الجمهوريـة الجزائـريـة الديمقراطيـة الشعبيـة

People's Democratic Republic of Algeria

وزارة التعليــم العالـي والبحـث العلمـي

Ministry of higher education and scientific research

معهد علوم الطبيعة والحياة

Nature and Life Sciences Institute

قسم العلوم البيولوجية والفلاحية

Department of Biological and Agricultural Sciences

Botany Courses

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Course Sheet

- **Course:** Botany
- **Teaching Unit:** Fundamental Teaching Unit
- **Semester: 4th Semester Biological Sciences)**
  - Credits: 06
  - Coefficient: 02
- **Student target:**
  - **2nd grade License, Common Core in Agricultural Sciences.**
  - **2nd grade License, Common Core in Biological Sciences.**
- **Weekly Teaching Hours:**
  - 3h Lecture per week (14 weeks)
  - 3h Practical work / week for 14 weeks
- **Assessment: Continuous evaluation, Final exam**
- **For any information, you can contact the course coordinator:**
  - **By email:** torche.yacine@yahoo.fr
  - **At the SNV Institute on Sundays from 11:00 AM to 12:00 PM**

Course Objectives and Prerequisites

Course Objectives:

a. General Botany

- Understand the major groups within the plant kingdom.
- Recognize ancient groups historically classified within the plant kingdom.
- Develop familiarity with botanical systematics.
- Identify major plant families.
- Understand the different classification systems of living organisms.
- Grasp the principles of molecular biosystematics.

b. Pure and Applied Botany

- Learn to identify the main divisions of the plant kingdom.
- Distinguish plants based on their morphological characteristics.
- Understand the relevance of plants to human needs.
- Explore the biochemical compounds in plants and their applications.
- Examine the uses of botany in agriculture, forestry, aquaculture, and pharmaceutical technologies.

Prerequisites:

To successfully follow this course, students should have prior knowledge of:

- Organic chemistry
- Cell biology
- Plant biology
- General ecology

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Learning outcomes

By the end of this chapiter, students should be able to:

1. Understand Plant Diversity – Identify major plant groups and their evolutionary relationships.
2. Analyze Plant Structure and Function – Explain plant anatomy, physiology, and their roles in growth, reproduction, and adaptation.
3. Classify Plants Scientifically – Use taxonomic principles to classify and name plants correctly.
4. Explore Ecological Interactions – Describe how plants interact with their environment and other organisms.
5. Apply Botanical Knowledge – Discuss the importance of plants in agriculture, medicine, and biotechnology.
6. Use Scientific Methods – Conduct basic botanical research, including observation, data collection, and analysis.

I. Generalities

1. Botany: What is it?

In the literature, there are several definitions of botany that tend to converge in meaning. We will see some definitions in this course.

- ***Def.1*** Botany is the science that studies plants, including their structure, growth, reproduction, physiology, classification, distribution, ecology, and use by humans. It encompasses a wide range of disciplines, from plant anatomy and physiology to plant ecology, taxonomy, and genetics.
- ***Def.2*** Botany is a branch of biology that deals with plants (phytology). It studies the life cycle, metabolism, growth, and composition of plants, along with their ingredients (medical science), their ecology (biocenosis), their economic benefits (cultivation), and their classification.
- ***Def.3*** Botany, or phytology, is the science that brings together all disciplines studying plants, the science of plant biology. This plant biology is a branch of biology involving the scientific study of living plants; the study of dead plants is paleobotany. A botanical organism is related to plants.

- Traditionally, botany also includes the study of fungi (mycology), algae (algology, phycology), and viruses (microbiology, phytopathology). The specialist is the botanist or phytologist. Botany integrates phyllotaxy, the science of leaves.

- Today, botanists study more than 550,000 species of living organisms by conducting vegetation inventories using botanical surveys, studying the reasons for species distribution in botanical geography, geobotany, ethnobotany, and phytosociology.
- The concept of the botanical region thus makes it possible to delineate areas or territories including endemic plants or species specific to certain regions.
- Often, there is a division between "general and special botany" and "applied botany." Applied botany particularly deals with the use of plants in agriculture, forestry, horticulture, landscape management, and environmental protection (including medicinal plants in phytotherapy).

Botany is a fundamental discipline that plays a crucial role in our understanding of life on Earth and in our sustainable use of plant resources.

2. *The Main Areas Covered by Botany*

- ***Plant Anatomy***: Study of the internal structure of plants, including plant tissues and organs.
- ***Plant Physiology***: Study of the metabolic and physiological processes of plants, such as photosynthesis, respiration, water and nutrient absorption, transpiration, etc.
- ***Plant Reproduction***: Study of plant reproduction mechanisms, including pollination, gamete formation, fertilization, and sexual and asexual reproduction.
- ***Palynology***: Study of pollen grains and spores, both in their living and fossil forms. These grains are small and produced by the reproductive organs of plants, particularly flowers, cones, and sporangia of ferns and seed plants.
- ***Plant Taxonomy***: Classification and identification of plants into taxonomic groups based on their morphological, anatomical, genetic, and evolutionary characteristics.
- ***Plant Systematics***: Organization and classification of plants into evolutionary groups based on phylogenetic evidence, using techniques such as cladistics and molecular genetics.
- ***Phytochemistry***: Study of chemical compounds produced by plants. This field examines natural chemical substances present in plants, such as alkaloids, flavonoids, terpenes, tannins, lignans, saponins, glucosinolates, and essential oils.
- ***Plant Ecology***: Study of interactions between plants and their environment, including interactions with other living organisms, the geographical distribution of plant species, plant communities, and ecosystems.
- ***Plant Biogeography***: Study of the distribution of plants worldwide and the factors influencing this distribution, such as climate, soil, and environmental disturbances.
- ***Plant Genetics***: Study of genetic variation, heredity, and plant evolution, as well as the application of genetics in the improvement of cultivated plants.
- ***Ethnobotany***: Study of the uses of plants by humans, including agriculture, horticulture, pharmacology, food, forestry, biotechnology, and other practical applications.

3. *Importance of Botany*

Botany is crucial for multiple fields, especially in plant biotechnology and breeding. Here's a more detailed breakdown:

☞ ***Crop Improvement & Food Security***

- Helps develop disease-resistant and high-yielding crop varieties through breeding and genetic modification.
- Enables understanding of polygenic traits (e.g., drought tolerance, salt tolerance) for improving stress resistance.
- Aids in hybridization to enhance heterosis (hybrid vigor) in crops.

☞ ***Genetic Diversity & Conservation***

- Supports biodiversity conservation through in-situ (protected areas) and ex-situ (seed banks, botanical gardens) methods.
- Essential for assessing genetic structure of plant populations (e.g., using SSR markers, as in your Quercus afares study).
- Provides insights into outbreeding vs. inbreeding effects on genetic health.

☞ ***Plant Physiology & Stress Tolerance***

- Explains mechanisms of salinity, drought, and temperature stress in plants.
- Supports biotechnological approaches (e.g., transgenic plants, CRISPR gene editing) to improve stress tolerance.
- Helps optimize photosynthesis efficiency for higher productivity.

☞ ***Medicinal & Industrial Applications***

- Identifies and extracts bioactive compounds for pharmaceuticals (e.g., alkaloids, flavonoids).
- Develops biofuels, essential oils, and plant-based polymers for sustainable industries.
- Advances plant-derived bioplastics and biodegradable materials.

☞ ***Climate Change & Ecosystem Services***

- Studies plant carbon sequestration to mitigate climate change.
- Supports reforestation and afforestation efforts to restore degraded ecosystems.
- Enhances knowledge of plant-microbe interactions for soil fertility and sustainable agriculture.
- Since you work on genetic diversity and population structure, botany provides the essential framework for understanding gene flow, linkage disequilibrium, and adaptive traits in plant populations.

4. Historical Overview of Botany and Plant Classification

a. Antiquity

Early plant classification was based on utility—plants were grouped by their medicinal, edible, or toxic properties. Theophrastus, often called the "Father of Botany," described over 500 plant species in *Historia Plantarum*, focusing on growth forms like trees, shrubs, and herbs.

b. Middle Ages

Botanical knowledge declined in Europe but was preserved in monasteries and Islamic texts. Works like Dioscorides' *De Materia Medica* were copied and used for centuries. The focus was mainly on medicinal uses, illustrated in herbals.

c. Renaissance and Early Modern Period

The 16th century saw renewed interest in plant study through exploration and empirical observation. Botanists like Cesalpino classified plants by structure rather than use. Botanical gardens and herbaria emerged as scientific tools.

d. Pre-Linnaean Systems

Before Linnaeus, plant names were long and descriptive. Efforts by botanists like Ray and Tournefort moved toward classifying plants based on flower parts, but no standardized system existed. Classifications varied greatly between authors.

e. Linnaeus and the Sexual System

Carl Linnaeus revolutionized plant classification in *Systema Naturae* (1749) and *Species Plantarum* (1753). He introduced binomial nomenclature and grouped plants by reproductive organs, forming the first universal system—simple, practical, and widely adopted.

f. Fixism vs. Transformism

Fixism held that species were unchanging, a view supported by religious beliefs. In contrast, early evolutionists like Lamarck proposed that species could change over time through inherited traits. This debate paved the way for Darwin's ideas.

g. Darwin and Evolution

Charles Darwin's *On the Origin of Species* (1859) introduced natural selection and common descent. His theory transformed botany, shifting classification from static groupings to evolutionary relationships. Plants were now studied in terms of their ancestry and variation.

h. Modern Systematics

Today, plant classification uses molecular tools like DNA sequencing to build phylogenetic trees. Modern systematics combines morphology, genetics, and evolution. The International Code of Nomenclature ensures consistency and reflects evolutionary history.

i. Phenetics, Cladistics, and Phylogenetic Classification

In the mid-20th century, **phenetics** aimed to classify organisms based on overall similarity, using as many traits as possible without considering evolutionary history. It used numerical methods to group species, but often led to unnatural classifications.

Cladistics, developed by Willi Hennig, focused instead on **shared derived characters** (synapomorphies) to reflect evolutionary relationships. It produces **cladograms** showing branching patterns of descent, not just similarity.

Today, **phylogenetic classification** combines cladistic principles with **molecular data** (like DNA sequences) to construct trees that reflect actual evolutionary histories. It replaces artificial groupings with natural, monophyletic groups—those including a common ancestor and all its descendants.

5. Introduction to Cladistics

Cladistics is a method of classification that organizes species based on their **evolutionary history**. It uses shared **derived characters** (synapomorphies) to build **cladograms**, or branching diagrams, that represent hypothesized evolutionary relationships.

a) Key Principles of Cladistics

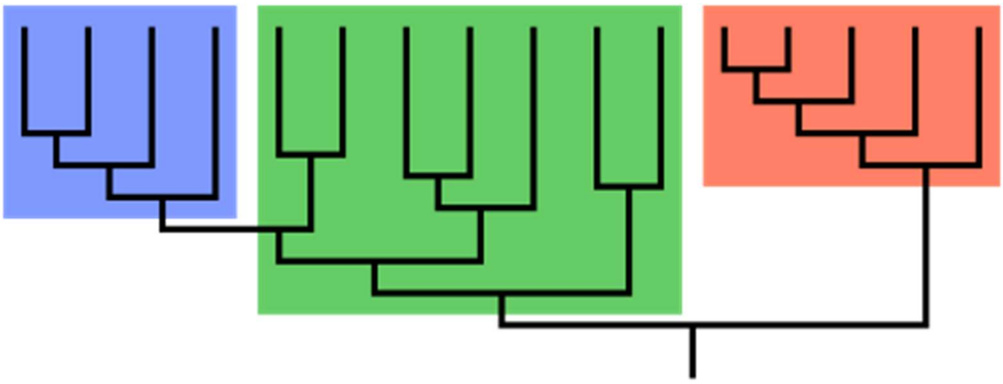
- **Common ancestry** is central: organisms are grouped based on descent from a shared ancestor.
- Focuses only on **evolutionary innovations**, not overall similarity.
- All valid groups should be **monophyletic**, meaning they contain an ancestor and *all* its descendants.

b) Cladogram Basics

A **cladogram** shows the branching sequence of evolution:

- **Nodes** represent common ancestors.
- **Branches** represent lineages.
- **Outgroups** help identify which traits are ancestral vs. derived.

Cladograms do not show time, only **relative branching order**.



Cladogram (a branching tree diagram) illustrating the relationships of organisms within groups of taxa known as clades. The vertical line *stem* at the base represents the last common ancestor. The blue and orange subgroups are clades, each defined by a common ancestor stem at the base of its respective subgroup *branch*. The green subgroup alone, however, is *not* a clade; it is a paraphyletic group relative to the blue subgroup because it excludes the blue branch, which shares the same common ancestor. Together, the green and blue subgroups form a clade.

c) Types of Phylogenetic Groups

🔶 **Monophyletic group (clade):**

- Includes a common ancestor and **all** of its descendants.
- Example: All flowering plants (*angiosperms*).

✅ This is the only type of group accepted in modern phylogenetic classification.

🔶 **Paraphyletic group:**

- Includes a common ancestor and **some**, but not all, descendants.
- Example: "Reptiles" excluding birds (*Aves*).

⚠️ Considered artificial and misleading in cladistics.

🔶 **Polyphyletic group:**

- Includes organisms from **different ancestors** but excludes their most recent common ancestor.

- Example: Grouping together bats and birds based on wings.

❌ Invalid in phylogenetic systematics; based on convergent traits.

d) Shared Characters

- **Ancestral character (plesiomorphy):** present in ancestor and all descendants, not useful for grouping.
- **Derived character (apomorphy):** a new trait evolved in a group, useful for defining clades.

Only **synapomorphies** (shared derived characters) help define clades.

e) Applications in Botany

Cladistics is widely used in botany to revise plant families and genera:

- Example: Molecular data helped redefine groups like **Brassicaceae** and **Fabaceae**.
- It ensures plant taxonomy reflects **true evolutionary history**.

f) Limitations and Challenges

- **Homoplasy** (convergent evolution) can mislead analyses.
- Some traits evolve multiple times independently.
- Need for high-quality molecular and morphological data.

6. Taxonomy and classification

Taxonomy is the identification, naming, and classification of organisms. Compared to systemization, classification emphasizes whether a species has characteristics of a taxonomic group.

The Linnaean classification system developed in the 1700s by Carolus Linnaeus is the foundation for modern classification methods. Linnaean classification relies on an organism's phenotype or physical characteristics to group and organize species.

With the emergence of biochemistry, organism classifications are now usually based on phylogenetic data, and many systematists contend that only monophyletic taxa should be recognized as named groups.

The degree to which classification depends on inferred evolutionary history differs depending on the school of taxonomy: phenetics ignores phylogenetic speculation altogether, trying to represent the similarity between organisms instead; cladistics (phylogenetic systematics) tries to reflect phylogeny in its classifications by only recognizing groups based on shared, derived characters (synapomorphies); evolutionary taxonomy tries to take into account both the branching pattern and "degree of difference" to find a compromise between them.