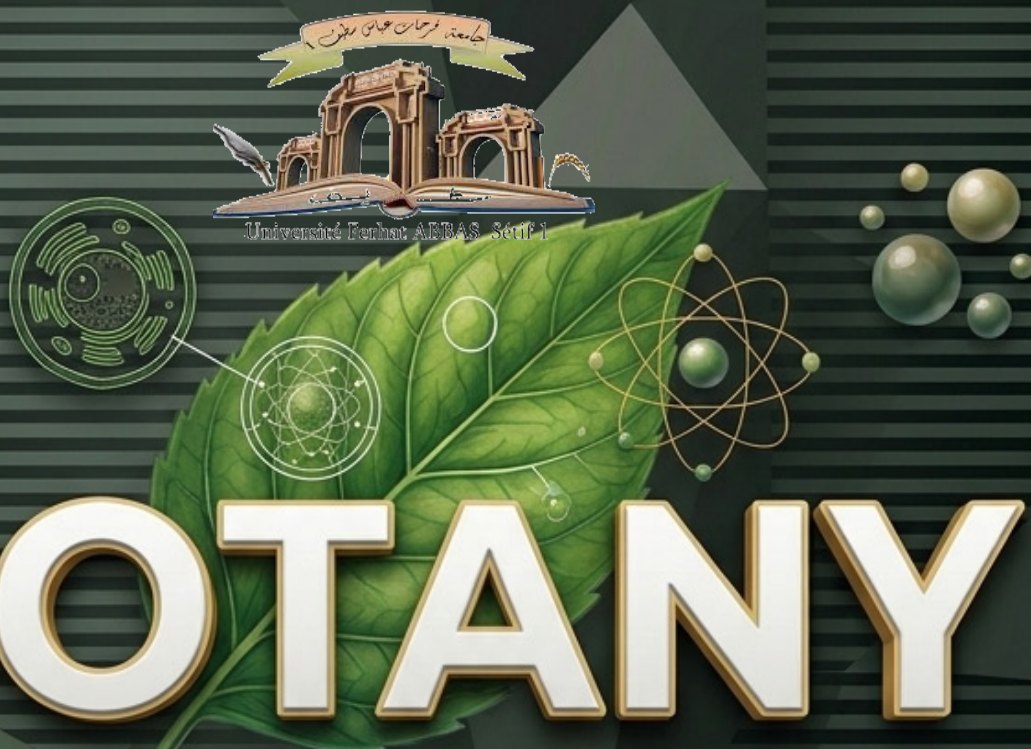


PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

FERHAT ABBAS UNIVERSITY – SETIF 1
FACULTY OF NATURAL AND LIFE SCIENCES
DEPARTMENT OF BASIC STUDIES



BOTANY

Second-Year Students

Natural and Life Sciences (L2 SNV)

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CHAPTER I: GENERAL INTRODUCTION AND TAXONOMY

1. Definition and Etymology

The term Botany comes from the Ancient Greek **botanikē** (feminine of **botanikos**, "relating to herbs"), itself derived from **botanē**, meaning "herb, plant, fodder". In a modern and academic sense, botany is the biological science devoted to the study of plants.

It is not limited to the simple description of plants, but encompasses the study of their structure (morphology and anatomy), their functioning (physiology), their relationships with the environment (ecology) and their classification (systematics).

Historically, botany included algae, fungi, and lichens. Although modern systematics (phylogenetics) now places fungi in a separate kingdom (the Fungi kingdom), the study of these organisms remains a fundamental component of the botany curriculum due to their ecological importance and their biological interactions with plants.

2. Classification criteria

Plant classification is based on morphological, anatomical, and reproductive criteria. Historically, two main levels of organization have been distinguished, based on the complexity of the vegetative system:

A. The Thallophytes

This group comprises plants whose vegetative structure is a thallus. A thallus is a simple structure, lacking roots, stems, and true leaves. It does not contain differentiated vascular tissues (xylem and phloem). This group traditionally includes algae and fungi.

B. Cormophytes

These organisms possess a cormus, that is, a differentiated vegetative structure comprising roots (for anchorage and absorption), stems (for support), and leaves (sites of photosynthesis). They have specialized vascular tissues that allow the circulation of sap. This group includes Bryophytes, Pteridophytes, and Spermatophytes.

Plants can also be classified according to their mode of reproduction:

- **Cryptogames:** Plants whose reproductive organs are not very visible (Mosses, Ferns, Algae).
- **Phanerogams:** Plants whose reproductive organs are visible (Flowers or Cones).

3. Modern Nomenclature and Systematics

Botanical nomenclature is governed by the International Code of Nomenclature (ICN). Each plant is designated by a Latin binomial written in italics: the Genus (capital letter) and the specific epithet (lowercase).

A fundamental point of distinction between the groups lies in their mode of cell division.

Binary Fission (or scission): This occurs in prokaryotes (e.g., cyanobacteria). It is a simple division by constriction of the cell without the formation of a mitotic spindle.

Mitosis: Characteristic of Eukaryotes. It involves a complex reorganization of the nucleus and a precise separation of chromosomes thanks to a microtubular spindle.

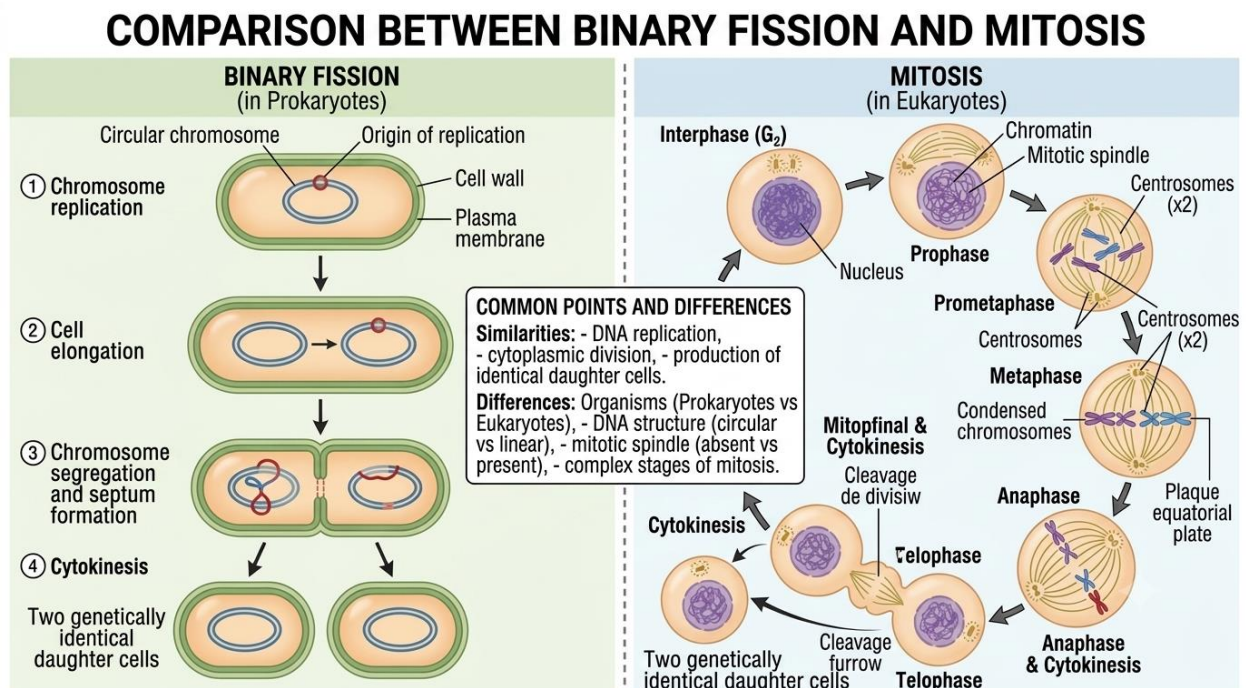


Figure 1: Schematic comparison between binary fission (in Prokaryotes) and mitosis (in Eukaryotes).

PART ONE:
THALLOPHYTES
(ALGAE, FUNGI AND LICHENS)

CHAPTER II: ALGAE (PHYCOLOGY)

1. Introduction and Definition

Algae constitute a vast and heterogeneous group of organisms capable of oxygenic photosynthesis. Although they share the presence of chlorophyll with terrestrial plants, they are distinguished by a thallus-like vegetative organization, lacking roots, stems, and true leaves, as well as by the absence of complex vascular tissues.

1.1. Ecology and Biological Role

Algae colonize a variety of environments, primarily aquatic (oceans, lakes), but also humid terrestrial environments (tree bark, soils). They play crucial roles:

- **Primary producers:** They form the basis of aquatic food webs (phytoplankton).
- **Oxygen Production:** They generate more than 50% of Earth's atmospheric oxygen.
- **Biological indicators:** Their presence provides information about water quality (eutrophication).

2. Classification and Groups of Thales

The morphological diversity of algae is immense. Groups are distinguished according to the organization of their thallus:

1. **Unicellular algae:** Isolated forms (e.g., *Chlamydomonas*).
2. **Colonial Algae:** Cell groups (e.g., *Volvox*).
3. **Multicellular algae:** Complex thalli (filamentous, foliose or massive).

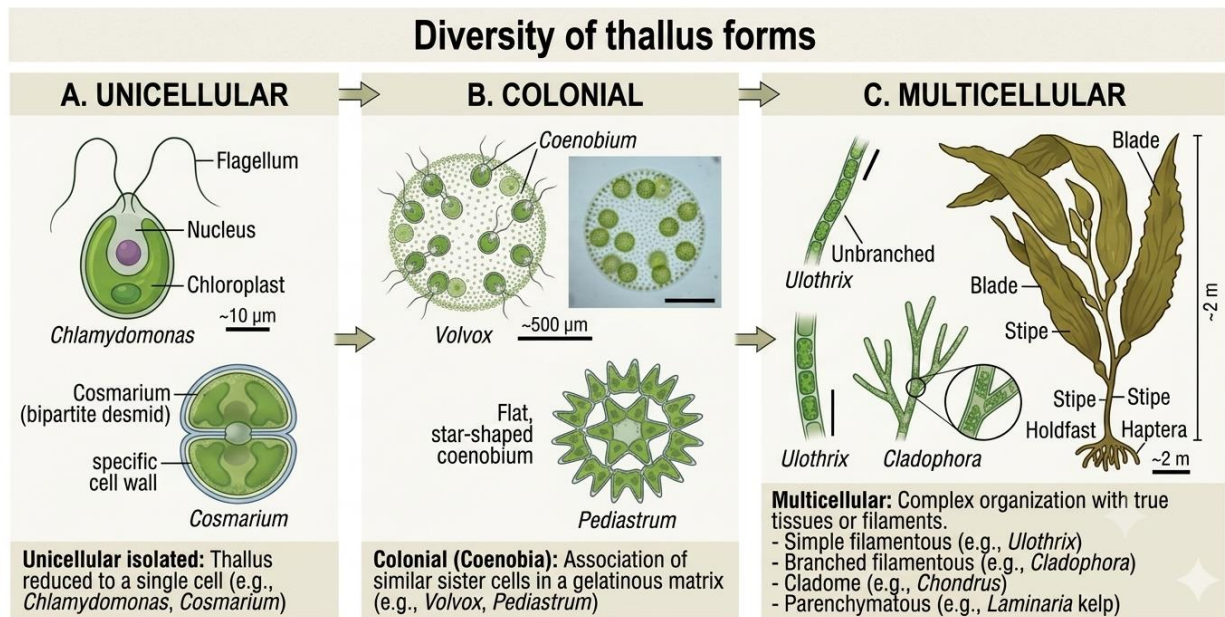


Figure 2: Representation of the morphological diversity of thalli in algae (unicellular, colonial and multicellular).

3. Prokaryotic Algae: Cyanobacteria (Cyanophyta)

Cyanobacteria, often called "blue-green algae" are the oldest known photosynthetic organisms (dating back approximately 3.5 billion years). Although studied in botany, they are prokaryotes.

3.1. Cytological Characteristics

Their cellular structure is simplified but extremely efficient:

- **Absence of a nucleus:** The genetic material (circular DNA) is directly bathed in the cytoplasm (nucleoid).
- **Photosynthetic system:** They do not possess chloroplasts. Photosynthesis takes place in folds of the plasma membrane called thylakoids.
- **Pigments:** In addition to chlorophyll a, they possess characteristic accessory pigments: phycocyanin (blue) and phycoerythrin (red), grouped in complexes called phycobilisomes.
- **Cell wall:** Gram-negative type, composed of peptidoglycan.

3.2. Cell Forms and Differentiation

Cyanobacteria can be unicellular or filamentous. In some filamentous species (e.g., *Anabaena*), specialized cells are observed:

1. **Heterocyst:** Thick-walled cells dedicated to the fixation of atmospheric nitrogen (N_2).
2. **The Akinetes:** Resistance cells (spores) that allow survival under adverse conditions.

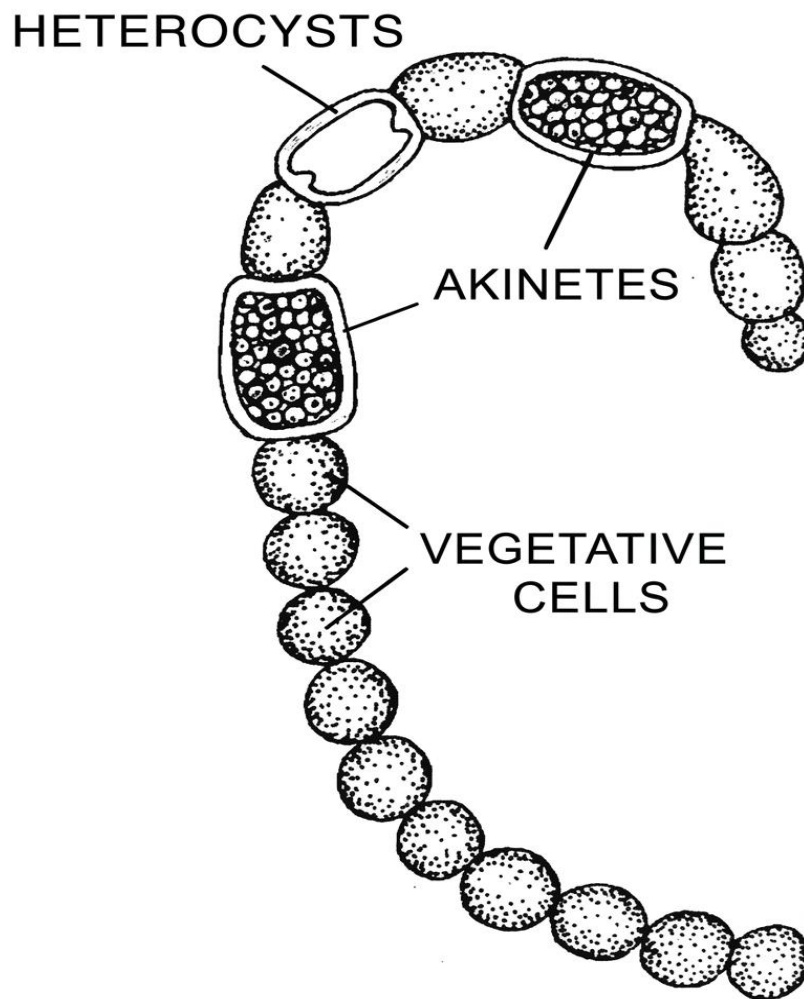


Figure 3: Cellular organization of a filamentous cyanobacterium showing heterocysts and thylakoids.

3.3. Reproduction and Multiplication

In cyanobacteria, reproduction is exclusively asexual. It occurs in two main ways:

- **Binary Fission (Scissipation):** This is the most common mode of reproduction in unicellular forms. The mother cell divides into two genetically identical daughter cells after DNA replication.
- **Fragmentation:** In filamentous forms, the trichome (string of cells) breaks into segments called hormogonia, which move apart to form new filaments.

4. Eukaryotic Algae

Unlike cyanobacteria, eukaryotic algae possess a complex cellular structure with a compartmentalized nucleus and specialized organelles.

4.1. Cytology and Cell Structure

1. **The Core:** Contains genetic information in the form of chromosomes, delimited by a double membrane (nuclear envelope).
2. **Chloroplasts:** As the sites of photosynthesis, they contain thylakoids grouped or not into grana. They possess their own DNA.
3. **The Wall:** Generally composed of cellulose, it can be impregnated with silica (Diatoms) or limestone (Corallinales).
4. **Vacuoles and Flagella:** They respectively ensure the maintenance of osmotic pressure and mobility.

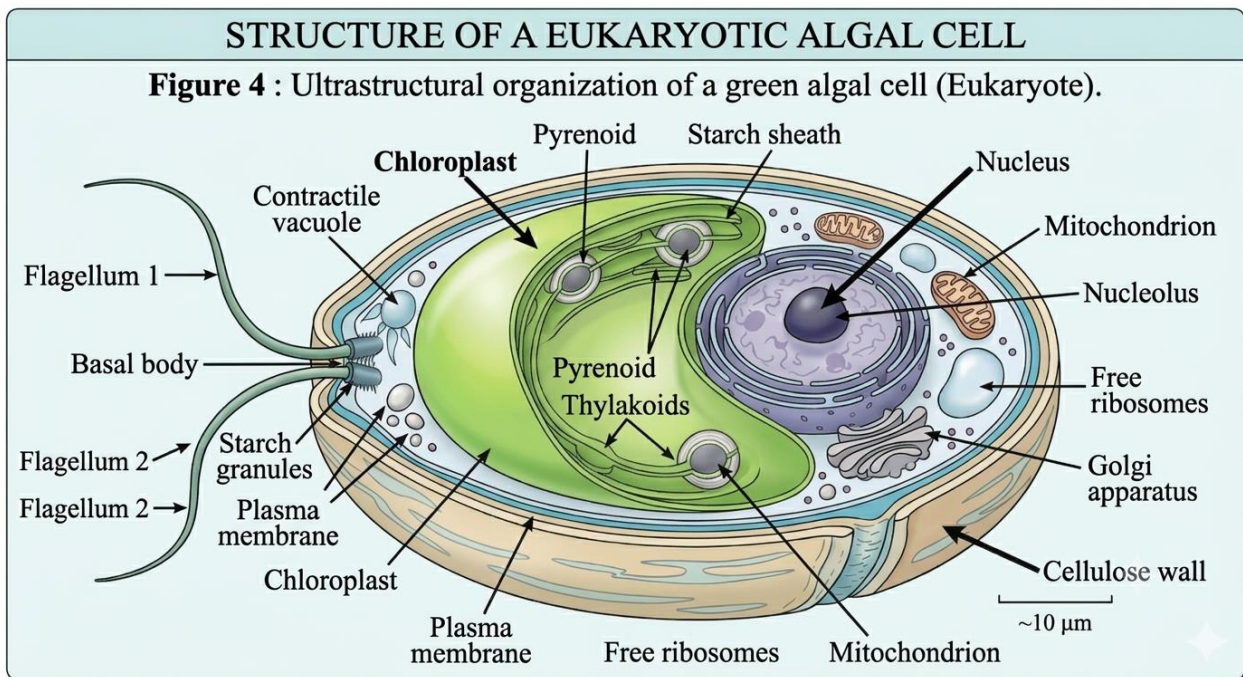


Figure 4: Ultrastructural organization of a green algal cell (Eukaryote).

5. Reproduction and Development Cycles

In eukaryotic algae, reproduction is highly diverse. It can be of two types:

5.1. Asexual reproduction (Vegetative propagation)

It allows for rapid colonization of the environment. It occurs through:

- **Bipartition:** Simple cell division (in unicellular organisms).
- **Thallus fragmentation:** A piece of thallus breaks off and gives rise to a whole individual.
- **Sporulation:** Production of spores (motile zoospores or immobile aplanospores) in sporocysts.

5.2. Sexual reproduction (Gambling)

It involves the union of two gametes to form a zygote. Several variations exist depending on the morphology of the gametes:

- **Isogamy:** Male and female gametes are identical.
- **Anisogamy:** Different gametes (often the female is larger).
- **Oogamy:** Large and immobile female gamete (oosphere), small and mobile male gamete (antherozoid).

Figure 1 : Comparative diagrams of isogamy, anisogamy, and oogamy.

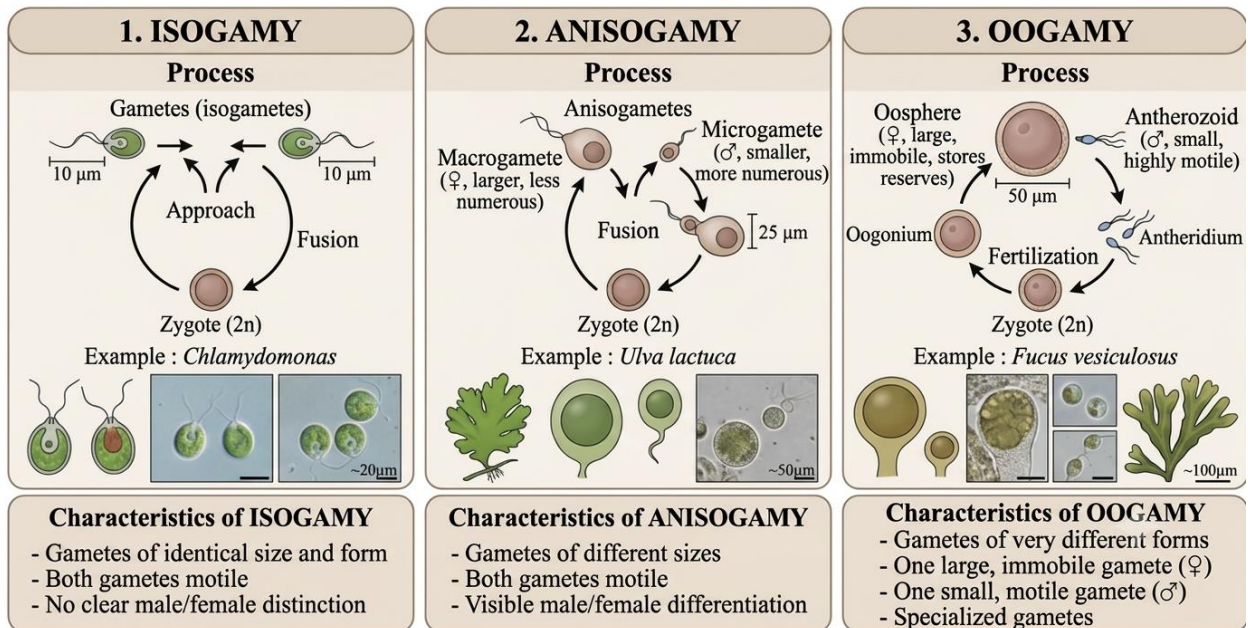


Figure 5: Comparative diagrams of isogamy, anisogamy and oogamy.

5.3. Development cycles (Alternating phases)

A developmental cycle (or biological cycle) is the period during which events occur from the formation of a zygote to the production of new gametes by the mature individual.

It is marked by two key events:

1. **Karyogamy (fertilization):** Transition from the haploid state (n) to the diploid state (2n).
2. **Meiosis:** Transition from the diploid state (2n) to the haploid state (n).

Depending on the position of meiosis in the cycle, three main types are distinguished in algae:

A. The Monogenetic Cycle (One generation only)

The cycle consists of only one generation of individuals.

1. **Haploid:** Meiosis immediately follows fertilization (e.g., *Chlamydomonas*).
2. **Diploid:** Meiosis takes place during the formation of gametes (e.g., *Fucus*).

B. The Digenetic Cycle (Two generations)

There is an alternation between two morphologically identical or different individuals:

1. **The Gametophyte (n):** Produces gametes.
2. **The Sporophyte (2n):** Produces spores.

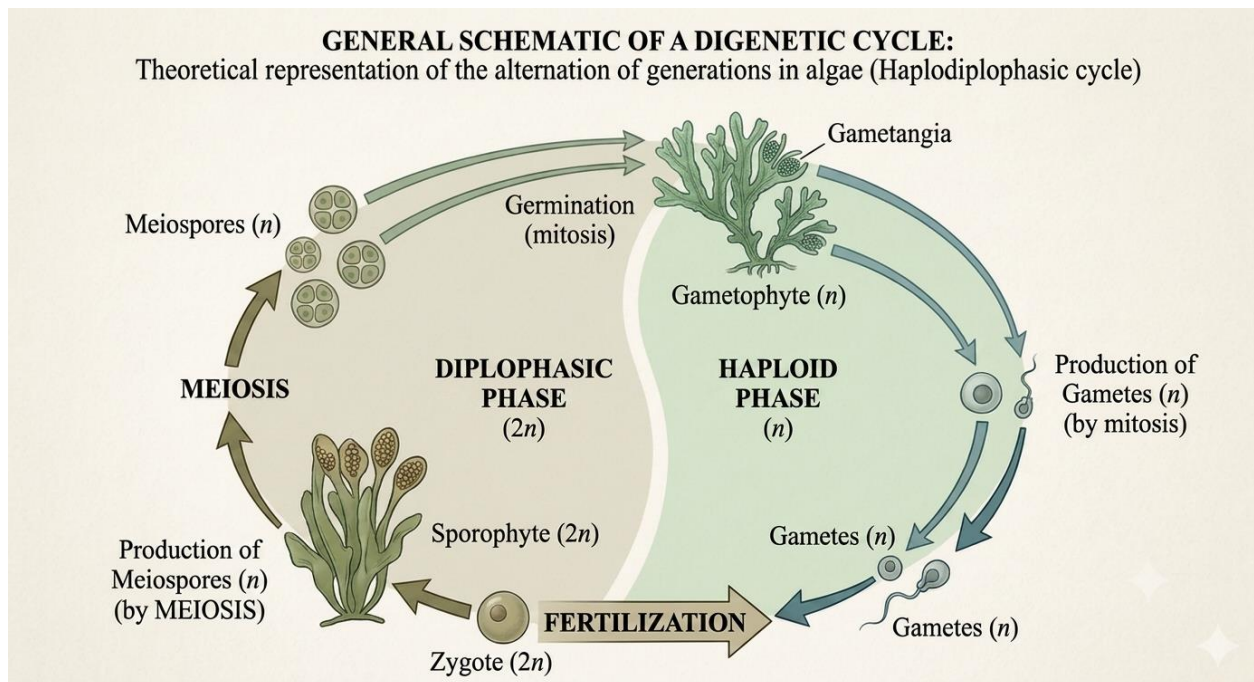


Figure 6: Theoretical representation of the alternation of generations in algae (Haplodiplophasic cycle).

6. Diversity and classification of algal lineages

Modern classification of algae is based on the nature of their pigments, the structure of their chloroplasts, the composition of their cell wall, and the nature of their carbohydrate reserves. Several major evolutionary lineages are distinguished:

6.1. Glaucophytes (Glaucophyta)

These are small, single-celled freshwater algae. They are of major evolutionary interest because their chloroplasts, called cyanelles, still possess a residual peptidoglycan wall, testifying to the endosymbiotic origin of the organelle from a cyanobacterium.

6.2. Red Algae (Rhodophyta)

Primarily marine and multicellular, they are characterized by:

- **Pigments:** Chlorophyll a and d, as well as phycobiliproteins (phycoerythrin) which give them their red color.
- **Absence of flagella:** At no stage of their development cycle.
- **Reservations:** Floridaxanthin (cytoplasmic).
- **Usage:** Source of agar (Agar-agar) and carrageenans (food processing industries).

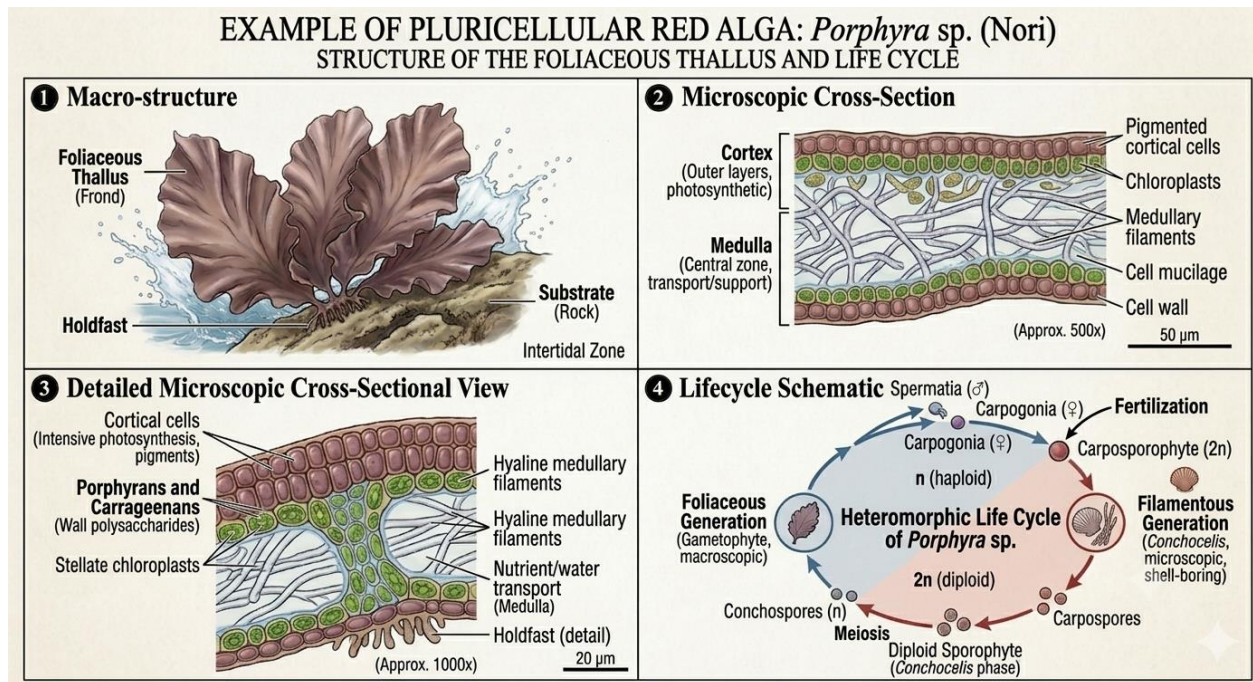


Figure 7 : Example of a multicellular red alga: *Porphyra* sp. (Nori) showing the structure of the leafy thallus

6.3. The Green Lineage (Chlorobionta)

This lineage includes organisms sharing the presence of chlorophylls a and b, and the storage of starch within the chloroplast. It is divided into two main groups:

1. **Chlorophytes (Chlorophyta):** They are very diverse and occupy all environments (marine, freshwater, terrestrial). Example: *Ulva lactuca* (Sea Lettuce), whose leafy thallus resembles a lettuce leaf.
2. **Streptophytes:** These include certain freshwater green algae (Charophytes) and all terrestrial plants (Embryophytes).

6.4. Brown Algae (Ochrophyta / Phaeophyceae)

Brown algae are almost exclusively marine. They are distinguished by:

- **Pigmentations:** Fucoxanthin (brown pigment) which masks chlorophylls.
- **Morphology:** Thalases are often very complex, differentiated into crampons (anchoring), stipe (support) and frond (photosynthesis).
- **Economic role:** Source of alginates for the cosmetic and pharmaceutical industries.

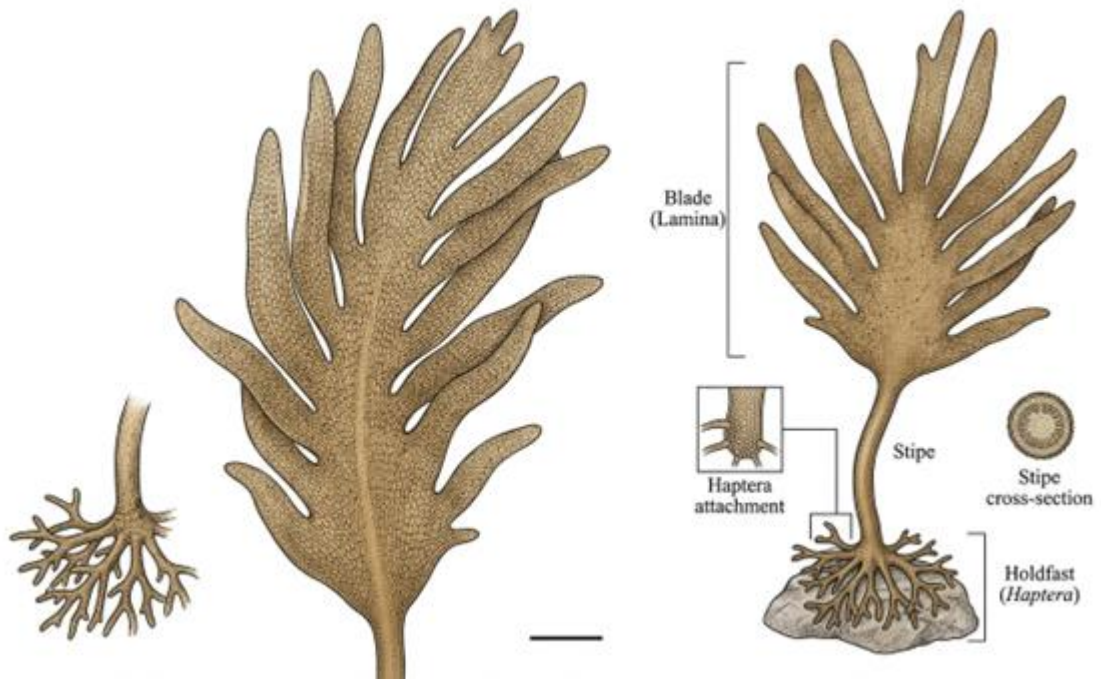


Figure 8 : Morphological organization of the thallus in a multicellular brown alga (*Laminaria digitata*).

CHAPTER III: FUNGI AND LICHENS

1. Introduction to Mycology

Fungi are no longer considered plants. They belong to the kingdom Fungi (or Mycetes). They are heterotrophic eukaryotic organisms for carbon, which means they must absorb pre-existing organic matter (saprophytism, parasitism or symbiosis).

1.1. Problems posed by classification

The classification of fungi has long been debated. Unlike plants, their cell walls are composed of chitin (not cellulose), and their carbohydrate reserves are stored as glycogen (as in animals). Today, we distinguish between:

The "True Fungi" (Eumycota): Opisthokonts related to the animal lineage.

"Pseudo-fungi" (e.g., Oomycota): Related to the lineage of brown algae (Stramenopiles).

1.2. Structure of thalli

The vegetative part of fungi is a thallus called mycelium, composed of microscopic filaments: hyphae. We distinguish:

1. **Diffuse Mycelium:** A collection of hyphae exploring the substrate.
2. **The Stroma:** A compact cluster of hyphae protecting the reproductive organs.
3. **The Sclerotium:** A condensed form of resistance that allows one to survive the winter.

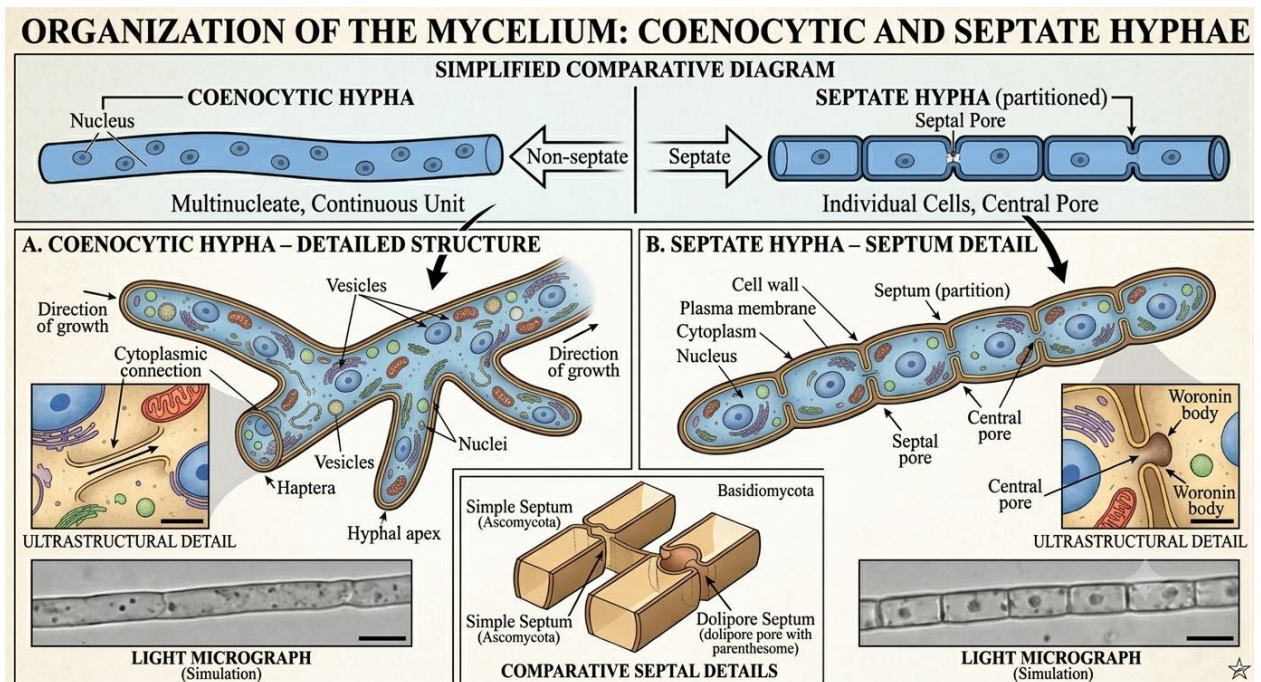


Figure 9: Organization of a mycelium showing siphonate (non-septate) hyphae and septate (septate) hyphae.

2. Reproduction and Multiplication of Fungi

Reproduction in fungi is complex and often characterized by alternating phases. It can be broken down into two major modes:

2.1. Vegetative (Asexual) Reproduction

This is the predominant mode during the active growth phase. It ensures the rapid dispersal of the species via:

- **Mycelium fragmentation:** Each segment can give rise to a new individual.
- **Budding:** Typical of yeasts (*Saccharomyces*).
- **The production of asexual spores:** Conidia (produced outside) and sporangiospores (produced inside sporocysts) are distinguished.

2.2. Sexual Reproduction (Plasmogamy and Karyogamy)

It generally occurs under adverse conditions and unfolds in three fundamental chronological stages:

1. **Plasmogamy:** Fusion of the cytoplasm of two compatible cells. It often results in a unique state: the dikaryon ($n+n$), where the two nuclei coexist without fusing.
2. **Karyogamy:** Fusion of the two nuclei to form a diploid zygote ($2n$).
3. **Meiosis:** Reductional division which restores haploidy (n) and allows the production of sexual spores (Ascospores or Basidiospores).

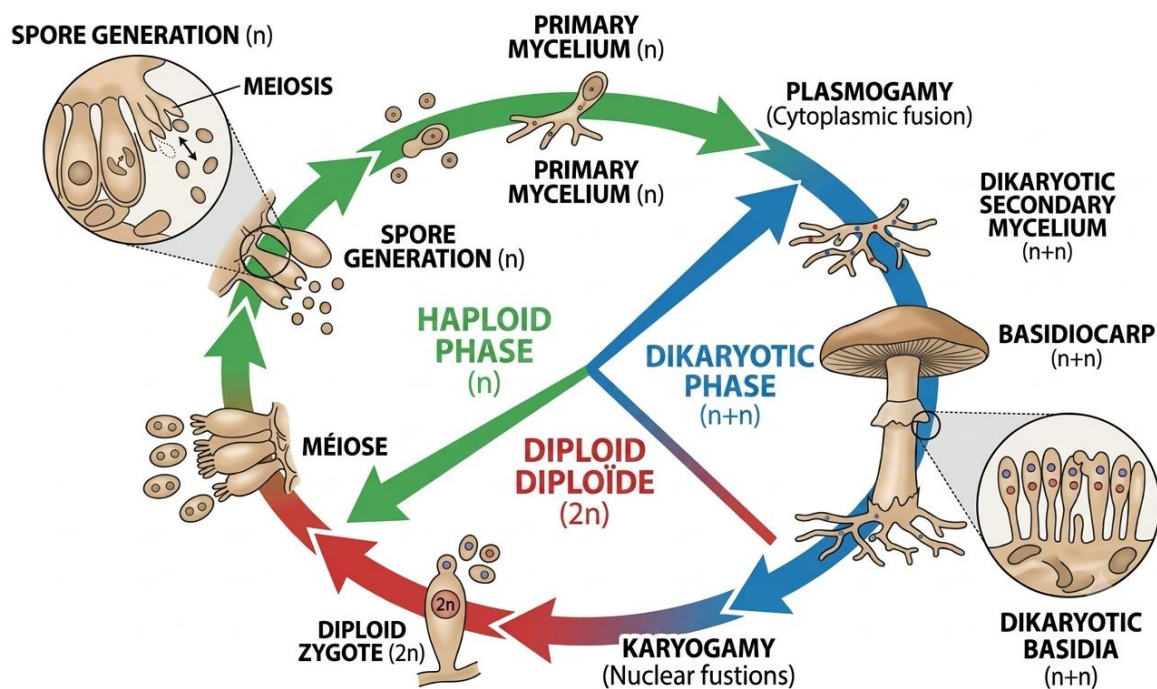


Figure 10 : Typical life cycle of a higher fungus showing the alternation between haploid, dikaryotic and diploid phases.

3. Systematics and characteristics of the main groups

The Fungi kingdom is subdivided into several branches based on the mode of sexual reproduction:

1. **Chytridiomycota:** Primitive fungi, often aquatic, possessing flagellated spores (zoospores).

2. **Zygomycota:** Characterized by the formation of a thick-walled zygospore (e.g., *Rhizopus nigricans*, black bread mold).
3. **Ascomycota:** The largest group. Sexual spores (ascospores) are produced inside sacs called asci. Examples: Morels, Yeasts, *Penicillium*.
4. **Basidiomycota:** Includes cap-shaped fungi. The spores (basidiospores) are borne on structures called basidia.

4. Lichens: The symbiotic association between algae and fungi

Lichen is not a single organism, but a stable symbiotic association between two partners of different natures:

1. **The Photobiont (Photosynthetic Partner):** A green alga (80% of cases) or a cyanobacterium. It provides organic matter (sugars) via photosynthesis.
2. **The Mycobiont (Fungal Partner):** Generally, an Ascomycete (95% of cases). It provides support, protection against desiccation, as well as the absorption of water and mineral salts.

4.1. Morphology and types of thalli

The morphology of the lichen is determined by the fungus. Four main types are distinguished according to their visual appearance:

- **Thallus Crustaceans:** They form a crust that is inseparable from the substrate (rocks, bark).
- **Thallus Foliaceae:** Shaped like leaves, attached by rhizines.
- **Thalles Fruticuleux:** In the form of small upright or hanging bushes (ex: *Usnea*).
- **Thales Complexes:** They have a crustacean base and an upright part.

4.2. Anatomical organization

If we make a cross-section of a foliose lichen, we observe a stratified structure (heteromerous thallus):

1. **Superior cortex:** Compact hyphae for protection.
2. **Algal layer:** Area where the algal cells are surrounded by hyphae.
3. **Medulla:** Central aerated zone composed of loose hyphae (water storage).
4. **Lower cortex:** Equipped with rhizines for anchoring.

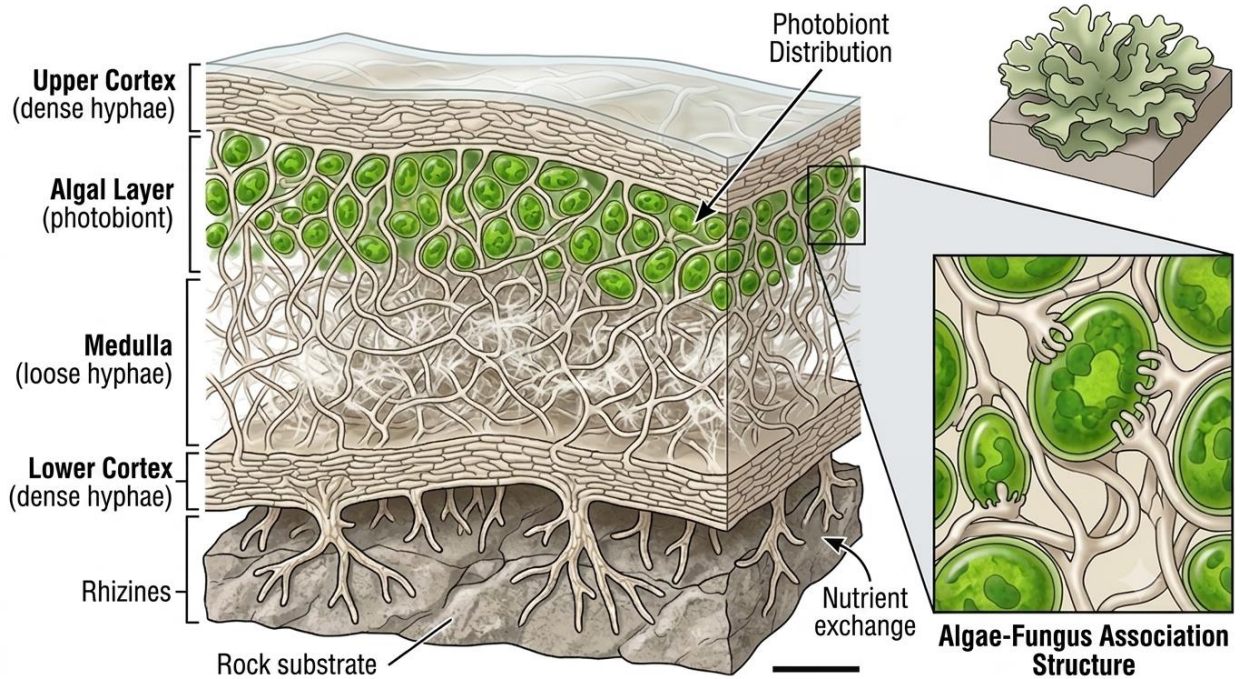


Figure 11 : Internal structure of a lichen thallus showing the distribution of algal cells within the fungal hyphal network.

4.3. Modes of reproduction

Lichen reproduction must ensure the continued existence of the association between the two partners. It occurs primarily through asexual (vegetative) means:

- **Fragmentation:** A single piece of dried thallus becomes brittle, detaches, and can regenerate into a new, complete thallus if it falls on a favorable substrate.
- **The Soredies:** Small clusters of algal cells surrounded by fungal hyphae, escaping through tears in the cortex (soralia).
- **The Isidies:** Outgrowths of the thallus, cylindrical or coralloid in shape, which break off to ensure dispersal.

4.4. Ecological Importance and Bio-indication

Lichens are pioneer organisms capable of colonizing hostile environments (bare rock). They play a major role as bio-indicators of air quality. Lacking a cuticle, they directly absorb atmospheric pollutants (sulfur dioxide, heavy metals). Their disappearance or a change in color in a given area is a warning sign of the pollution level.

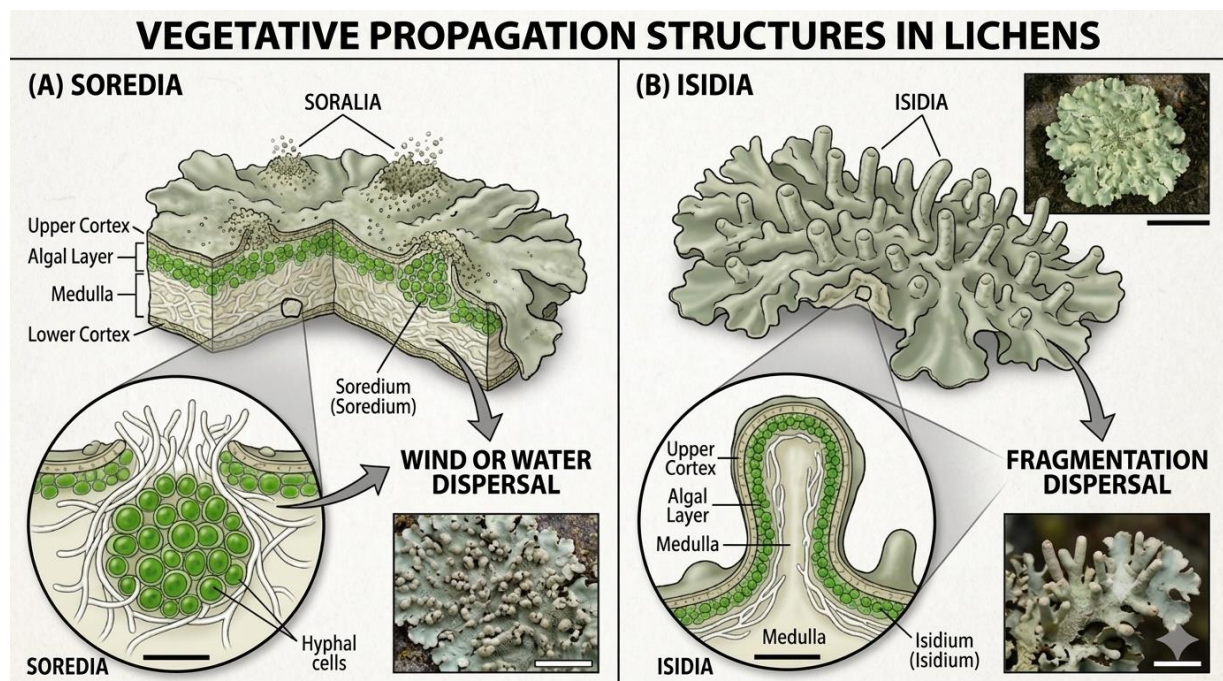


Figure 12 : Details of vegetative dispersal structures in lichens: (A) Soredia and (B) Isidia.

PART TWO:

THE EMBRYOPHYTES
(BRYOPHYTES, PTERIDOPHYTES
AND SPERMATOPHYTES)

CHAPTER IV : BRYOPHYTES

1. Introduction to Embryophytes

The transition from aquatic to terrestrial life required major adaptations. Embryophytes are distinguished from algae by:

- The presence of a cuticle (waxy layer) limiting desiccation.
- The protection of the embryo within maternal tissues.
- The development of support structures.

2. Bryophytes (Mosses in the broad sense)

Bryophytes are small terrestrial plants, still very much dependent on humidity because they lack true lignified vascular tissue. They are divided into three branches:

1. **Marchantiophytes (Livers):** Flattened thallus or foliated axis, often pressed against the ground.
2. **Anthocerotophytes:** They possess a sporophyte shaped like a small horn.
3. **Bryophytes s.str. (Mosses):** Upright axes equipped with "leaves" (phylloids) arranged in a helix.

2.1. Morphology and Organization

The vegetative structure of bryophytes is either a thallus (thalloid liverworts) or a leafy stem (mosses). In the absence of true roots, anchorage is provided by rhizoids. Water absorption occurs across the entire surface of the plant, which explains their small size and their sensitivity to pollution.

2.2. Reproductive cycle: The alternation of generations

The cycle is haplo-diplophasic with a marked dominance of the gametophyte (n).

2.2.1. The Gametophyte (n): This is the visible green plant. It bears the reproductive organs: the antheridia (males, producing flagellated antherozoids) and the archegonia (females, containing the oosphere).

2.2.2. Fertilization: It is necessarily aquatic. The antherozoids swim in a film of water to reach the archegonium.

2.2.3. The Sporophyte ($2n$): Originating from the zygote, it lives as a parasite on the gametophyte. It is composed of a foot (seed) and a capsule (urn) where meiosis takes place to release the spores.

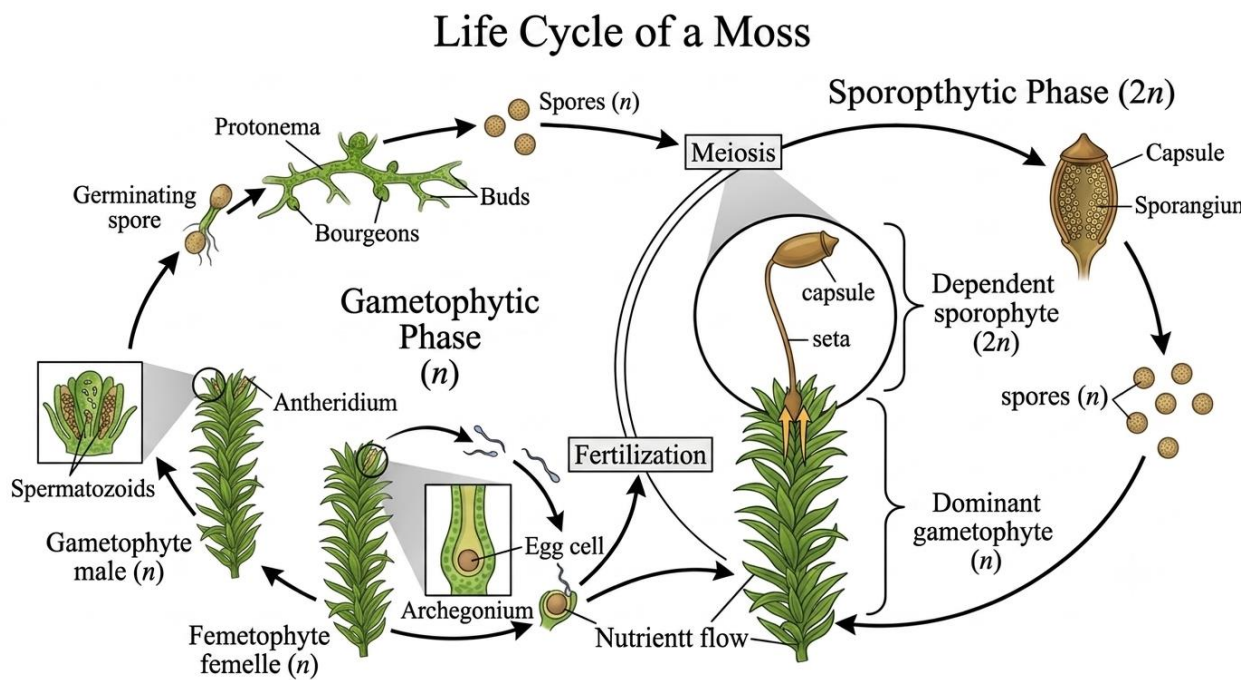


Figure 13 : Biological cycle of a moss showing the dependence of the sporophyte ($2n$) on the gametophyte (n).

CHAPTER V : PTERIDOPHYTES

1. Pteridophytes: The first vascular plants

Pteridophytes marked a major turning point in the evolution of the plant kingdom with the appearance of lignin. This biological innovation enabled the transition from a creeping flora (Bryophytes) to an upright flora, capable of partially freeing itself from the immediate proximity of water.

1.1. Anatomical organization and innovations

Unlike mosses, the sporophyte of Pteridophytes is a true corm and constitutes the dominant and perennial phase. It exhibits three major innovations:

1. **The Vascular System:** Presence of tracheids (xylem) for the conduction of raw sap and sieve tubes (phloem) for elaborated sap.
2. **Lignification:** Provides the mechanical rigidity necessary for upright porting.
3. **Organ specialization:** Clear differentiation between roots, stems (often underground rhizomes) and complex leaves called fronds.

1.2. Reproductive Biology

Although vascular, Pteridophytes remain Cryptogams (hidden reproduction).

- **Sporangia:** Located generally on the underside of the fronds, they are grouped in clusters called sori.
- **Fertilization:** It remains a zoidogamy, requiring water for the antherozoids to reach the archegonium on the prothallus (gametophyte).

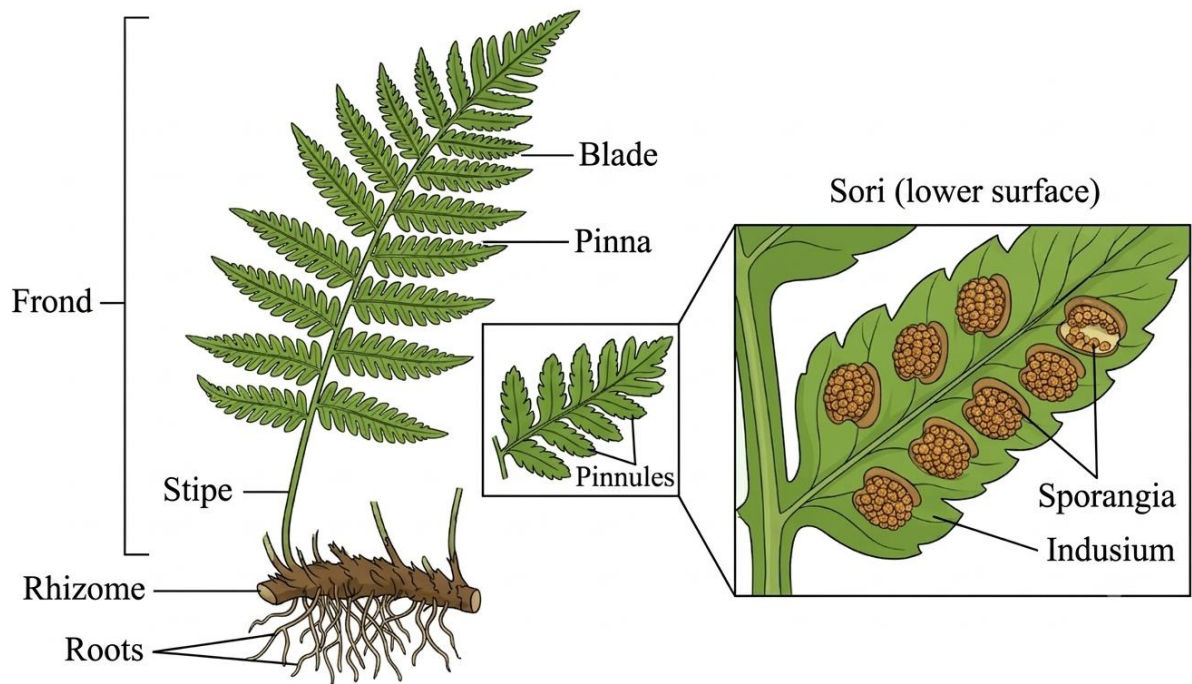


Figure 14 : General organization of a fern (*Dryopteris*) showing the rhizome, fronds and sori.

2. Classification and Diversity of Pteridophytes

The classification of Pteridophytes has been profoundly revised by data from molecular phylogeny. Three major lineages are traditionally distinguished:

2.1. Lycophytes (Lycophyta)

These are the oldest living vascular plants. They are characterized by small leaves called microphylls, each with only a single unbranched vein. The sporangia are borne in the leaf axils, often grouped in terminal spikes called strobiles.

2.2. Sphenophytes (Equisetinae)

Represented today by a single genus, *Equisetum* (horsetail), these plants have grooved and jointed stems, rich in silica. The leaves are reduced to scales arranged in whorls at the nodes.

2.3. Filicophytes (True Ferns)

This is the most diverse group. Their leaves are megaphylls (or fronds) with complex and branched venation. The prefoliation is described as circinate: the young fronds develop by curling around themselves (in the shape of a shepherd's crook).

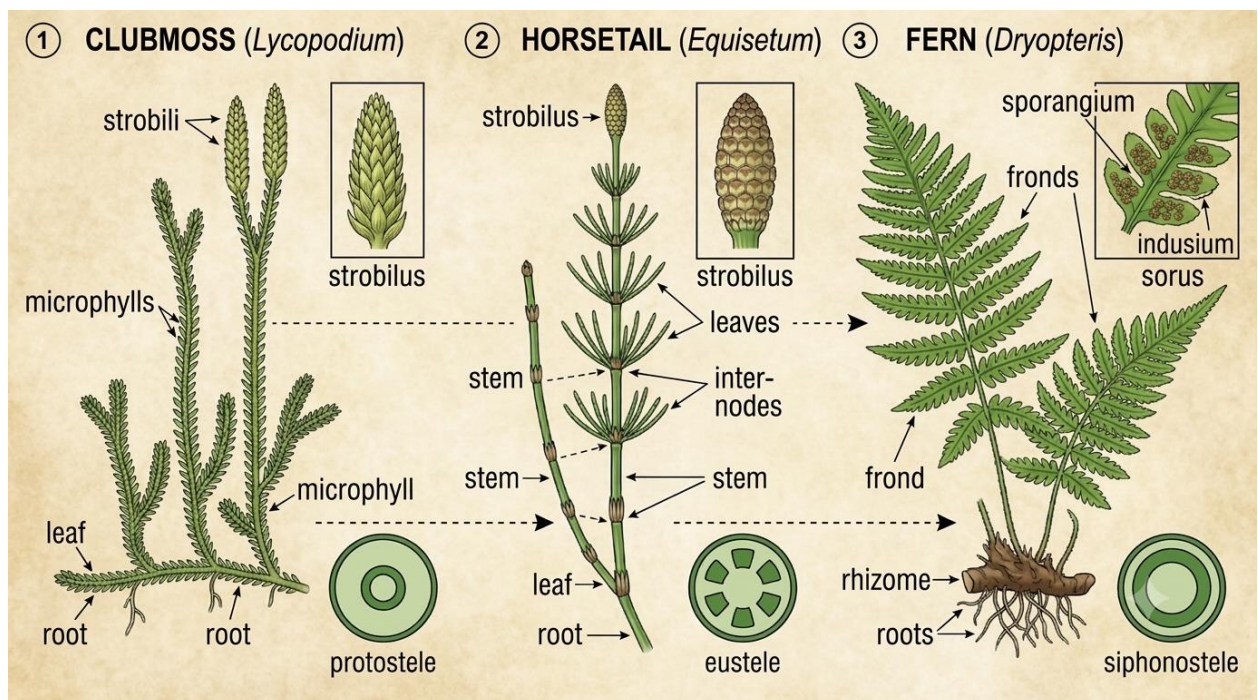


Figure 15 : Morphological comparison between a Clubmoss, a Horsetail (*Equisetum*) and a Fern (*Dryopteris*).

3. Life cycle: The example of the fern (*Dryopteris*)

The life cycle of Pteridophytes is haplo-diplophasic, marked by an absolute dominance of the sporophyte (2n).

1. **Diplophasic Phase (The Sporophyte):** At maturity, the sporangia located beneath the fronds produce haploid spores (n) by meiosis. These spores are released by a dehydration mechanism of the sporangium's mechanical ring.
2. **Haplophasic Phase (The Gametophyte):** The spore germinates in the soil to produce the prothallus. This is a small, green, cordiform (heart-shaped), photosynthetic, and bisexual blade.
3. **Fertilization:** The antheridia release multiflagellate antherozoids that swim towards the archegonia. Fertilization results in a zygote that develops into a young sporophyte, which quickly becomes independent while the prothallus degenerates.

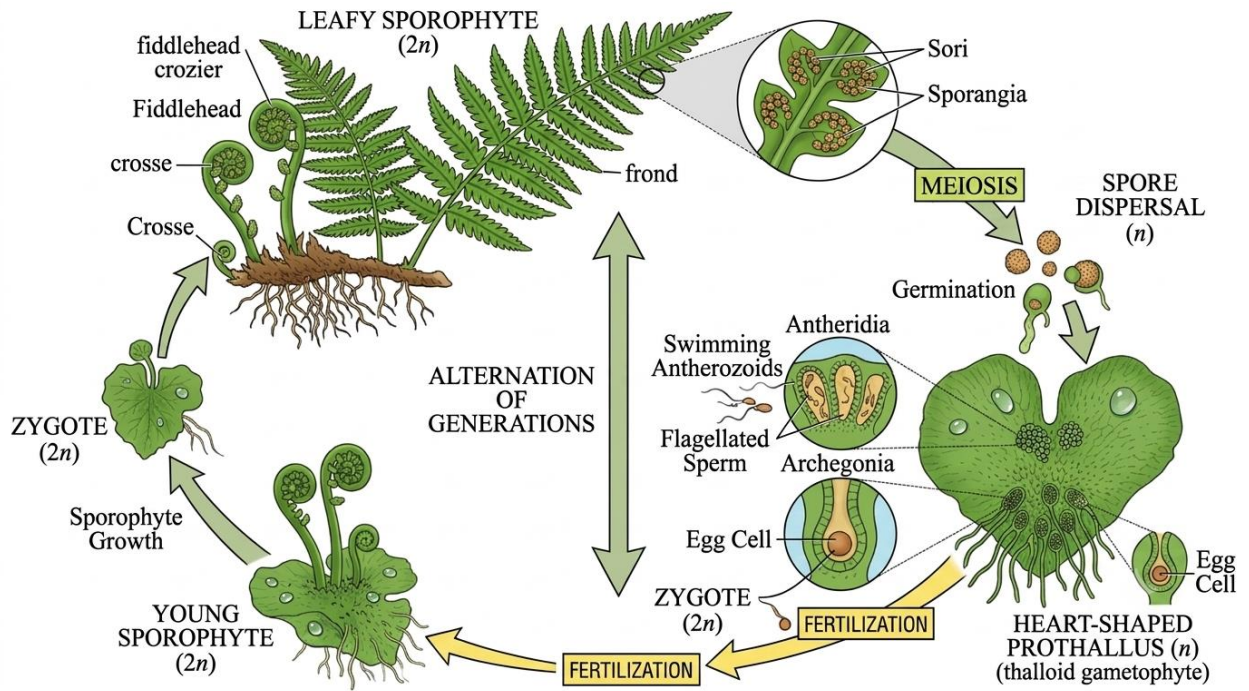


Figure 16 : Life cycle of *Dryopteris filix-mas* showing the alternation between the large leafy sporophyte and the small thalloid prothallus.

CHAPTER VI: SPERMATOPHYTES (SEED PLANTS)

1. Introduction and Evolutionary Innovations

Spermatophytes (from the Greek **sperma**, seed) represent the pinnacle of plant adaptation to terrestrial life. Their evolutionary success rests on two fundamental innovations that completely free them from the aquatic environment for reproduction:

1. **Pollen:** The male gametophyte is reduced to a pollen grain protected by a resistant cell wall (sporopollenin). Its dispersal by wind or animals replaces the need for liquid water for fertilization (Siphonogamy).
2. **The Ovum and the Seed:** The ovule is a complex structure protecting the female gametophyte. After fertilization, it transforms into a seed, a dispersal organ containing the embryo, nutrient reserves, and protected by integuments.

2. Gymnosperms: Plants with naked ovules

Gymnosperms (from the Greek **gymnos**, naked) are characterized by ovules borne on ovuliferous scales, without being enclosed in a closed ovary. Four main groups are distinguished:

- **Cycadophytes:** Palm tree appearance, reproduction by flagellated spermatozoa (concept of ovum).
- **Ginkgophytes:** Represented by a single current species, Ginkgo biloba.
- **Coniferophytes (Conifers):** The largest group (Pines, Firs, Cedars).
- **Gnetophytes:** A pivotal group exhibiting certain characteristics similar to Angiosperms.

3. Coniferophytes: The example of the Pine (Pinus)

The genus *Pinus* is the classic model for studying the biology of Gymnosperms. These are woody, perennial plants with acicular (needle-shaped) leaves adapted to reduce transpiration.

3.1. Reproductive system: The cones

Gymnosperms do not possess flowers in the strict sense (with a perianth), but unisexual cones (strobiles) borne by the same individual (monoecious species):

1. **Male cones:** Small in size, located at the base of the branches. They consist of scales bearing pollen sacs where pollen grains are produced, equipped with air sacs for transport by the wind (anemochory).
2. **Female cones:** Larger, located at the tips of the branches. Each scale bears two naked ovules.

3.2. From ovule to seed

Fertilization in pine trees is a slow process that takes place over two years. The pollen grain germinates to form a pollen tube (siphonogamy) which carries the male nuclei to the egg cell. After fertilization, the ovule develops into a winged seed, ensuring efficient dispersal by wind.

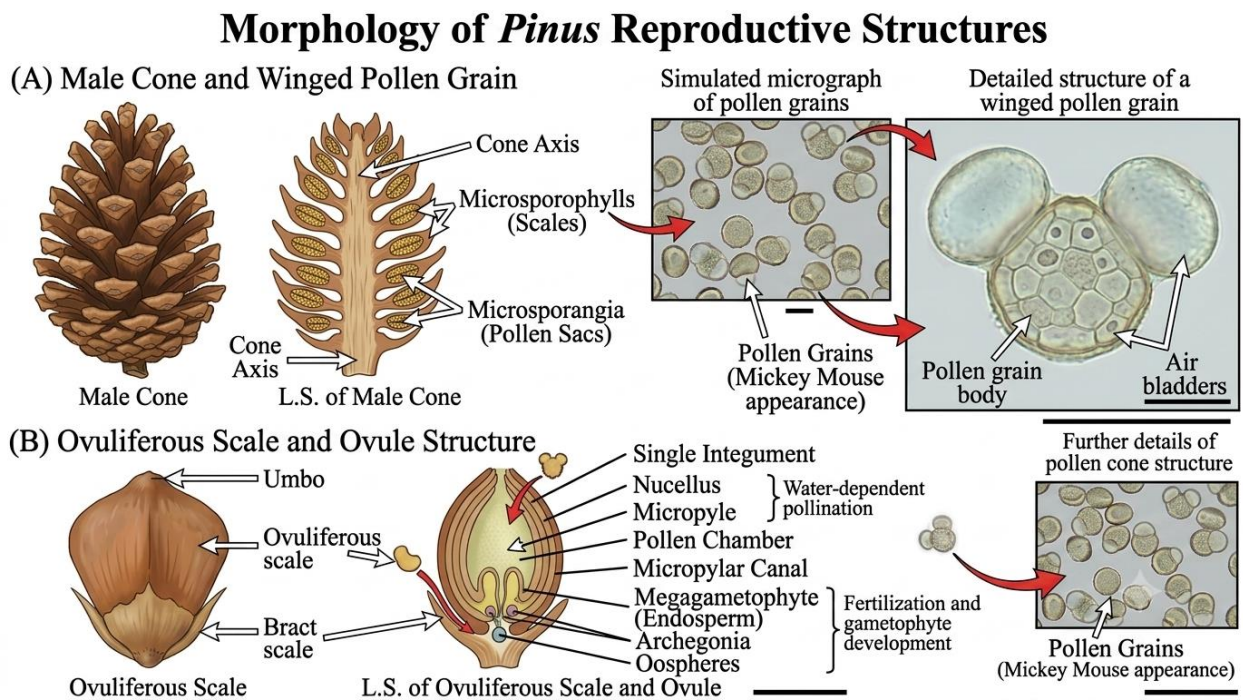


Figure 17 : Morphology of reproductive structures in *Pinus*: (A) Male cone and winged pollen grain, (B) Ovuliferous scale and ovule structure.

4. Angiosperms: Flowering and fruiting plants

Angiosperms (from the Greek **angeion**, vase) are characterized by the protection of their ovules within a closed structure: the ovary. They are the most diverse group, having colonized all terrestrial ecosystems through close co-evolution with pollinators.

4.1. The Vegetative System and Morphogenesis

The **cormus** of angiosperms exhibits maximum complexity. Growth is ensured by meristems (primary and secondary):

- **The Root:** Ensures anchoring and symbiosis (mycorrhizae).
- **The Stem:** Supporting and conducting organ (xylem with perfect vessels).
- **The Leaf:** The site of photosynthesis, exhibiting a great diversity of shapes and venation.

4.2. Floral Morphology: The organization of the flower

The flower is a branch with limited growth whose leaves are transformed into floral parts. A complete flower is organized into four whorls:

1. **The Chalice:** The entire set of sepals (protection).
2. **The Corolla:** The petals together (attraction).
3. **The Androcea:** Male reproductive organ formed by the stamens.
4. **The Gynoecium (Pistil):** Female reproductive system formed by the carpels.

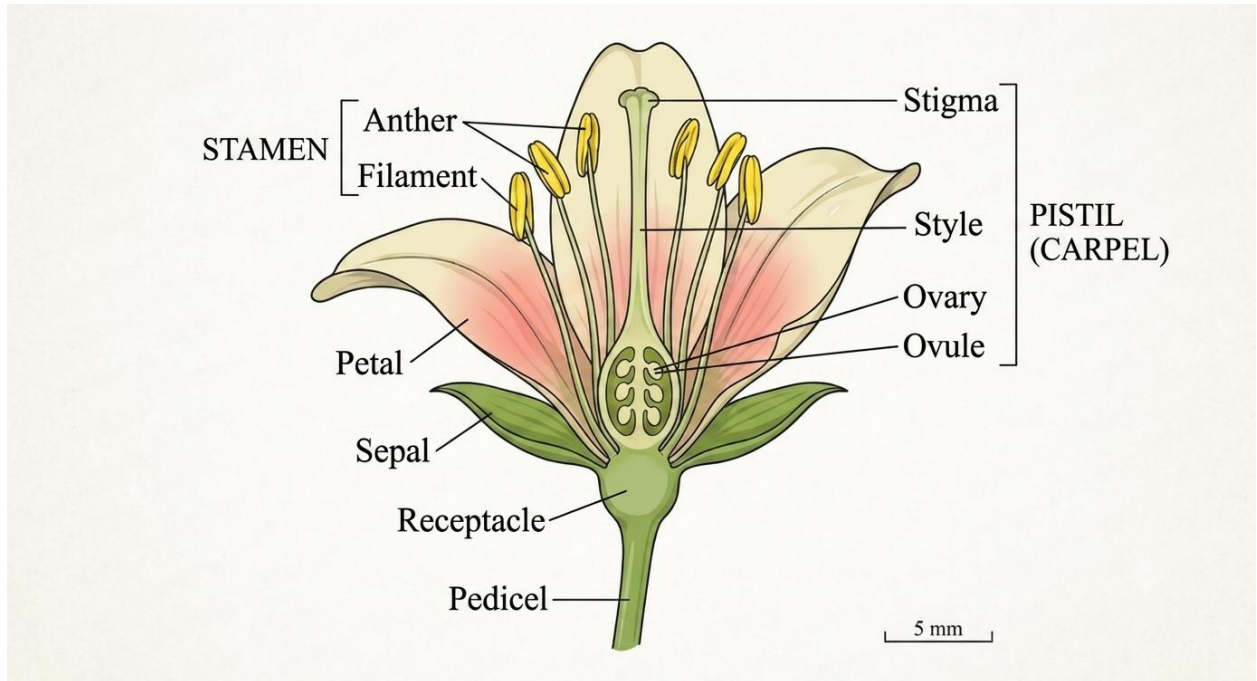


Figure 18 : Schematic organization of an Angiosperm flower in longitudinal section.

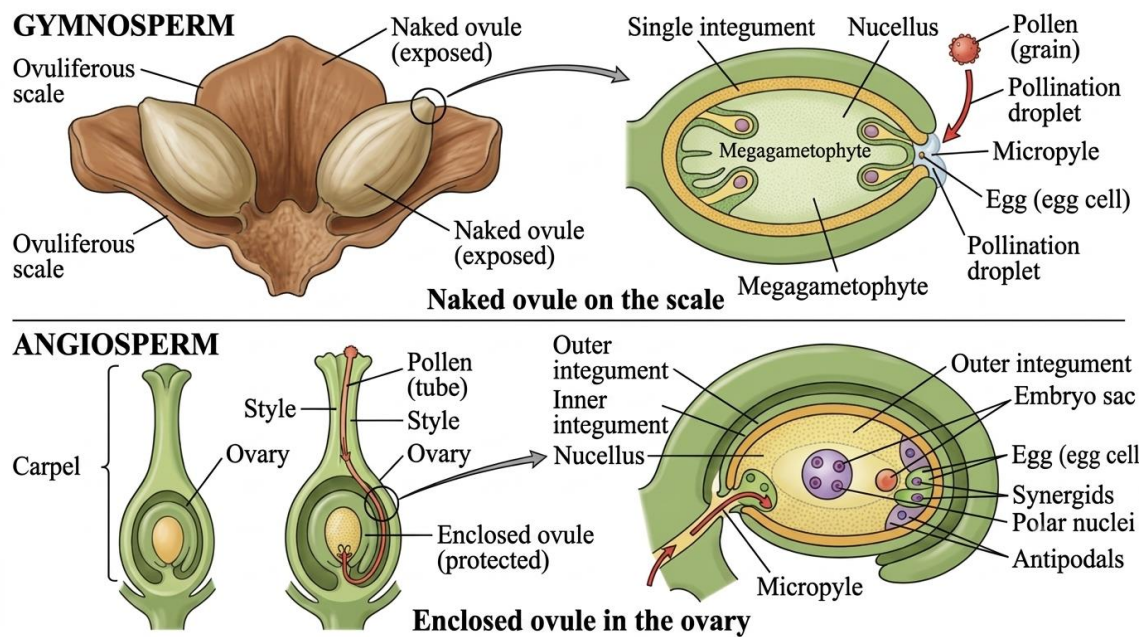


Figure 19 : Comparative diagram between a Gymnosperm ovule (naked on the scale) and an Angiosperm ovule enclosed in the ovary)

4.3. Floral Biology: Microsporogenesis and Double Fertilization

The reproduction of angiosperms is characterized by a mechanism unique in the living world: double fertilization. This process ensures that nutrient reserves only develop if the ovule is actually fertilized.

Pollination: The pollen grain (male gametophyte) is deposited on the stigma. It germinates by emitting a pollen tube that passes through the style to reach the ovule.

Double Fertilization: The pollen tube releases two antherozoids (sperm nuclei) into the embryo sac:

The first antherozoid fuses with the oosphere to give the main zygote ($2n$), which will become the embryo.

The second antherozoid fuses with the two polar nuclei to form the accessory zygote ($3n$), which will give rise to the albumen (triploid reserve tissue).

4.4. Seeds and Fruits

After fertilization, the ovule develops into a seed and the ovary (the wall of the carpel) metamorphoses into a fruit. The fruit protects the seeds and facilitates their dispersal (by wind, water, or animals).

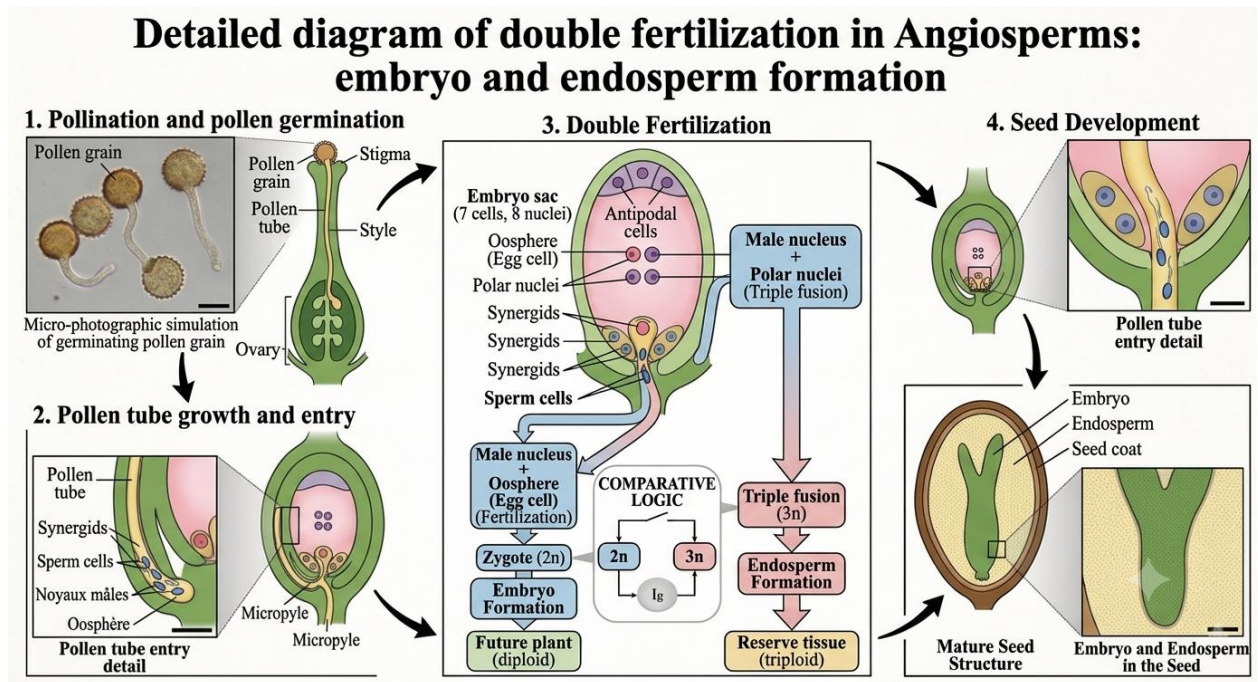


Figure 20 : Detailed diagram of double fertilization in Angiosperms: formation of the embryo and the albumen.

4.5. Concept of modern systematics and main taxa

The classification of plants has radically changed with the advent of molecular biology. Two major approaches can be distinguished in the history of botany:

- 1. The Classical Classification (e.g., Engler, 1924):** Based primarily on morphological criteria (number of petals, position of the ovary). Although useful for quick identification in the field, it does not always reflect the true relationships.
- 2. The Phylogenetic Classification (APG IV, 2016):** This is the current reference system. It classifies plants according to their DNA and evolutionary history. It has led to the suppression of some older groups (such as Dicotyledons in the strict sense) in favor of monophyletic groups.

4.5.1. Distinction between Monocotyledons and Eudicots

Despite the changes, a fundamental distinction remains for the student:

- **Monocotyledons:** A single cotyledon, parallel leaf venation, flowers often of type 3 (ex: Lilies, Grasses).
- **Eudicots:** Two cotyledons, reticulate venation, flowers often of type 4 or 5 (ex: Rose, Oak).

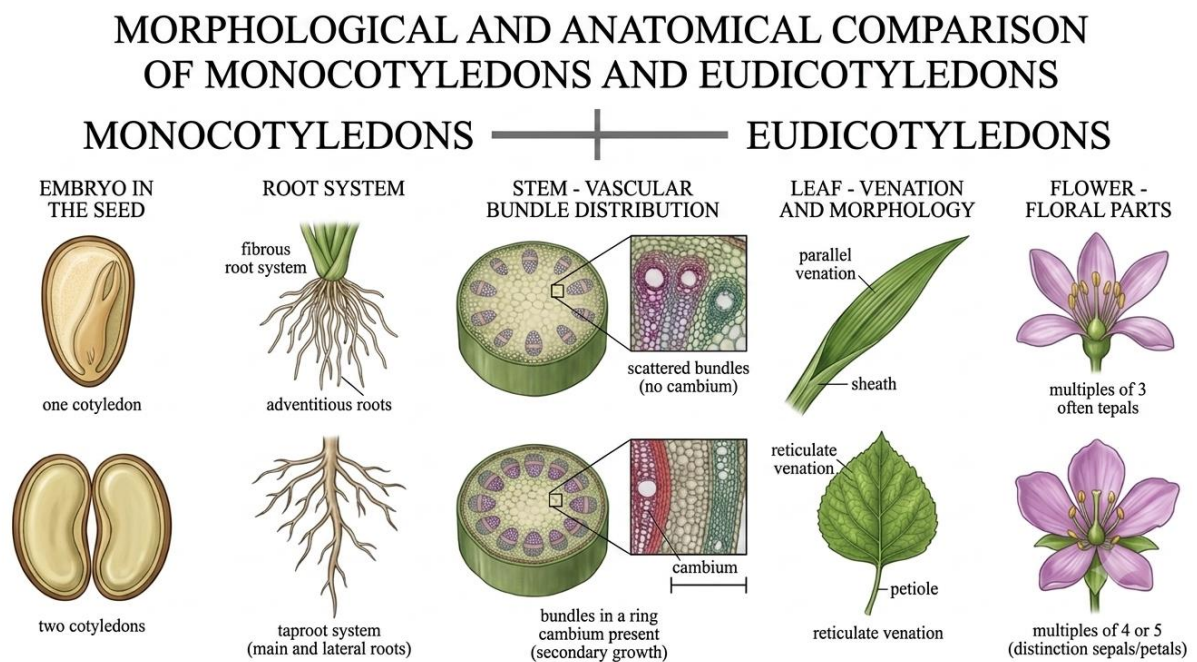


Figure 21 : *Morphological and anatomical differences between Monocotyledons and Eudicots.*

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GLOSSARY OF BOTANICAL TERMS

- Akinete:** Thick-walled resistance cell in certain cyanobacteria.
- Albumen:** Triploid (3n) reserve tissue of the Angiosperm seed, resulting from double fertilization.
- Angiosperm:** A plant whose ovules are enclosed in an ovary and whose seeds are in a fruit.
- Antheridium:** Male reproductive organ (gametangium) producing antherozoids.
- Archegone:** Female reproductive organ (gametangium) shaped like a flask containing the oosphere.
- Cormus:** Differentiated vegetative apparatus comprising roots, stems and leaves.
- Cyanobacteria:** Photosynthetic prokaryotic organism (blue-green algae).
- Dikaryon:** State of a fungal cell possessing two unfused haploid nuclei ($n+n$).
- Embryophyte:** A terrestrial plant protecting its embryo within maternal tissues.
- Gametophyte:** Haploid phase (n) of the developmental cycle producing gametes.
- Gymnosperm:** Seed plant whose ovules are naked (carried by a scale).
- Heterocyst:** Specialized cell of Cyanobacteria ensuring nitrogen (N_2) fixation.
- Hyphe:** Microscopic filament constituting the mycelium of fungi.
- Lignin:** Complex macromolecule ensuring the rigidity and impermeability of conducting vessels.
- Mycorrhiza:** Symbiosis between the roots of a plant and the mycelium of a fungus.
- Phylloid:** Structure having the appearance of a leaf but lacking true conductive tissues (in mosses).
- Siphonogamy:** Fertilization method via a pollen tube, eliminating the need for liquid water.
- Sporophyte:** Diploid phase ($2n$) of the development cycle producing spores by meiosis.

Thallus: Simple vegetative apparatus, without roots, stems, or true leaves.

Zoidogamy: Fertilization method requiring water for the movement of flagellated gametes.

BOTANICAL

Semester: 4th Semester

UE: Fundamental Teaching Unit 1

Material: Botany

Course Objectives: This course aims to introduce students to the classification and anatomical characterization of the major groups of the plant kingdom. The instruction also seeks to provide students with an understanding of reproductive processes. Recommended Prior Knowledge: Students should have knowledge of plant biology (morphology, anatomy, physiology).

Botanical

Content of the material

Introduction to botany - Definitions, concepts and classification criteria. Systematics of the major groups of the "plant" kingdom.

PART ONE:

ALGAE AND FUNGI

1. Algae

1.1. Prokaryotic algae (Cyanophytes / Cyanobacteria)

1.2. Eukaryotic Algae

1.2.1. Morphology

1.2.2. Cytology

1.2.3. Reproduction (concept of gamy, development cycle)

1.3. Systematics and characteristics of the main groups

1.3.1. The Glaucophyta

1.3.2. The Rhodophyta

1.3.3. Chlorophyta and Streptophyta

1.3.4. Haptophyta, Ochrophyta, Dinophyta, Euglenozoa, Cryptophyta, Cercozoa

2. Fungi and lichens

2.1. Problems posed by the classification of fungi

2.2. Structure of the thalli (mycelia, stroma, sclerotium)

2.3. Reproduction

2.4. Systematics and characteristics of the main groups of fungi

2.4.1. The Myxomycota

2.4.2. The Oomycota

2.4.3. Eumycota (Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, Basidiomycota)

2.5. A particular algal-fungus association: lichens

2.5.1. Morphology

2.5.2. Anatomy

2.5.3. Reproduction

PART TWO:

Embryophytes

1. Bryophytes: Morphology and reproduction of the different phyla

1.1. Marchantiophytes

1.2. Anthocerotophytes

1.3. Bryophytes s. str.

2. Pteridophytes: Morphology and reproduction of the different phyla

2.1. Lycophytes

2.2. Sphenophytes (= Equisetinae)

2.3. Filicophytes

3. Gymnosperms sensu lato

- 3.1. Cycadophytes: the concept of the ovule
- 3.2. Ginkgophytes
- 3.3. Coniferophytes: the concepts of flower, inflorescence, and seed
- 3.4. Gnetophytes: a pivotal group

4. Angiosperms

- 4.1. Vegetative apparatus and the concept of morphogenesis: growth of stems, leaves and roots
- 4.2. Floral morphology (flower structure, inflorescences)
- 4.3. Floral biology: microsporogenesis and macrosporogenesis
- 4.4. Seeds and fruits
- 4.5. Concept of modern systematics, cladogenesis and principal taxa. Présentation of classifications (Engler 1924, APG II)

PRACTICAL WORK (3 SESSIONS PER WEEK):

PW N° 1. Algae (Phycophytes) Morphology and reproduction of some species such as *Ulva lactuca* and *Cystoseira mediterranea*.

PW N° 2. Mushrooms (Fungi) Morphology and reproduction of *Rhizopus nigricans* (Zygomycetes), *Agaricus campestris* (Basidiomycetes)

PW N° 3. Lichens: Morphology of different types of lichens and study of *Xanthoria parietina*

PW N° 4. Bryophytes Morphology and reproduction of *Bryum sp.*

PW N° 5. Pteridophytes Morphology and reproduction of *Polypodium vulgare* and *Selaginella denticulata*

PW N° 6. Cycadophytes Morphology and reproduction of *Cycas revoluta*

PW N° 7. Coniferophytes (Gymnospermes sensu stricto) Morphology and reproduction of *Pinus halepensis* and *Cupressus sempervirens*

PW N° 8 and 9: Monocotyledonous and Eudicotyledonous Angiosperms. Illustration of the concept of trimerery and pentamery, of the concept of actinomorphy and zygomorphy; dialypetaly, gamopetaly, hypogynous flower, epigynous flower....

PW N° 8. Floral morphology of monocotyledonous angiosperms using examples such as *Asphodelus* (or *Allium*)

PW N° 9. Floral Morphology of Eudicots: Angiosperms (using examples such as *Lathyrus* and *Vicia*)

PW N° 10. Sexual Reproduction in Angiosperms: Pollen Grain, Pollination and Fertilization in Angiosperms; Types of Fruits and Types of Seeds.