then cooled so that the primer can bind to the single-stranded template. Once the primer has bound, the temperature is raised again, allowing DNA polymerase to synthesize new DNA starting from the primer. DNA polymerase will continue adding nucleotides to the chain until it happens to add a dideoxy nucleotide instead of a normal one. At that point, no further nucleotides can be added, so the strand will end with the dideoxy nucleotide.**

- **This process is repeated in a number of cycles. By the time the cycling is complete, it’s virtually guaranteed that a dideoxy nucleotide will have been incorporated at every single position of the target DNA in at least one reaction. That is, the tube will contain fragments of different lengths, ending at each of the nucleotide positions in the original DNA (see figure below). The ends of the fragments will be labeled with dyes that indicate their final nucleotide.**

- **After the reaction is done, the fragments are run through a long, thin tube containing a gel matrix in a process called capillary gel electrophoresis. Short fragments move quickly through the pores of the gel, while long fragments move more slowly. As each fragment crosses the “finish line” at the end of the tube, it’s illuminated by a laser, allowing the attached dye to be detected.**

- The smallest fragment (ending just one nucleotide after the primer) crosses the finish line first, followed by the next-smallest fragment (ending two nucleotides after the primer), and so forth. Thus, from the colors of dyes registered one after another on the detector, the sequence of the original piece of DNA can be built up one nucleotide at a time. The data recorded by the detector consist of a series of peaks in fluorescence intensity, as shown in the chromatogramabove. The DNA sequence is read from the peaks in the chromatogram.





Advances in next generation DNA sequencing

BOX I

The milestones listed below correspond to key developments in the evolution of sequencing technologies. This is a large topic, and we apologize for any omissions.

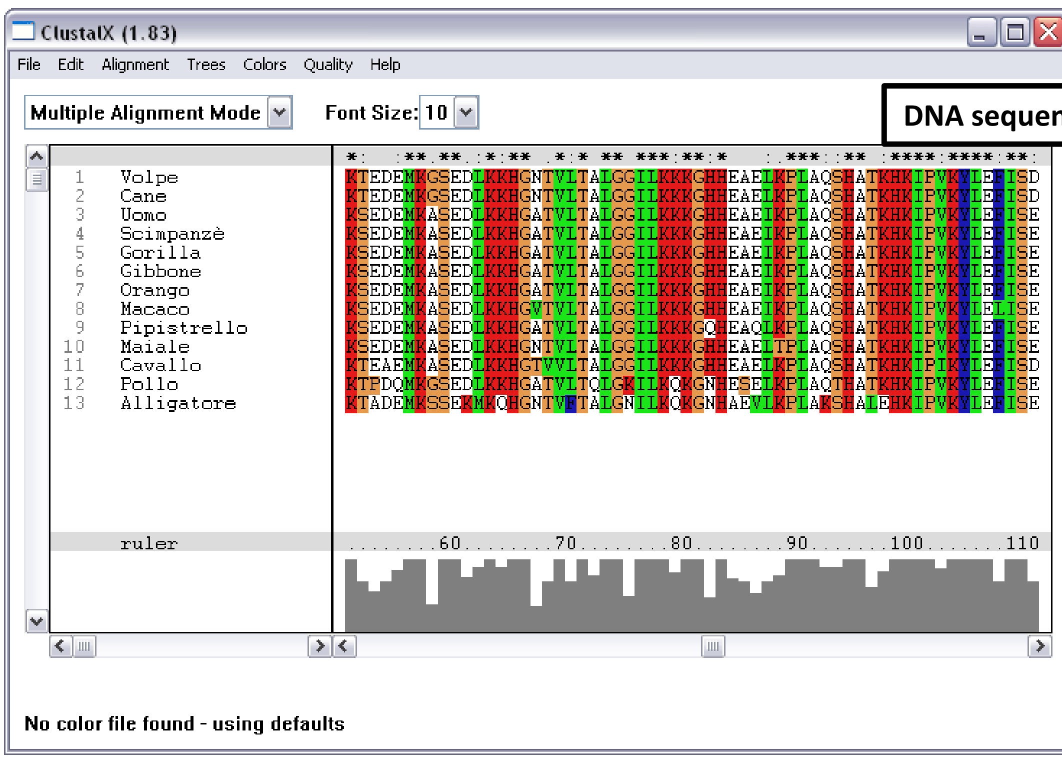
Technical milestones

1953: Sequencing of insulin protein[2]
1965: Sequencing of alanine tRNA[4]
1968: Sequencing of cohesive ends of phage lambda DNA[6]
1977: Maxam–Gilbert sequencing[9]
1977: Sanger sequencing[8]
1981: Messing's M13 phage vector[12]
1986–1987: Fluorescent detection in electrophoretic sequencing[14,15,17]
1987: Sequenase[18]
1988: Early example of sequencing by stepwise dNTP incorporation[139]
1990: Paired-end sequencing[23]
1992: Bodipy dyes[140]
1993: *In vitro* RNA colonies[37]
1996: Pyrosequencing[44]
1999: *In vitro* DNA colonies in gels[38]
2000: Massively parallel signature sequencing by ligation[47]
2003: Emulsion PCR to generate *in vitro* DNA colonies on beads[42]
2003: Single-molecule massively parallel sequencing-by-synthesis[33,34]
2003: Zero-mode waveguides for single-molecule analysis[57]
2003: Sequencing by synthesis of *in vitro* DNA colonies in gels[49]
2005: Four-colour reversible terminators[51–53]
2005: Sequencing by ligation of *in vitro* DNA colonies on beads[41]
2007: Large-scale targeted sequence capture[93–96]
2010: Direct detection of DNA methylation during single-molecule sequencing[65]
2010: Single-base resolution electron tunnelling through a solid-state detector[141]
2011: Semiconductor sequencing by proton detection[142]
2012: Reduction to practice of nanopore sequencing[143,144]
2012: Single-stranded library preparation method for ancient DNA[145]

DNA sequence dataset preparation

gene, partial sequence

GTCGAAACCTGCATAGCAGAACGACCCGCGAACACGTTACACTACCAGGTGAGGGACGAGGGGTGCGCAA
GCTCCCCAAGTTTCAAACCCATGGTCGGGGACCACCCTTGGGTGGCCTCGTCCGAACAACGACCCCCCGG
CGCGGAATGCGCCAAGGAAATCAAACTGAACTGCACGCGTCCCCCCCGTTTGCGGGCGGCGGAAGCGTCT
TTCTAAAACACAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCGAAATG
CGATACTTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGTCTTTGAACGCAAGTTGCGCCCGAAGCCA
TTAGGCCGAGGGCACGTCTGCCTGGGCGTCACACATCGCGTCGCCCCCCAACCCATCACTCCCTTGCGGG
AGTTGAGGCGGAGGGGCGGATAATGGCCTCCCGTGTCTCACCGCGCGGTTGGCCCAAATGCGAGTCCTTG
GCGATGGACGTCACGACAAGTGGTGGTTGTAAAAAGCCCTCTTCTCATGTCGTGCGGTGACCCGTCGCCA
GCAAAATCTCTCATGACCCTGTTGCGCCGAGCCTCGACGCGCGCTCCGACCGCGACCCC

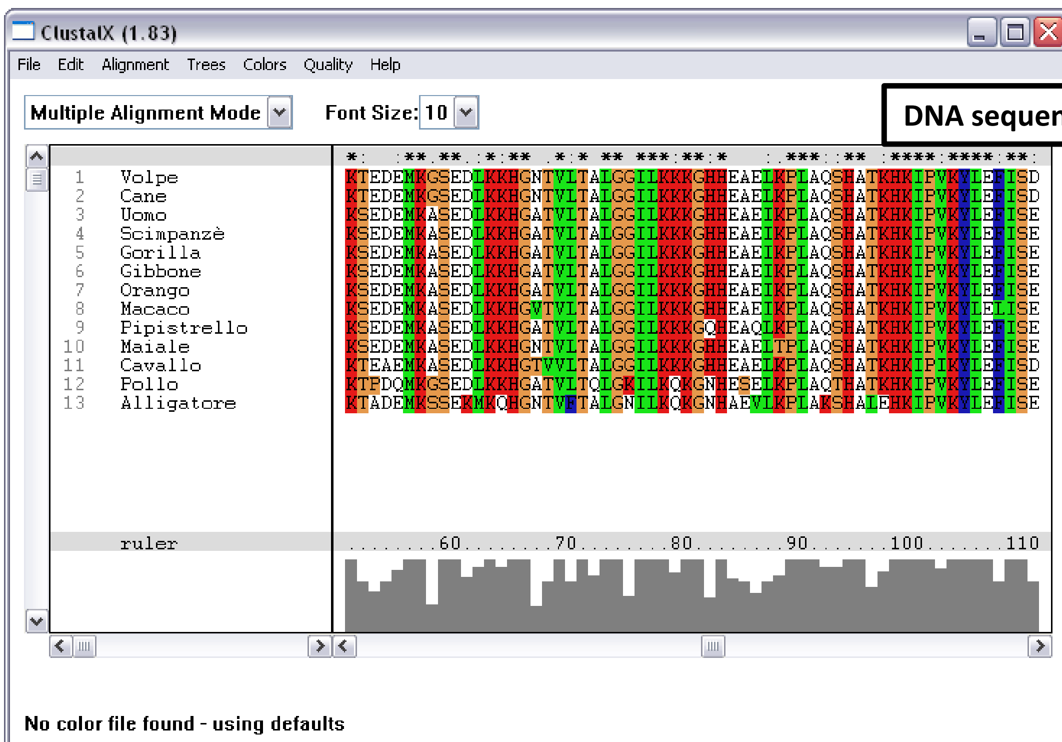


DNA sequence alignment using ClustalX

DNA sequence dataset preparation

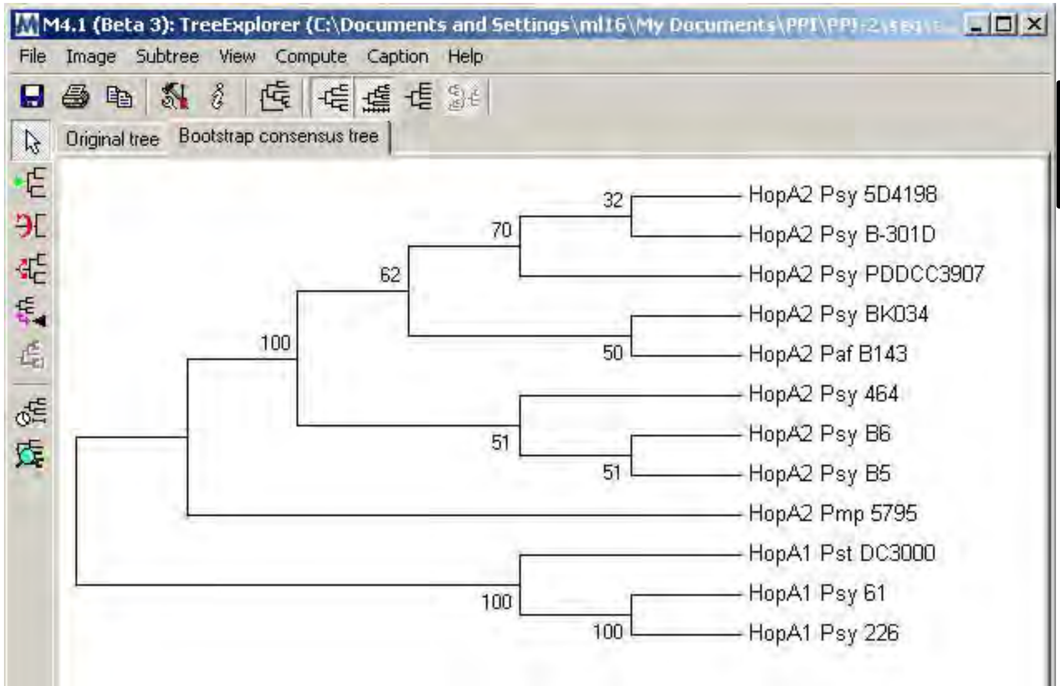
gene, partial sequence

GTCGAAACCTGCATAGCAGAACGACCCGCGAACACGTTACACTACCAGGTGAGGGACGAGGGGTGCGCAA
GCTCCCCAAGTTTCAAACCCATGGTCGGGGACCACCCTTGGGTGGCCTCGTCCGAACAACGACCCCCCGG
CGCGGAATGCGCCAAGGAAATCAAACTGAACTGCACGCGTCCCCCCCGTTTGCGGGCGGCGGAAGCGTCT
TTCTAAAACACAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCGAAATG
CGATACTTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGTCTTTGAACGCAAGTTGCGCCCGAAGCCA
TTAGGCCGAGGGCACGTCTGCCTGGGCGTCACACATCGCGTCGCCCCCCAACCCATCACTCCCTTGCGGG
AGTTGAGGCGGAGGGGCGGATAATGGCCTCCCGTGTCTCACCGCGCGGTTGGCCCAAATGCGAGTCCTTG
GCGATGGACGTCACGACAAGTGGTGGTTGTAAAAAGCCCTCTTCTCATGTCGTGCGGTGACCCGTCGCCA
GCAAAATCTCTCATGACCCTGTTGCGCCGAGCCTCGACGCGCGCTCCGACCGCGACCCC



DNA sequence alignment using ClustalX

Molecular Phylogenetic analyses using MEGA



NCBI Genbank

- **Whole Chloroplast Genome Sequencing of *Adenium obesum***

- **Chloroplast (cp) is a special subcellular organelle which contains the entire enzymatic machinery for photosynthesis.**

- **Chloroplast contains its own small genome of 120–217 kb in size and 110-130 genes, consists of a circular double-stranded DNA.**

- **The cp genome can be used to investigate molecular evolution and phylogenies.**

- **The cp genomes are maternally inherited, which is beneficial in genetic engineering.**

Whole genome sequencing

- ***Chenopodium quinoa* (quinoa) is a highly nutritious grain identified as an important crop** Jarvis 2017 Nature. ; 542(7641):307-312. **The genome of Chenopodium quinoa.**

Molecular systematic studies on *Polygonum palaestinum* Zohary (polygonaceae) from Saudi Arabia using ITS sequences of nuclear ribosomal DNA

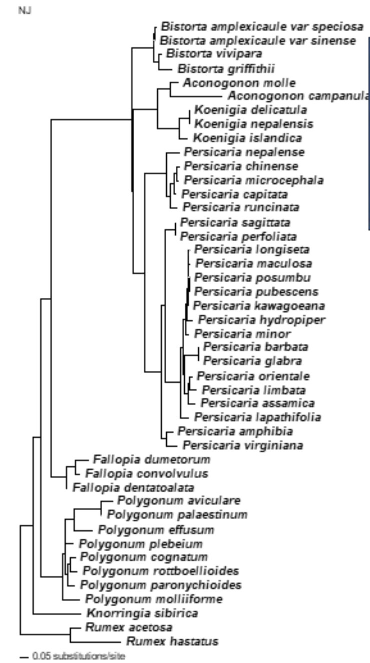
- **The taxonomy of the genus Polygonum is highly controversial because of diverse variation within species among the species has resulted into lack of consensus on taxonomic circumscription. Therefore, there is disagreement among the taxonomists that to which species should be retain within the genus Polygonum and to which species should be elevated to their own genus.**

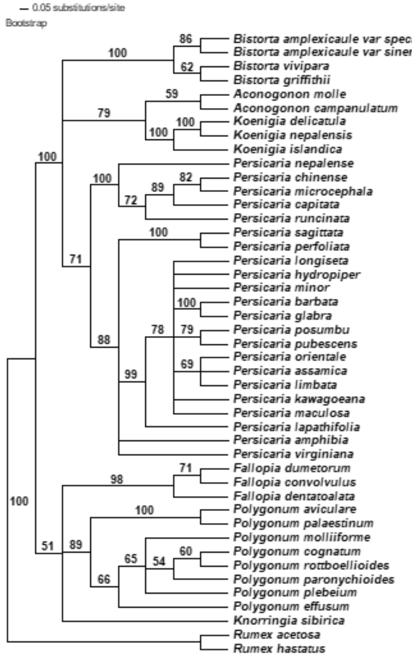
- **The genus Polygonum in Saudi Arabia includes P. argyrocoleum Steud. ex Kunze, P. aviculare L. and P. palaestinum Zohary. Two out of these Polygonums of Saudi Arabia i.e. P. argyrocoleum and P. aviculare are common weed distributed throughout. The distribution of P. palaestinum is restricted to Harratal Harra area of Saudi Arabia.**

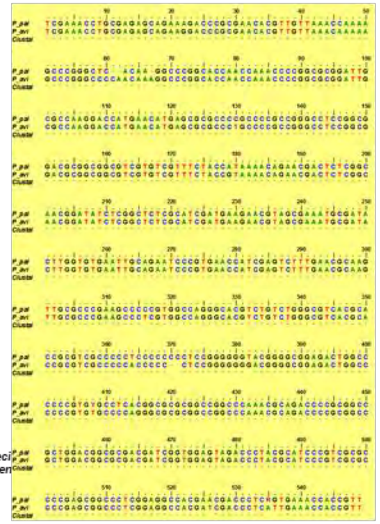
- **Decraene and Akeroyd (1988) have segregated Polygonum in the broad sense into two separate tribes, Polygoneae and Persicarieae.**

- **The systematic status of P. palaestinum is unresolved**

Polygonum palaestinum Zohary (polygonaceae)



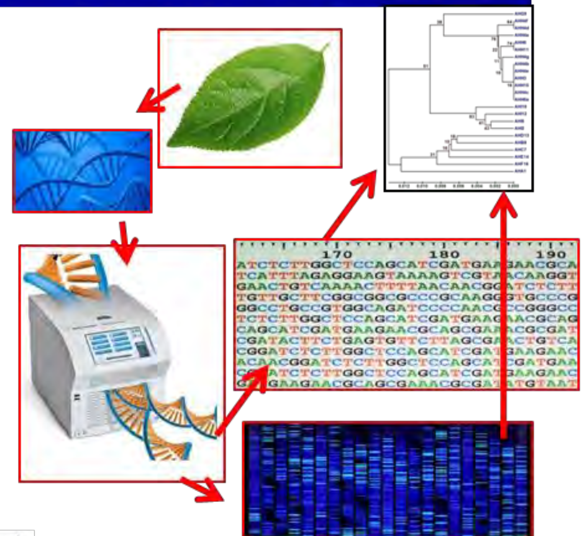




Position in sequence alignment	*Polygonum aviculare*	*Polygonum palaestinum*
22	G	A
46	A	C
59	C	T
61	C	-
62	A	-
67	A	-
130	T	C
179	G	A
316	T	C
364	A	T
370	-	C
371	-	C
382	G	T
408	T	Y C T
413	C	T
415	G	C
526	T	A
535	A	R A G
536	T	G

GENETIC DIVERSITY

Genetic diversity is the total number of genetic characteristics in the genetic makeup of a species.

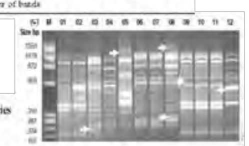


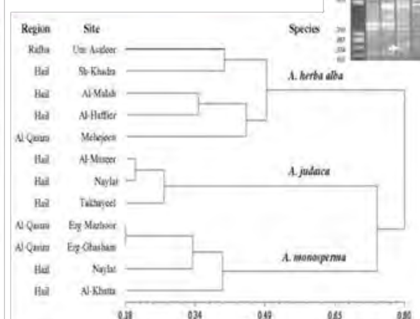
- **Molecular analyses comprise a large variety of DNA molecular markers, which can be employed for analysis of variation.**

AFLP	Amplified Fragment Length Polymorphism
AP-PCR	Arbitrarily primed PCR
ARMS	Amplification Refractory Mutation System
ASAP	Arbitrary Signatures from Amplification
ASH	Allele-Specific Hybridization
ASLP	Amplified Sequence Length Polymorphism
ASO	Allele Specific Oligonucleotide
CAPS	Cleaved Amplification Polymorphic Sequence
CAS	Coupled Amplification and Sequencing
DAF	DNA Amplification Fingerprint
DGGE	Denaturing Gradient Gel Electrophoresis
GBA	Genetic Bit Analysis
IRAO	Inter-Retrotrasposon Amplified Polymorphism
ISSR	Inter-Simple Sequence Repeats
ISTR	Inverse Sequence-Tagged Repeats
MP-PCR	Microsatellite-Primed PCR
OLA	Oligonucleotide Ligation Assay
RAHM	Randomly Amplified Hybridizing Microsatellites
RAMPs	Randomly Amplified Microsatellite Polymorphisms
RAPD	Randomly Amplified Polymorphic DNA
RBIP	Retrotrasposon-Based Insertion Polymorphism
REF	Restriction Endonuclease Fingerprinting
REMAP	Retrotrasposon-Microsatellite Amplified Polymorphism
RFLP	Restriction Fragment Length Polymorphism
SAMPL	Selective Amplification of Polymorphic Loci
SCAR	Sequence Characterised Amplification Regions
SNP	Single Nucleotide Polymorphism
SPAR	Single Primer Amplification Reaction
SPLAT	Single Polymorphic Amplification Test
S-SAP	Sequence-Specific Amplification Polymorphisms
SSCP	Single Strand Conformation Polymorphism
SSLP	Single Sequence Length Polymorphism
SSR	Simple Sequence Repeats
STMS	Sequence-Tagged Microsatellite Site
STS	Sequence-Tagged-Site
TGGE	Thermal Gradient Gel Electrophoresis
VNTR	Variable Number Tandem Repeats
RAMS	Randomly Amplified Microsatellites

- **Genetic diversity of *Artemisia* in central and north Saudi Arabia based on RAPD**

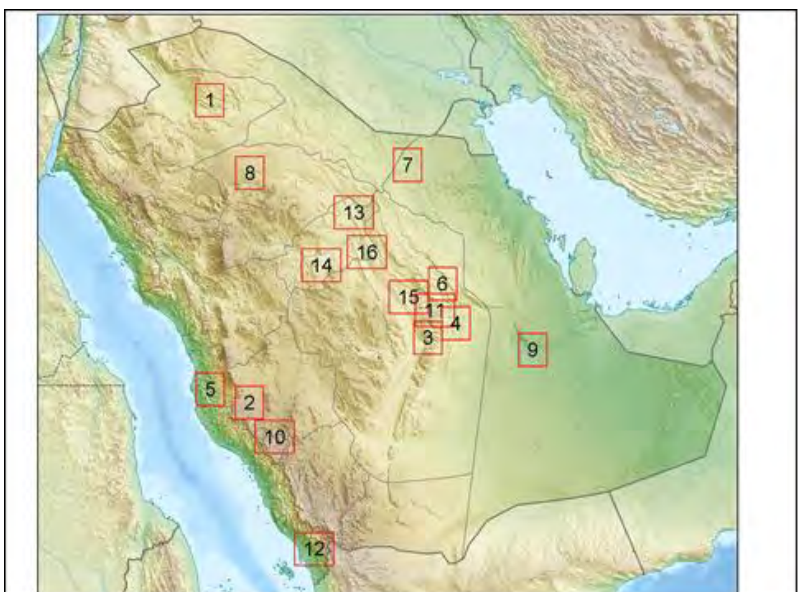
Serial	Primer	Nucleotide sequences
01	OPA-02	5'-TGCCGAGCTG-3'
02	OPA-05	5'-AGGGGTCTTG-3'
03	OPA-07	5'-GAAACGGGTG-3'
04	OPA-08	5'-GTGACGTAGG-3'
05	OPA-09	5'-GGGTAACGCC-3'
06	OPA-13	5'-CAGCACCCAC-3'
07	OPA-14	5'-TCTGTGCTGG-3'
08	OPA-18	5'-AGGTGACCGT-3'
09	OPB-10	5'-CTGCTGGGAC-3'
Total number of bands		

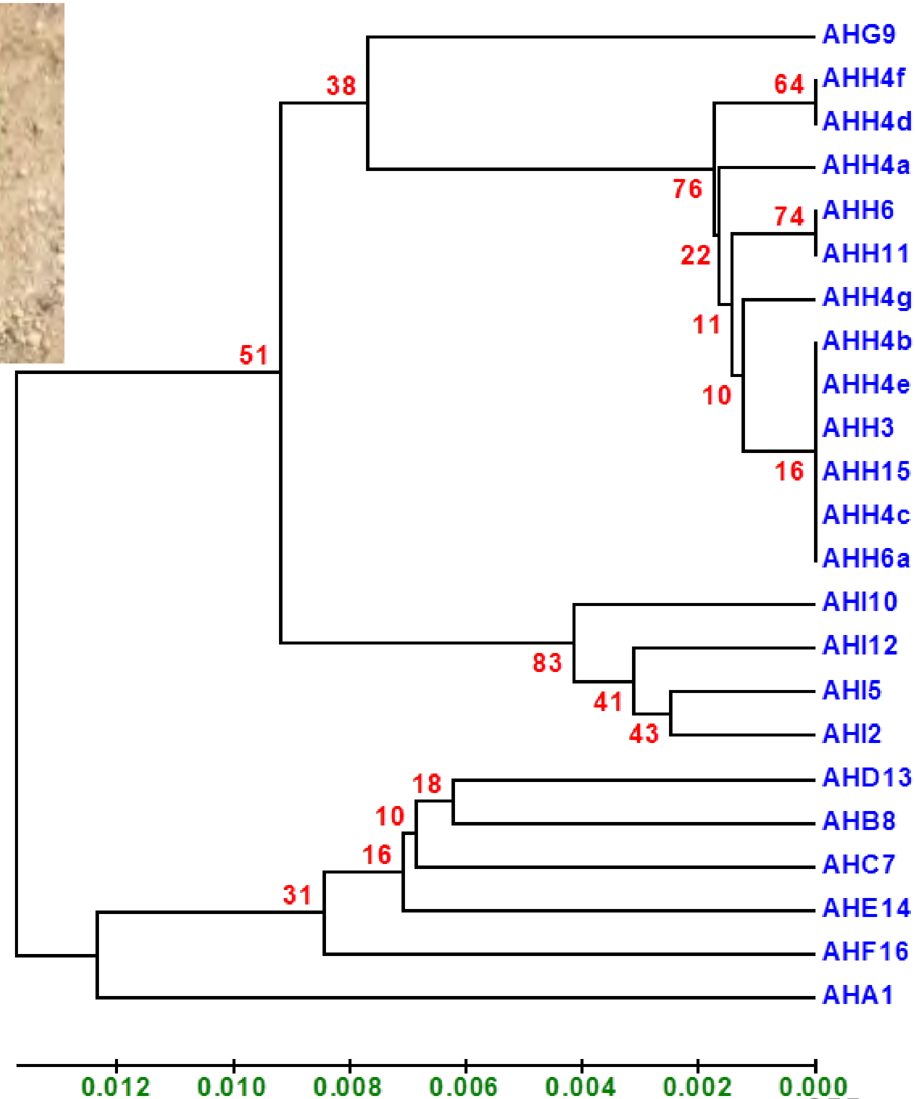




Badr, A., El-Shazly, H.H., Helail, N.S. et al. Genetic diversity of *Artemisia* populations in central and north Saudi Arabia based on morphological variation and RAPD polymorphism. Plant Syst Evol (2012) 298: 871)

Assessment of genetic diversity of *Anastatica hierochuntica* (kaff maryam) from Saudi Arabia based on Internal Transcribed Spacer sequences of nuclear ribosomal DNA gene





- ***Anastatica hierochuntica*** **(Rose of Jericho) is among the common medicinal plants widely used in Hijaz, Najd, and Al Rub'Al Khali. The plant is prescribed in folk medicine for difficult labor, uterine hemorrhage and to facilitate the expulsion of dead fetuses. A total number of 23 population of Anastatica hierochuntica from Saudi Arabia were sequenced.**

- **The resulted UPGMA tree reveals that the populations of different geographic location sampled in the present study grouped into three major group.**

- **Group I consists of population from Hanifa valley, Summan, Rumah, Hair area, Riyadh, Khurma, and Khoris;**

- **Group II consists of population from Al-Baha, Jeedah, Ranyah and Zazan; and**

- **Group III consists of population from Hail, Darb Al Hafer, Qasim Buraydah, Afif, and Marat), and the groups were according to their geographic locations;**

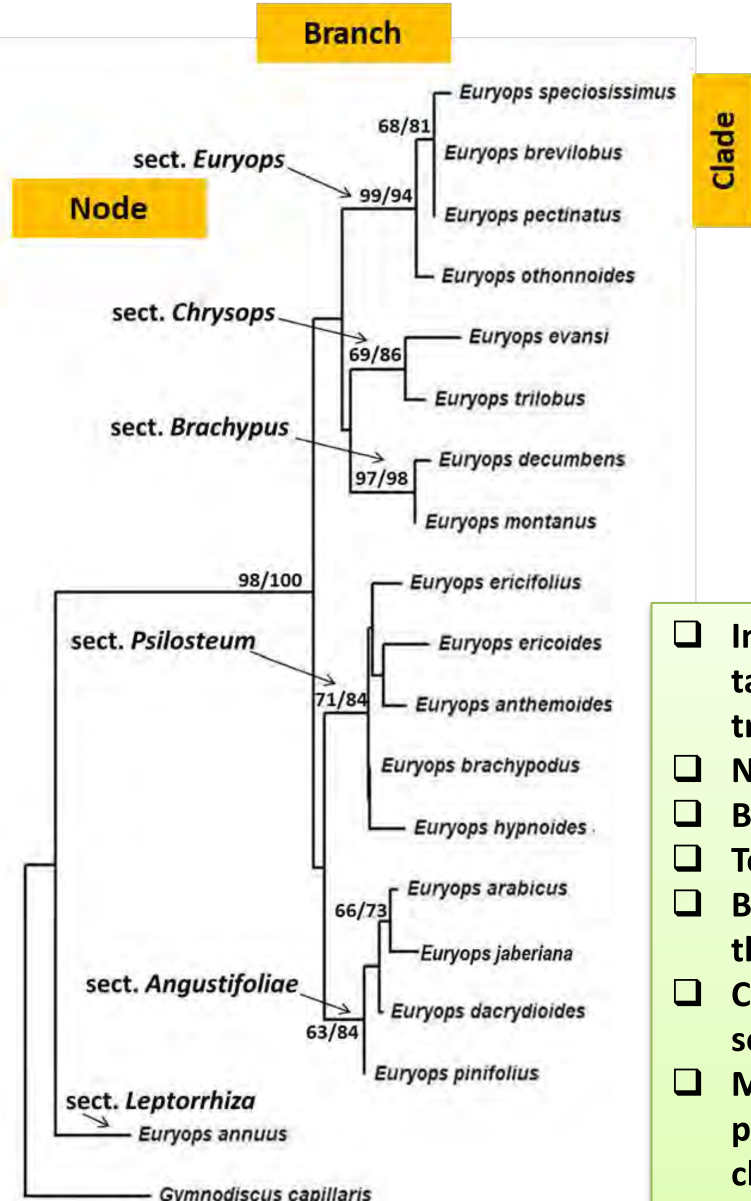
- **however it was interesting to note that population collected from the geographic location of Haradh and Buseita (Tabarjal) and were nested within the group I and II respectively, which might be due to evolution under reproductive isolation and different environmental conditions, and this may be most probably due to long distance distribution, and possibility of genetic exchange among the populations of *Anastatica hierochuntica* distributed in Saudi Arabia.**

WEEK 12

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

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

E. arabicus

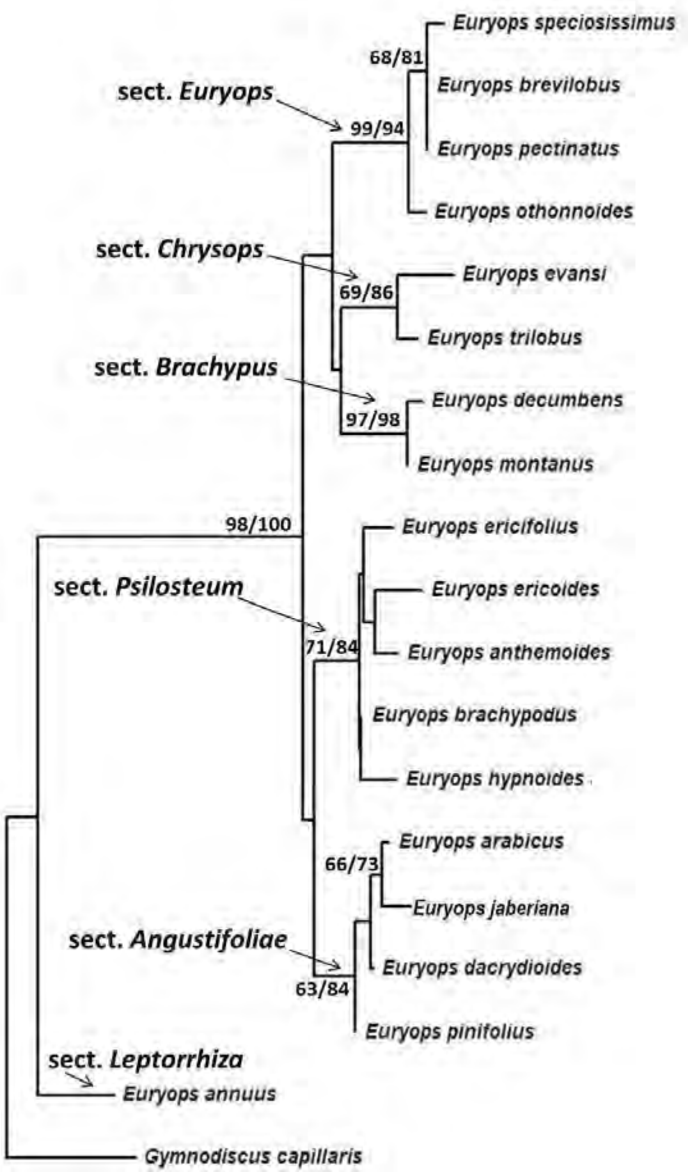


- **The key morphological features which differentiate *E. jaberiana* from *E. arabicus* are: leaves 3-lobed at the tips, pappus hairs transparent or rarely dull white, and achenes glabrescent, while in *E. arabicus*, the leaves are unlobed, pappus hairs are dull white and achene densely lanate hairy (Abedin and Chaudhary, 2000).**

- **The Maximum Parsimony analyses reveals that *E. jaberiana* nested within the clade of the section *Angustifoliae.***

- ***E. jaberiana* shows proximity with *E. arabicus* (66% bootstrap support.**

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



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

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

```
                             10        20        30        40        50        60        70        80        90       100
                     ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
Euryops_jabriana     TCGAAACCTGCATAGCAGAACGACCCGTGAACATGTAATAACAATCGGGTGTCCATGGTTTCCGACTATTGTTTGATTCTTTGGATACCCTGATAATGTG
Euryops_arabicus     ............................................................................................T.......
Clustal Consensus    ******************************************************************************************** *******

                            110       120       130       140       150       160       170       180       190       200
                     ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
Euryops_jabriana     CGTCTTTGGTCAGCCGCTTGGGTCCTAATGATGTCACATTAACACAATAACAAACCCCCGGCACGGCATGTGCCAAGGAAAATAAAACTTAAGAAAAGCT
Euryops_arabicus     ...............C....................................................................................
Clustal Consensus    *************** ************************************************************************************

                            210       220       230       240       250       260       270       280       290       300
                     ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
Euryops_jabriana     TGTATCATGTTACGTCGTTCGCGGGGTTTGCATGATACGTGGCTTCTTTATAATCATAAACGACTCTCGGCAACGGATATCTCGGCTCACGCATCGATGA
Euryops_arabicus     C...................................................................................................
Clustal Consensus     ***************************************************************************************************

                            310       320       330       340       350       360       370       380       390       400
                     ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
Euryops_jabriana     AGAACGTAGCAAAATGCGATACTTGGTGTGAATTGCAGAATCCCGTGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCAAAGCCTTTTGGCCGAGGGCA
Euryops_arabicus     ....................................................................................................
Clustal Consensus    ****************************************************************************************************

                            410       420       430       440       450       460       470       480       490       500
                     ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
Euryops_jabriana     CGTCTGCCTGGGCGTCACACATCGCGTCGCCCCCCACAACATCTCTTGATTGGGATGTTGTAATGGGGGCGGATATTGGTCTCCCGTTCCTAAGGTTCGG
Euryops_arabicus     ..........................................G.................G.......................................
Clustal Consensus    ****************************************** ***************** ***************************************

                            510       520       530       540       550       560       570       580       590       600
                     ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
Euryops_jabriana     TTGGCTAAAATAGGAGTCCCCTTCGAAGGATGCACGATTAGTGGTGGTTGTCAAGACCTTCTTATCGACTCGCGCGTTACAAGTAGTAGGGAAGATCTCT
Euryops_arabicus     ..............................C.........................................T...........................
Clustal Consensus    ****************************** ***************************************** ***************************

                            610       620       630       640
                     ....|....|....|....|....|....|....|....|....|
Euryops_jabriana     TCAAAGACCCTAATGTGTTGTCTTGTGACAATGCTTCGACCGCGA
Euryops_arabicus     ..........C..................................
Clustal Consensus    ********** **********************************
```

DNA barcoding

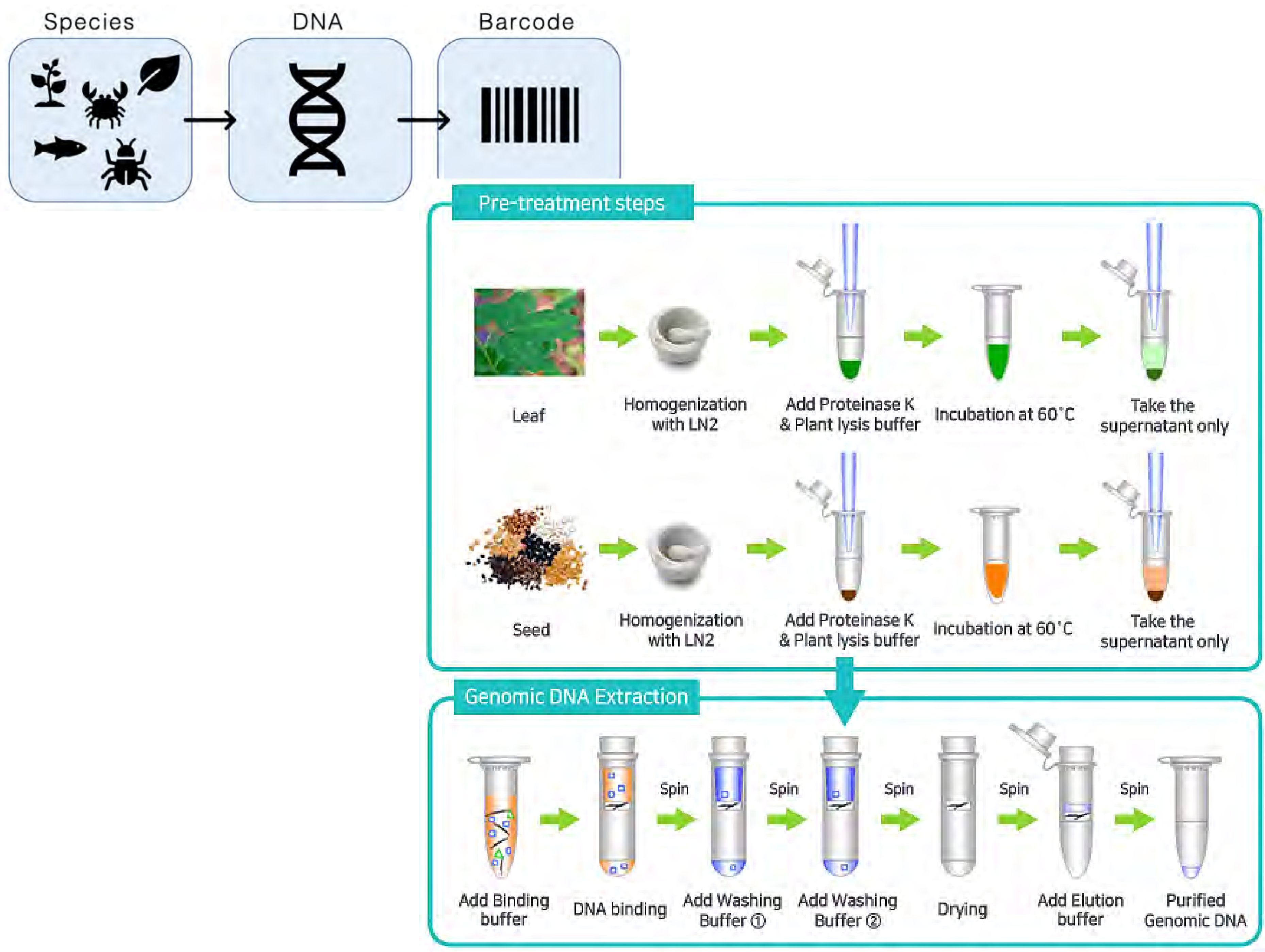
- DNA barcoding is a system for fast and accurate species identification that makes ecological system more accessible by using short DNA sequence instead of whole genome and is used for eukaryotes. The short DNA sequence is generated from standard region of genome known as marker. This marker is different for various species like CO1 cytochrome c oxidase 1 for animals, matK for plants and Internal Transcribed Spacer (ITS) for fungus. DNA barcoding has many applications in various fields like preserving natural resources, protecting endangered species, controlling agriculture pests, identifying disease vectors, monitoring water quality, authentication of natural health products and identification of medicinal plants.

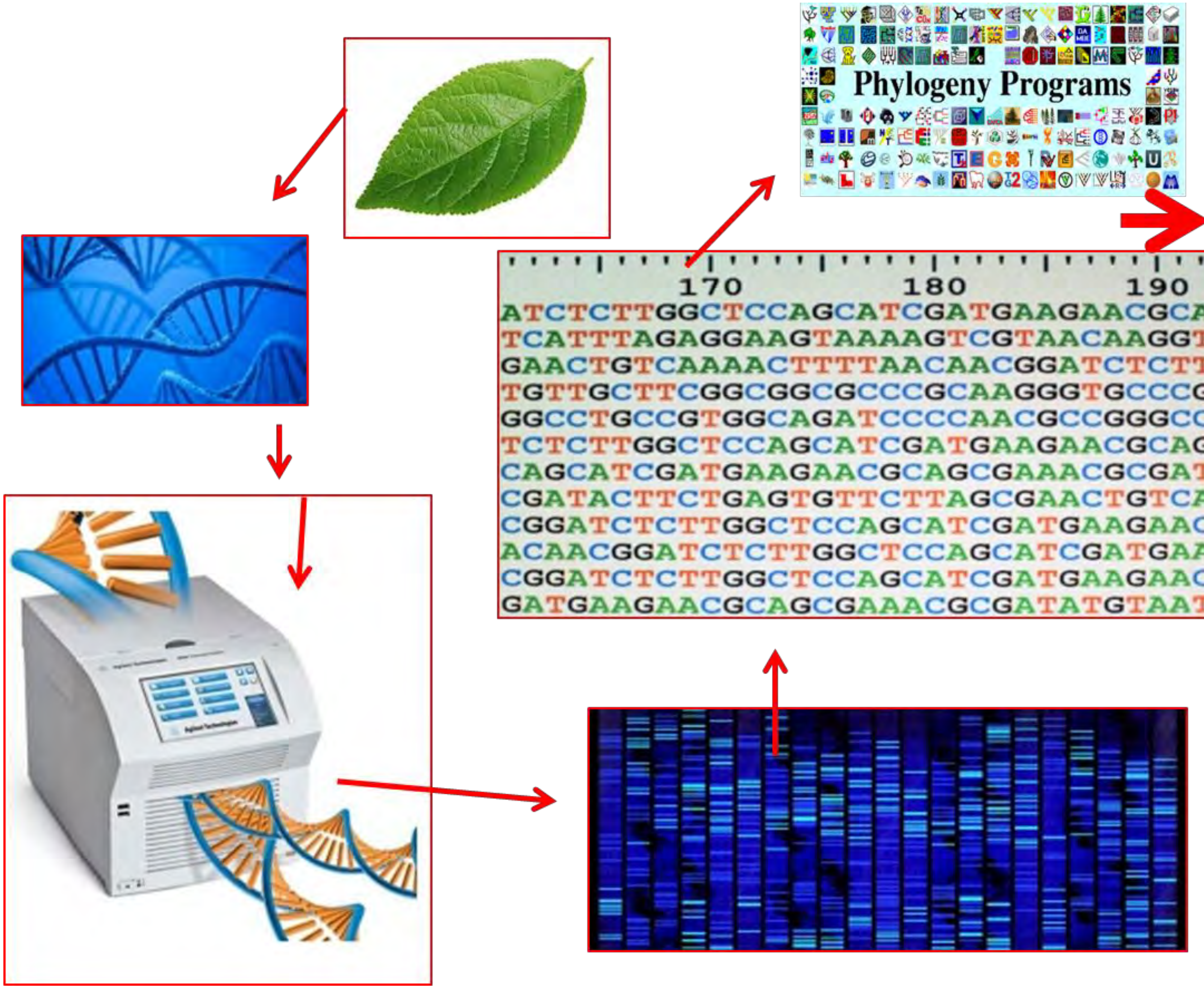
❖**DNA barcoding can speed up identification of species.**

❖**DNA barcoding can provide an avenue to encourage new participants into taxonomy.**

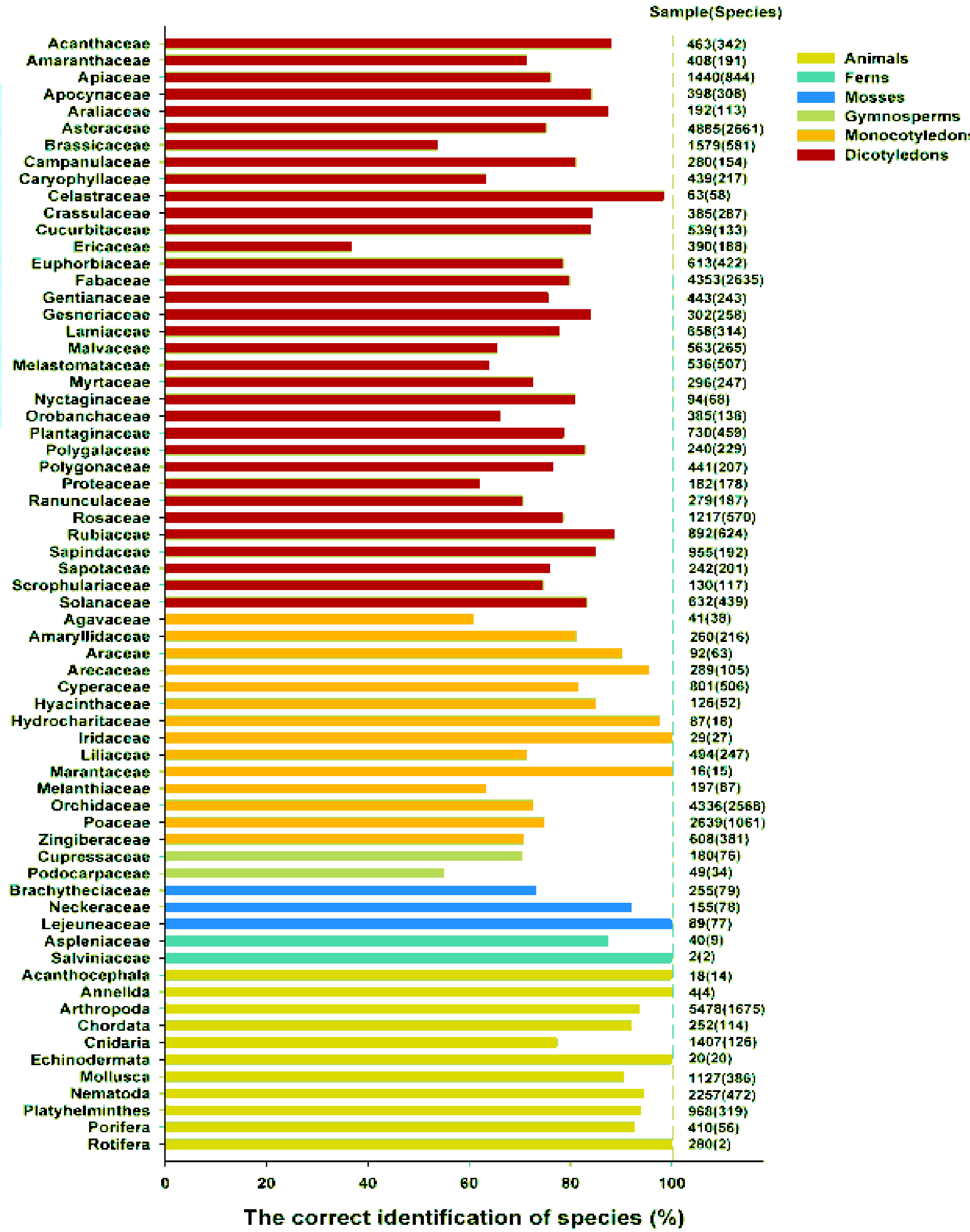
❖**Raw drug authentication / Medicinal plant identification or authentication**

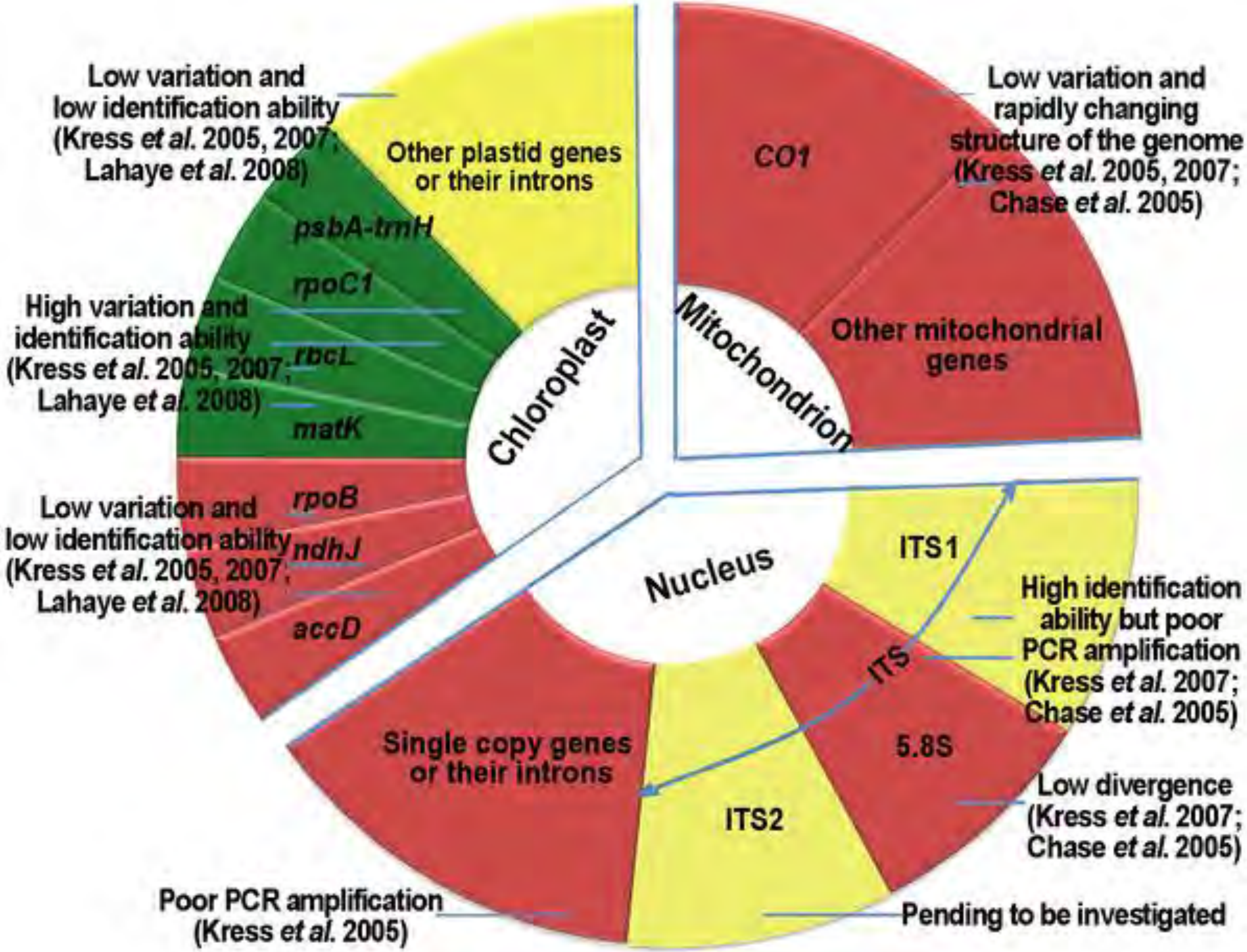
- In DNA barcoding, complete data set can be obtained from a single specimen irrespective to morphological or life stage characters.
- The core idea of DNA barcoding is based on the fact that the highly conserved stretches of DNA, either coding or
- non coding regions, vary at very minor degree during the evolution within the species.
- Sequences suggested to be useful in DNA barcoding include cytoplasmic mitochondrial DNA (e.g. cox1) and chloroplast DNA (e.g. rbcL, trnL-F, matK, ndhF, and atpB rbcL), and nuclear DNA (ITS)
- The term “DNA barcode” for global species identification was first coined by Hebert in 2003.
- The ideal DNA barcode region is reliably amplified and sequenced across large assemblages of taxa and provides a high level of species discrimination


Species
DNA
Barcode
Pre-treatment steps
Leaf
Homogenization with LN2
Add Proteinase K & Plant lysis buffer
Incubation at 60˚C
Take the supernatant only
Seed
Homogenization with LN2
Add Proteinase K & Plant lysis buffer
Incubation at 60˚C
Take the supernatant only
Genomic DNA Extraction
Add Binding buffer
DNA binding
Spin
Add Washing Buffer ①
Spin
Add Washing Buffer ②
Spin
Drying
Spin
Add Elution buffer
Spin
Purified Genomic DNA


Phylogeny Programs
170
180
190
ATCTCTTGGCTCCAGCATCGATGAAGAACGCA
TCATTTAGAGGAAGTAAAAGTCGTAACAAGGT
GAACTGTCAAAACTTTTAACAACGGATCTCTT
TGTTGCTTCGGCGGCGCCCGCAAGGGTGCCCG
GGCCTGCCGTGGCAGATCCCCAACGCCGGGCC
TCTCTTGGCTCCAGCATCGATGAAGAACGCAG
CAGCATCGATGAAGAACGCAGCGAAACGCGAT
CGATACTTCTGAGTGTTCTTAGCGAACTGTCA
CGGATCTCTTGGCTCCAGCATCGATGAAGAAC
ACAACGGATCTCTTGGCTCCAGCATCGATGAA
CGGATCTCTTGGCTCCAGCATCGATGAAGAAC
GATGAAGAACGCAGCGAAACGCGATATGTAAT


Phylogeny Programs

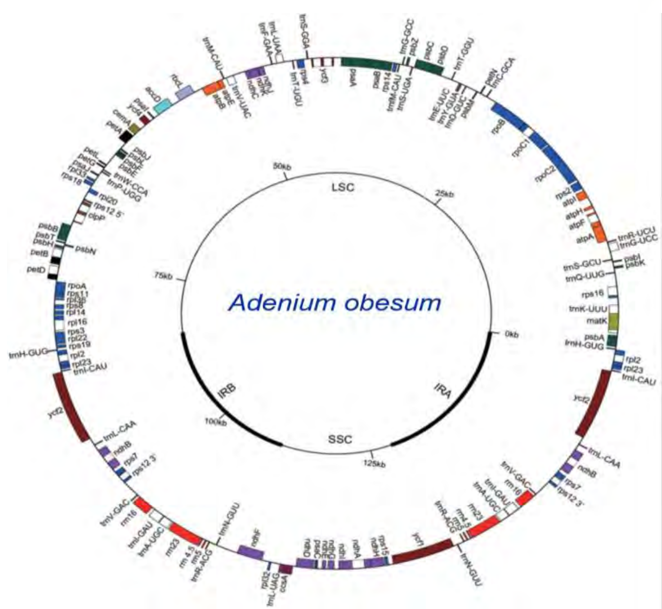

Sample(Species)
Animals
Ferns
Mosses
Gymnosperms
Monocotyledons
Dicotyledons
Acanthaceae 463(342)
Amaranthaceae 408(191)
Apiaceae 1440(844)
Apocynaceae 398(308)
Araliaceae 192(113)
Asteraceae 4885(2661)
Brassicaceae 1579(581)
Campanulaceae 280(154)
Caryophyllaceae 439(217)
Celastraceae 63(58)
Crassulaceae 385(287)
Cucurbitaceae 539(133)
Ericaceae 390(188)
Euphorbiaceae 613(422)
Fabaceae 4353(2635)
Gentianaceae 443(243)
Gesneriaceae 302(258)
Lamiaceae 658(314)
Malvaceae 563(265)
Melastomataceae 536(507)
Myrtaceae 296(247)
Nyctaginaceae 94(68)
Orobanchaceae 385(136)
Plantaginaceae 730(459)
Polygalaceae 240(229)
Polygonaceae 441(207)
Proteaceae 182(178)
Ranunculaceae 279(187)
Rosaceae 1217(570)
Rubiaceae 892(624)
Sapindaceae 955(192)
Sapotaceae 242(201)
Scrophulariaceae 130(117)
Solanaceae 632(439)
Agavaceae 41(38)
Amaryllidaceae 260(216)
Araceae 92(63)
Arecaceae 289(105)
Cyperaceae 801(506)
Hyacinthaceae 126(52)
Hydrocharitaceae 87(18)
Iridaceae 29(27)
Liliaceae 494(247)
Marantaceae 16(15)
Melanthiaceae 197(87)
Orchidaceae 4336(2568)
Poaceae 2639(1061)
Zingiberaceae 608(381)
Cupressaceae 180(76)
Podocarpaceae 49(34)
Brachytheciaceae 255(79)
Neckeraceae 155(78)
Lejeuneaceae 89(77)
Aspleniaceae 40(9)
Salviniaceae 2(2)
Acanthocephala 18(14)
Annelida 4(4)
Arthropoda 5478(1675)
Chordata 252(114)
Cnidaria 1407(126)
Echinodermata 20(20)
Mollusca 1127(386)
Nematoda 2257(472)
Platyhelminthes 968(319)
Porifera 410(56)
Rotifera 280(2)
0
20
40
60
80
100
The correct identification of species (%)

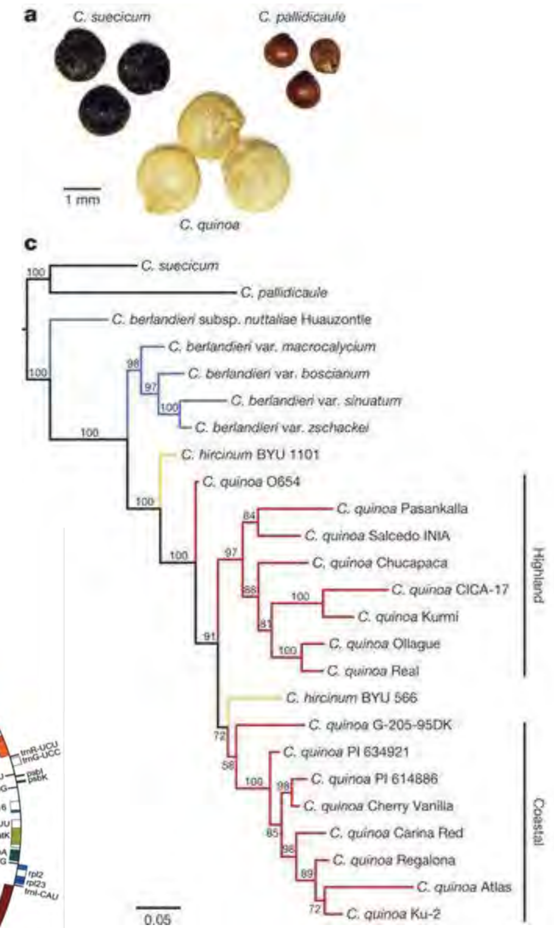


Low variation and
low identification ability
(Kress et al. 2005, 2007;
Lahaye et al. 2008)
Other plastid genes
or their introns
psbA-trnH
rpoC1
High variation and
identification ability
(Kress et al. 2005, 2007;
Lahaye et al. 2008)
rbcL
matK
Chloroplast
rpoB
Low variation and
low identification ability
(Kress et al. 2005, 2007;
Lahaye et al. 2008)
ndhJ
accD
CO1
Low variation and
rapidly changing
structure of the genome
(Kress et al. 2005, 2007;
Chase et al. 2005)
Mitochondrion
Other mitochondrial
genes
Nucleus
ITS1
ITS
High identification
ability but poor
PCR amplification
(Kress et al. 2007;
Chase et al. 2005)
5.8S
Low divergence
(Kress et al. 2007;
Chase et al. 2005)
Single copy genes
or their introns
ITS2
Poor PCR amplification
(Kress et al. 2005)
Pending to be investigated

- **Chen S, Yao H, Han J, Liu C, Song J, et al. (2010) Validation of the ITS2 Region as a Novel DNA Barcode for Identifying Medicinal Plant Species. PLOS ONE 5(1): e8613.**
- **Yao H, Song J, Liu C, Luo K, Han J, Li Y, et al. (2010) Use of ITS2 Region as the Universal DNA Barcode for Plants and Animals. PLoS ONE 5(10): e13102.**
- **Zuo Y, Chen Z, Kondo K, Funamoto T, Wen J, Zhou S. (2011) DNA barcoding of Panax species. Planta Med. 2011 Jan;77(2):182-7.**

Advances in next generation DNA sequencing and its application in systematics





WEEK 13

QUESTIONS FOR PRACTICE

Multiple Choice Questions (MCQs)

Which type of stomata is characterized by two subsidiary cells parallel to the guard cells?
a) Anomocytic
b) Paracytic
c) Diacytic
d) Anisocytic
Answer: b) Paracytic

Which of the following is a secondary metabolite commonly used in plant taxonomy?
a) Glucose
b) Alkaloids
c) Starch
d) Cellulose
Answer: b) Alkaloids

Which vascular tissue is responsible for water conduction in plants?
a) Phloem
b) Xylem
c) Epidermis
d) Cortex
Answer: b) Xylem

Multiple Choice Questions (MCQs)

What is the primary function of trichomes in plants?
a) Photosynthesis
b) Water absorption
c) Protection against herbivory
d) Transport of nutrients
Answer: c) Protection against herbivory

Which of the following is an example of a xerophytic adaptation?
a) Amphistomatic leaves
b) Epistomatic leaves
c) Hypostomatic leaves
d) Hydrostomatic leaves
Answer: a) Amphistomatic leaves

The presence of which compound differentiates Caryophyllales from Polygonales?
a) Alkaloids
b) Flavonoids
c) Betalains
d) Anthocyanins
Answer: c) Betalains

Multiple Choice Questions (MCQs)

Which pollen aperture type is characteristic of eudicots?
a) Monocolpate
b) Tricolpate
c) Porate
d) Colporate
Answer: b) Tricolpate

What type of inflorescence is a panicle?
a) Simple
b) Compound
c) Solitary
d) None of the above
Answer: b) Compound

What is the term used for the phenotypic appearance of somatic chromosomes?
a) Genome
b) Karyotype
c) Idiogram
d) Chromatin
Answer: b) Karyotype
Which DNA marker technique is commonly used for species identification?
a) SSR
b) AFLP
c) SNP
d) All of the above
Answer: d) All of the above

Fill in the Blanks

- The study of pollen grains and spores is called ____**Palynology**.
- Stomata found on both leaf surfaces are known as ____**Amphistomatic**.
- The term _____**Idiogram** refers to the diagrammatic representation of a karyotype.
- In taxonomy, _______**flavonoids** are used for chemical differentiation among species.
- **________Glandular trichomes** secrete oils and resins.
- The DNA region ________**rbcL** is commonly used in plant DNA barcoding.
- **________C3, C4, and CAM** are three types of photosynthetic pathways in plants.
- **________Polyploidy** plays a crucial role in plant evolution and speciation.
- A _______**taproot system** is characteristic of dicots.
- **________Diacytic** stomata have two subsidiary cells arranged at right angles to the guard cells.

Short Answer Questions

What is the significance of secondary metabolites in taxonomy?
Answer: Secondary metabolites help in plant classification by providing chemotaxonomic markers, such as alkaloids and flavonoids, which are unique to specific plant groups.

How does wood anatomy aid in plant taxonomy?
Answer: Growth rings, fiber arrangements, and vessel elements provide taxonomic and ecological insights.

What is an idiogram?
Answer: A diagrammatic representation of a karyotype showing the number, shape, and structure of chromosomes.

Define trichomes and their function.
Answer: Trichomes are hair-like structures on plant surfaces that help in protection, water retention, and secretion of essential oils.

What are the different types of stomatal distribution?
Answer: Amphistomatic, hypostomatic, and epistomatic.

Short Answer Questions

Name two electron microscopy techniques used in plant taxonomy.
Answer: Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM).

What is the significance of chromosome number in taxonomy?
Answer: Chromosome number helps in identifying species and understanding their evolutionary relationships.

What is the role of cuticular patterns in plant classification?
Answer: Cuticular patterns such as thickness and ornamentation help differentiate plant taxa.

How does seed coat micromorphology aid in taxonomy?
Answer: It provides species-specific textural details that help in classification.

Why is DNA sequencing important in modern taxonomy?
Answer: DNA sequencing helps determine genetic relationships and evolutionary history of plants.

True or False

- DNA sequencing is not useful in plant taxonomy. (**False**)
- Diacytic stomata are found in Caryophyllaceae. (**True**)
- Monocots have two cotyledons. (**False**)
- Pollen grains can be used in taxonomic classification. (**True**)
- Amphistomatic leaves are commonly found in shade plants. (**False**)
- The idiogram represents the arrangement of genes on a chromosome. (**False**)
- Wood anatomy is irrelevant in plant taxonomy. (**False**)
- Tricolpate pollen is a characteristic of eudicots. (**True**)
- Alkaloids are primary metabolites in plants. (**False**)
- Fossil stomata provide evidence for past climates. (**True**)

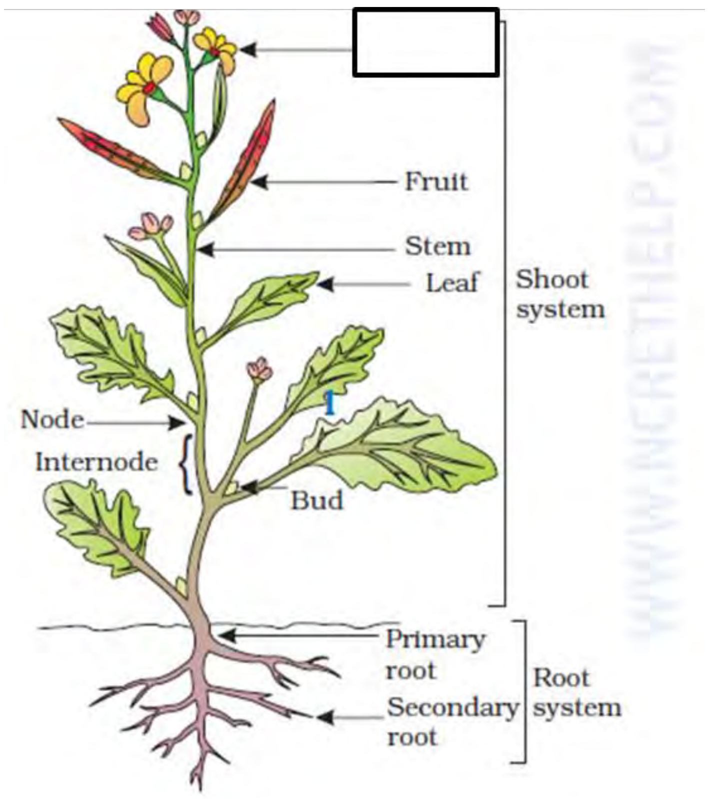
Match the Following

	Column A	a	Column B
1	Palynology	b	Study of pollen grains
2	Diacytic stomata	c	Caryophyllaceae
3	Amphistomatic	d	Both leaf surfaces
4	Karyotype	e	Chromosome appearance
5	DNA barcoding	f	rbcL gene
6	Alkaloids	g	Chemical taxonomy
7	Polyploidy	h	Chromosome duplication
8	Electron microscopy	i	Micromorphology study
9	CAM photosynthesis	j	Desert plants
10	Idiogram	k	Chromosome diagram

1–a, 2–b, 3–c, 4–d, 5–e, 6–f, 7–g, 8–h, 9–i, 10–j

Image-Based Question

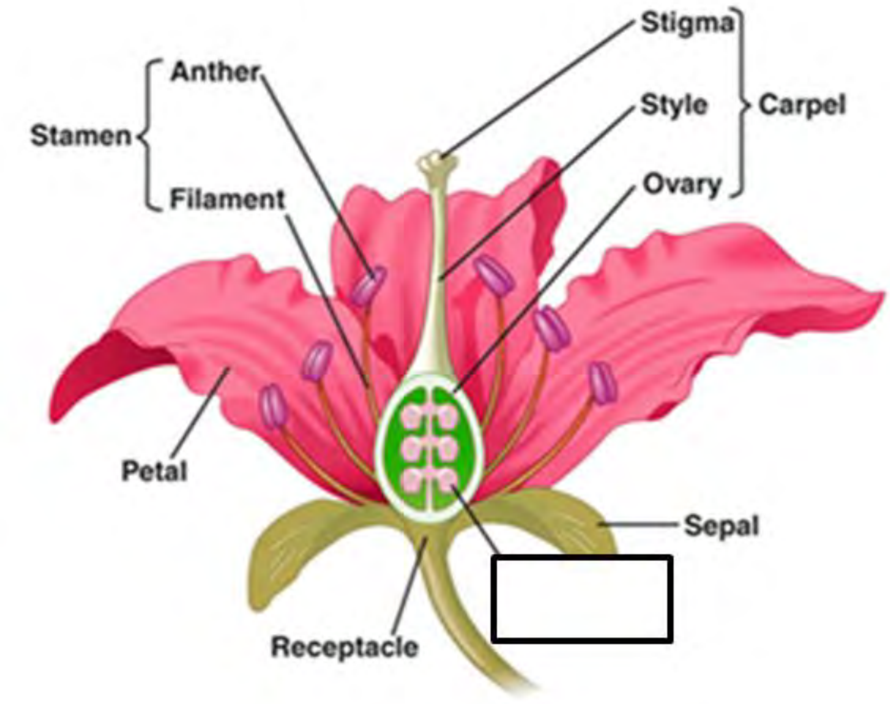
Examine the provided diagram. What is the appropriate term to fill in the blank box?



Answer: Flower

Image-Based Question

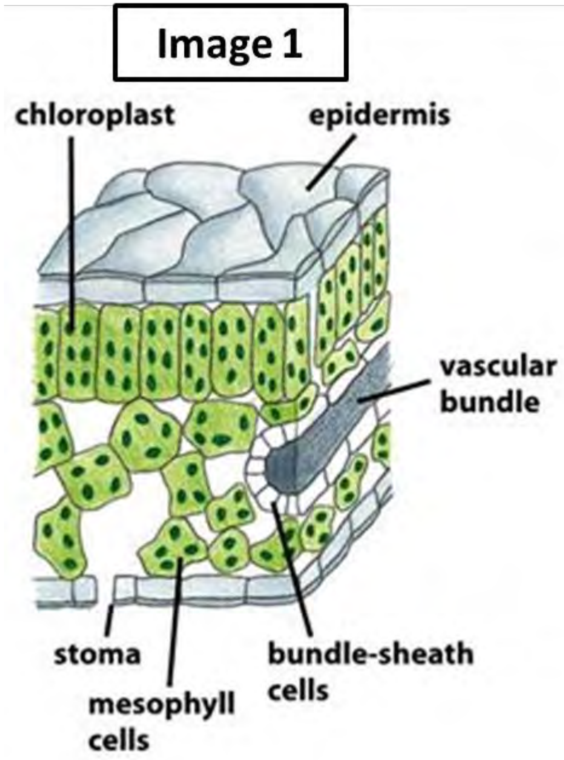
Examine the provided diagram. What is the appropriate term to fill in the blank box?

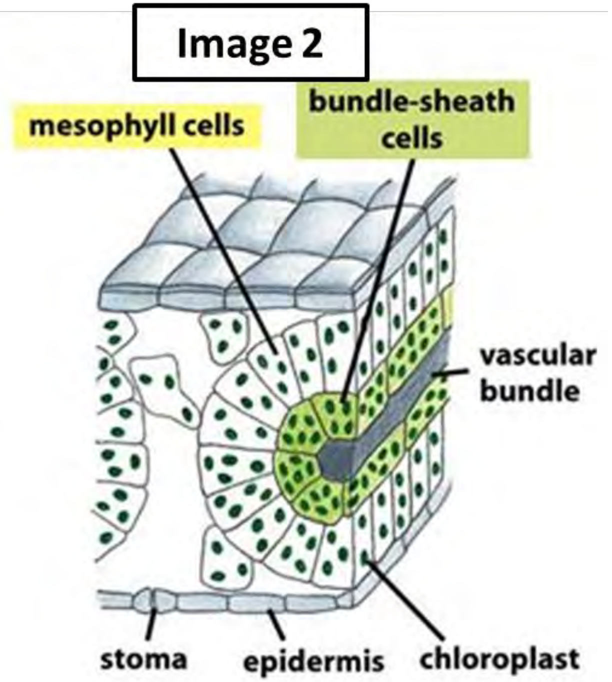


Answer: Ovule

Image-Based Question

Examine the provided diagram. What is the appropriate image for C3 and C4 leaf section?

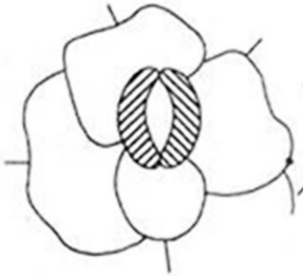




Answer: Image 1; C3, Image 2; C4

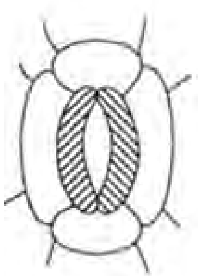
Image-Based Question

What type of stomata is shown in the image?



Answer: Anomocytic

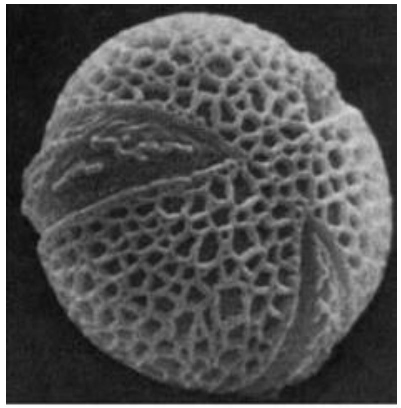
What type of stomata is shown in the image?



Answer: Tetracyctic

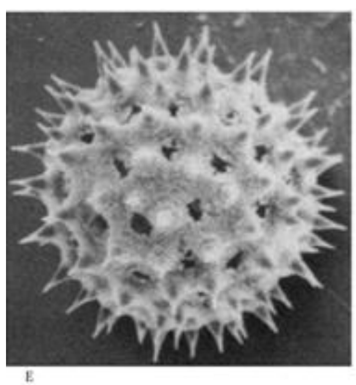
Image-Based Question

Identify the type of pollen aperture visible in the microscopic image



Answer: Tricolpate

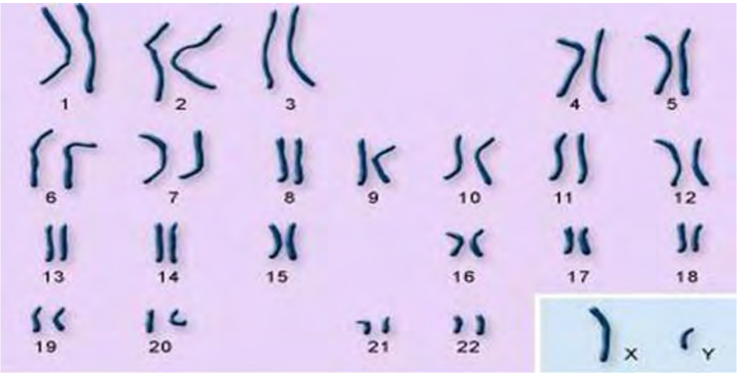
Identify the type of pollen aperture visible in the microscopic image.



Answer: spinose

Image-Based Question

Observe the given diagram carefully. What is the correct term to label this image?



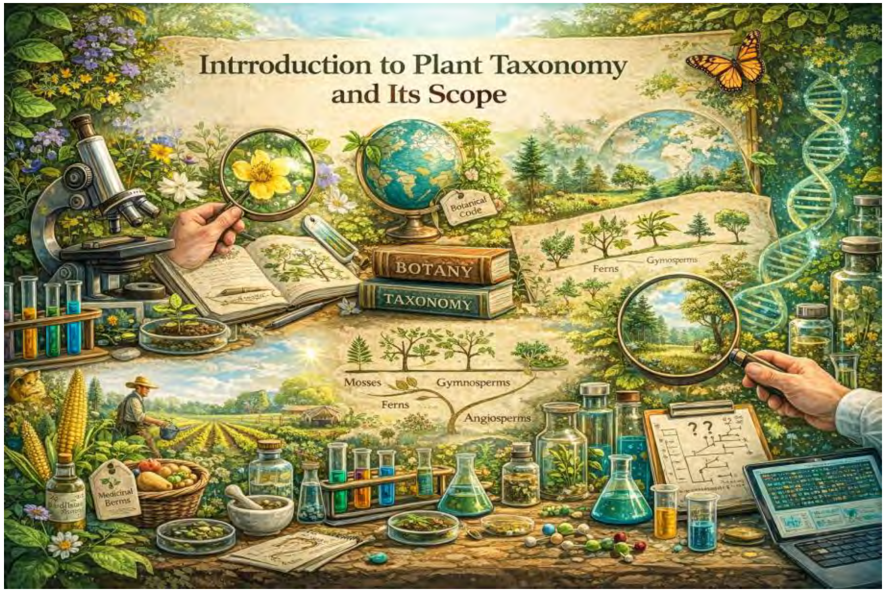
Answer: Karyotype

WEEK 14

Introduction to Plant Taxonomy and Its Scope

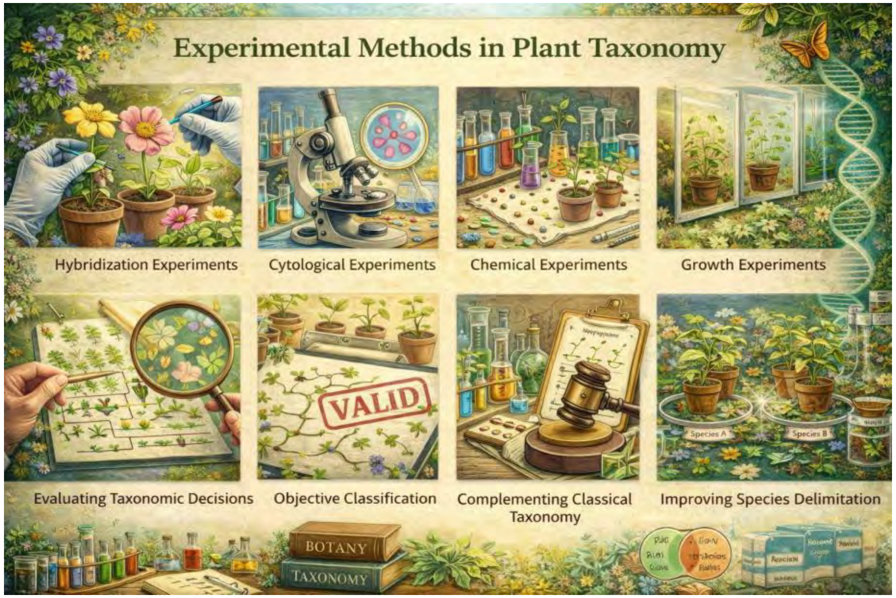
Plant taxonomy is the science of identifying, naming, and classifying plants.

- It provides a universal system for plant identification worldwide.
- Taxonomy helps in understanding plant diversity and evolution.
- It forms the foundation of all botanical sciences.
- Accurate taxonomy is essential for biodiversity conservation.
- It aids in the discovery of new plant species.
- Taxonomy supports agriculture, forestry, and medicine.
- It integrates data from morphology, anatomy, and genetics.
- Taxonomic studies help resolve classification problems.
- The scope of taxonomy continues to expand with modern techniques.



Experimental Methods in Plant Taxonomy

- Experimental taxonomy uses controlled experiments to study plant variation.
- It helps verify taxonomic relationships objectively.
- Common methods include hybridization experiments.
- Cytological experiments provide chromosome data.
- Chemical experiments reveal metabolite differences.
- Growth experiments assess phenotypic plasticity.
- Experimental data strengthen taxonomic decisions.
- It reduces subjectivity in classification.
- These methods complement classical taxonomy.
- Experimental taxonomy improves species delimitation.



Comparative Experimental Approaches in Taxonomy

Comparative taxonomy compares multiple plant taxa systematically.

It evaluates similarities and differences among species.

Comparative experiments assess evolutionary relationships.

Morphological traits are often compared quantitatively.

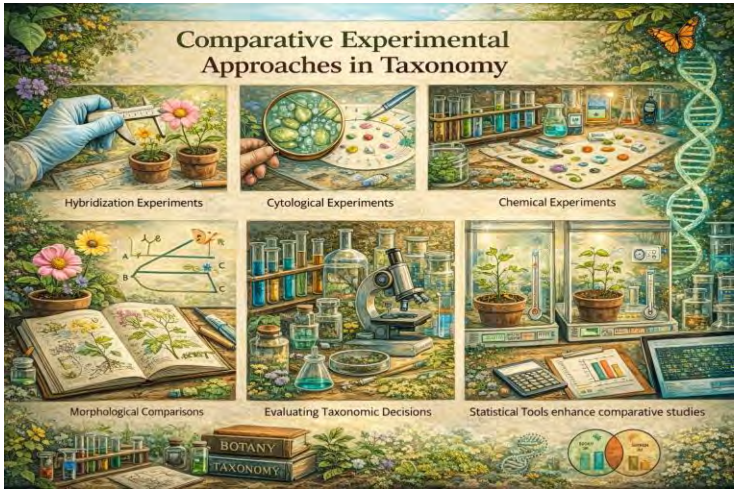
Anatomical and cytological features are examined compar atively.
Chemical profiles support comparative analyses.

Environmental responses are compared experimentally.

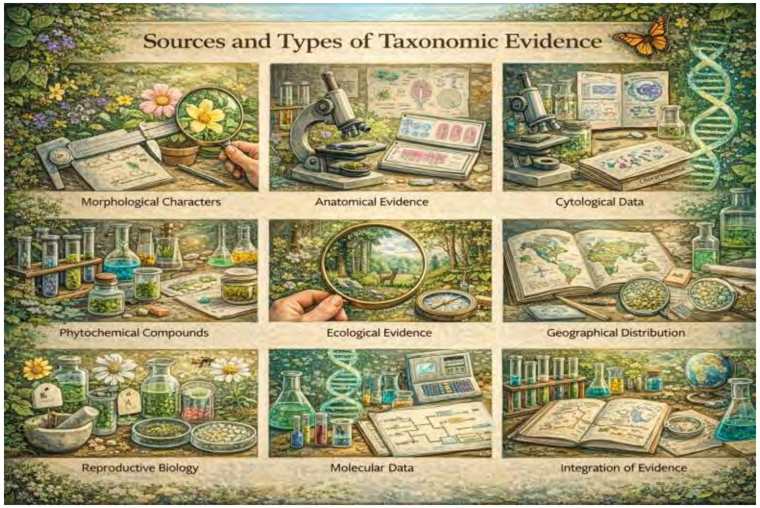
Statistical tools enhance comparative studies.

These approaches improve classification accuracy.

Comparative taxonomy supports phylogenetic interpretation.



Sources and Types of Taxonomic Evidence



Taxonomy relies on multiple sources of evidence.

Morphological characters are primary taxonomic tools.

Anatomical evidence supports internal structure analysis.

Cytological data reveal chromosome behavior.

Phytochemical compounds serve as chemical markers.

Ecological evidence explains habitat adaptation.

Geographical distribution supports species differentiation.

Reproductive biology provides fertility information.

Molecular data strengthen modern taxonomy.

Integration of evidence ensures reliable classification.

Plant Morphological Characters as Taxonomic Evidence

Morphology studies the external features of plants.

Vegetative characters include roots, stems, and leaves.

Reproductive characters involave flowers and fruits.

Morphological traits are easy to observe and compare.

They are widely used in plant identification keys.

Stable morphological characters aid classification.

Variations reflect evolutionary adaptation.

Morphology helps distinguish closely related species.

It is fundamental to traditional taxonomy.

Morphological evidence remains taxonomically significant.

Plant Anatomical Characters as Taxonomic Evidence

Anatomy studies internal plant structures.

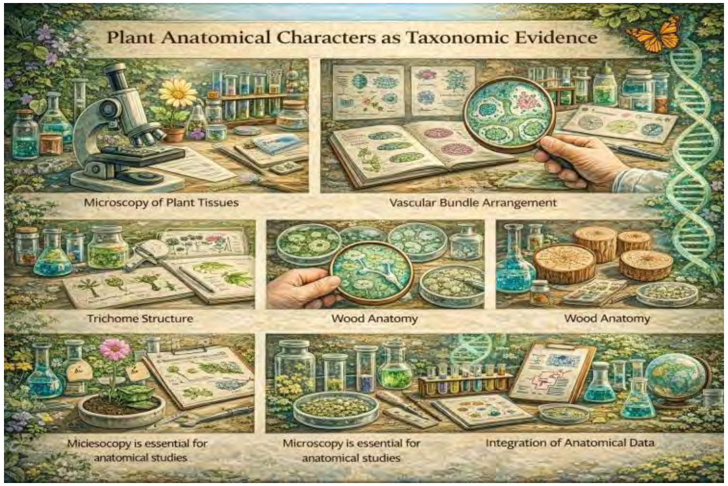
Tissue organization provides taxonomic clues.

Vascular bundle arrangement aids classification.

Stomatal types are important anatomical markers.

Trichome structure supports species identification.

Wood anatomy assists in woody plant taxonomy.



Anatomical traits are less influenced by environment.

Microscopy is essential for anatomical studies.

Anatomical data complement morphological evidence.

Plant anatomy strengthens taxonomic conclusions.

Phytochemical Evidence in Plant Taxonomy

Phytochemistry studies chemical compounds in plants.

Secondary metabolites serve as taxonomic markers.

Alkaloids indicate evolutionary relationships.

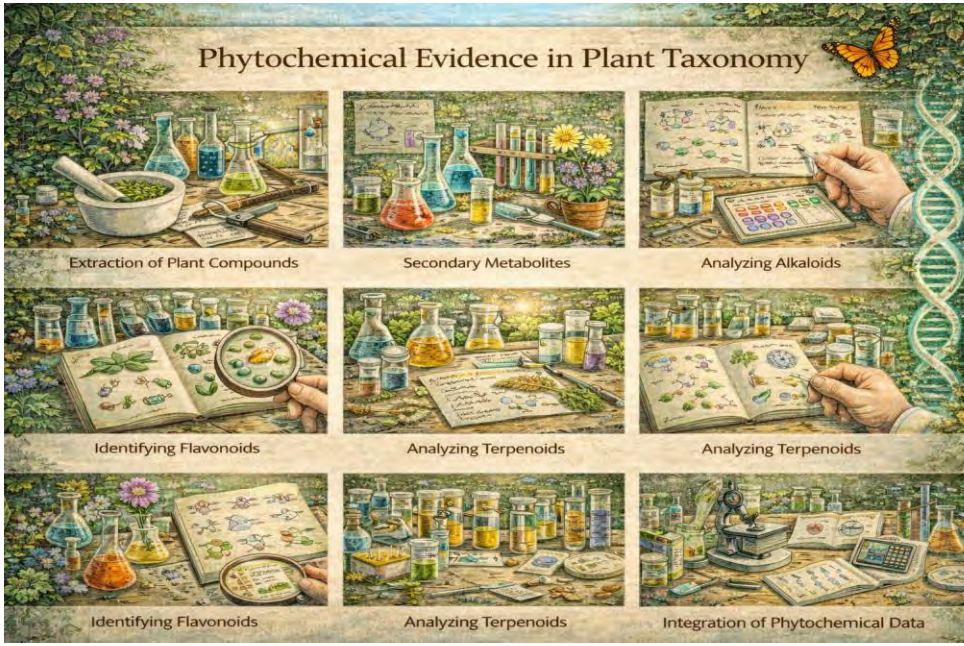
Flavonoids help differentiate plant groups.

Terpenoids support family-level classification.

Chemical profiles are genetically controlled.

Phytochemical data reduce misidentification.

They support chemotaxonomy studies.

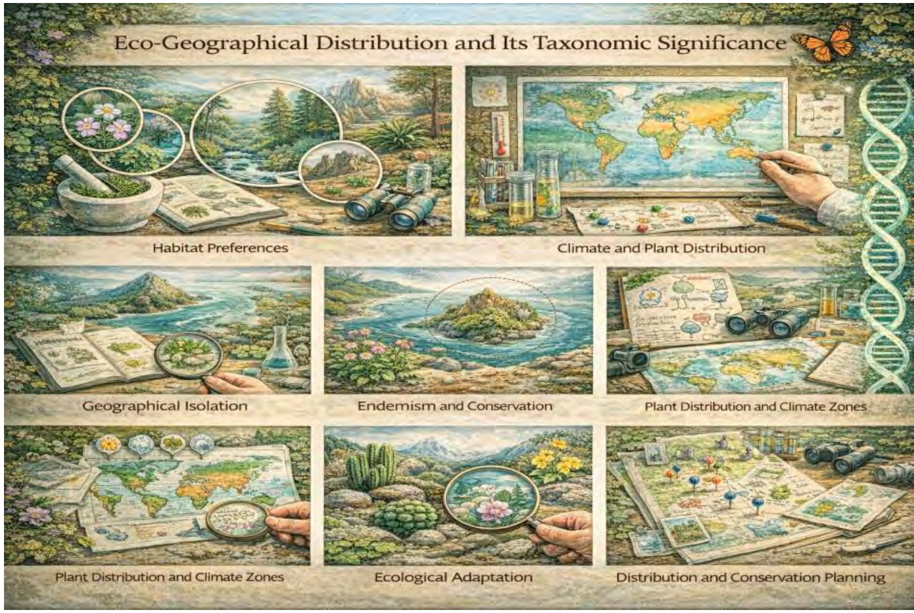


Chemical evidence complements other data sources.

Phytochemistry enhances modern taxonomic research

Eco-Geographical Distribution and Its Taxonomic Significance

Eco-geography studies plant distribution patterns.



Habitat preference aids species differentiation.

Geographical isolation promotes speciation.

Climate influences plant distribution.

Endemism supports taxonomic recognition.

Distribution data explain evolutionary history.

Ecological adaptation reflects taxonomic divergence.

Biogeography supports classification systems.

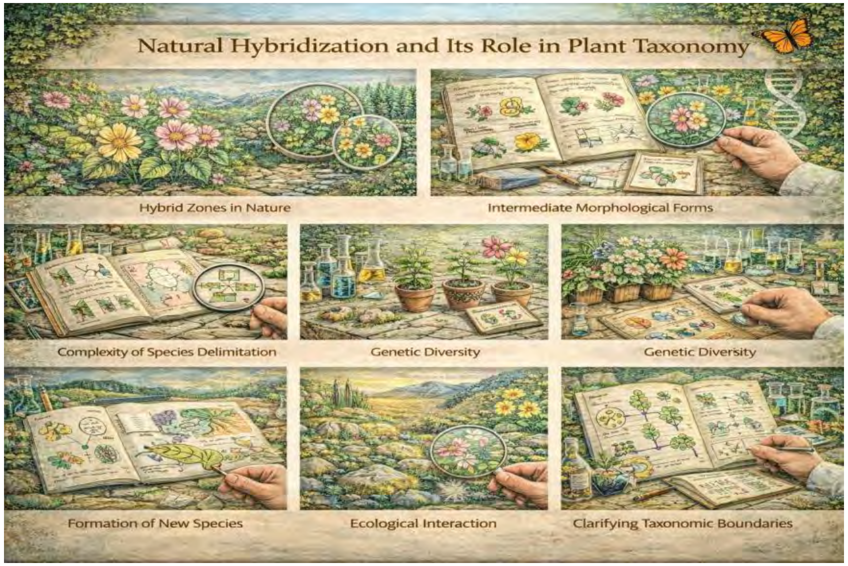
Eco-geographical data aid conservation planning.

Distribution patterns strengthen taxonomic decisions.

Natural Hybridization and Its Role in Plant Taxonomy

Natural hybridization occurs between related species.

It produces intermediate morphological forms.



Hybrids complicate species delimitation.

Hybrid zones reveal evolutionary processes.

Hybridization contributes to genetic diversity.

It may lead to new species formation.

Studying hybrids clarifies taxonomic boundaries.

Hybrid fertility affects classification decisions.

Hybridization reflects ecological interactions.

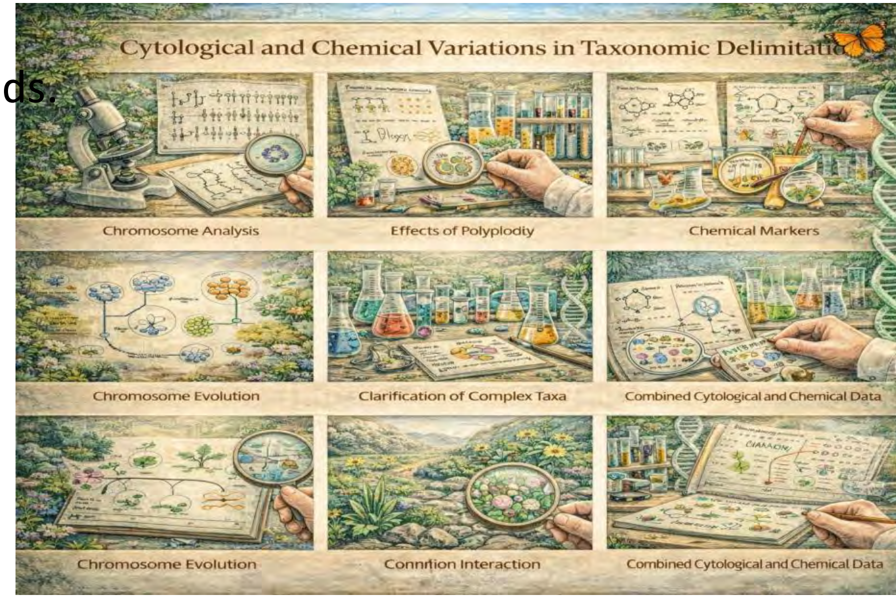
It plays a significant role in plant evolution.

Cytological and Chemical Variations in Taxonomic Delimitation

Cytology examines chromosome number and structure.

Polyploidy influences species classification.

Chromosomal behavior reflects evolutionary trends.



Chemical variation supports species separation.

Cytological data clarify complex taxa.

Chemical markers reveal hidden diversity.

Combined data improve taxonomic resolution.

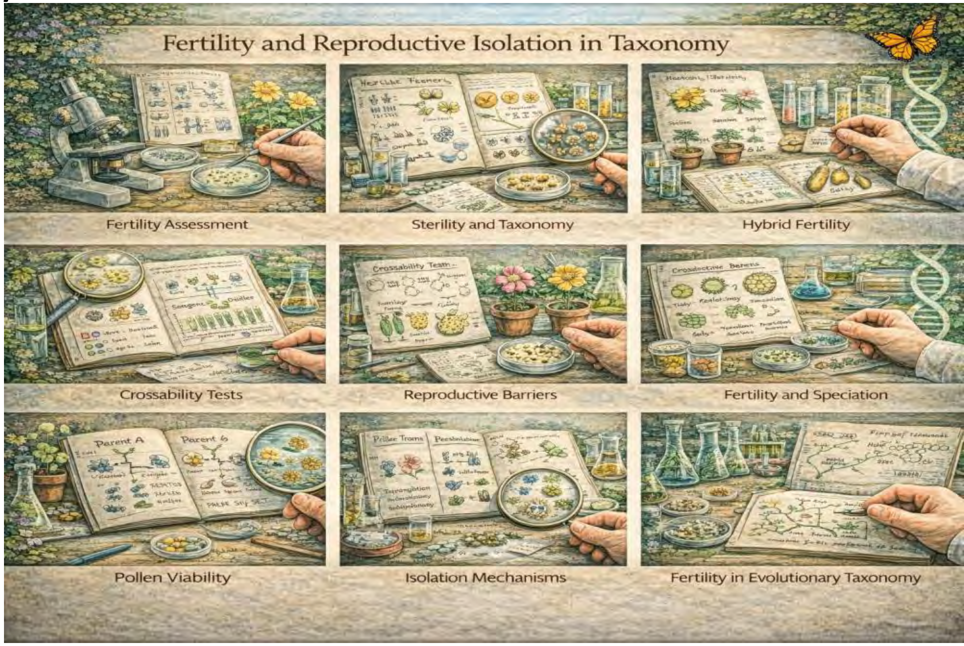
These variations explain evolutionary divergence.

Cytological studies support experimental taxonomy.

They aid accurate taxonomic delimitation.

Fertility and Reproductive Isolation in Taxonomy

Fertility determines reproductive compatibility.



Reproductive isolation separates species.

Sterility indicates taxonomic distinctness.

Hybrid fertility influences classification.

Crossability tests assess species boundaries.

Reproductive barriers promote speciation.

Fertility studies support evolutionary taxonomy.

Reproductive data clarify species concepts.

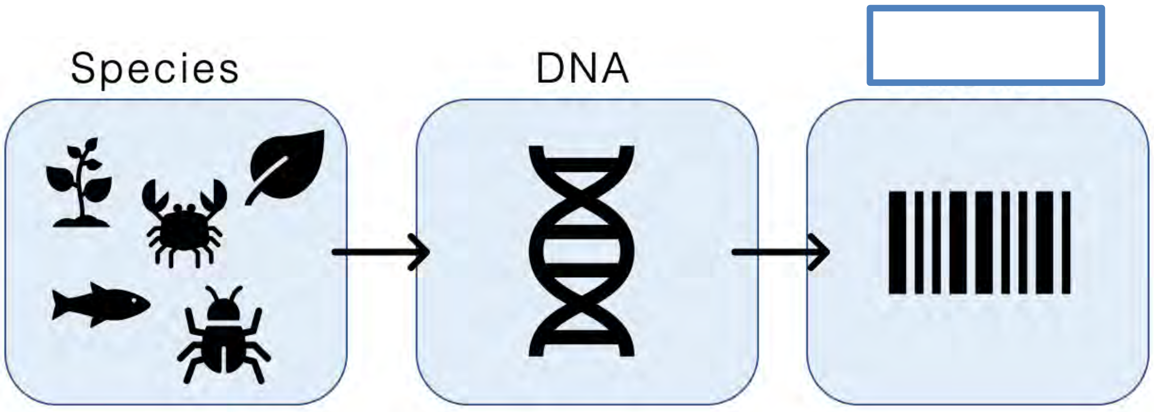
Isolation mechanisms maintain species integrity.

Fertility is vital in taxonomic interpretation.

QUESTIONS FOR PRACTICE

Image-Based Question

Question: Observe the image given and fill the blue box which used in the molecular taxonomy:



Answer: Barcode

Multiple Choice Questions (MCQs)

Which molecular marker is commonly used for DNA barcoding in plants?
a) COI
b) ITS
c) matK
d) 16S rRNA
Answer: c) matK

Which of the following is NOT a commonly used molecular marker in plant systematics?
a) rbcL
b) matK
c) COI
d) ITS
Answer: c) COI

Which step is NOT involved in molecular systematics?
a) DNA extraction
b) PCR amplification
c) Light microscopy
d) DNA sequencing
Answer: c) Light microscopy

Which DNA sequencing method uses chain-terminating nucleotides?
a) Next-generation sequencing
b) Sanger sequencing
c) Microarray sequencing
d) RNA sequencing
Answer: b) Sanger sequencing

Multiple Choice Questions (MCQs)

Which molecular marker is commonly used for DNA barcoding in plants?
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b) PCR amplification
c) Light microscopy
d) DNA sequencing
Answer: c) Light microscopy

Multiple Choice Questions (MCQs)

Which DNA sequencing method uses chain-terminating nucleotides?
a) Next-generation sequencing
b) Sanger sequencing
c) Microarray sequencing
d) RNA sequencing
Answer: b) Sanger sequencing

Which component of the cell contains ribosomal DNA (rDNA)?
a) Chloroplast
b) Mitochondria
c) Nucleus
d) All of the above
Answer: d) All of the above

What is the purpose of PCR in molecular systematics?
a) Breaking DNA strands
b) Amplifying specific DNA sequences
c) Separating DNA fragments
d) Detecting proteins
Answer: b) Amplifying specific DNA sequences

Which scientist(s) proposed the DNA double-helix model?
a) Watson and Crick
b) Mendel
c) Darwin and Wallace
d) Linnaeus
Answer: a) Watson and Crick

Multiple Choice Questions (MCQs)

ITS markers are part of which genetic region?
a) Chloroplast DNA
b) Mitochondrial DNA
c) Nuclear ribosomal DNA
d) None of the above
Answer: c) Nuclear ribosomal DNA

What is the primary function of DNA barcoding?
a) Species identification
b) Protein synthesis
c) Cell division
d) Photosynthesis
Answer: a) Species identification

The main advantage of molecular systematics over morphological taxonomy is:
a) It is faster
b) It provides more accurate relationships
c) It is cheaper
d) It uses only one type of data
Answer: b) It provides more accurate relationships

Fill in the Blanks

- The enzyme used in PCR is called _______**Taq polymerase**.
- The DNA barcode marker for animals is __________**COI (cytochrome c oxidase 1)**.
- The non-coding regions of DNA used for phylogenetic studies are called _________**spacers**.
- DNA moves towards the _________**positive electrode** in gel electrophoresis.
- The model of DNA was proposed by _________**Watson and Crick** in ___**1962**.
- **_________ITS (Internal Transcribed Spacer)** is commonly used for fungal identification.
- The process of converting DNA to RNA is called _________**transcription**.
- The full form of PCR is ________**Polymerase Chain Reaction**.
- The Sanger sequencing method uses ___________**dideoxy nucleotides** to terminate DNA strands.
- The mitochondrial DNA in plants is ________**maternally inherited**.

Short Answer Questions

What is molecular systematics?
The study of evolutionary relationships using molecular data such as DNA, RNA, and proteins.

What is DNA barcoding?
A technique that uses a short DNA sequence from a standardized region of the genome for species identification.

Why is chloroplast DNA useful in plant molecular systematics?
It is highly conserved, maternally inherited, and useful for phylogenetic studies.

What are the three main sources of molecular data in plants?
Nuclear DNA, chloroplast DNA, and mitochondrial DNA.

What is the role of PCR in molecular systematics?
It amplifies specific DNA regions to facilitate further sequencing and analysis.

Name one advantage of molecular systematics over traditional taxonomy.
It provides more objective and accurate classification.

What is the function of the ITS region in phylogenetics?
It provides high-resolution data for species-level classification.

What is the purpose of using agarose gel electrophoresis in DNA studies?
To separate and analyze DNA fragments based on size.

Which molecular marker is commonly used for deep phylogenetic studies?
18S rRNA and 26S rRNA.

What is the function of a DNA primer in PCR?
It binds to the target DNA sequence and initiates replication.

True or False

- **DNA barcoding can be used to identify medicinal plants.** (True)
- **Mitochondrial DNA is more stable than chloroplast DNA in plants.** (False)
- **ITS regions are coding regions of nuclear DNA.** (False)
- **PCR is used to break down DNA strands.** (False)
- **Sanger sequencing uses chain-terminating nucleotides.** (True)
- **DNA barcoding can be applied to bacteria and archaea.** (False)
- **Gel electrophoresis can separate DNA fragments based on size.** (True)
- **rbcL is a nuclear DNA marker used for plant barcoding.** (False)
- **Doyle and Doyle (1990) proposed a widely used DNA extraction method.** (True)
- **In electrophoresis, DNA moves towards the negative electrode.** (False)

Match the Following

Column A	Column B
1. rbcL	a. Chloroplast marker
2. ITS	b. Nuclear DNA marker
3. PCR	c. DNA amplification
4. Agarose	d. Gel electrophoresis
5. COI	e. Animal DNA barcoding
6. matK	f. Plant DNA barcoding
7. Mitochondrial DNA	g. Maternal inheritance
8. DNA sequencing	h. Sanger method
9. Electrophoresis	i. DNA separation
10. Taxonomy	j. Classification of organisms

1–a, 2–b, 3–c, 4–d, 5–e, 6–f, 7–g, 8–h, 9–i, 10–j

QUESTIONS FOR PRACTICE

Final Term Exam (Model questions)

Multiple choice question

Who is credited with creating the first herbarium?
a) Carl Linnaeus
b) Luca Ghini
c) Andrea Cesalpino
d) Alexander von Humboldt
Answer: b) Luca Ghini

What was the initial name given to herbariums?
a) Hortus Siccus
b) Plant Archive
c) Botanical Repository
d) Herbarium Garden
Answer: a) Hortus Siccus

Which chemical is commonly used to prevent pest attacks in herbarium specimens?
a) Ethanol
b) Mercuric chloride
c) Sodium chloride
d) Hydrogen peroxide
Answer: b) Mercuric chloride

Which type of stomata is characterized by two subsidiary cells parallel to the guard cells?
a) Anomocytic
b) Paracytic
c) Diacytic
d) Anisocytic
Answer: b) Paracytic

Final Term Exam (Model questions)

Multiple choice question

Which of the following is a secondary metabolite commonly used in plant taxonomy?
a) Glucose
b) Alkaloids
c) Starch
d) Cellulose
Answer: b) Alkaloids

Which vascular tissue is responsible for water conduction in plants?
a) Phloem
b) Xylem
c) Epidermis
d) Cortex
Answer: b) Xylem

Which molecular marker is commonly used for DNA barcoding in plants?
a) COI
b) ITS
c) matK
d) 16S rRNA
Answer: c) matK

Final Term Exam (Model questions)

Multiple choice question

Which of the following is NOT a commonly used molecular marker in plant systematics?
a) rbcL
b) matK
c) COI
d) ITS
Answer: c) COI

Which step is NOT involved in molecular systematics?
a) DNA extraction
b) PCR amplification
c) Light microscopy
d) DNA sequencing
Answer: c) Light microscopy

Which DNA sequencing method uses chain-terminating nucleotides?
a) Next-generation sequencing
b) Sanger sequencing
c) Microarray sequencing
d) RNA sequencing
Answer: b) Sanger sequencing

Final Term Exam (Model questions)

Fill in the blanks

The first herbarium was created by _______.
Answer: Luca Ghini

Herbarium sheets are usually ______ inches in size.
Answer: 11.5 x 16.5

The study of pollen grains and spores is called _______
Answer: Palynology.

Stomata found on both leaf surfaces are known as_____
Answer: Amphistomatic.

The enzyme used in PCR is called _____
Answer: Taq polymerase.

The DNA barcode marker for animals is __________
Answer: COI (cytochrome c oxidase 1).

The non-coding regions of DNA used for phylogenetic studies are called __________
Answer: spacers.

Final Term Exam (Model questions)

Mark the True / False

- The first herbarium was created by Carl Linnaeus. (False)
- Herbarium specimens help in biodiversity conservation. (True)
- DNA sequencing is not useful in plant taxonomy. (False)
- Diacytic stomata are found in Caryophyllaceae. (True)
- DNA barcoding can be used to identify medicinal plants. (True)
- Mitochondrial DNA is more stable than chloroplast DNA in plants. (False)
- ITS regions are coding regions of nuclear DNA. (False)
- PCR is used to break down DNA strands. (False)

Final Term Exam (Model questions)

Figure based question

Question 1 Identify the Tool

- **Question:** Identify the tool shown and describe its function.
- **Answer:** Herbarium presser- Preserving plant specimens for herbarium collections.

Final Term Exam (Model questions)

Figure based question

Question 2 Identify the Taxonomic Key in Use

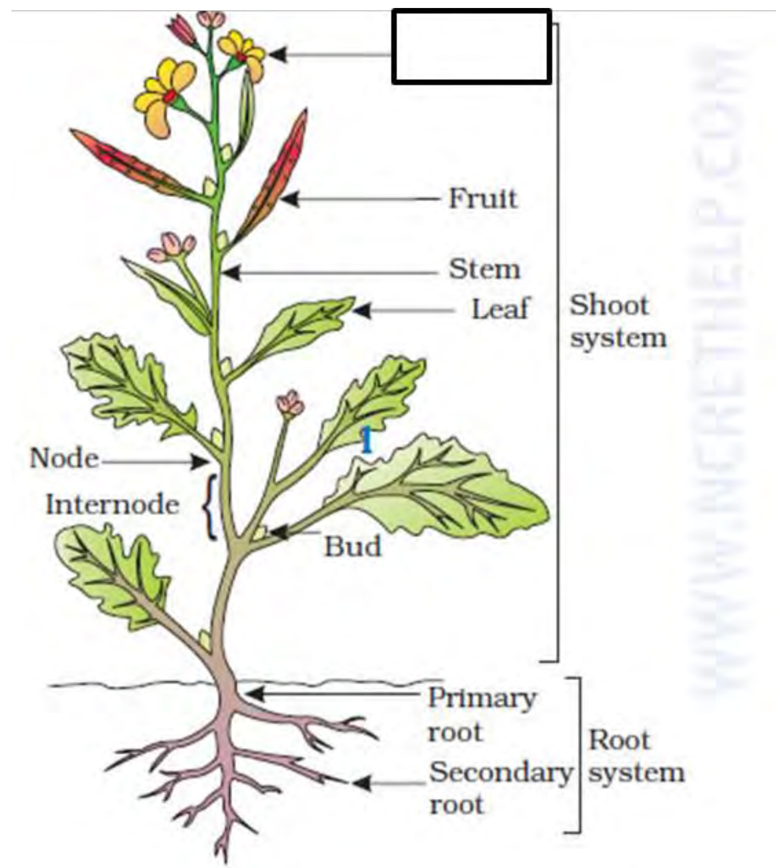
1. Fruit achene.................................. 2
1. Fruit follicle 5
2. Calyx differentiated from corolla 3
2. Calyx not differentiated from corolla 4
3. Petal with basal nectary ... 1. *Ranunculus*
3. Petal without basal nectary ..... 2. *Adonis*
4. Plants woody .... 4. *Clematis*
4. Plants herbaceous .... .3. *Anemone*
5. Spur present 6
5. Spur absent .... 5. *Caltha*
6. Number of spurs 1 .... 6. *Delphinium*
6. Number of spurs 5 .... 7. *Aquilegia*

- **Question:** What type of key is being used in the image, and how does it assist in plant identification?
- **Answer:** This is a **dichotomous key**, which helps identify plants by making step-by-step choices between paired characteristics.

Final Term Exam (Model questions)

Figure based question

Question 3 Examine the provided diagram. What is the appropriate term to fill in the blank box?

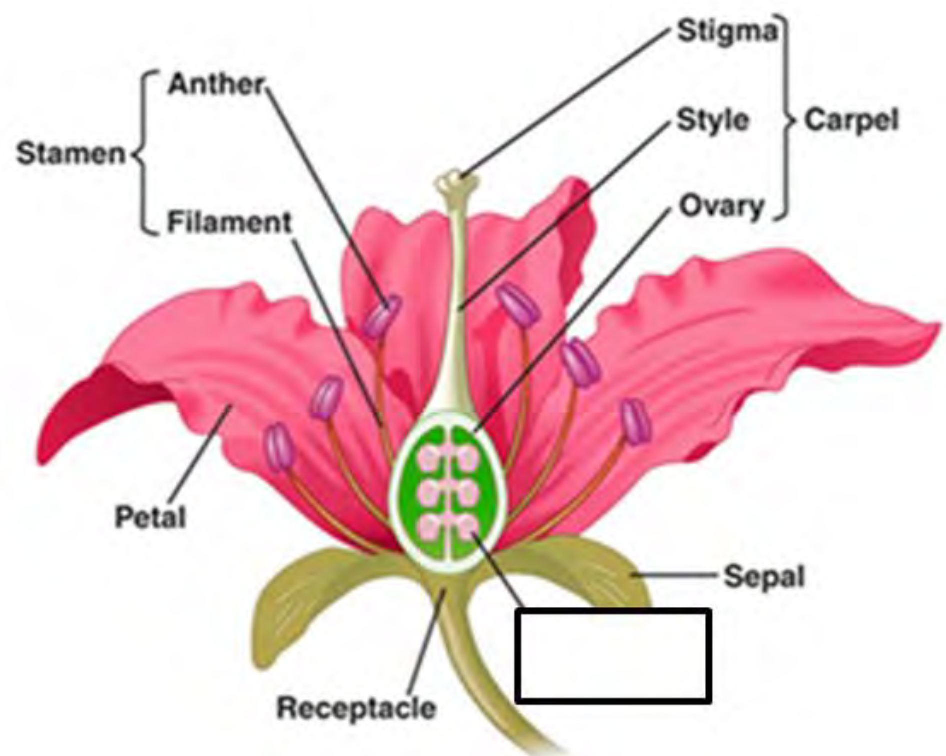


Answer: Flower

Final Term Exam (Model questions)

Figure based question

Question 4 Examine the provided diagram. What is the appropriate term to fill in the blank box?



Answer: Ovule

Final Term Exam (Model questions)

Figure based question

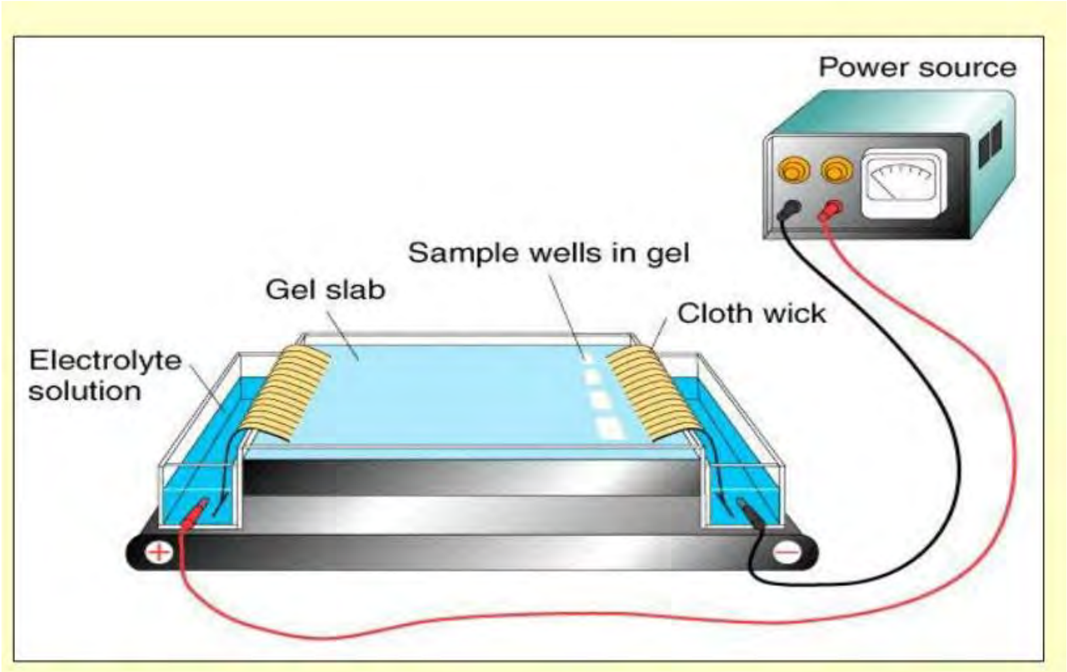
Question 5 Examine the provided diagram and answer?

Answer: PCR machine

Final Term Exam (Model questions)

Figure based question

Question 6 Examine the provided diagram and answer?

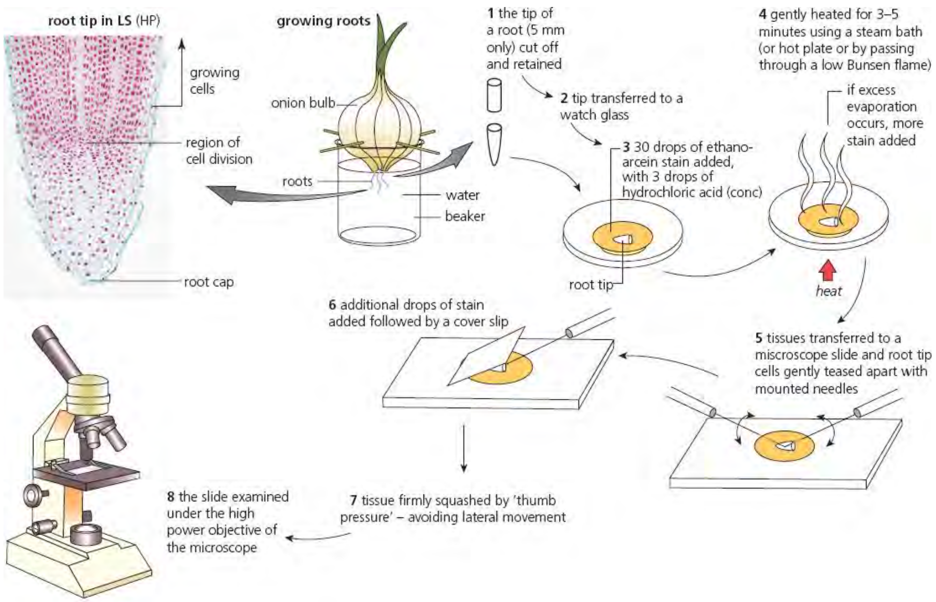


Answer: Agarose Gel Electrophoresis

Final Term Exam (Model questions)

Figure based question

Question 7 Examine the provided diagram and answer?



Answer: mitosis preparation

Final Term Exam (Model questions)

Match the following

Question

A	B
Palynology	Sanger method
Karyotype	Desert plants
CAM Photosynthesis	Chromosome appearance
rbcL	DNA amplification
PCR	Chloroplast marker
DNA sequencing	Study of pollen grains

Answer

A	B
Palynology	Study of pollen grains
Karyotype	Chromosome appearance
CAM Photosynthesis	Desert plants
rbcL	Chloroplast marker
PCR	DNA amplification
DNA sequencing	Sanger method

Final Term Exam (Model questions)

Short answer question

What is a herbarium?
A herbarium is a collection of preserved plant specimens used for scientific study and reference.

What is DNA barcoding?
A technique that uses a short DNA sequence from a standardized region of the genome for species identification.

Final Term Exam (Model questions)

Multiple choice question

What is the primary function of a herbarium? a) Preserving animal fossils
b) Preserving and studying plant specimens
c) Storing genetic material
d) Growing plants for commercial use

Answer: b) Preserving and studying plant specimens
Who introduced the binomial nomenclature system? a) Carl Linnaeus
b) Luca Ghini
c) Alexander von Humboldt
d) Andrea Cesalpino
Answer: a) Carl Linnaeus

What is the standard size of herbarium sheets? a) 8.5 x 11 inches
b) 11.5 x 16.5 inches
c) 12 x 18 inches
d) 10 x 15 inches
Answer: b) 11.5 x 16.5 inches

Which institution is known for having one of the largest herbarium collections? a) Harvard University
b) Royal Botanic Gardens, Kew
c) Smithsonian Institution
d) Oxford University
Answer: b) Royal Botanic Gardens, Kew

What is the purpose of labeling in herbarium sheets? a) To enhance the appearance of the specimen
b) To provide scientific details about the plant
c) To increase the weight of the specimen
d) To prevent contamination
Answer: b) To provide scientific details about the plant

Final Term Exam (Model questions)

Multiple choice question

Which of the following is NOT a function of a herbarium? a) Studying plant taxonomy
b) Preserving plant biodiversity
c) Conducting animal research
d) Assisting forensic investigations
Answer: c) Conducting animal research

Which online platform provides access to digitized herbarium collections? a) GBIF
b) Wikipedia
c) Google Scholar
d) ScienceDirect
Answer: a) GBIF

What is the primary function of trichomes in plants?
a) Photosynthesis
b) Water absorption
c) Protection against herbivory
d) Transport of nutrients
Answer: c) Protection against herbivory

Final Term Exam (Model questions)

Multiple choice question

Which of the following is an example of a xerophytic adaptation?
a) Amphistomatic leaves
b) Epistomatic leaves
c) Hypostomatic leaves
d) Hydrostomatic leaves
Answer: a) Amphistomatic leaves

The presence of which compound differentiates Caryophyllales from Polygonales?
a) Alkaloids
b) Flavonoids
c) Betalains
d) Anthocyanins
Answer: c) Betalains
Which pollen aperture type is characteristic of eudicots?
a) Monocolpate
b) Tricolpate
c) Porate
d) Colporate
Answer: b) Tricolpate

What type of inflorescence is a panicle?
a) Simple
b) Compound
c) Solitary
d) None of the above
Answer: b) Compound

Final Term Exam (Model questions)

Multiple choice question

What is the term used for the phenotypic appearance of somatic chromosomes?
a) Genome
b) Karyotype
c) Idiogram
d) Chromatin
Answer: b) Karyotype

Which DNA marker technique is commonly used for species identification?
a) SSR
b) AFLP
c) SNP
d) All of the above
Answer: d) All of the above

Which DNA sequencing method uses chain-terminating nucleotides?
a) Next-generation sequencing
b) Sanger sequencing
c) Microarray sequencing
d) RNA sequencing
Answer: b) Sanger sequencing

Final Term Exam (Model questions)

Multiple choice question

Which component of the cell contains ribosomal DNA (rDNA)?
a) Chloroplast
b) Mitochondria
c) Nucleus
d) All of the above
Answer: d) All of the above

What is the purpose of PCR in molecular systematics?
a) Breaking DNA strands
b) Amplifying specific DNA sequences
c) Separating DNA fragments
d) Detecting proteins
Answer: b) Amplifying specific DNA sequences

Which scientist(s) proposed the DNA double-helix model?
a) Watson and Crick
b) Mendel
c) Darwin and Wallace
d) Linnaeus
Answer: a) Watson and Crick

ITS markers are part of which genetic region?
a) Chloroplast DNA
b) Mitochondrial DNA
c) Nuclear ribosomal DNA
d) None of the above

Answer: c) Nuclear ribosomal DNA
What is the primary function of DNA barcoding?
a) Species identification
b) Protein synthesis
c) Cell division
d) Photosynthesis
Answer: a) Species identification

Final Term Exam (Model questions)

Multiple Choice Questions (MCQs)

Which type of stomata is characterized by two subsidiary cells parallel to the guard cells?
a) Anomocytic
b) Paracytic
c) Diacytic
d) Anisocytic
Answer: b) Paracytic

Which of the following is a secondary metabolite commonly used in plant taxonomy?
a) Glucose
b) Alkaloids
c) Starch
d) Cellulose
Answer: b) Alkaloids

Which vascular tissue is responsible for water conduction in plants?
a) Phloem
b) Xylem
c) Epidermis
d) Cortex
Answer: b) Xylem

Final Term Exam (Model questions)

Fill in the blanks

1. The largest herbarium collection is found at _______.
   Answer: Royal Botanic Gardens, Kew

2. The process of treating specimens with chemicals to prevent pest attacks is called _______.
   Answer: Poisoning)

3. _______ is an example of a modern online herbarium database.
   Answer:GBIF or JSTOR Global Plants)

4. The part of the herbarium sheet where scientific details are written is called the _______.
   Answer: Label)

5. The term _______refers to the diagrammatic representation of a karyotype.
   Answer: Idiogram

6. In taxonomy, ________are used for chemical differentiation among species.
   Answer: flavonoids

7. ________ secrete oils and resins.
   Answer: Glandular trichomes

8. The DNA region ______ is commonly used in plant DNA barcoding.
   Answer: rbcL

9. The model of DNA was proposed by _______in **1962**.
   Answer: Watson and Crick

10. _______is commonly used for fungal identification.
    Answer: ITS (Internal Transcribed Spacer)

11. The process of converting DNA to RNA is called_____.
    Answer: transcription

12. The full form of PCR is__________.
    Answer: Polymerase Chain Reaction

13. The Sanger sequencing method uses _______to terminate DNA strands.
    Answer: dideoxy nucleotides

14. The mitochondrial DNA in plants is __________
    Answer: maternally inherited.

Final Term Exam (Model questions)

Mark the True / False

1.Herbarium specimens help in biodiversity conservation. (True)

2.Andrea Cesalpino developed the binomial nomenclature system. (False)

3.Digitization of herbaria has improved global access to plant data. (True)

4.Herbariums play no role in forensic science. (False)

5.Plasmodesmata are found in plant cell walls. (True)

6.Monocots have two cotyledons. (False)

7.Pollen grains can be used in taxonomic classification. (True)

8.The idiogram represents the arrangement of genes on a chromosome. (False)

9.Wood anatomy is irrelevant in plant taxonomy. (False)

10.Tricolpate pollen is a characteristic of eudicots. (True)

11.Sanger sequencing uses chain-terminating nucleotides. (True)

12.DNA barcoding can be applied to bacteria and archaea. (False)

13.Gel electrophoresis can separate DNA fragments based on size. (True)

14.rbcL is a nuclear DNA marker used for plant barcoding. (False)

15.Doyle and Doyle (1990) proposed a widely used DNA extraction method. (True)

16.In electrophoresis, DNA moves towards the negative electrode. (False)

Final Term Exam (Model questions)

Match the following

Question

Column A	Column B
Palynology	Classification of organisms
Diacytic Stomata	Sanger method
Karyotype	rbcL gene
DNA Barcoding	Chromosome appearance
Alkaloids	Chemical taxonomy
Polyploidy	Nuclear DNA marker
Idiogram	DNA amplification
ITS	Chromosome diagram
PCR	Chromosome duplication
Mitochondrial DNA	Caryophyllaceae
DNA sequencing	Maternal inheritance
Taxonomy	Study of pollen grains

Answers

Column A	Column B
Palynology	Study of pollen grains
Diacytic Stomata	Caryophyllaceae
Karyotype	Chromosome appearance
DNA Barcoding	rbcL gene
Alkaloids	Chemical taxonomy
Polyploidy	Chromosome duplication
Idiogram	Chromosome diagram
ITS	Nuclear DNA marker
PCR	DNA amplification
Mitochondrial DNA	Maternal inheritance
DNA sequencing	Sanger method
Taxonomy	Classification of organisms

Final Term Exam (Model questions)

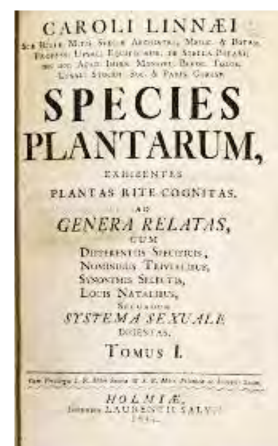
Figure based question

Question. Identify the person in the photo?

Answer: Andrea Cesalpino

Question Who was the author of the book?

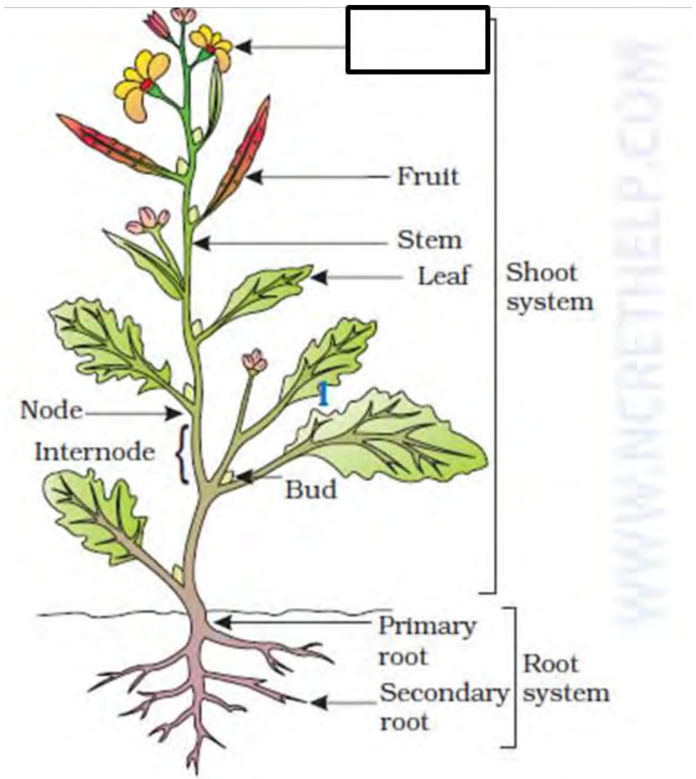
Answer: Carl Linnaeus



Final Term Exam (Model questions)

Figure based question

Question Examine the provided diagram. What is the appropriate term to fill in the blank box?

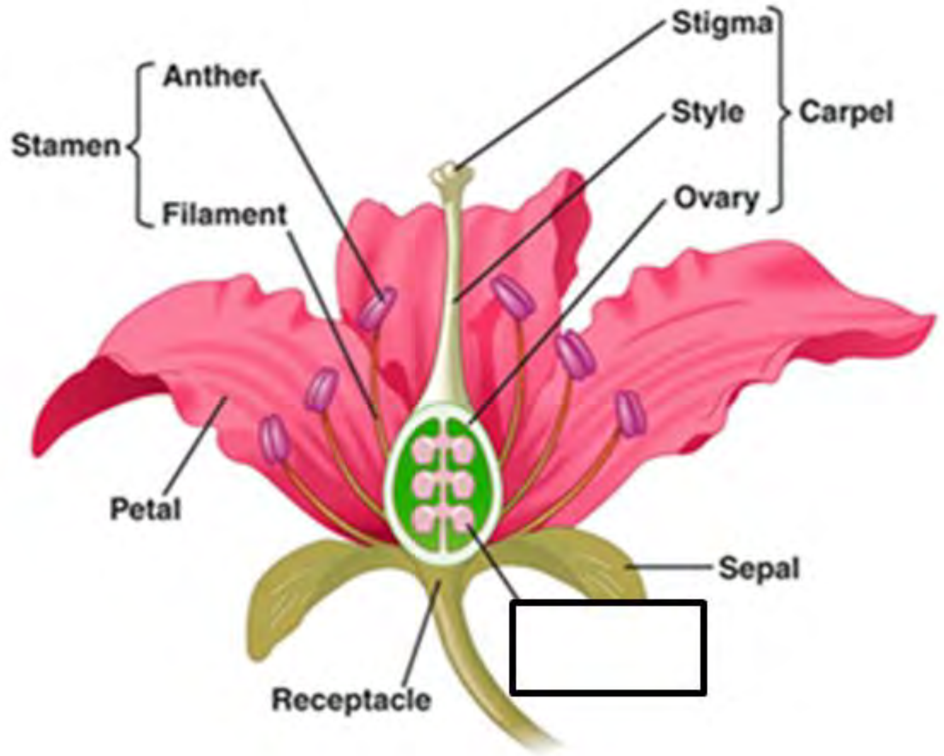


Answer: Flower

Final Term Exam (Model questions)

Figure based question

Question Examine the provided diagram. What is the appropriate term to fill in the blank box?

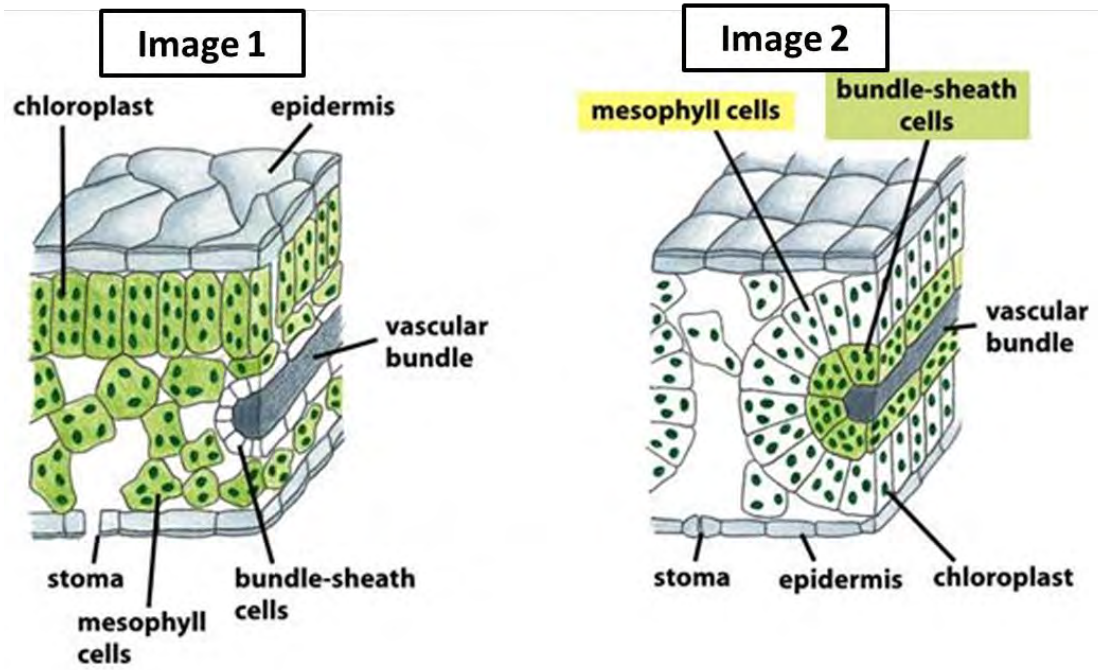


Answer: Ovule

Final Term Exam (Model questions)

Figure based question

Question Examine the provided diagram. What is the appropriate image for C3 and C4 leaf section?

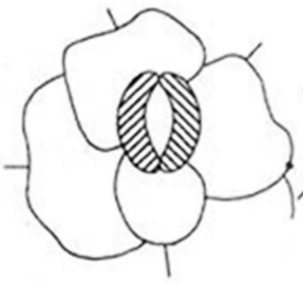


Answer: Image 1; C3, Image 2; C4

Final Term Exam (Model questions)

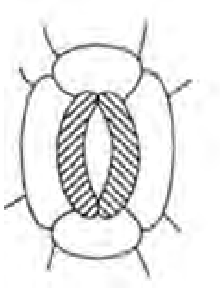
Figure based question

Question What type of stomata is shown in the image?



Answer: Anomocytic

Question What type of stomata is shown in the image?

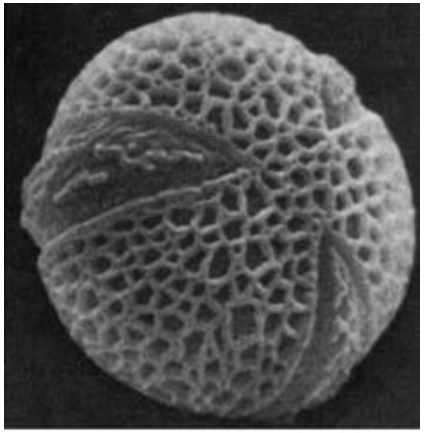


Answer: Tetracyctic

Final Term Exam (Model questions)

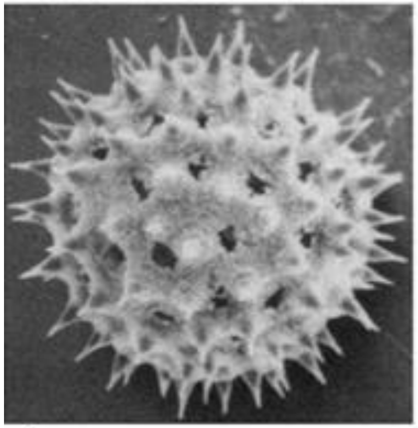
Figure based question

Question Identify the type of pollen aperture visible in the microscopic image



Answer: Tricolpate

Question Identify the type of pollen aperture visible in the microscopic image.



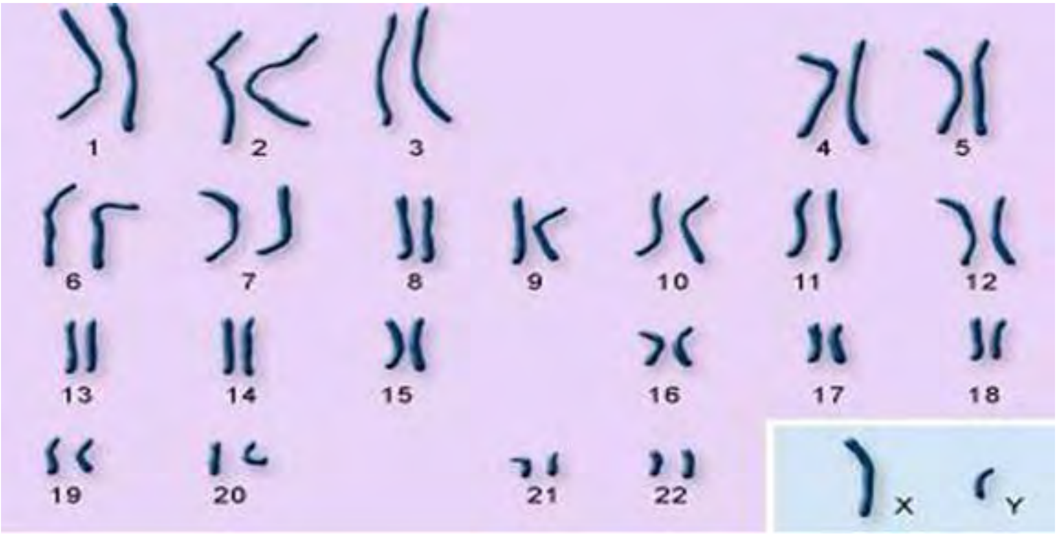
E

Answer: spinose

Final Term Exam (Model questions)

Figure based question

Question. Observe the given diagram carefully. What is the correct term to label this image?



Answer: Karyotype

Final Term Exam (Model questions)

Figure based question

Question. Look at the image below and identify.

Answer: Bar code

Final Term Exam (Model questions)

Figure based question

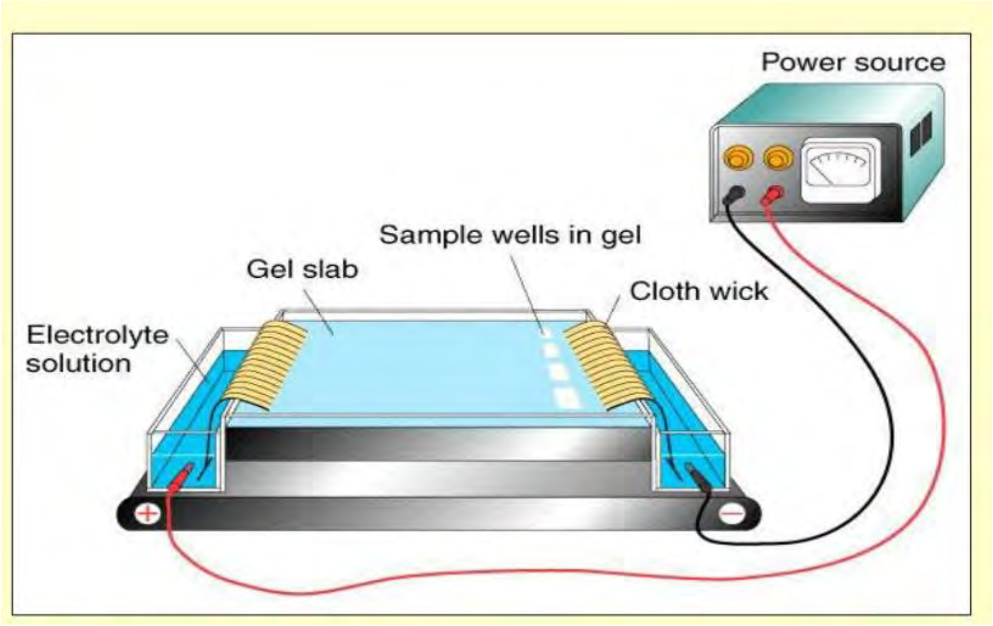
Question Examine the provided diagram and answer?

Answer: PCR machine

Final Term Exam (Model questions)

Figure based question

Question Examine the provided diagram and answer?



Answer: Agarose Gel Electrophoresis

Final Term Exam (Model questions)

Short answer question

1. **What is an idiogram?**
   Answer: A diagrammatic representation of a karyotype showing the number, shape, and structure of chromosomes.

2. **Define trichomes and their function.**
   Answer: Trichomes are hair-like structures on plant surfaces that help in protection, water retention, and secretion of essential oils.

3. **What is the function of a DNA primer in PCR?**
   It binds to the target DNA sequence and initiates replication.

4. **Name one advantage of molecular systematics over traditional taxonomy.**
   It provides more objective and accurate classification.

WEEK 14

FINAL EXAM

(all slides

Week 1 -13

THANKS

ALL THE VERY BEST FOR YOUR FINAL EXAM