الجمهورية الجزائرية الديموقراطية الشعبية

وزارة التعليم والبحث العلمي

Université Ferhat Abbas Sétif 1

جامعة فرحات عباس سطيف1

Faculty of Natural and Life Sciences

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Department of Plant Biology and Ecology

Course Handout

Course in taxonomy and systematics of higher plants
And their biotechnological applications

Intended for students:

***Bachelor's degree in Biotechnology and Plant Improvement**

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Summary

PREFACE

The course on Taxonomy and Systematics of Higher Plants is a fundamental subject of semester 6, more specifically of the academic degree program taught in the third year "Bachelor's degree in Biotechnology and Plant Improvement". This subject has a coefficient of 3 and a credit of 4, with a total teaching time (VHG) of 67.5 hours, 1.5 hours of lessons and 1.5 hours of practical work.

The teaching of this subject aims to provide theoretical and practical bases allowing the acquisition of knowledge and concepts for the description, nomenclature and classification of plant species, especially so-called "higher" plants (Phanerogams) and their representation in a single phylogenetically ordered hierarchical body.

This handout is useful for the career of a university student in the field of "natural and life sciences" particularly in the specialties of the plant field (biology, ecology and biodiversity …….). It will even be useful for students preparing a Master's degree specializing in Biodiversity and Environment as it can also be intended for 2nd year students of the Base of basic studies of biological and agronomic sciences and finally for all those who are interested in the scientific study of the plant kingdom especially in the part of Spermaphytes (Phanerogams) and its organization. To better understand this subject. It is necessary that the student must have prerequisites in plant biology (morphology, anatomy), ecology and genetics.

This course handout only covers the Phanerogams part (2nd part of the plant kingdom) according to the table of contents described by the framework of the Biotechnology and Plant Improvement specialty and since the Cryptogams part has already been taught in semester 5 under the title "Taxonomy and systematics of lower plants", it is articulated firstly in an introduction on systematics and taxonomy and their relationship with biotechnology and plant improvement followed by the major groups of higher plants starting with the Prespermaphytes considered as a group linking lower plants to higher plants. Then the description of Gymnosperms and Angiosperms while passing through the intermediate group "Chlamydosperms " by presenting the general characteristics, reproduction and systematics for each group studied in an evolutionary sense going from archaic forms to the most evolved.

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General introduction

The history of systematics and taxonomy of higher plants is marked by constant evolution, moving from a purely descriptive classification to an integrative approach based on evolution and molecular data. This evolution continues to shape our understanding of plant diversity and its relationships. Systematics and taxonomy of higher plants involve the identification, classification, and nomenclature of plants. The former focuses on the evolutionary relationships between species, often using morphological and molecular data, while the latter is the art of classifying these species into hierarchical categories, such as phylum, class, order, family, genus, and species. The ultimate goal is to create a system that reflects the diversity and relationships among plants, thus allowing a better understanding of their ecology and evolution.

Finally, the general objective of this manuscript is to have an idea about taxonomy (description of diagnostic and differential characters) and systematics (enumeration and classification of taxa in a certain order), plant morphology (describing the organs or parts of plants) …etc. Also, the detailed knowledge of plants playing a crucial role in several fields such as pharmacology, in agriculture and forestry more especially in the field of biotechnology and plant improvement, which can be represented by some key points:

- Identification and Classification

Basis for improvement: A clear understanding of plant diversity allows researchers to select the species or varieties most suited to improvement.

Genetic Resources Assessment: Taxonomy helps identify and catalogue genetic resources, which are essential for conservation and use in biotechnology.

- Evolutionary Relationships

Phylogenetics: Modern systematics uses phylogenetic techniques to understand evolutionary relationships, which is essential for selecting parents in breeding programs.

Gene transfer: Understanding the relationships between species allows us to assess the possibilities of transferring genes between them to introduce desirable traits.

- Genetic Characterization

Molecular biotechnology: Taxonomic and systems knowledge helps target specific genes for genome editing or genetic transformation.

Molecular markers: The use of molecular markers for species classification allows the inheritance of traits to be tracked in breeding programs.

- Conservation and Sustainability

Resource management: Good classification helps in the conservation of endangered species and the sustainable management of plant resources.

Ecosystems: Understanding plant taxonomy contributes to ecosystem restoration, which is an important aspect for the sustainability of agricultural practices.

- Practical Applications

Marker-assisted selection (MAS): Systematics allows better targeting of traits of interest for selection, making breeding programs more effective.

Tissue culture and bioprocesses: Knowledge of species relationships helps to optimize culture conditions and transformation techniques.

In summary, plant systematics and taxonomy provide an essential framework for biotechnology and plant breeding, facilitating the identification of genetic resources and the application of modern techniques to develop more resistant and productive varieties.

I. Generalities on Systematics and Taxonomy

I.1. Definition of classification

Classification is the classification of living beings into more or less important groups, using well-chosen criteria. A criterion is a characteristic that living beings possess and which can be used to classify them. The disciplines involved in classification are: **systematics** and **taxonomy**

I.2. Definition of Systematic

Systematics seeks to establish a description of species and organize them in relation to each other within a classification by focusing on the evolutionary relationships between species.

I.3. Definition of Taxonomy

Taxonomy deals with the assignment of names (nomenclature) and the construction of hierarchical systems.

- **Taxonomic hierarchy**

Given the vast number of organisms, it is necessary to arrange and put in order the taxa (taxon) in a hierarchical system.

*** Units of systematics Hierarchy of species**

Several species can have a certain number of common characteristics (Exp: Genus); we can thus create a whole hierarchy whose main terms classified in order of increasing importance are (fig.1):

***Unit of systematics (classical Linnaean classification)**

- **Reign:**
- **Phylum (division or phylum):**

Sub-branch:

Super-class

- **Class:**

Subclass:

Infra-class

Super-order

- **Order:**

Sub-order

Infra-order

Super-family

- **Family:**

Subfamily:

Tribe

- **Gender:**

Subgenre

- **Species**

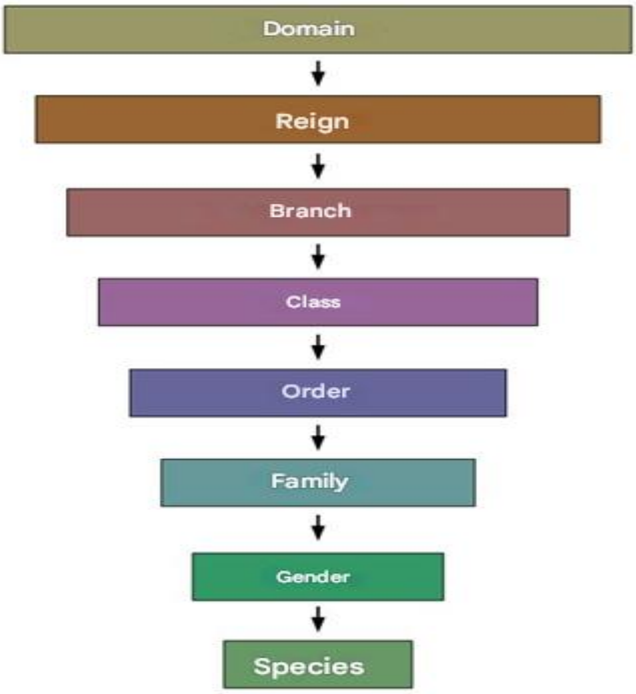


Fig.1: hierarchy of different systematic units.

A taxon: is a conceptual entity that is supposed to group together all living organisms possessing certain well-defined taxonomic characteristics in common).

The most used taxa are given below (example of durum wheat):

- **Reign:** Plantae
- **Branch**: *Liliophyta* (Phanerogams)
- **Subphylum:** Angiosperms
- **Class:** *Liliopsida*
- **Subclass:** *Commelinidea*
- **Order:** *Graminales* or *Poales*
- **Family:** *Poaceae (Gramineae)*
- **Tribe:** *Triticeae*
- **Genus:** *Triticum*
- **Species:** *durum L.*

The suffixes used to designate the groups governed by the botanical nomenclature code (De Riviers, 2002) are as follows (Table.1).

Table 1: The different types of suffixes depending on the type of plant.

Taxon rank	Algae	Mushrooms	Embryophytes
Branch	-phyta	-mycota	-phyta
Class	-phyceae	-mycetes	-opsida
Subclass	-phycidae	-mycetidae	-idae
Family	-aceae	-aceae	-aceae
Subfamily	-oideae	-oideae	-oideae
Tribe	-eae	-eae	-eae
Subtribe	-inae	-inae	-inae

I.4. Rules of botanical nomenclature

The naming of species is based on the International Code of Botanical Nomenclature. The last updated code was adopted by the 17th Botanical Congress in Vienna in 2005.

*The name of a plant is always a **Latinized binomial.**

*The **genus name** begins with a **capital letter** and is written in italics or is underlined, for example: *Ulva, Avena, Medicago, Lens* or Ulva, Avena

*The **name of the species** is written in **lowercase, italicized** or **underlined:**
lactuca, sterilis or Lactuca sterilis.

The nomenclatural binomial is followed by the name of the first author who described the plant, for example: *Avena sterilis* L. (L. for Linnaeus), or Avena sterilis L.

Convallaria latifolia Miller 1768 or Convallaria latifolia Mill. 1768.

I.5. Classification of the living world and place of plants

I.5.1. Linnaeus' classification of the two kingdoms (1753)

Linnaeus (1753) divided living beings into animals and plants (vegetables). He classified fungi in the plant kingdom. Unicellular organisms or protists are divided between the two kingdoms.

I.5.2. Whittaker's (1969) classification of the five (5) kingdoms

In the 20th century, with the progress of microscopy, it was possible to observe and describe single-celled organisms and until the 1950s, the living world was subdivided into three kingdoms: bacteria, plants, animals. In this three-kingdom system, blue algae (although prokaryotes) are classified among plants.

Whittaker in 1969 developed the classification of the living world to arrive at the constitution of the five kingdoms according to biology:

- Prokaryotes (Monera = Monera, bacteria and archaea)
- Protists (Protista, unicellular eukaryotes)
- Fungi (Fungi, multicellular eukaryotes, heterotrophs and absorbotrophs)
- Plants (Plantae, multicellular eukaryotes, autotrophs)
- Animals (Animalia, multicellular eukaryotes)

➢ **Classification of species**

The classification of species has long been based on:

- The only morphological aspect “Thalli and Cormus”.
- The way of life.
- The modalities of sexual reproduction.

➢ **Plant Kingdom**

The main classification criteria:

Cytological criteria → at the cellular level Prokaryotes - Eukaryotes

Morphological criteria → multicellular organization presence of a Thallus or a Cormus

➢ **Characteristics of plants**

Vegetative apparatus Main differences between Thallophytes and Cormophytes (Tab.2):

► **Thallophytes:** vegetative apparatus Thallus → no well differentiated organs (Algae, Fungi, Lichens)

► **Cormophytes:** vegetative apparatus with well-differentiated organs Cormus → leaves, stems and roots.

Table 2: Differences between Thallophytes and Cormophytes

Criteria for differentiation	Thallophytes	Cormophytes
Environment	Aquatic	Terrestrial
Vegetative apparatus	Thallus	Cormus
Life cycle	Mono, di, tri-Genetic cycle	Haplo- diplophasic digenetic cycle
Reproductive organs	Sporocyst and gametocyst	Reproductiv organs: Male gametangium: anthéridia Female gametangium: Archegonia

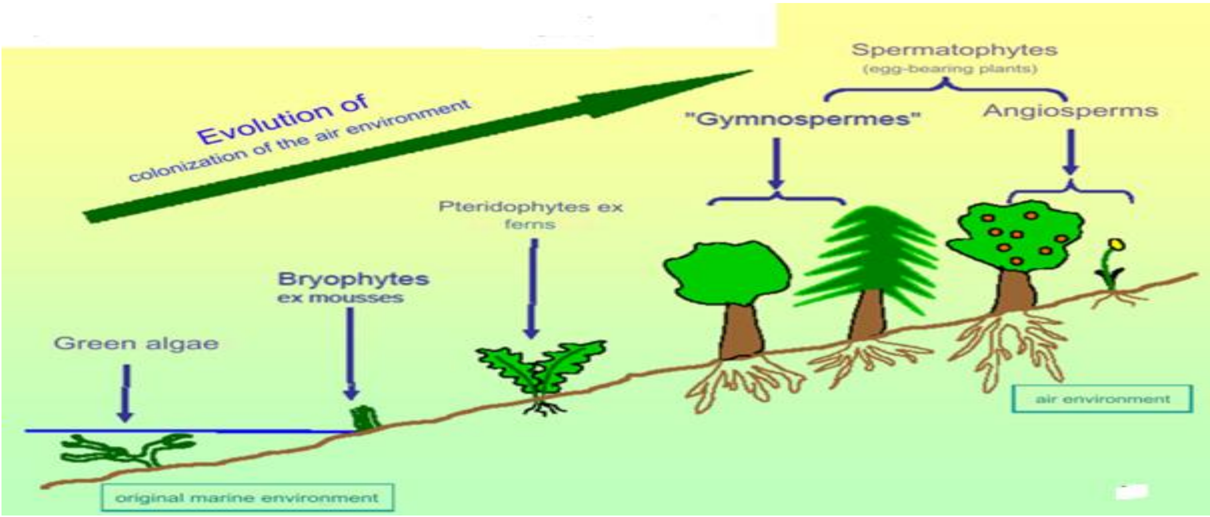
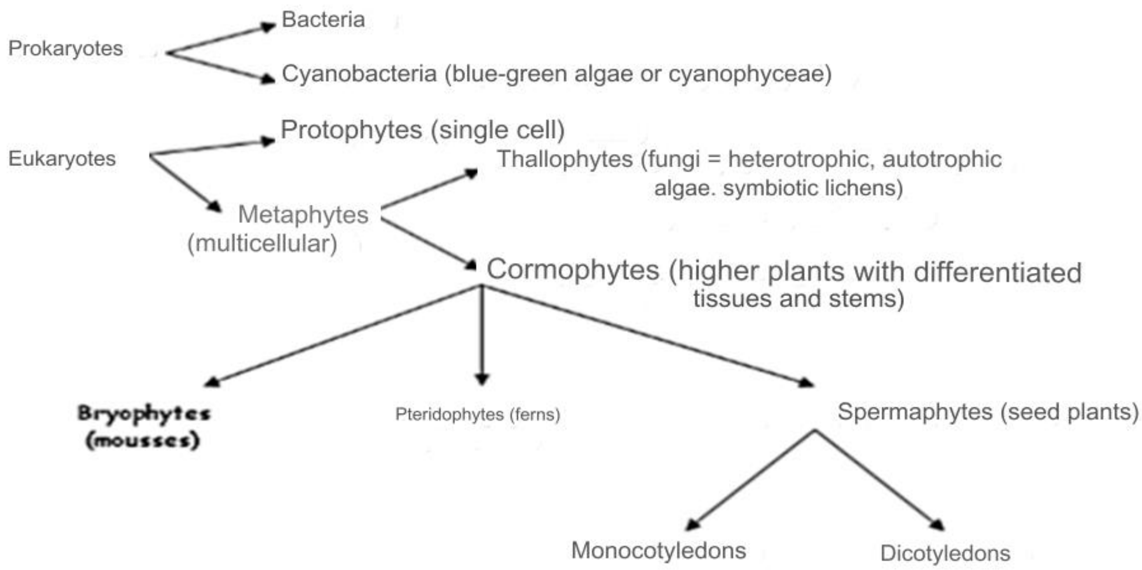


Fig 2: The evolution of the plant world

I.6. The major groups of plants



* **Prokaryotes:** cells lacking a nuclear membrane.
* **Eukaryotes:** cells with true nuclei bounded by a membrane (Table3).

Table 3: Difference between prokaryotic and eukaryotic cell.

Property	Prokaryotes	Eukaryotes
Representatives	Mainly bacteria	Protists, fungi, plants, animals...
Typical size	1–10 μm	10–100 μm
Core	Nucleoid; no true nucleus delimited by an envelope; no nucleolus	Nucleus with a nuclear envelope; presence of nucleolus
DNA	Circular (single chromosome), without histones;	Linear molecules (chromosomes) with histone proteins
mRNA/protein synthesis	Both take place in the hyaloplasm	RNA synthesis in the nucleus; protein synthesis in the cytoplasm
Plasma membrane	Phospholipids, proteins, low carbohydrates and no cholesterol	Phospholipids, cholesterol, proteins and carbohydrates
Organelles	Absence of organelle	REG, REL, Golgi apparatus, mitochondria...
Reproduction	Scissiparity	Mitosis and Meiosis (formation of gametes)
Cytoskeleton	Absent	Here

Chapter II : The Préhanerogams

The phanerogams (from the Greek: phaneros: **visible** and gamos: **marriage**) comprising the most advanced plants of the plant kingdom, they are also called spermaphytes **or spermatophytes** comes (from the Greek word **sperma: seed**, and **phuton: plant**. These are vascular plants whose reproductive system is best adapted to life in an aerial environment. The latter have stems, leaves, roots and a conductive system.

The element of dissemination and conservation of the species in phanerogams is a diploid sporophyte called: seed, fertilization does not take place in water unlike cryptogams (from the Greek: **cryptos** : hidden and gamos: **marriage**) which designate all plants whose element of dissemination is a haploid spore and whose fertilization takes place in an aqueous environment.

The trend towards reduction in gametophyte size continues in seed plants (fig. 3). The gametophytes of the latter are even smaller than those of seedless vascular plants. During the evolutionary history of plants, there has been a reduction in the gametophytic phase (reduction in size but also in life time) in favor of the sporophytic phase (the leafy plant at 2n).

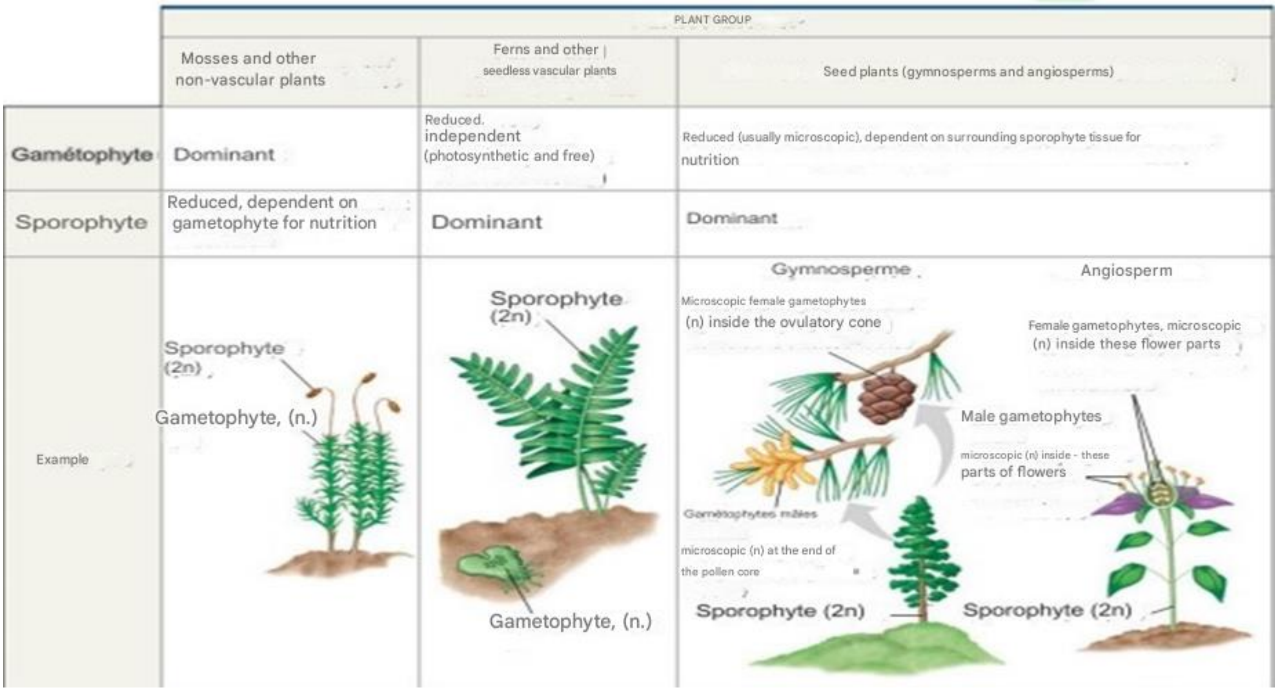


Fig.3: Comparison of the two generations (gametophyte and sporophyte) of the last three phyla.

Linked to this adaptation is the appearance of specialized reproductive elements:

- Female gametophyte protected by integument: ovule (endoprothallia)
- Male gametophyte reduced to pollen grain
- Buds producing branches located in the axils of the leaves.
- Secondary growth of stems and roots through a meristem II ^{area} (bifacial cambium Wood II ^{area} towards the inside, Liber II ^{area} towards the outside), except in Angiosperms (Monocotyledons).

According to the position that the ovule occupies on the plant, we distinguish several groups of Phanerogams corresponding to increasing degrees of evolution:

- Phanerogams whose ovule is naked, that is to say not included in a protective organ. These are the **Gymnosperms** (from gumnus = naked, and sperm = seed), whose ovules are directly pollinated.
- Phanerogams whose ovule is entirely enclosed by a protective organ, the ovary. These are the **Angiosperms** (from aggeion = box), whose ovules can no longer be directly pollinated.
- Some primitive Gymnosperms have an archaic sexual reproduction which evokes in some of its aspects that of the Pteridophytes. They are sometimes separated from the rest of the Gymnosperms, and therefore from the Phanerogams, under the name of **Prephanerogams also called Prespermaphytes.** Furthermore, other Gymnosperms, very evolved (the Gnetales) have an ovule partially enclosed in a protective envelope. Some authors make them an intermediate group, as for the organization of their reproductive apparatus, between the Gymnosperms and the Angiosperms, under the name of **Chlamydosperms .**

phylogenetic point of view, gymnosperms group together four branches (fig.4):

- Cycadophytes, including cycads;
- Ginkgophytes **,** with only one species still existing, *Ginkgo_biloba;*
- Pinophytes **,** also called **conifers** , are among the largest trees in the **world** .
- Gnetophytes

While angiosperms only have one branch, that of Magnoliophytes, in other words flowering plants.

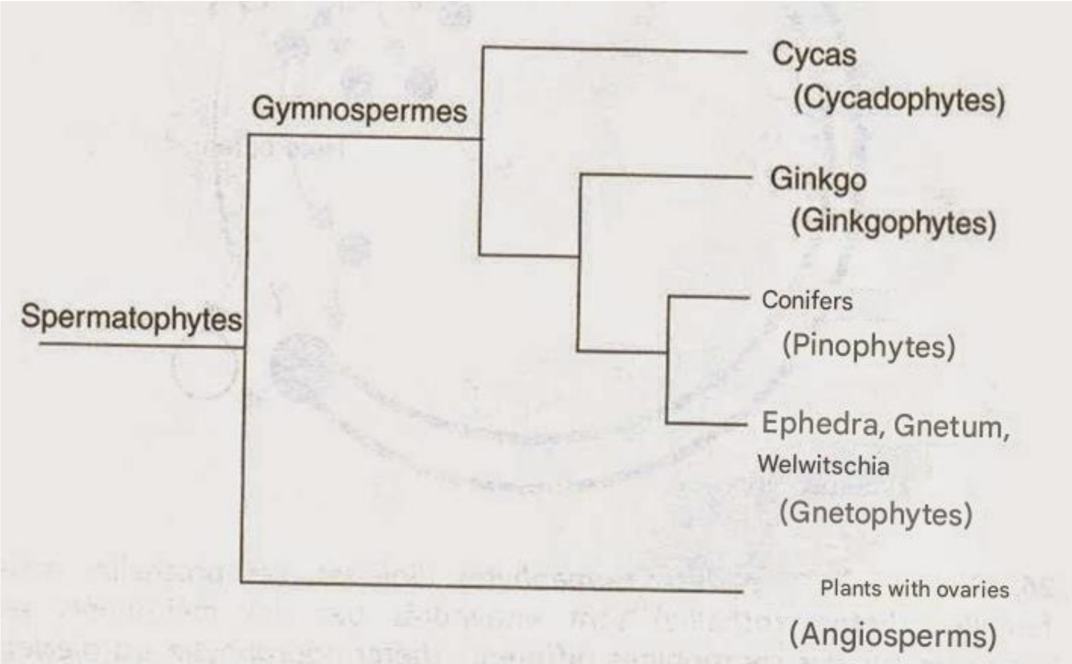


Fig. 4: Phylogenetic classification of phanerogams or spermatophytes.

II. The Prephanerogames

The Prephanerogams (Prespermaphytes, Seed Ferns, Primitive Gymnosperms, Archaic Gymnosperms) are an intermediate group between the Pteridophytes and the true Spermaphytes. It is a group which constitutes, with the pteridophytes, one of the essential elements of the flora of the primary area.

They appeared around the Upper Devonian, 400 million years ago and would have reached their peak in the Antracolithic 300 million years ago, then declined 200 million years ago and disappeared in the Cretaceous. Since then, this group has been declined to make way for spermaphytes. Today, there are only about a hundred species left, true "living fossils" which, with the samples reconstructed by paleobotanists, make it possible to study the organization of this group. The Prephanerogams are part of the plant lineage, that is to say a set of autotrophic and phototrophic organisms. These are generally species that appear in an ornamental state.

II.1. Importance of Prephanerogams from an evolutionary point of view

- These plants, which occupied an important place in the flora of the past, especially in the Paleozoic, are now almost all extinct. At present, this group is represented by a few relict plants, the Ginkgo, the Cycas and their allies.
- The Prephanerogams have not yet acquired a precise position in systematics and appear to be a paraphyletic taxon. Some appear to be affiliated with gymnosperms, others have been proposed as possible ancestors of angiosperms.
- The Prephanerogams would derive from the group of pteridophytes called *Psilophytineae*. The great evolutionary characteristic of this group concerns the miniaturization of the gametophytes and their integration into protective structures. This ensures a better adaptation to the terrestrial environment. This evolutionary movement had been initiated by the heterosporous and heteroprothallate Pteridophytes of the selaginella type. It leads to the formation of particular reproductive structures: the ovule, the stamens and the pollen grains.
- The Prephanerogams, however, are not very far removed from the Phanerogams, as is shown by the ovule and the anatomical structure. For all these reasons, we consider that it is appropriate to consider the Pteridospermae and the Cordaitales as an autonomous systematic group, distinct from the Phanerogams and the vascular Cryptogams and having the same rank as them: we could call these plants Prephanerogams .
- Several botanists emphasize the physiological, or even real, separation of the ovule before fertilization and the presence of ciliated, mobile male gametes, to consider that Prephanerogams are truly oviparous, while gymnosperms and angiosperms, grouped under the name of phanerogams, would be the equivalent of viviparous.
- For other authors, the term Prephanerogams, proposed to designate the first stages of evolution in gymnosperms, would only represent a horizontal evolutionary level across vertical phyla; these authors continue to make it a class of the gymnosperm branch, called the class of **Natrices** because of their swimming male gametes, which distinguishes it from the class of **Vectrices**, in which fertilization is carried out by means of a pollen tube leading the sperm nuclei to the

oosphere, after transport of the pollen by the wind: this is the fundamental opposition between aquatic fertilization, which recalls the thallophytes, and fertilization by aerial vehicle.

II.1.1. The distinctive characteristics of Prephanerogams compared to pteridophytes are essentially

- Important evolutionary step in plant sexuality;
- A new organ of dissemination, constituting the female reproductive system: the ovum.
- Mode of fertilization - Archaic floral apparatus.
- Production of pre-seeds: ovules loaded with reserves before fertilization.
- Presence of ovules that do not develop into seeds.
- A fertilized egg is identical to a virgin egg.

II.1.2. Characteristics of Prephanerogams

This is a group that perfected the ovule (a new organ of dissemination). But not a real seed.

• Female gametophyte protected by integument: ovule (endoprothallia)

• eggs with reserves made before fertilization

• Male gamete is still mobile

• Archaic floral apparatus.

• Morphologically, a fertilized egg is identical to an unfertilized egg, on the other hand in phanerogams an egg after fertilization changes appearance and is transformed.

• Fertilization takes place in a liquid medium, characterized by two types:

• The development of the egg into an embryo always occurs when the fertilized egg falls into the soil, it continues to grow and then the young seedling takes root and gives a new individual.

II.2. Reproduction of Prephanerogams

II.2.1. The reproductive organs

II.2.1.1. Female reproductive system: concept of ovum

One of the major characteristics of Prespermaphytes compared to pteridophytes is to have a new organ of dissemination, constituting the female reproductive system: the ovule. It is thought that the genesis of this organ results from an evolutionary trend initiated by heterosporous and heteroprothallate pteridophytes. For example, in pteridophytes of the selaginella type, the female gametophyte develops in the wall of the macrospore, it is thus better protected. In the latter (*Selaginellae*), the macrospores are disseminated, but are formed inside the macrosporangium which originates at the base of the sporangiferous spike in the axil of a macrosporophyll. Which at the level of figure 3 **,** shows that for several species of fossil plants testifies to an integration of these structures into a whole inseparable called **ovule** .

- At the house of ***Lepidocarpopsis lanceolatus*** (*Lycopodinae*) the macrosporangium always differentiates in the axil of a macrosporophyll, but at the end of meiosis, 3 macrospores degenerate, the sporangium only contains one megaspore which will then be disseminated and within which the female gametophyte or macroprothallium will develop.

- In ***Lepidocarpopsis semialata,*** the system is the same, but in addition we see the beginning of the envelopment of the macrosporangium by the macrosporophyll.

- In ***Lepidocarpopsis lomaxi*** , the macrosporophyll completely envelops the macrosporangium within which the macrospore and then the female gametophyte have differentiated: it is then this assembly which is disseminated and which constitutes a primitive ovule in which the female gametophyte is protected by two envelopes, the wall of the spore and that of the sporangium.

The ovule as we currently know it in *Ginkgo biloba* results from the fusion of these different elements: the macrosporophyll gives the integument, the macrosporangium a nourishing tissue: the nucellus, the female gametophyte is then called the endosperm. This increased protection of the female gametophyte is certainly one of the key factors that ensured the evolutionary success of the Prespermaphytes and their descendants. The ovule also innovates with the accumulation of nutrient reserves before fertilization in the endosperm, which will fuel the development of the future embryo resulting from the fertilization of one of the female gametes or oospheres (fig.5).

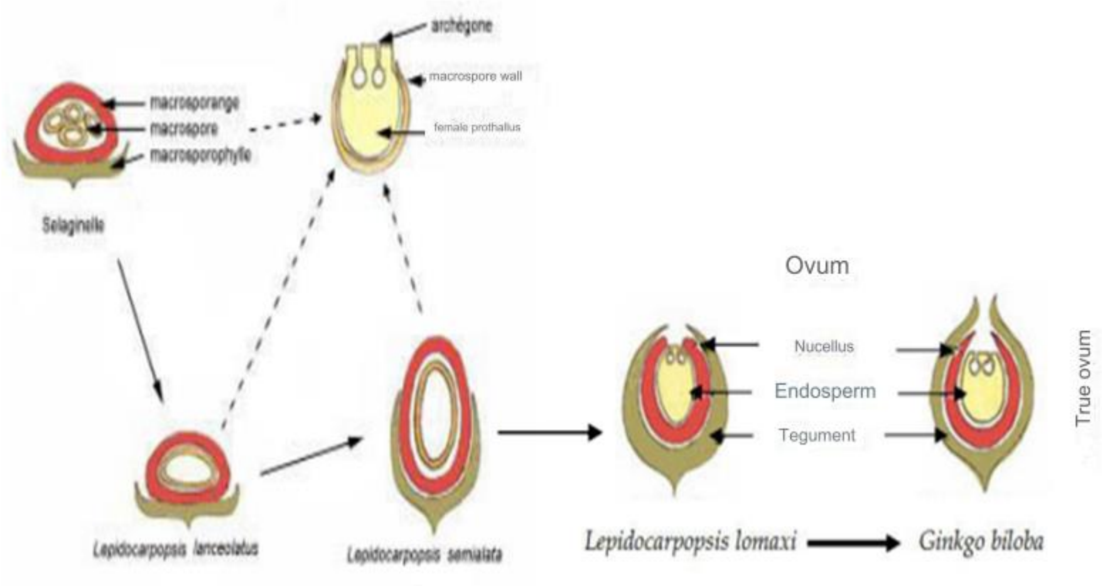


Fig. 5: Evolutionary cycle of reproductive organs in Prephanerogams.

II.2.1.2. Male reproductive system

Stamens and pollen grains; as in the case of the female reproductive tract, the male reproductive tract has undergone transformations leading to the formation of male flowers composed only of stamens. The stamens consist of a thin pedicel or filament at the end of which there are two pollen sacs. The phylogenetic origin of the filament is the microsporophyll of heterosporous pteridophytes while each pollen sac derives from the microsporangium.

Inside the pollen sacs, microspores are formed by meiosis. These are not disseminated, but inside the thick wall of the microspores develop by successive mitoses the microprothallus or male gametophyte, reduced to 4 cells, called pollen grain (fig.6). It is these pollen grains, or ciliated antherozoids, which will be disseminated and which, on contact with the ovule, will release the two male gametes into the pollen chamber of the ovule.

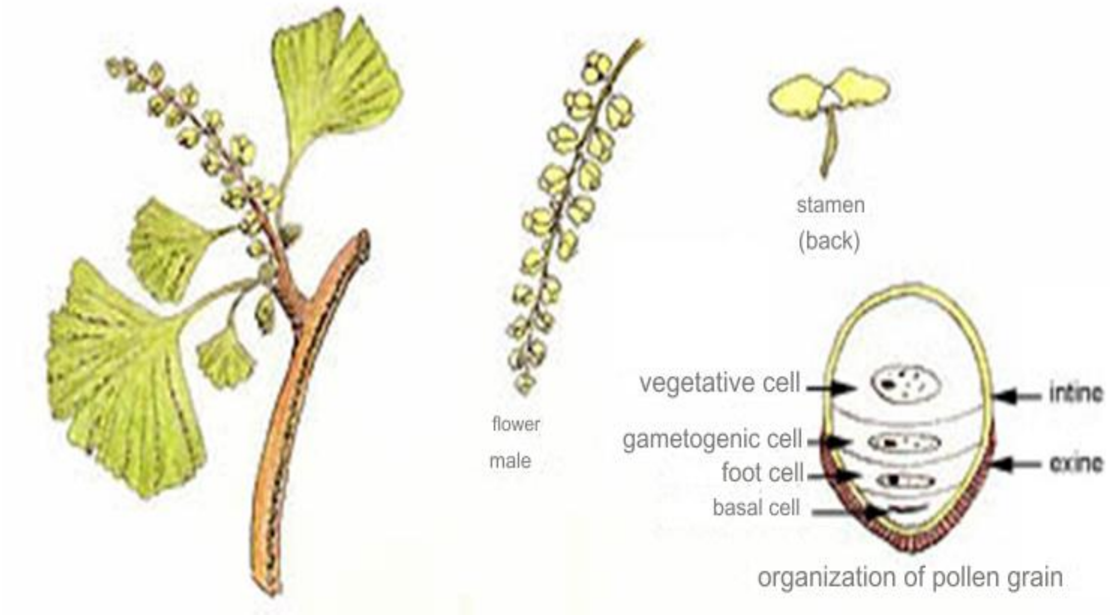


Fig. 6: Evolutionary cycle of male reproductive organs in Prephanerogams.

II.2.1.3. Development cycle of Prephanerogams

As in pteridophytes, the reproductive cycle of Prespermaphytes or Prephanerogams is typically **diplo-haplophasic**. Spoophytic-dominant digenetics. With a very reduced gametophytic generation that develops on the sporophyte while it was always independent in pteridophytes. Only the male gametophyte (pollen grain) is released while the female gametophyte (endosperm) remains included inside the ovule.

The nucellus of the ovules is hollowed out by a pollen chamber filled with a mucilaginous fluid (fertilization fluid). When a wind-blown pollen grain (anemophilous pollen) lands on the large ovule (pollination of the ovules), it penetrates inside through the micropyle and releases two large ciliated antherozoids into the pollen chamber where they swim actively. A single antherozoid fertilizes one of the two oospheres, thus forming a diploid zygote. Usually, the ovule then falls from the tree (fertilization can also take place after the ovule has fallen) and the development of the zygote, at the expense of the ovule's reserves, begins immediately (under the original climatic conditions) and gives rise to a new sporophyte. These species still have an archaic mode of reproduction since fertilization is carried out by mobile male gametes that reach the female gametes by actively moving in the water. This is still a zoidogamy. However, fertilization now takes place inside a protective organ: the ovum, full of reserve substances that will allow the embryo to be both protected and nourished.

Noticed:

In Prephanerogams, fertilization occurs in two different ways:

- **Zoîdogamous fertilization:** in this type of fertilization, the male gametes, ciliated antherozoids, come into contact with the archegonia by swimming through a water-filled pollen chamber above the ovule.

- **Siphonogamous fertilization:** As in pteridophytes, fertilization takes place in a liquid medium (the antherozoids are ciliated but do not swim, they descend by gravity): however, the water necessary for the movement of the antherozoids is no longer provided by the medium but by the liquefaction of the upper part of the nucellus which surmounts the archegonia. The fusion of the gametes can last several months.

II.3. Systematics of Prephanerogams

According to Morphology, Prespermaphytes are subdivided into two classes (fig.7):

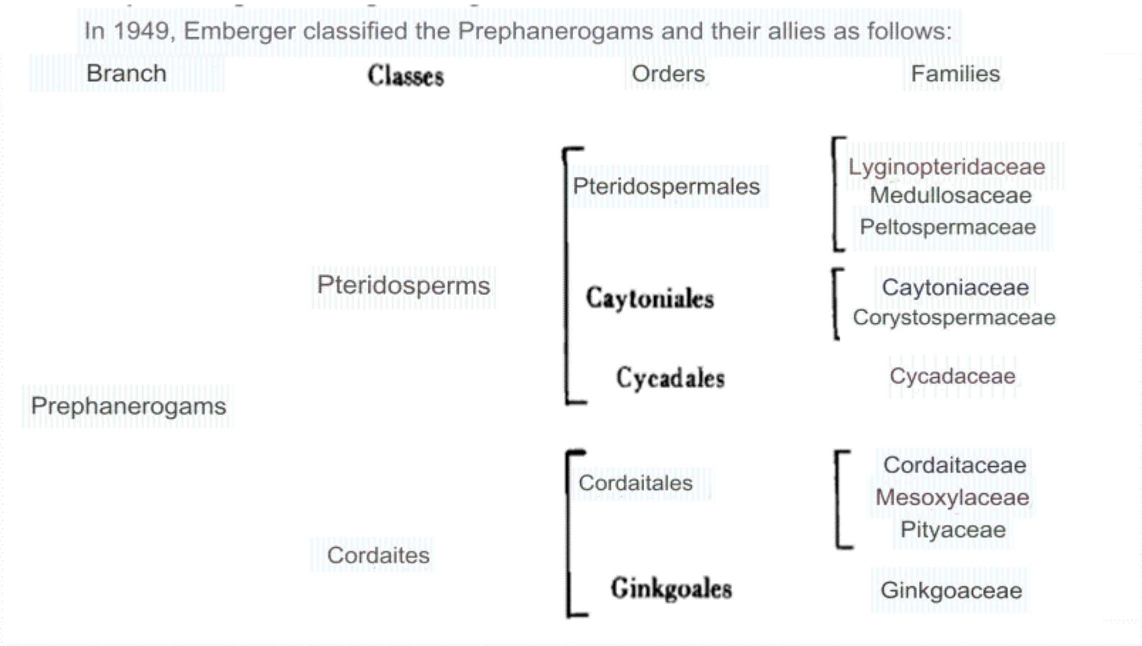


Fig. 7: Classification of Prephanerogams

- **The class of pteridosperms (= Cycadopsida or "seed ferns")** which groups together plants whose vegetative apparatus resembles that of tree ferns with fronds. This is the case for example of the ***Cycas*** , decorative surviving species of this class.

- **The class of Cordaites (= Gingkopsida)** is now represented by only one living species, the ***Ginkgo biloba*** or thousand crowns tree, whose leaves turn a beautiful golden yellow in the fall and whose last survivors were identified near monasteries in China. This plant has an arborescent vegetative system, already typical of that of gymnosperms with small, well-differentiated leaves.

II.3.1. The class of *Pteridosperms* (= *Cycadopsida)*

This class: ***Cycadopsida,*** is divided into **03 Orders:**

- ✓ Order 1: ***Pteridopsermales***

This is an extinct order comprising "seed" ferns. Indeed, the fronds are morphologically quite similar to those of ferns. The presence of the ovule has made it possible to classify the genera: ***Alethopteris, Linopteris, Mixoneura, Sphenopteris, Glossopteris, Lyginopteris, Mariopteris, Neuropsteris*** among the *Pteridospermales.*

- ✓ Order 2: ***Caytoniales .*** it is a vanished order.
- ✓ Order 3: ***Cycadales*.**

II.3.1.1. Order *Cycadales*

It is an order that is represented by only a hundred species grouped into 3 families and eleven genera. The first known fossils date from the Permian (270-280 million years) and a peak in the Jurassic often called "Cycad age".

They are plants with pinnate compound leaves (large leaves/megaphylls) and a palm or tree fern shape, with a thick and rarely branching trunk. There are particular biochemical characteristics, in particular the synthesis of toxic glycosides, called cycasins, which protect the plant against bacteria and fungi. The plant is dioecious. The plant has male and female feet , these feet are distinct. They are native to tropical and subtropical regions. From an anatomical point of view, the trunk (the stem) contains:

- Abundant marrow, loaded with starchy reserves.
- A low thickness of vascular tissues including a small amount of secondary xylem (areolate tracheids).

The root system consists of a taproot as wide as the trunk, from which a large number of secondary roots emerge. Some of these roots, called **coralloid roots** (Fig.8), have negative geotropism and approach the surface of the soil; there, they divide abundantly and form nodules. This change in behavior and form is related to the presence of a Cyanophyte (genus ***Anabaena***) in the cells of the bark of these roots (symbiotic association).

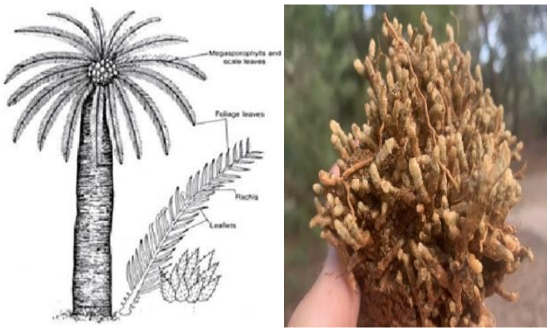
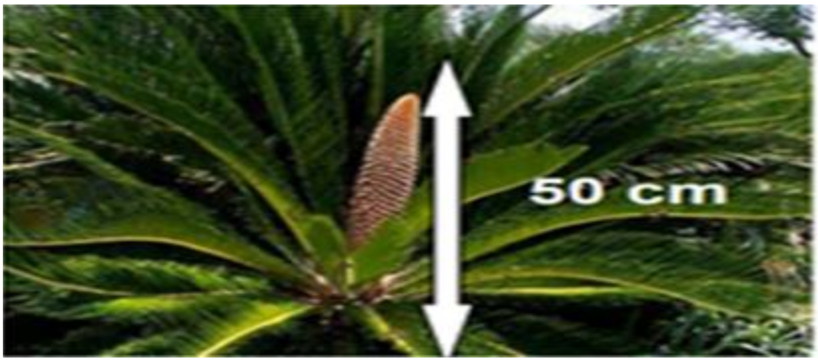
a  **b**

Fig. 8: a. Appearance of *Cycas*; b. Appearance of coralloid roots

A. Reproductive system of cycads

❖ Male reproductive system

It is organized in a cone, at the top of the plant, between a bouquet of chlorophyll leaves. This cone, the equivalent of a flower, is composed of several hundred scales. Each scale is a modified leaf or microsporophyll, bearing on its lower face groups of pollen sacs (3 to 6 sacs) which are microsporangia (fig. 8). Before the dehiscence of the microsporangium, following meiosis, the mother cell of the microspores (2n) gives rise to 4 spores (n), which give rise, by mitosis, to male prothalli: the pollen grains (male gametophyte) (fig.9).



The male reproductive system: a cone, made up of scales (Microsporophylls)

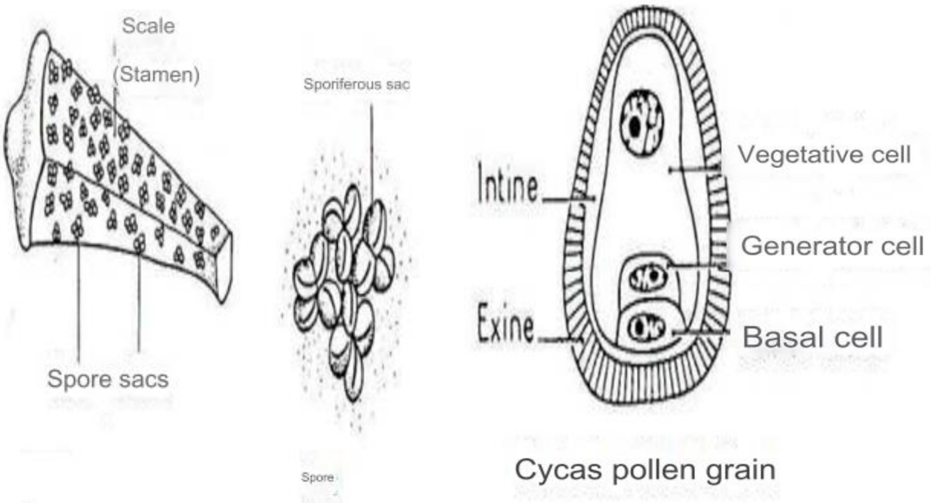


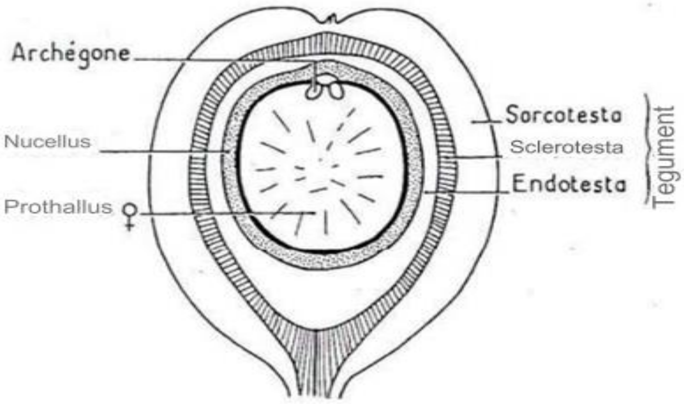
Fig.9: The male reproductive system and Male gametophyte of Cycads.

Pollen grains are released by dehiscence of the pollen sacs. They are male prothalli, each consisting of 3 cells: a basal cell, a vegetative cell and a generative cell. These cells are protected by 2 envelopes, one internal (intine) and the other external (exine). The pollen grain is disseminated by the wind and comes into contact with the ovules.

- **Female reproductive system**

At the top of the plant, there is a cone, located between non-chlorophyllous leaves. The female gametophyte is enveloped by 2 envelopes with 2 n chromosomes: the integument (itself composed of 3 parts respectively from the outside to the inside: the sarcotesta, the sclerotesta and the endotesta) and the nucellus (fig.10).

The reproductive system female: the cone made up of megasporophylls which carry ovules at their base



Cycas ovule

Fig. 10: The reproductive system female and ovule of cycads

One of the cells of the nucellus undergoes meiosis, 3 of the 4 cells will degenerate and the one that survives will give a multinucleated megaspore. Later, this megaspore transforms into a female gametophyte where a pollen chamber will differentiate, which will later be hollowed out by one or two archegonia (fig. 11).

Nb: During the entire period of formation of the archegonia, the female gametophyte will accumulate nutrient reserves.

Fig. 11: Female gametophyte of Cycads

- **Cycad development cycle**

At maturity, the pollen grains are disseminated by the wind. They are captured by a drop of liquid called a "micropylar drop" emitted by the ovule. The resorption of this drop introduces the pollen into the pollen chamber, dug in the nucellus above the archegonia. Once inside, the pollen grain emits a pollen tube which penetrates the nucellus, above the pollen chamber; the rest of the grain is suspended in the pollen chamber; inside, the generative cell divides: it then gives a generative cell divides: it then gives a base cell and a spermatogenic cell which will give by mitosis 2 antherozoids. The pollen tubes break, their contents are poured into the bottom of the pollen chamber; the antherozoids then swim in the drop of liquid coming from the pollen tube: fertilization results in a zygote which divides immediately to give a coenocytic proembryo, then a cellular embryo. Several oospheres can be fertilized, but only one embryo develops into a 2-cotyledon seedling. Germination is immediate. Therefore, fertilization takes place in a liquid medium. But the water necessary for the movement of the antherozoids is no longer provided by the external environment. Therefore, fertilization has freed itself from the water of the external environment and can occur in dry periods (fig. 12)**.**

As soon as fertilization is carried out, the embryo develops, then the seedling which will give a new cycad. Cycads disseminate fertilized ovules in the process of maturation (There is no rest period for the "seed", allowing for dispersal or waiting for better environmental conditions).

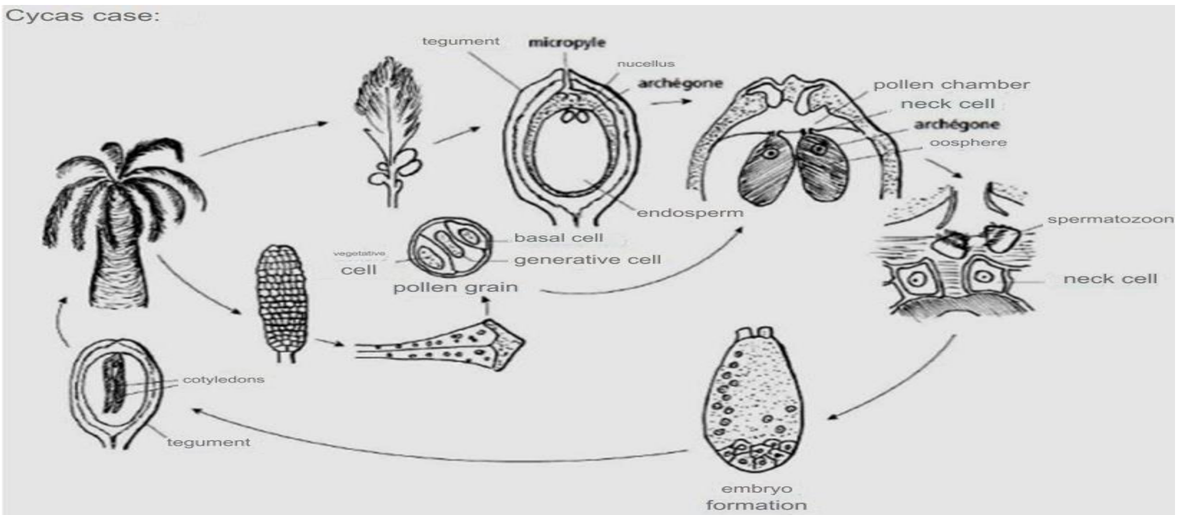


Fig. 12: Cycas development cycle.

The three current families are: ***Zamiaceae, Cycadaceae*** and ***Stangeriaceae*** (fig.13).

-Cycas revoluta; Cycadaceae; Cycads.

- Stangeria eriopus; Stangeriaceae; Cycadales.

- Zamia slanted; Zamiaceae; Cycads.

Zamia obliqua ***Cycas revoluta*** ***Stangeria eriopus***

Fig. 13: The different species of the different cycad families.

Cycas form a genus that includes 20 species. Only one species ***Cycas revoluta***: A type of small ornamental palm tree common in Algerian gardens.

Systematics of *Cycas revoluta

Kingdom: Plantae

Subkingdom: *Tracheobionta*

Branch : *Cycadophyta*

Class: *Cycadopsida*

Order: *Cycadales*

Family: *Cycadaceae*

Genus: *Cycas*

Species: ***Cycas revoluta***

II.3.2. The class of Cordaites (= *Cordaïtopsida)*

This single class is divided into 02 Orders

- **The order of *Cordaitales***: Are essentially Paleozoic arborescent Prephanerogams.
- **The order of Ginkgoales**: Order that mainly occurred in the Mesozoic, currently represented by a single species: *Ginkgo biloba* (or 40-

maidenhair tree), a species that lives in China (replica species). It is currently found in many ornamental gardens (fig. 14).

Fig. 14: a. *Ginkgo biloba* (tree); b. *Ginkgo biloba leaf*

II.3.2.1. The order of *Ginkgoales*

Ginko ***biloba*** is a slow-growing tree of Asian origin, can reach 40m high, the branched stem with short branches which bears deciduous leaves with a fan-shaped blade with dichotomous veins, without a main vein (fig.15). They are more or less incised or divided in the middle of the upper edge (bilobed appearance) and become golden yellow as they age.

Fig 15 : *Ginkgo biloba* fan leaf

This is a dioecious species: the male and female organs are borne by different trees. Male trees form cylindrical catkins on short branches; female trees produce ovoid ovules on peduncles (fig.16).

- ✓ A male flower (false flower), each flower is reduced to a stamen with 2 pollen sacs. The sac that contains the pollen is called an anther.

Fig. 16: a. Male foot; b. male flower of *Ginkgo biloba.*

The male gametophyte is composed of 4 cells:

1. Vegetative
2. Gametogenic
3. Foot cell
4. Basal cell

These are the pollen grains which will be disseminated and which, upon contact with the ovule, will release the two male gametes into the pollen chamber of the ovule.

- ✓ A female flower (false flower) is carried on a long peduncle.
- ✓ The almond is ovoid, fleshy on the outside, yellowish, the endosperm rich in starch (fig.17).
- ✓ Wood is said to be homoxylated because it is formed from a single type of element (tracheids).

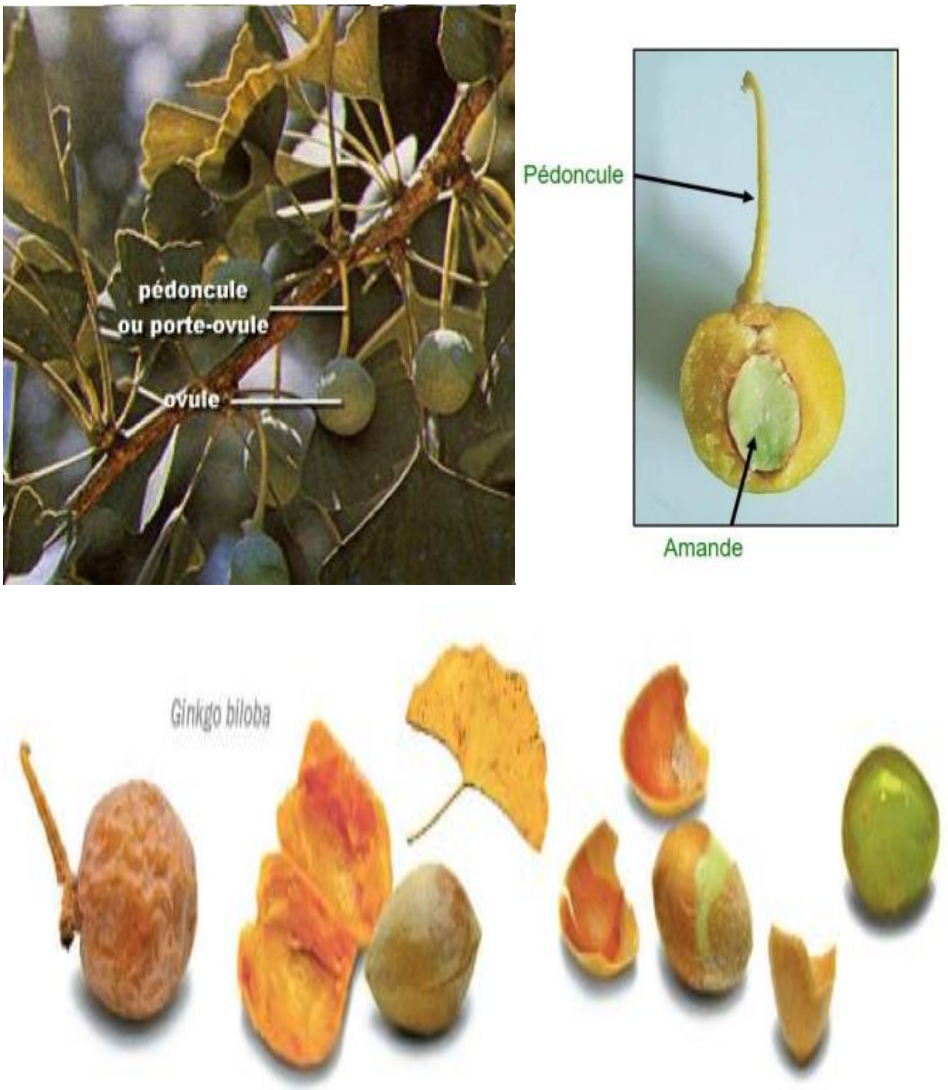


Fig. 17: Female foot and fruit of *Ginkgo biloba*

Ginkgo biloba ovule has the same organization as the Cycas ovule. It results from the fusion of different elements, the macrosporophyll gives the integument (protective envelope of the seed, of the ovule) of the ovule, the macrosporangium a tissue with a nourishing role called nucellus. The female gametophyte is at the origin of the endosperm (nourishing tissue). The ovules in the ginkgo develop in pairs, one of the two aborts. They are always observed at the end of a peduncle to constitute what is called a female flower. The ovule innovates the new capacity to accumulate nutrient reserves before fertilization at the level of the endosperm. These reserves will allow the feeding and development of the future embryo resulting from the fertilization of one of the female gametes or oosphere.

❖ *Ginkgoales* development cycle

Anemophilous pollination (by wind). The theoretical diagram of the reproductive cycle of Cycads (fig. 18) can also be applied to Ginkgophytes because the sequence of the different phases is the same (pollination and fertilization) with the exception of the fertilization fluid which is here produced by the ovule (nucellus cells) and the pollen tubes which are very branched. Like cycads, the fertilized ovule falls before its complete development into a **preseed** with a fleshy integument.

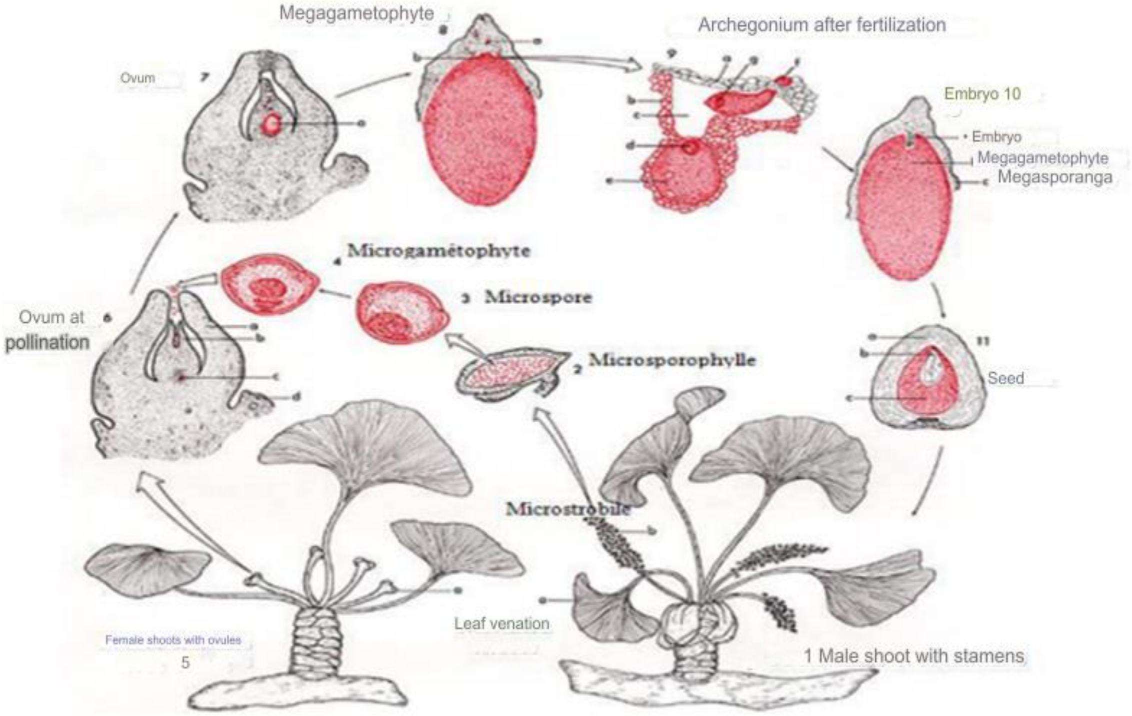


Fig. 18: Development cycle of *Ginkgo biloba.*

Chapter III: The Gymnosperms

The term gymnosperms refers to plants with naked ovules "(sperma: seed) (gymno: naked)". They are Embryophytes. They also belong to the group of Tracheophytes. They are also called tree ferns, the most primitive group, appeared at the end of the primary era; they constituted the dominant terrestrial flora of the secondary era, before being supplanted by the Angiosperms.

Gymnosperms are the remains of a once very large group which, at its peak in the Jurassic (about 150 million years ago), numbered some 20,000 species. They are spermaphytes in decline, and are currently represented by only about 700 species.

1) These are woody plants, often arborescent, with a characteristic pyramidal shape.

2) Presence of a bifacial cambium whose tissues contain oleoresin secretory canals.

3) These are plants with naked ovules, that is to say not included in a protective organ, they are gymnosperms whose ovules are directly pollinated and do not produce true fruits.

4)Their life cycle is characterized by a vegetative phase longer than the reproductive phase.

Typical current Gymnosperms are essentially represented by Conifers (around 5.000 species).

III.1. Morphological characters

III.1.1. Vegetative apparatus

Gymnosperms are all woody (trees, shrubs), that is to say they have a rigid stem formed of wood: no species is herbaceous. They are very often large trees, less often shrubs or small trees. They have a development cycle spanning several years. Their longevity can be high; the Long-lived Pine (**Pinus *longaeva***) lives more than 4.000 years. They almost always have orthotropic monopodial growth, that is to say they have a single, straight trunk; They have a pyramidal or conical shape, due to a very strong apical dominance. Its branches are often arranged in crowns or pseudo-whorls. The leaves are small, either needle-shaped (pines, larches, cedars) or scale-shaped (cypresses, thujas). These leaves are either alternate, opposite or whorled (fig.19). In most cases, the leaves are evergreen, which is why the trees are always green. They are xerophytic plants (resistant to mountain drought, rare thick cuticle, few stomata hidden in the crypts, very reduced leaf surface)

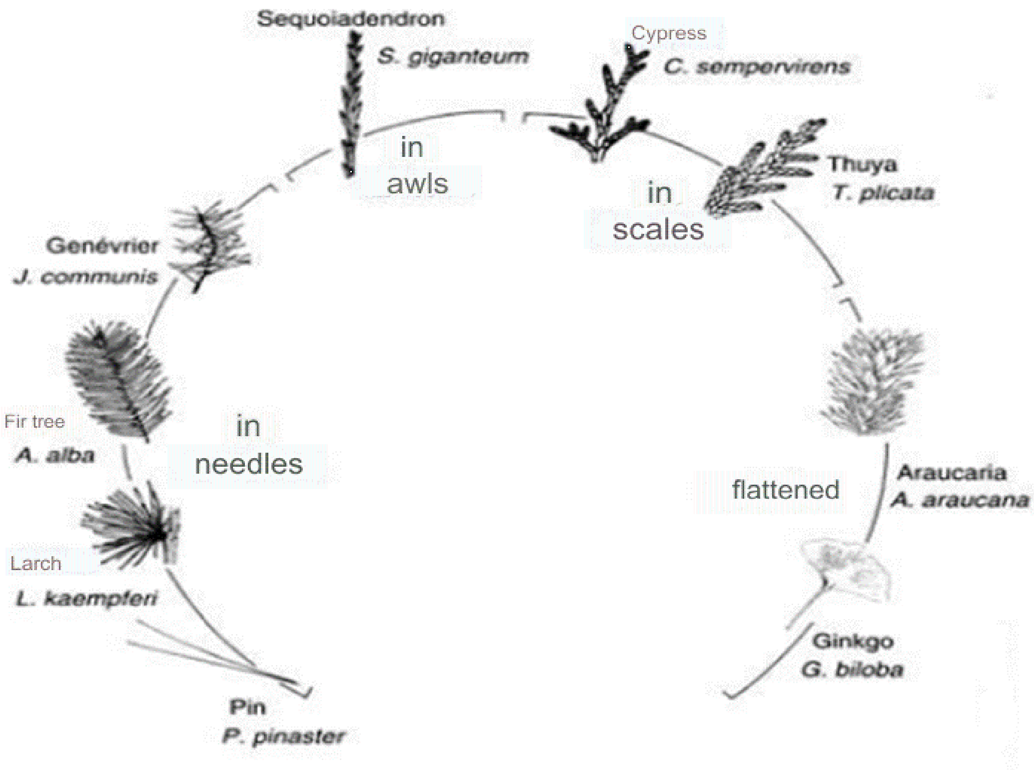


Fig. 19: Types of leaves in Gymnosperms.

III.1.2. Reproductive system

Gymnosperms are generally monoecious (pines, firs) with the exception of some species which are dioecious (yews). They have an indefinite growth of the terminal bud; their sexual organs are grouped in unisexual cones either male or female which are carried by the same foot: monoecious species. They bear woody cones (cone, strobile, galbulae) in adulthood (fig.20) with naked ovules (with a certain tendency towards angiospermy). The sporungiferous spikes constitute cones: the male sexual organs in the form of small cones are represented by sporungiferous leaves (scales) or stamens bear microsporangia (pollen sacs) with a number generally of 2 to 20 pollen sacs on their lower face, releasing a large number of microspores (pollen seeds).

A while the female sexual organs (the ovules), sometimes of caulinary origin (from the stem), bearing 1 to 3 naked ovules on the dorsal face of the scales and doubled by a bract which together forms a female cone. These scales, which have the same value as the carpel of angiosperms, never close completely to form a closed cavity protecting the ovules. The latter are always unigumented and orthotropic.

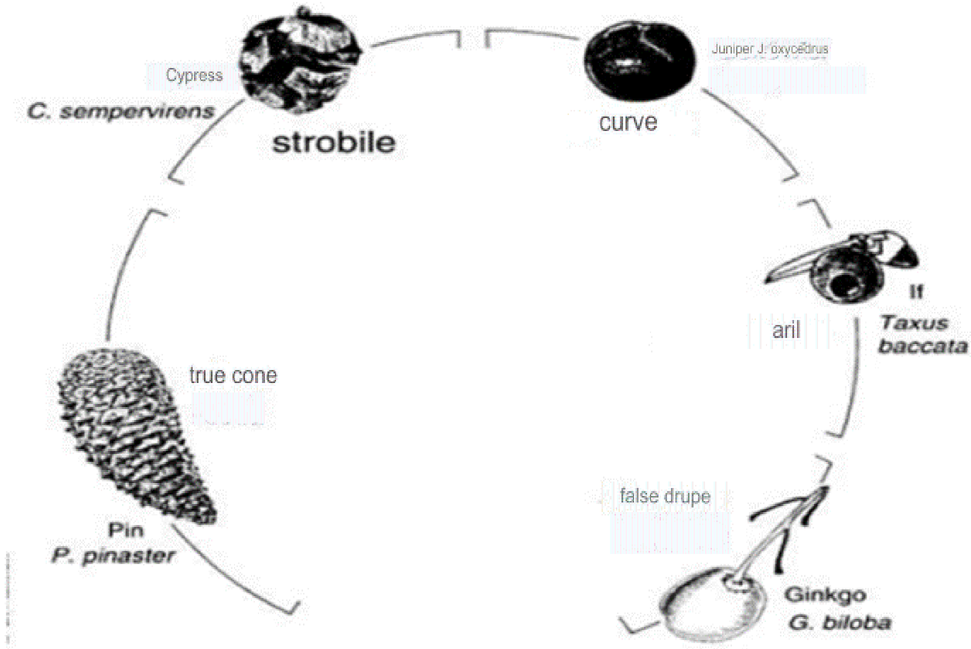


Fig. 20: The different types of cones in gymnosperms.

III.2. Anatomical Characteristics

-Presence of secondary libero-ligneous and subero-phello-dermic formations; a homogeneous secondary wood, formed only of tracheids with areolate punctuations. Their secretory apparatus is most often constituted by oleo- resin canals. They have a homogeneous and pleated mesophyll in the transverse section of the leaves in "needles", characteristic of very many gymnosperms. Composed of a primary formation of criblo -vascular, as in Eudicots, with centrifugal xylem and centripetal phloem;

- In pine wood, the same cell type (tracheids) ensures both the functions of conduction of raw sap and support: it is called homoxylated wood;

-The secondary xylem is homogeneous (homoxylated) and formed only of tracheids with areolate punctuations (fibers) with the existence of a resin secretory apparatus in conifers. The woody rays (or horizontal parenchyma) are often visible to the naked eye, and are distinguished by their radial arrangement, their thinness and their light color. They have a limited length (radial direction), a height (vertical direction) and a thickness (tangential direction), but characteristic for each species. As well as a crossing of the vertical elements (vertical parenchyma, fibers and conductive elements).

III.3. Chemo- taxonomic characters

Chemotaxonomy, chemotaxonomy, or chemosystematics, is a scientific discipline that lies at the intersection of chemistry and biology. It is a powerful and complementary approach to traditional taxonomy. By focusing on the chemical aspects of organisms, it enriches our understanding of biological diversity, evolutionary relationships, and ecological adaptations. It is based on the analysis of secondary metabolites, i.e. chemical compounds produced by organisms that are not directly involved in their growth or reproduction, but that may play a role in their adaptation to the environment. This taxonomic method is based on the comparative analysis of chemical profiles between different species or groups of organisms. The underlying assumption is that similarities in chemical composition reflect evolutionary proximity between the species studied. While the term chemotaxonomy is relatively new, its principle is old. Over the years, many approaches have evolved towards plant taxonomy, including morphological, anatomical and chemotaxonomic classification. The first two can be grouped under traditional classifications while the third is a modern approach to classifying plants.

During the 18th and 19th centuries, knowledge in this field increased and some taxonomists used several chemical characteristics in an attempt to delimit plant taxa and demonstrate their phylogeny. Chemotaxonomy has undoubtedly made a great contribution to taxonomic work in the past and will most certainly continue to do so in the future. The valuable information it offers is best used in conjunction with other sources of taxonomic evidence and a multidisciplinary approach is therefore necessary in order to establish a classification system that reflects natural relationships as accurately as possible.

Plants produce primary metabolites (carbohydrates, proteins, lipids) as a result of photosynthesis, and transform them into secondary metabolites. They serve for defense against pathogens, insects and herbivores, for internal communication, for adaptation to the environment, for competition with other plants for nutrients, for attraction of pollinators. Outside of plants, secondary metabolites are known in fungi, prokaryotes, insects and some vertebrates. Many of these markers are unique to a species or group of species, and can therefore be used to identify or compare them. Chemical characteristics of plants will be very valuable for plant taxonomy in the future. Chemotaxonomic studies are useful to taxonomists, phytochemists, and pharmacologists in solving taxonomic problems.

In this classification method, the materials to be analyzed can be dried or ground. Fresh or whole materials are not mandatory.

The concept of chemotaxonomy was developed in the last century. According to De Candolle.

1) Plant taxonomy will be the most useful guide to man in his search for new industrial technologies and medicinal plants.

2) Chemical characteristics of plants will be very valuable for plant taxonomy in the future.

Both of these statements are important in current studies of natural products.

The rise of chemotaxonomy is mainly due to advances in chemical analysis techniques that can detect even trace amounts of chemical compounds.

III.3.1. Main aspects of chemotaxonomy

1.Secondary metabolites: These compounds include flavonoids, alkaloids, terpenoids and essential oils. Their presence and variation between species may indicate phylogenetic relationships.

2.Comparative approach: Chemotaxonomy compares the chemical profiles of different species to establish classifications. This may include techniques such as chromatography (CCM), (HPLC) and (GCP), mass spectrometry (MS) and nuclear magnetic resonance (NMR) as well as Nucleic acid analysis (DNA sequencing).

3.Integration with other methods: Chemotaxonomy is often combined with other approaches, such as morphology, molecular biology, and ecology, to obtain a more comprehensive overview of evolutionary relationships.

III.3.2. Applications of chemotaxonomy

It is used in various fields including:

1. Species identification: Helps in the recognition of species that are difficult to distinguish by morphological means.

2. Ecology and conservation: Contributes to the understanding of ecological interactions and the preservation of biodiversity.

3. Pharmacology: Identifies active compounds in medicinal plants.

4. Evolutionary importance: Chemotaxonomy helps to understand the adaptations of organisms to their environment and the mechanisms of evolution.

5. Agriculture: Selection of plant varieties based on their chemical properties, such as disease resistance or nutritional quality

III.3.3. Principles of chemotaxonomy

1. Specificity of metabolites: Some metabolites are specific to certain families, genera or species, which allows phylogenetic relationships to be established.

2. Chemical variation: Variations in chemical composition among populations may reflect evolutionary and ecological adaptations.

3. Chemical homology: Compounds shared between different species can indicate common ancestry, providing clues about their evolution.

4. Interdisciplinarity: Integration of chemical data with morphological, ecological and molecular information for more robust classification.

III.3.4. Chemotaxonomic characters of Gymnosperms

Gymnosperm chemotaxonomy is based on the analysis of secondary metabolites, such as resins, flavonoids, and terpenoids to establish phylogenetic relationships. For example, the presence of certain types of flavonoids can help distinguish families, while resins are often specific to genera or species. These compounds can reveal information about the evolution and adaptation of species, thus allowing a better understanding of their diversity. They play a crucial role in the identification and classification of gymnosperms. These chemotaxonomic characters not only help to classify gymnosperms, but also to understand their ecological and evolutionary adaptations.

III.3.4.1. Chemotaxonomic compounds of Gymnosperms

***Flavonoids**: The presence of flavonoids, such as quercetin and kaempferol, can vary among Gymnosperm families. For example, some genera of Conifers have distinct flavonoid profiles that help differentiate them.

***Terpenes**: Terpenes, especially monoterpenes and diterpenes, are widely distributed among Gymnosperms. For example, the genus Pinus produces specific terpenes that can be used to identify species.

Resins**: Resins produced by some species, such as those of the genus ***Picea or ***Abies***, contain compounds that may be unique to those genera and are often used in identification.

Organic Acids**: Some Gymnosperms, such as those in the genus ***Juniperus, contain specific organic acids, which can also help in their classification.

*** Alkaloids and other metabolites**: Although less common, some alkaloids have been identified in some species, adding another layer to the chemotaxonomic analysis.

Comparative studies on secondary metabolites between different gymnosperm species have been carried out to better understand their chemical diversity and geographical distribution. These studies help to establish identification keys based on chemical profiles by demonstrating the importance of chemotaxonomic characters in the classification and understanding of gymnosperms, shedding light on their chemical diversity and evolution.

Here are some important families or classes of gymnosperms that have been extensively studied for their chemotaxonomic characters:

- ✓ ***Pinaceae*** (Conifers): Studies on resins, terpenes and flavonoids, allowing to distinguish genera like ***Pinus*** and ***Picea***.
- ✓ ***Taxaceae***: Analyses of phenolic acids and flavonoids, contributing to the classification of genera such as ***Taxus***.
- ✓ ***Cupressaceae***: Research on essential oils and volatile compounds, useful for identifying species such as ***Juniperus*** and ***Cupressus.***
- ✓ ***Cycadaceae*** (***Cycas***): Studies of secondary metabolites, including flavonoids and alkaloids, to understand phylogenetic relationships within this family.
- ✓ ***Ginkgoaceae*** (***Ginkgo***): Analyses of flavonoids and terpenes, particularly in ***Ginkgo biloba***, to establish evolutionary links.
- ✓ ***Ephedraceae*** (***Ephedra***).

Example of a study on the chemotaxonomic characteristics of two families of Gymnosperms

- ❖ The ***Pinales***, which include the Conifers, have distinct chemotaxonomic characters. For example:

Flavonoids: Quercetin is common in many species, while some genera, such as ***Picea***, may have specific flavonoids.

Terpenes: Monoterpenes, such as pinene, are abundant and vary between species. Diterpenes, such as resins, help identify specific genera.

Resins: The Pinales often produce resins, which contain resin acids unique to each genus, especially in ***Pinus*** and ***Abies***.

- **Cycadophytes, or *Cycas***, have several distinctive chemotaxonomic characters

Flavonoids: Compounds such as cyanidin and other flavonoid pigments are present, often specific to genera.

Steroids: Steroids, such as brassinosteroids, are important for their classification and adaptation.

Alkaloids: Some ***Cycas*** contain alkaloids, such as cycasin, which are toxic and can help distinguish species.

Resins and essential oils: They also produce resins and oils that can vary from species to species.

There are many works on the chemotaxonomic characters of Gymnosperms, of which we cite a few articles:

*Chemotaxonomy: A Tool for Plant Classification (Ram Singh, 2016).

* Study at three systematic levels: reality of Prespermatophytes, originality of the genus ***Pinus***, polymorphism of ***Juniperus thurifera*** (Lebreton,1990).

* Polyphenolic analysis recognizing the validity of the major subdivisions of the genus ***Abies*** proposed by classical botanists (Gauquelin, Idrissi and Lebreton, 1988)

* Pinales considered from a chemotaxonomic point of view: The flavonoid analysis of 132 samples (92 species, 9 genera) of ***Pinales*** (Emberger sensu) made it possible to justify the autonomy of the group and to specify its internal structure (Lebreton et Starte, 2011).

* The biflavones of the cycads revisited: Biflavones in ***Stangeria eriopus***, ***Chigua restrepoi*** and 32 other species of Cycadales (Meurer-Grimes and Stevenson, 1994).

III.4. Reproduction

Gymnosperms reproduce sexually; pollination is always by wind. The reproduction processes (fertilization, embryogenesis) are long-lasting, so that there are often, for example in pines, several generations of female cones visible on the same branches. The scales, initially small and spaced apart, allow the pollen to arrive freely; then they grow and close, protecting the ovules which transform into seeds.

In general, the cones become lignified (pines, spruces, cypresses) and finally open by desiccation, releasing their seeds. Exceptionally, they become fleshy (juniper "berries"). Yews form a red, fleshy fold around the fertilized ovule (aril); there is no cone.

Fertilization occurs by **siphonogamy.** This type of fertilization is found in the most evolved Gymnosperms and in all Angiosperms. The pollen grain emits non-ciliated male gametes which are carried to the archegonia through a pollen tube. The latter penetrates the neck of the archegonium and discharges its contents into the oosphere. An antherozoid fertilizes the oosphere and gives 1 zygote, the other gamete, the vegetative cell and the basement cell degenerate (fig. 21).

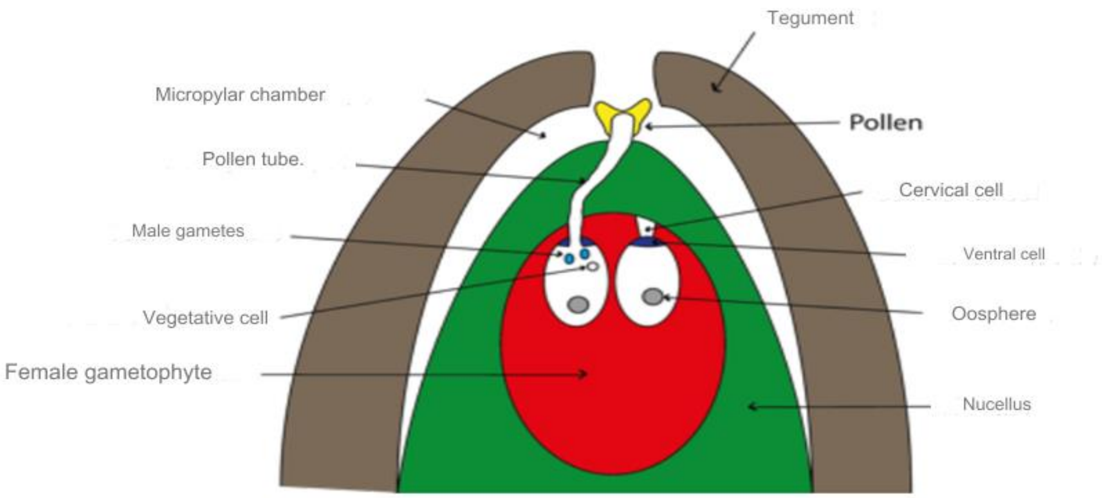


Fig. 21: Fertilization of Gymnosperms

The zygote undergoes 2 successive mitoses to give a tetra nucleated structure without cell division: this is the coenocytic proembryo. The four nuclei of the coenocytic proembryo undergo a transverse division followed by a septation to result in the formation of a cellular proembryo.

The cellular proembryo gives rise to 4 embryos, of which 3 embryos degenerate, the rest grow in the endosperm. During the development of the embryo, the nucellus as well as all the rest of the proembryo are digested by the endosperm to constitute reserves necessary for the growth of the embryo and also the reserves of the seed (fig. 22).

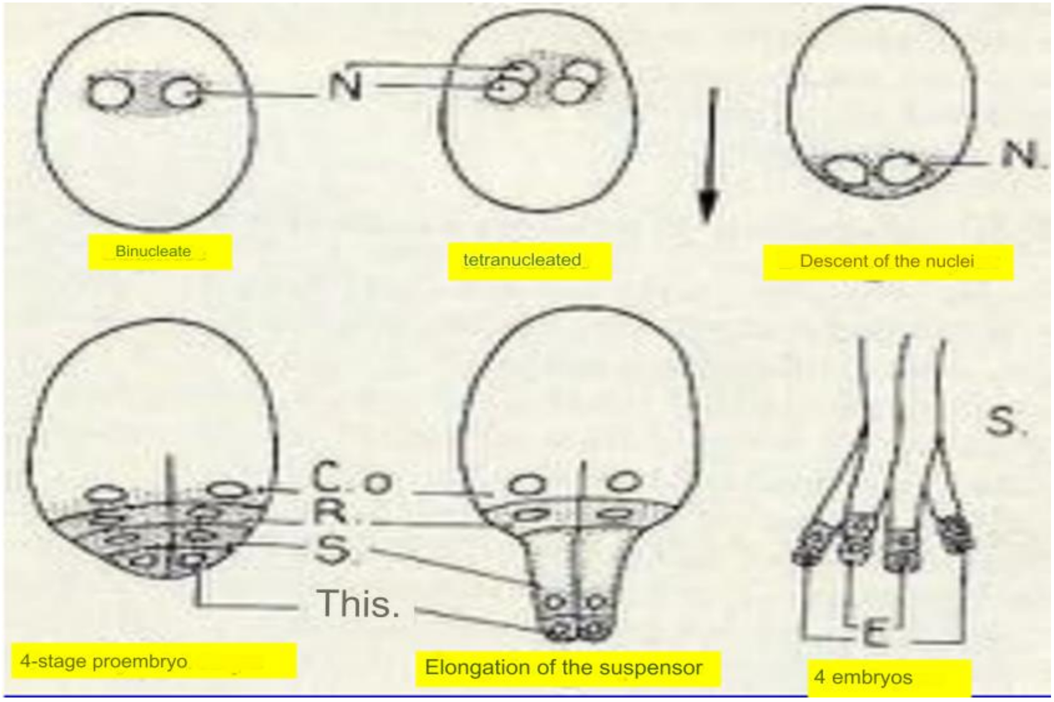


Fig. 22: Formation of the gymnosperm embryo.

The latter can remain dormant for years. It will only germinate if it finds suitable conditions (humidity). The seed of gymnosperms is naked; it is not enclosed in a fruit. The cone is not a fruit.

III.5. Systematics

Within Gymnosperms, two main classes are divided.

- The class ***Bennettitinae,*** which is only fossil.
- The **Conifer class,** still widely represented in the current flora.

Gymnosperms evolved from Prespermaphytes but their origin is twofold: ***Bennetettitines*** are thought to be derived from pteridosperms , while Conifers are thought to be derived from ***Cordaites***.

Bennetettitines are entirely fossil, while conifers, synonymous with "resinous", generally cover the botanical group of Gymnosperms, currently represented by about 560 living species. For this reason, we will only study conifers in the following pages.

III.5.1. Class of *Bennetettitinae*

This fossil group appeared in the Triassic, reached its peak in the Upper Jurassic and Lower Cretaceous, and became extinct in the Upper Cretaceous. The *Bennettitinae* form an intermediate group between the Prephanerogams and the Conifers (fig. 23), in fact they are zoîdogamous like the Prephanerogams, they have true seeds, like the Conifers, and in addition their reproductive apparatus mimics the flowers of the Angiosperms.

The group includes only one order, that of the ***Bennettitales*** among which we can cite the genus ***Bennettites,*** the genus ***Williamsonia*** and the genus ***Williamsoniella***.

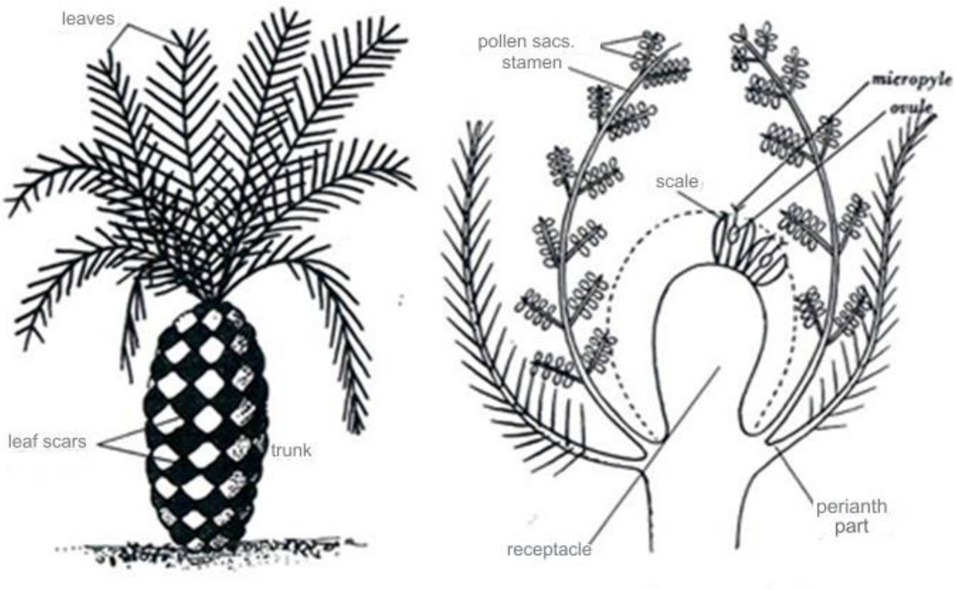


Fig. 23: Bennetettitines (left: *Bennettitale* foot and right: cross section of a hermaphrodite *Bennettitale* flower).

III.5.2. Class of conifers (*Coniferopsida* or *Pinopsida*)

Conifers represent the current gymnosperms producing true seeds. Most are evergreen trees or shrubs (except ***Larix decidua***; larch or ***Taxodium distichum***, bald cypress) which can be very large (***Sequoia- dendron gigantea***). Some are small bushes (***Juniperus***). The shape of conifers is characteristic in cone form comes from the Latin (" conus " = cone and " fero " = I carry) or in pyramid form (fig. 24). In general, the branches bear true leaves: the euphylls with a simple and wide blade in ***Podocarpus*** and ***Agathis***, in needles (acicular) or in scales (squamiform). Their reproductive apparatus is in the form of cones: strobili sometimes grouped in catkins in pine (fig. 25) and pollination is anemophilous.

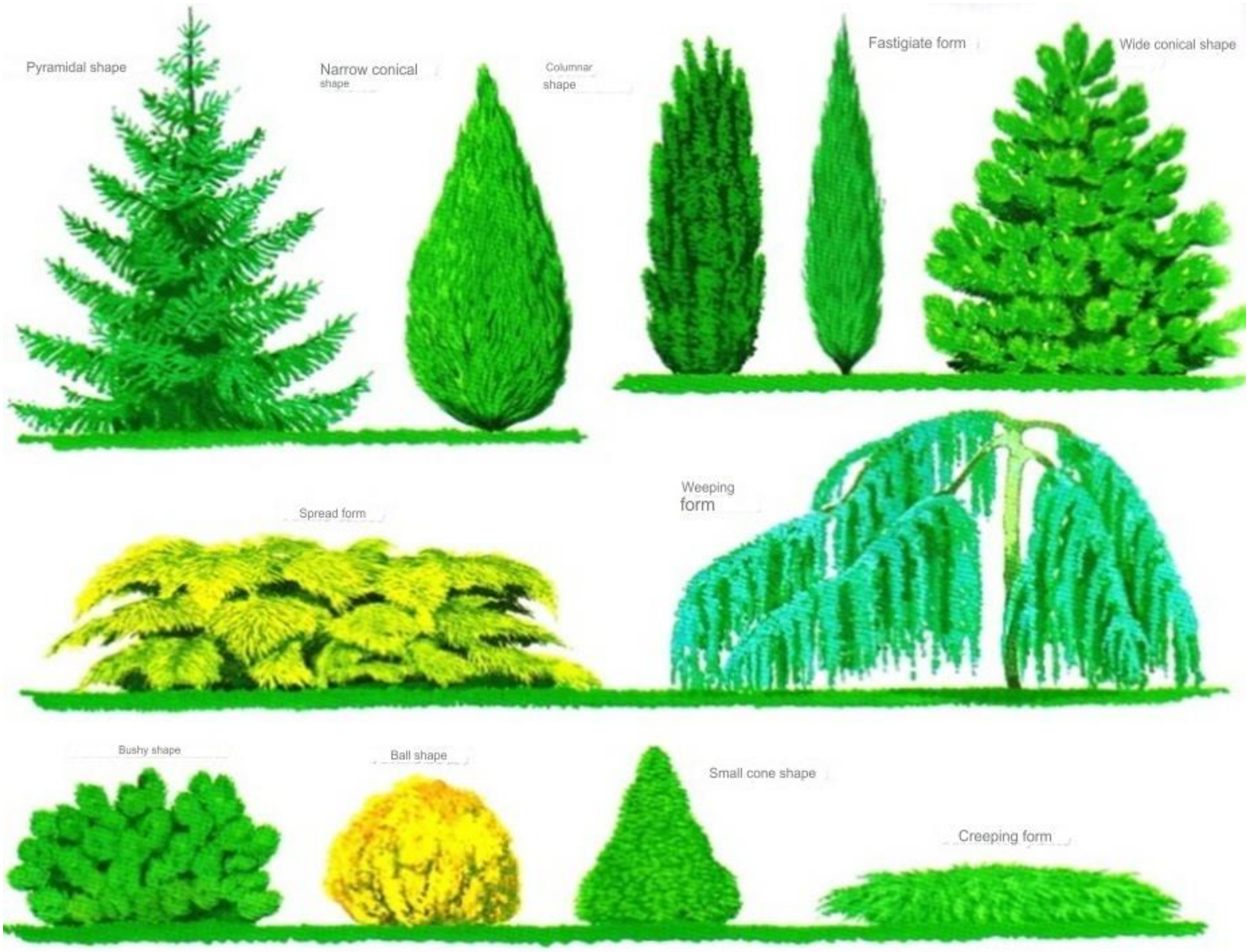


Fig. 24: The different shapes of coniferous trees.

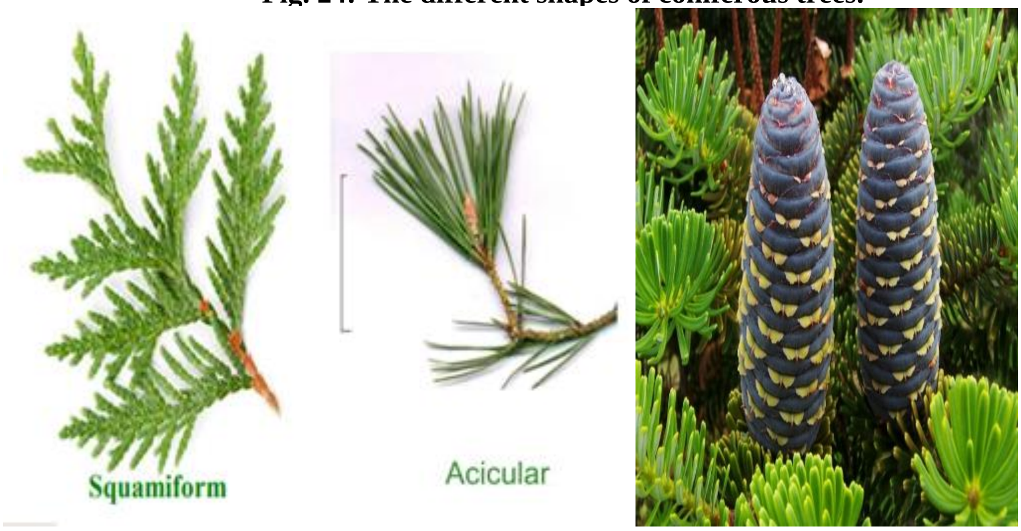


Fig. 25: The different shapes of conifer leaves and cones.

The class of conifers or also called Pinophytes (***Coniferopsida*** or ***Pinospsida***) divided into 05 Orders (Tab.3).

1. **Order of the *Pinales***
2. **Order of *Araucariales***
3. **Order of *Podocarpales***
4. **Order of *Cupressales***
5. **Order of the *Taxales***

Table.4: Systematics of taxa represented in Algeria

Order	Family	Gender	Species
Pinales	***Pinaceae***	***Pinus* (Pin)**	***Pinus halepensis*** ***Pinus pinaster*** ***Pinus clusiana*** ***Pinus nigra***
		Cedrus (Cedar)	***Cedrus atlantica***
		Latrix (larches)	
		Abies (Fir)	***Abies numidica***
		Picea (Epicéa)	
Araucariales	***Araucariaceae***	***Araucaria***	
		Agathis	
Podocarpales	***Podocarpaceae***		
Cupressales	***Taxodiaceae***	***Sequoidendron***	
	Cupressaceae	***Callitris***	**Callitris articulata**
		Juniperus	***J. oxycedrus*** ***J. communis*** ***J. phoenica*** ***J. thurifera*** ***J. sabina***
		Cupressus	***Cupressus dupreziena***
			Cupressus sempervirens
Taxales	***Taxaceae***	***Taxus (Yew)***	***Taxus baccata***

III.5.2.1 Order of *Pinales* or *Abietales*

This order includes only one family " ***Pinaceae*** *or* ***Abietaceae*** ". They have been known since the Jurassic and group 9 genera, 4 of which are represented in Algeria.

➢ **Family *Pinaceae* (or *Abietaceae*):**

It is a very important family currently with 9 genera and 210 species of trees located in different regions of the world. These trees are limited to the Northern Hemisphere; they are one of the most important timber resources.

- These are large trees, shrubs or bushes
- The branches are of 3 types: long, short and dwarf, where the different genera are characterized by one, both or all three types.
- All genera are monoecious.
- Evergreen foliage (with some exceptions) and of two types: scales and needles.
- The male reproductive organs are grouped together in the form of kittens.
- Existence of two pollen sacs and two ovules per scale
- Air-balloon pollen
- Resin plants
- The most common genera are: ***Pinus, Cedrus, Abies, Larix.***

➢ **Reproduction of Pinophytes**

The sexual organs of Conifers are grouped into unisexual cones, either male or female, generally carried by the same sporophyte (monoecious species).

***Male cones** are generally numerous, small (5 mm in diameter), sometimes globular or most often elongated. They can reach about twenty centimeters, located at the end of young branches on the tree and only live for one season. They are formed of a variable number of scales, however, from 2 to 8 pollen sac on their lower face (fig.26).

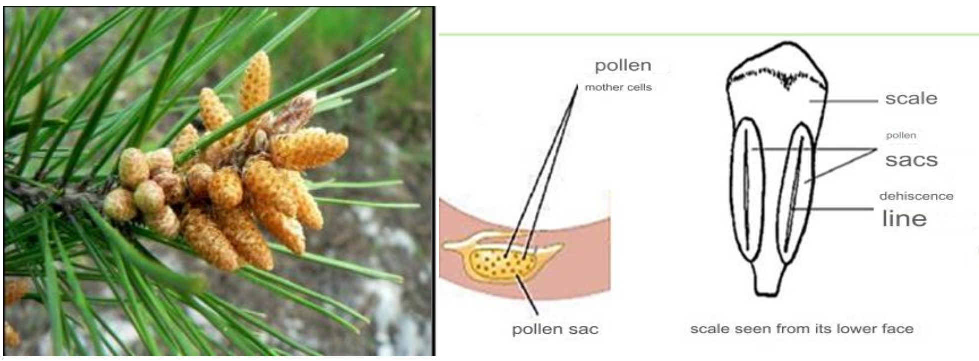


Fig. 26: Male cone of conifers

*__Female cones__ are few in number, elongated ovoid, often quite large. They measure between 10 and 20 cm, located at the base of the branches and can remain on the tree for several years. They are also formed of a very variable number of scales bearing on their upper surface, most often two ovules, sometimes only one, sometimes more than two(fig.27).

Fig. 27: Female cone of conifers.

(a. left young female cone; b. first- year cone; c. multi-year female cone.

The female cones are also formed of a very variable number of ovuliferous scales bearing on their upper surface, most often two ovules, sometimes only one, sometimes more than 2. The micropyle of the ovules is located on the side of the axis of the cone (fig. 28).

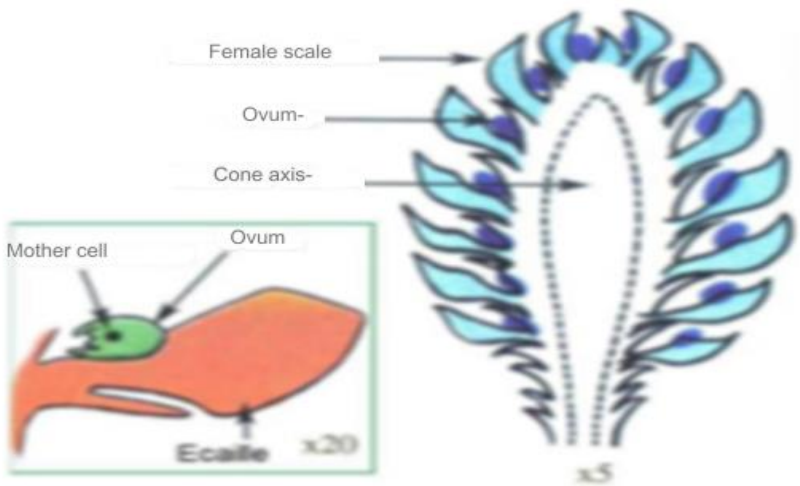


Fig. 28: Longitudinal section of an ovule.

- **Development cycle of conifers**

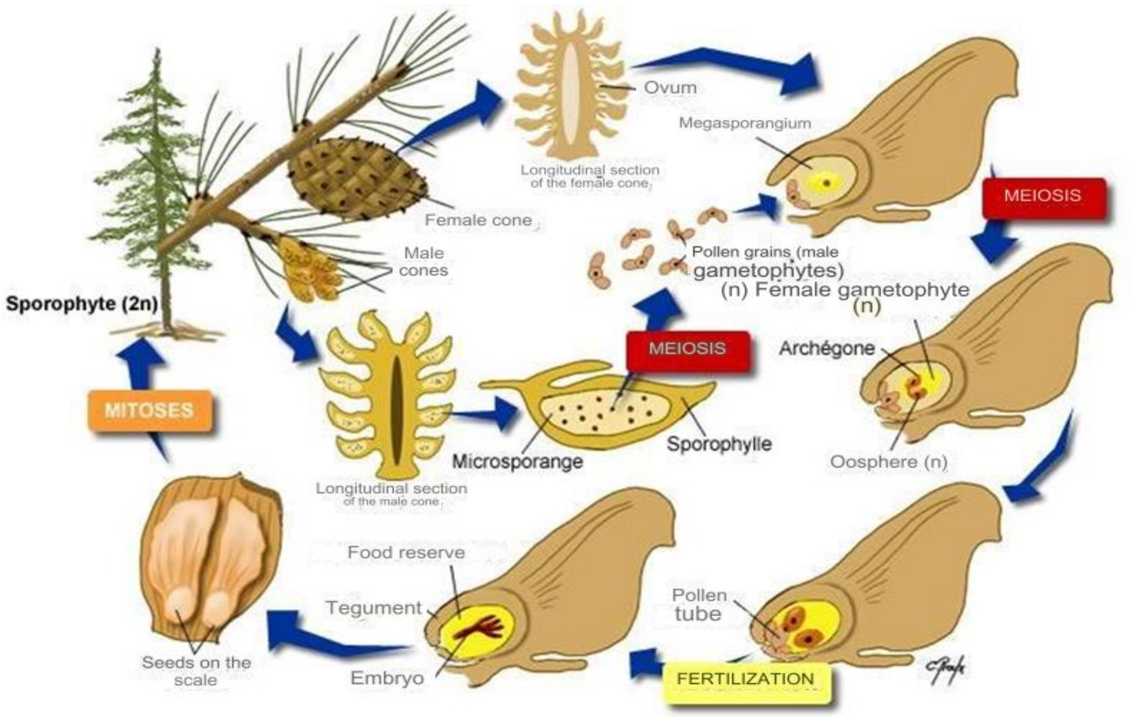


Fig. 29 : ***Pinophyta*** **Reproduction Cycle.**

Tab.5. Detail of Pollination fertilization in conifers.

Pollinisation - fertilization : SLOW

First year + 1month	**4megaspores (-3)**
+3 Month	**Pollen germination**
+7 Month	**Fertilization of the megaspore**
2nd year	**11 mitotic divisions 2000 free nuclei** **Formation of the integuments of the megagametophyte archegonia (2,3…)**
3rd Year	**Seed dispersal**

a) Genus *Pinus*

- **Aleppo pine (*Pinus halepensis*)**

This is the most important genus in the ***Abietaceae.*** It includes 150 forest species almost all located in the Northern Hemisphere. The leaves united by R2, R3, R5 (fig.30).

Fig. 30: Tree and reproductive organs of *Pinus halepensis*.

b) Genus *Cedrus*

➢ Atlas Cedar (*Cedrus atlantica*)

Cedars are trees of high mountains (over 900 m): Only one Algerian species: The Atlas Cedar (***Cedrus atlantica*** or ***Cedrus lebanotis ssp. atlantica***): Common on the Chréa, Djurdjura, Ouarsenis and Belezma mountains in the Aurès. Can reach a height of 30 to 40 meters. Its longevity is significant (500-600 years, sometimes much more in favorable conditions). Possessing numerous needle-like leaves grouped in a slightly prickly rosette. The ovoid female cone measures 6 to 11 cm (fig. 31)

Fig. 31: Genus *Cedrus atlantica.*

C) **Genus *Abies***

There are about 60 species of Fir trees in cold temperate climates. Only one Algerian species:

- **Numidian Fir (*Abies numidica*)**

It is a North African endemic species. In Algeria, it is found in the Babors and Tababors mountains in the east of the country towards Kherrata. It is an evergreen tree that can reach 25 meters in height. The dense branches extend horizontally from the trunk and form a conical crown. The leaves are needle-shaped, dark green, 15 to 20 millimeters in size. The cones, cylindrical, 15 to 20 centimeters long and 3.5 to 5.5 centimeters in diameter, are greenish yellow in color. The seeds are 12 to 14 millimeters long (fig. 32 and 33).

Fig. 32: Tree, leaves and male and female cones of *Abies numidica.*

Fig. 33: Comparison of different cones of Pinophytes: a. *Pinus*; b. *Cedar;* c. *Abies*.

d) Genus *Larix*

- **Common Larch (*Larix decidua*)** or European **Larch.**

The tree reaches a height of between 30 and 40 meters. The only conifers in Europe that lose their needles in winter. The deciduous leaves are not very leathery, inserted in a rosette on the short branches or singly on the long branches. They are concentrated in tufts composed of 35 to 40 needles along the branches. The male cones are numerous, small and yellowish. The female cones, bright pink when young, are brown when mature, relatively small (20 to 35 mm), ovoid in shape, in an upright position, with thin scales (fig. 34).

Fig. 34: Tree, leaves and female cones of the genus *Latrix*.

III.5.2.2. Order of *Araucariales*

This order includes only one family; that of ***Araucariacea***, grouped into 2 living genera (***Araucaria, Agathis***), located in the southern hemisphere. These are trees with needle-shaped or awl-shaped leaves (Spear-shaped) in the genus ***Araucaria*** with stepped ramifications or with a wide blade in the genus ***Agathis***. Their wood is formed of areolate tracheids whose punctuations are contiguous, with a polygonal outline (fig.35 and 36)

The genus ***Araucaria*** includes 16 species occupying South America and Australia provide good wood. In Algeria, 2 species of this genus are used as ornamental trees: ***Araucaria excelsa*** and ***Araucaria bidwillii***. While the genus ***Agathis*** includes 20 species from South Asia and New Zealand. Provide resin for the manufacture of varnishes.

a b

Fig. 35: Genus *Araucaria* (a. the tree; b. the female cone).

a b

Fig. 36: Genus *Agathis* (a. The tree; b. The female cone).

III.5.2.3. Order of *Podocarpales*

This order includes only one family, that of the ***Podocarpaceae*** (Southern Hemisphere). These are trees bearing leaves with a broad or reduced blade depending on the species. The sometimes very loose female cones bear ovules each provided with an outgrowth which during the maturation of the seed becomes fleshy.

The genus ***Podocarpus*** is the largest genus. It has between 82 and 100 species, found mainly in South America and Indonesia. The second is the genus ***Dacrydium*** (21 species), also very diverse in Indonesia.

III.5.2.4. Order of *Cupressales*

This order includes 2 families: ***Cupressaceae*** and ***Taxodiaceae***

The leaves are squamiform or awl-shaped. The male cones in catkins and female cones are small. In some genera, the scales become concrescent and completely enveloping. This forms a galbule (a kind of berry fruit). The seeds are unalloyed.

- Family ***Cupressaceae*** also called ***Cupressineae***

It corresponds to the largest family of conifers or resinous trees and which have resistant leaves. The content of this family has changed a lot between the classical classification and the phylogenetic classification. The family, which includes cypresses, is referenced among the emitters of allergenic pollens according to the National Aerobiological Surveillance Network. It contains 5 main genera.

- Genus ***Cupressus***.
- Genus ***Juniperus.***
- Genus ***Thuya.***
- Genus ***Tetraclinis***.
- Genus ***Biota.***

a) **Genus *Cupressus***

Used as a windbreak. There are two subspecies:

****Cupressus evergreen*** **ssp**. ***fastigiata*** (slender form) and

****Cupressus sempervirens*** **ssp. *horizontalis*** (Horizontal form).

Cypresses are native to warm temperate regions of the northern hemisphere. The number of species included in this genus varies according to authors from 16 to 31 or more. Many species are cultivated as ornamental trees (fig. 37).

These are bushy trees or shrubs evergreen (persistent foliage), which can reach a height of 5 to 40 meters. Their roots are lignified, which allows it to remain stable despite its large size.

The leaves are in the form of triangular scales 2 to 6 mm long, arranged in opposite-decussate pairs completely covering the branches. The male and female inflorescences are in the form of globose cones either staminate or pistillate. The globose or ovoid female cones, 8 to 40 mm long, are formed of 4 to 14 scales also arranged in opposite-decussate pairs. The seeds are small, measuring 4 to 7 mm long. They have two wings, on either side of the seed.

Fig: 37: *Cupressus sempervirens* (a. The Cupressus tree; b. Female cones of Cupressus).

The Cypress of Tassili (***Cupressus dupreziana***): It is endemic to the Tassili region. It is an endangered species and protected in the Tassili National Park (fig. 38). It has a regeneration problem (often sterile seeds).

Fig. 38: *Cupressus dupreziana*.

b) Genus *Juniperus* (Junipers)

Juniper (scientific name ***Juniperus***), also called **Poor Man's Pepper**, includes a large number of species, from "rigid" varieties with prickly needles to "flexible" varieties with scale-like foliage. Of American, Asian, African and European origin, this tree reaches 4 to 15 m in height and even 25 to 30 m for some species. It tolerates poor soils, possibly very calcareous, sandy and dry, up to 4,500 m above sea level. Some species of juniper can live more than 1,000 years (fig. 39).

- **Red Juniper (*Juniperus phoenicea*)**

With scale-like leaves, it is a common species in some coastal groups of Zeralda (Mazafran) with ***Quercus coccifera*** (Kermes oak) and in the Saharan Atlas Mountains.

- **Juniper oxycedra** (or Juniper cade) (***Juniperus oxycedrus***)

foliage. Cade oil (gatran) is extracted and is used against skin diseases and wounds of domestic animals.

- **Common juniper (*Juniperus communis*)**

Species with a stunted habit, common in the Djurdjura and Aurès massifs.

- **The juniper sabine (*Juniperus sabina* ssp. *Hemisphaerica*)**

Species found only on the very wet peaks of Djurdjura.

- **The Thuriferous Juniper (Or Wisdom Juniper) (*Juniperus thurifera*)**

It is found in the dry grasslands of the high mountains of the Aurès.

Juniperus phoenicea.

Juniperus oxycedrus.

Juniperus communis.

Juniperus thurifera.

Juniperus sabina.

Fig. 39: The different species of the genus Juniperus.

c) Genus *Tetraclinis*

The Berber Thuja (or false Thuja) (***Tetraclinis articulated***)

Native to North Africa and Southem Europe. The genus ***Tetraclinis*** contains only the species ***Tetraclinis articulata:*** the cones have four scales and the squamiform leaves are inserted in such a way as to present articulations. It sometimes forms pure populations in the gorges of Chiffa, the low mountains of Zaccar and the mountains of Tlemcen on schistose substrate (fig.40).

Fig.40 : The species *Tetraclinis articulated.*

- Family ***Taxodiaceae***

These are often monoecious trees. There are 10 genera among them, the most important of which is:

- **Genus Sequoia: *Sequoia gigantea (or Wellingtonia giganteum)***

Found in the Sierra Nevada in California. Can exceed 115 m in height and 12 m in diameter. This species can live up to 3800 years (fig.41).

- **Genus *Taxodium*: *Taxodium mucronatum***

Tulé tree, in Mexico, 16 m in diameter, 48 m high, more than 2000 years old (fig.42).

Fig. 41: ***Sequoia gigantea.***

Fig. 42: ***Taxodium mucronatum.***

III.5.2.5. Order of the *Taxales*

This order considered as a class while it is monotypic (with a single family) includes the family ***Taxaceae***.

Pyramidal tree or shrub, with linear, scattered leaves, spread over 2 opposite rows. Succulent fruit, red when ripe with one seed. Male catkins with 6-15 stamens surrounded by peltate scales, sub-globose and yellowish. Solitary female flowers with some imbricated, green scales.

There are 4 genera and 13 species in this family. The most important genus is the genus ***Taxus.***

- **Genus Yew (*Taxus baccata*)**

This species exists sporadically in the cold humid stage (Djurdjura, Chréa, Tlemcen Mountains). It is a shrub or tree (10-15m) with a very long life (1500-2000 years). It is dioecious. The leaves are flattened linear, 2-3cm in 2 rows, dark green, they do not have resin secretory canals (except in exceptional cases). The female cone with isolated ovules has a single black seed whose integument is surrounded at maturity by a fleshy outgrowth (aril) (Evolutionary character) (fig. 43).

The species provides excellent wood, it contains an alkaloid: Taxine (mixture of alkaloids or pseudo-alkaloids).

Fig.43: *Taxus baccata.*

Chapter IV. Gnetophytes or chlamydosperms or Anthophytes

Gnetophytes exhibit both gymnosperm characters (seeds not enclosed in a fruit) and angiosperm characters (double fertilization, reduced floral structures and vessels). Phylogenetic analyses based on morpho-anatomical characters place Gnetophytes as a sister group to Angiosperms (sharing floral characters and acquisition of double fertilization) hence the name Anthophytes (anthos: flower)

IV.1. Vegetative apparatus

These are woody plants, without dioecious resin canals (rarely monoecious). The leaves are simple, sometimes very reduced, opposite or whorled (fig. 44). The wood is structured by tracheids, vessels (cells very adapted to the transport of raw sap) and woody parenchyma (support and/or reserve tissue), in which case we speak of heteroxylated wood.

Fig.44: The general appearance of Gnetophytes.

IV.2. Reproductive system

Pollination is either anemophilous or entomophilous through the production of nectar. They resemble reduced flowers (pseudo-flowers) grouped in spikes or catkins or sometimes in cones. Female pseudoflowers have a single straight ovule (fig. 45). The male pseudoflowers are reduced to stamens with a filament. The seeds are surrounded by fleshy envelopes. These are not completely closed so we do not speak of fruits.

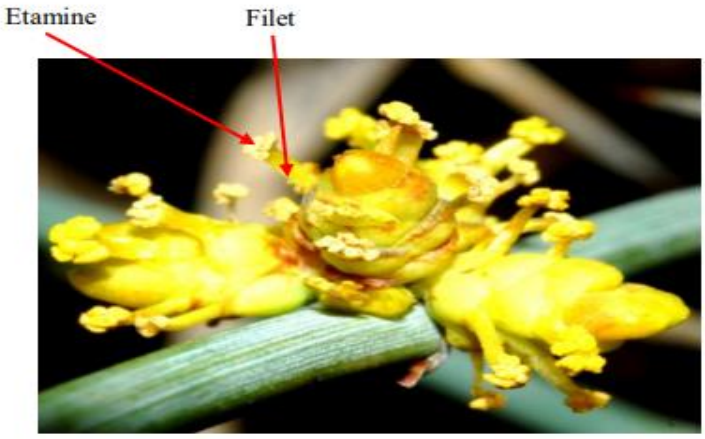


Fig. 45: The reproductive organs of Gnetophytes.
(a. Female pseudo-flowers; b. Male pseudo-flowers).

In Gymnosperms, the ovule is naked. It is located on a scale, except in Gnetophytes; an envelope open at its end protects the ovules which evokes the wall of an ovary of angiosperms hence the name Chlamydosperms (klamys: coat and sperma: seed) or Saccovulae.

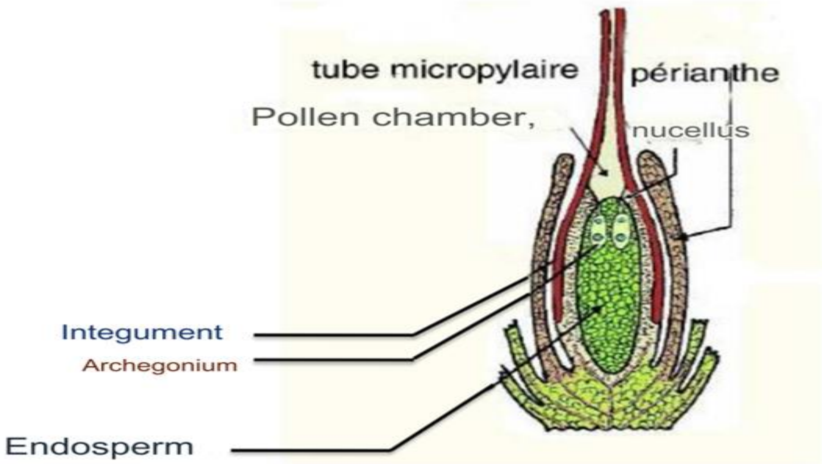


Fig. 46. Structure of the ovule in Gnetophytes.

IV.3. Reproduction

- The reproductive cycle is the same as in conifers.
- Transport of male gametes through the pollen tube (siphonogamy).
- The difference between Coniferophytes and Gnetophytes is:

*In Coniferophytes, two male gametes are released but only one achieves fertilization and the other degenerates.

*In Gnetophytes, the two male gametes carry out fertilization (double fertilization), one fusing with the oosphere, and the other with a cell of the endosperm, resulting in the formation of two embryos of which only one develops.

IV.4. Systematic

The Gnetophytes have a single class ***Gnetopsida*** comprising 3 orders: These orders have an unknown origin and the class only appeared in the Tertiary (65 million years ago)

IV. 4.1. Order *Gnetales*: represented by a single family ***Gnetaceae*** and a single **genus *Gnetum*** (30 species) generally found in the humid tropical regions of South East Asia. This genus is represented by lianas and some tree species with long and short branches with two kinds of leaves: scale leaves and limited leaves very developed to those of dicotyledons. Their reproductive organs are inflorescences arranged in whorls. The plants are dioecious. The seeds are surrounded by a fleshy external envelope (yellow, pink or red).

- **Species: *Gnetum africanum***

Fig. 47: Reproductive organs and seed of *Gnetum africanum.*
(left: male inflorescence, middle: female inflorescence and right: seed).

IV.4.2. Order *Ephedrales*: they only include one family: ***Ephedraceae*** and only one genus ***Ephedra*** and 35 species. Represented by 04 species in Algeria (fig.48).:

♣ ***Ephedra altissima***

♣ ***Ephedra alata***: And the Saharan subspecies: ***Ephedra. alata ssp. alenda.***

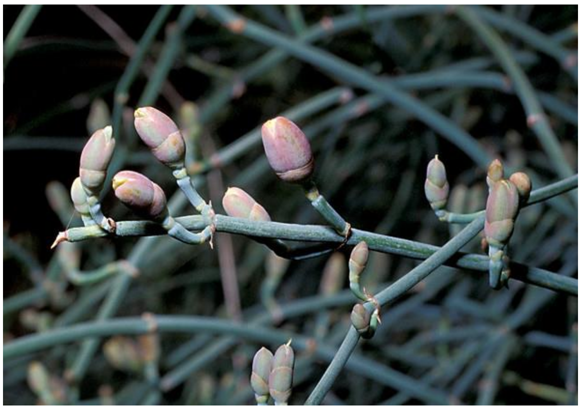
♣ ***Ephedra fragilis.***

➢ ***Ephedra major***.

They are woody plants, generally bushy or lianoid, dioecious or monoecious. The stem that plays the assimilatory role bears reduced leaves that are opposite or whorled. The anatomy of ***Ephedra*** is characteristic with the presence of ephedroid vessels with a widely perforated transverse wall. This type marks the transition from the tracheids of Gymnosperms to the true vessels of angiosperms. The ovules are surrounded by two fused bracts that become fleshy or leathery at maturity. They are found in arid and desert regions, hot or cold.

Ephedra altissima.

Ephedra alata.



Ephedra fragilis.

Ephedra major.

Fig. 48: The different species of the genus *Ephedra* in Algeria.

IV.4.3. Order *Welwitschiales*: Includes a single family: ***Welwitschiaceae*** and a single genus ***Welwitschia*** and a single species ***Welwitschia mirabilis*** (fig.49). This species lives in the desert regions of South Africa (Angola) in extreme desert conditions (no precipitation for 4 to 5 years). Welwitschia ***has*** a short, thick stem that can reach 1m in diameter. Its flattened top bears only 2 opposite leaves that can exceed 3m in length, with parallel venation and basal growth, living 100 years. Male inflorescences Male inflorescences are in spikes and bear "flowers" with six stamens, each with three locules. The female flowers, arranged in a cone, have a wing and an ovule with a tubular micropyle. The seeds are surrounded by a membranous and winged envelope.

Fig. 49: ***Welwitschia mirabilis.***

Chapter V: The Angiosperms

The name angiosperms (from the Greek aggeion: box and sperma: seed) appeared in the lower crustacean (secondary), 130 million years ago, currently represent the vast majority of terrestrial plants (200,000 to 250,000 species) grouped into 400 to 500 families and whose morphology is very variable (herbaceous, woody shrubs, arborescent ...) with several biological types: annuals, biennials or perennials. They inhabit the most varied places: all altitudes, aquatic environments (floating or anchored in the bottom of the water), all climates, the driest environments.

These are organizations:

- **Tracheophytes**: angiosperms are vascular plants, provided with conducting vessels.
- **Phanerogams**: provided with visible reproductive organs,
- **Cormophytes**: their vegetative apparatus, made up of a leafy stem and roots, is a true corm.
- **Flowering plants:** they carry out sexual reproduction through flowers of this group, called flowering plants.
- **Spermatophytes:** Just like gymnosperms, Angiosperms are spermatophytes because they have ovules.
- **Autotrophic or parasitic**. They are distinguished by:
    - Protection of the offspring by enclosing the ovule in the ovary, therefore ensures protection of the seed in the fruit.
    - The phenomenon of double fertilization with production of an embryo and a reserve tissue, the albumen
    - The reproductive organs are grouped into a single structure “the Flower”.

V.1. Morphological characteristics

Essentially, Angiosperms are distinguished from Gymnosperms by the following three characteristics:

- A typical flower consisting of a perianth surrounding sexual organs. Flowers can be unisexual but are most often hermaphroditic (in 90% of Angiosperms).
- An ovule, protected in a closed carpel or ovary hence the name Angiosperm, which after fertilization the ovule transforms into a seed and the ovary into a fruit.
- The female gametophyte, located in the ovule and called the embryo sac, is the site of a double fertilization, one at the origin of the embryo, the other forming the albumen, the reserve tissue of the seeds.

- The presence of heteroxyl wood (conductive vessels + fibers + parenchyma).
- A phloem with sieve tubes and companion cells.

V.1.1. Vegetative apparatus of angiosperms

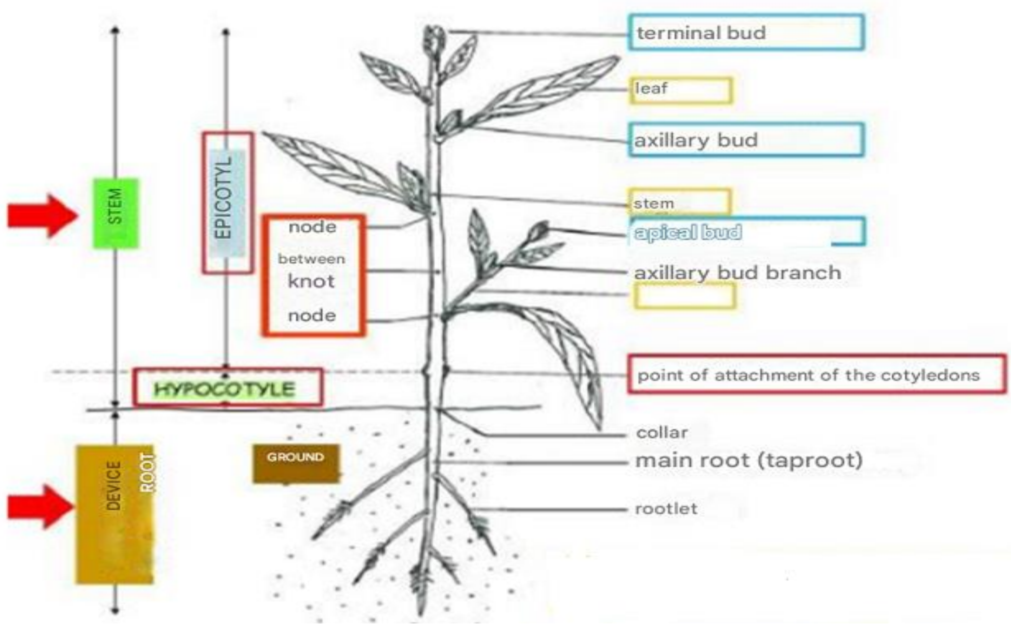


Fig. 50 : General organization of the vegetative apparatus of herbaceous angiosperms.

From an external morphological point of view, angiosperms are typical plants made up of 3 different groups of organs (fig. 50): root, stem and leaf (typical Cormus).

The great capacity for adaptation that angiosperms have shown since their appearance is reflected in a notable morphological diversity of their vegetative apparatus. However, these modifications are clearly more numerous and more spectacular for the cauline and foliar system than the root system.

V.1.1.1 The root

First, they allow water, mineral salts and nitrogenous nutrients to be pumped from the soil, and they also play a role in anchoring and supporting the plant. In some cases, various functions appear: respiratory (white mangrove), carbohydrate reserves (Daucus), etc.

There are several types of roots depending on the type and ecology of the plant (fig. 51):

* Taproot
* Fascicled root
* Tuberous Root

* Cauline or adventitious root

Fasciculated **Cauline** **Tuberculous** **Swivel**

Fig. 51: Root types.

V.1.1.2. The stem

The stem can be considered as a juxtaposition of articles at the end of which the leaves or flowers are born. It first has a role of support for the fundamental organs of nutrition (leaves) or reproduction (flowers).

The stems are characterized by the presence of nodes and internodes. These are those of higher plants (vascular plants) which house the networks of sap-conducting vessels. These ensure:

* The distribution of water and mineral salts essential for feeding the plant (raw sap);

* And direct the products of photosynthesis (processed sap) towards the reserve organs.

There are two types of stems:

A/ Aerial stems

They are formed of an erect axis whose end bears a terminal bud. The junction of the stem with the root is made at the collar. The leaves are inserted at the nodes, themselves separated by the internodes.

The stem is simple or branched; the branches then develop from the axillary buds located in the axils of the leaves. We distinguish herbaceous stems, thin and flexible, and woody stems, generally more robust. They are characterized by vertical growth for the main axis and by oblique growth for the ramifications

Among these plants, we distinguish (fig. 52):

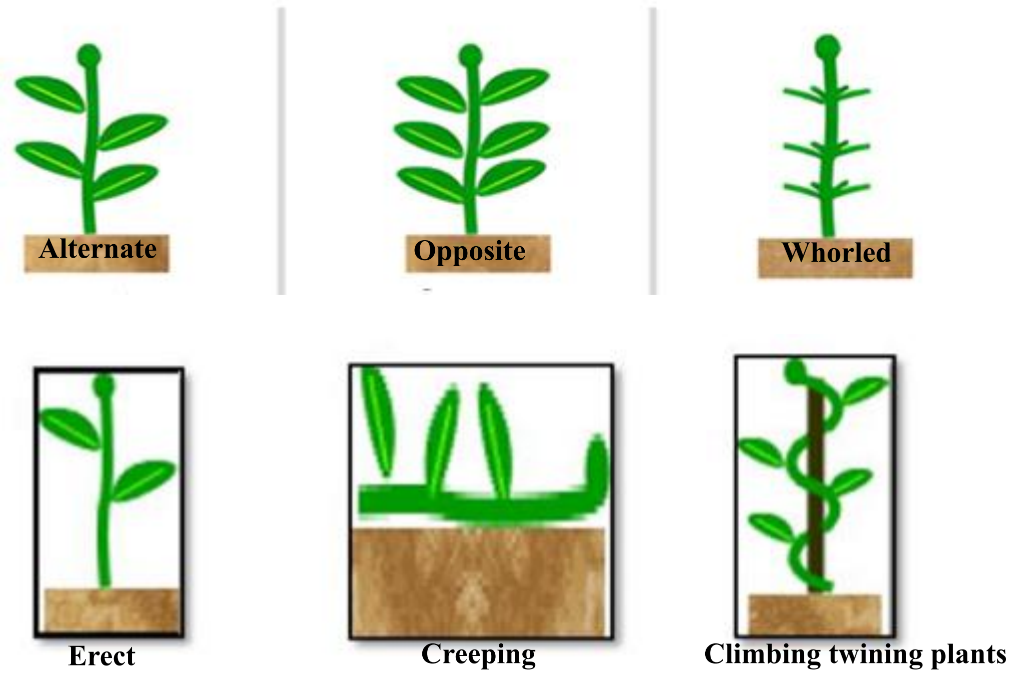


Fig. 52 : Type of aerial stems.

The stems generally have a circular section (figure 4), in some cases, this can be: Triangular - quadrangular - pentagonal… (fig. 53). The outline can be regular but also have a particular relief: grooved stem; winged stem.

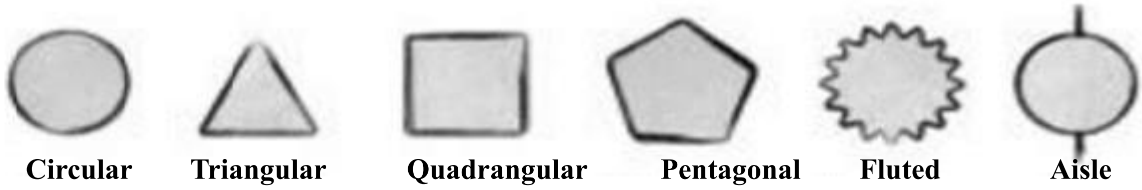


Fig. 53 : Different sections and outline of aerial stems.

B / Underground stems

They are characterized by the presence of nodes and by their role as reserve organs. We distinguish: Rhizomes, tubers and bulbs (fig. 54).

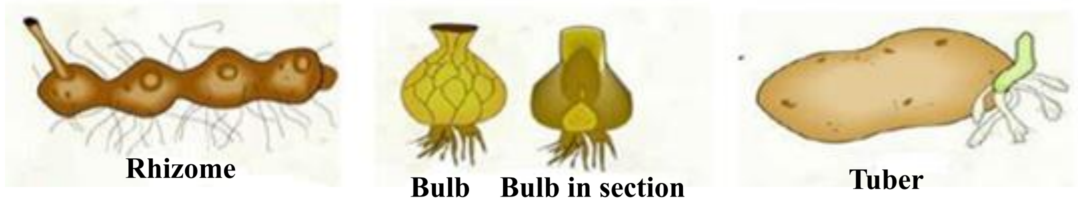


Fig. 54 : Type of underground stems

V.1.1.3. The sheet

These are flattened organs with bilateral symmetry, one of whose faces is called the upper or ventral face while the other face is called the lower or dorsal face. Its main role is to carry out photosynthesis and cellular respiration. Depending on their lifespan, we distinguish:

*Deciduous plants

*Evergreen plants

A complete sheet has three parts:

- The limb (where the veins run)
- The petiole (intermediate between the stem and the blade)
- Stipules are frequently observed on either side of the insertion of the petiole on the stem.

A / Types of leaves

From fig. 55, there are two types of leaves: simple leaf and compound leaf.

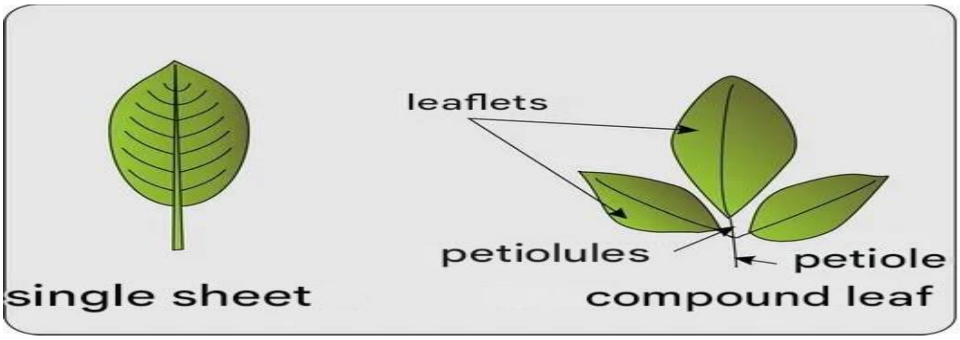
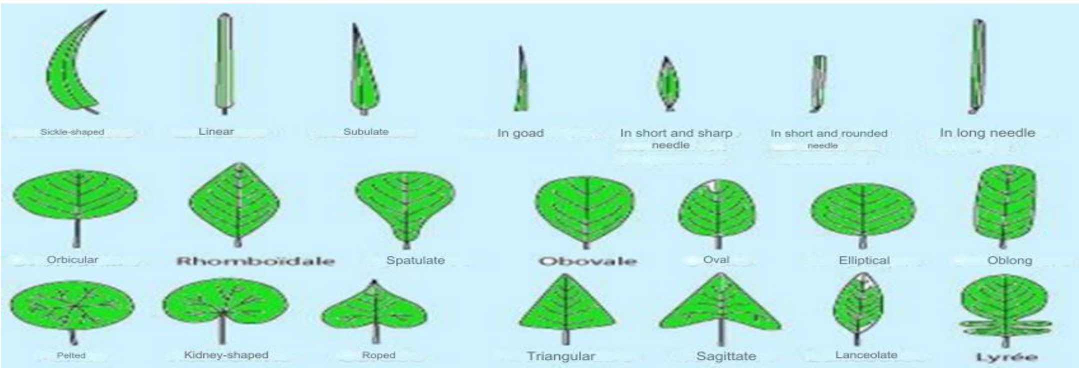


Fig. 55 : The two types of leaves

B/ different forms of limb

In Fig. 56, are presented the different shapes of the limbus



. **Fig. 56 : The different types of limbus**

C/ Different leaf shapes

Fig. 57, shows the different leaf shapes.

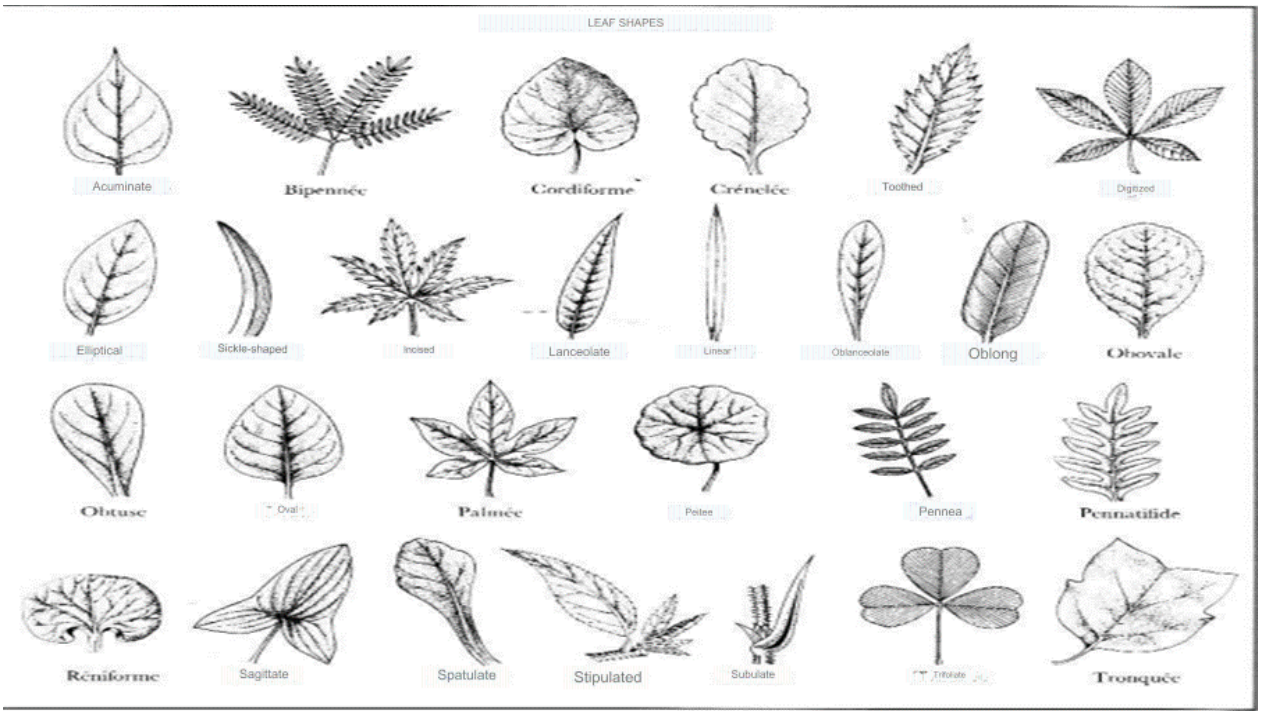


Fig. 57: The different shapes of leaves

D/ Different types of ribs

Fig. 58, shows the different types of ribs.

Fig. 58 : The different types of ribs

V.1.1.4. Phyllotaxis in angiosperms

This is the arrangement of the leaves on the stem and can follow different patterns (fig.59).

Fig. 59: The different types of leaf position on the stem.

V.1.2. Reproductive system

Presence of an organ specialized in reproduction: The flower. It is the main characteristic of angiosperms or flowering plants

V.1.2.1. Anatomy of the Flower

The flower comes from the development of a terminal or lateral flower bud. It is carried by a stem (on the swollen end: **the peduncle**), inserted in the axil of a leaf (**the bract**), and the whole is connected to a branch.

The flower is in fact a specialized stem with very short internodes (very highly modified) composed of modified leaves that have become floral parts (**sepals**, **petals**, **stamens** and **pistil**). These floral parts are fixed on the enlarged end or floral receptacle, of an axis called peduncle (fig.60). This receptacle is generally convex, the thalamus (=archaic groups) or successively, in several whorls on a flat or concave receptacle (=cyclic or whorled flowers).

The morphology of flowers is very little modified by the environment, so it is a good taxonomic criterion.

The typical complete Angiosperm flower consists of four whorls (groups of floral parts arranged in a circle) which are, from the outside to the inside:

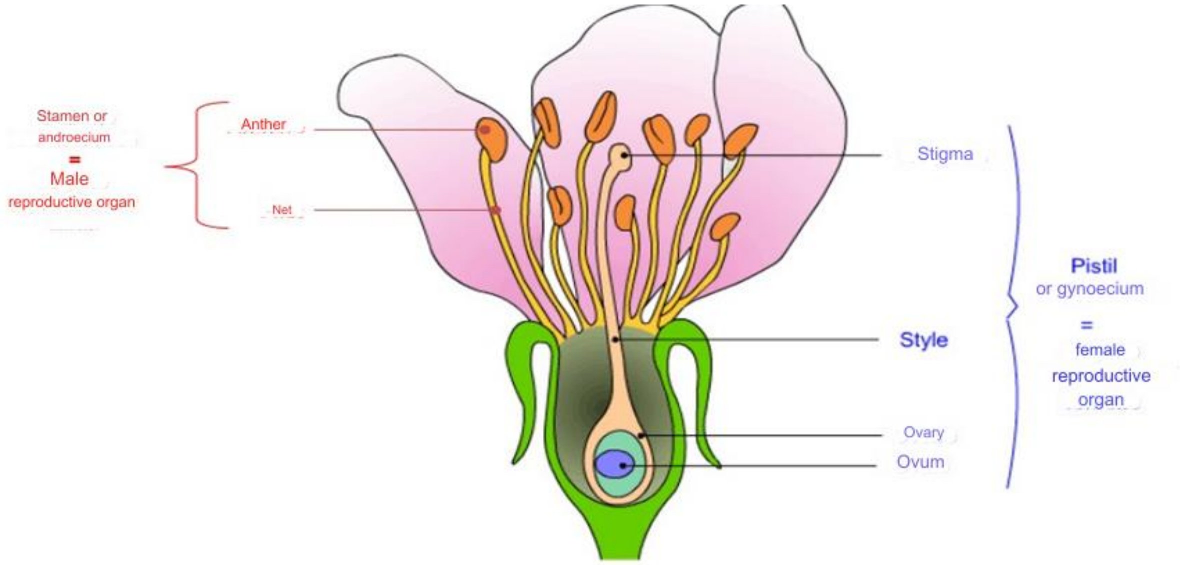


Fig. 60 : Anatomy of a typical flower

A/The calyx: constitutes the first whorl (the external part of the perianth), it is formed by all the sepals (at the base of the flower), often green and thicker than the petals (fig.61). The sepals envelop and protect the flower before hatching (during its development: bud = a closed rose). The calyx thus plays a role in photosynthesis but its main use is to protect the other floral parts.

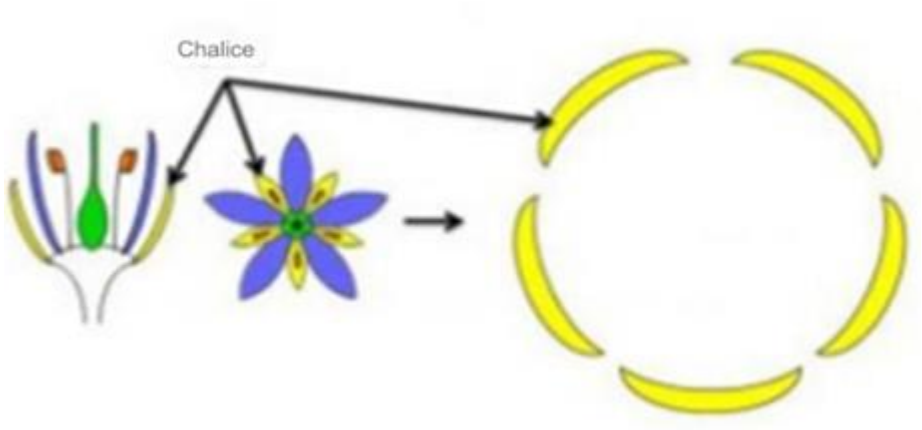


Fig. 61 : The calyx (first whorl).

B/The corolla: represents the second whorl (the internal part of the perianth), formed by all the petals, often brightly colored. They help to attract insects and other pollinators (fig. 62).

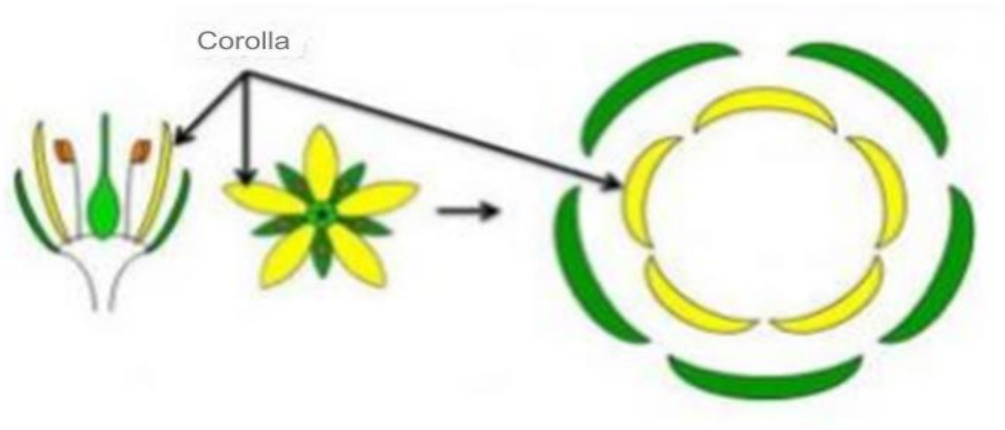


Fig. 62 : The corolla (second whorl).

The calyx and the corolla form the perianth, which is sterile and serves to protect the other floral parts and attract pollinators.

The sepals and petals are sterile parts of the flower that do not play a role in reproduction. When petals and sepals are so similar that they can be confused with each other, they are called tepals (the tulip).

C/The androecium: located in the center of the petals is the third whorl, corresponds to the set of stamens (male reproductive organs). The stamens are composed of a filament surmounted by the anther (fig.63), whose role is to produce pollen grains (male gametes).

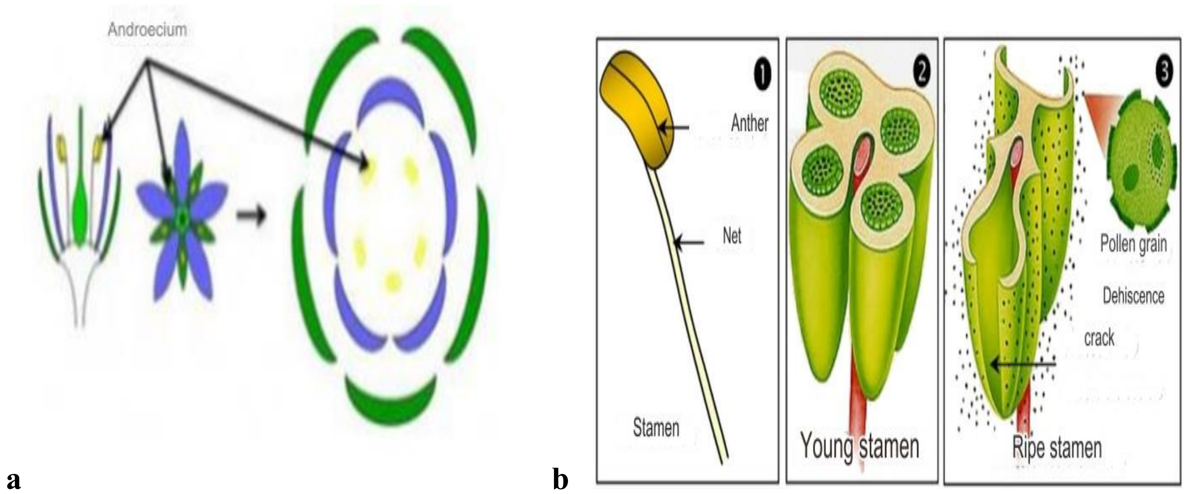
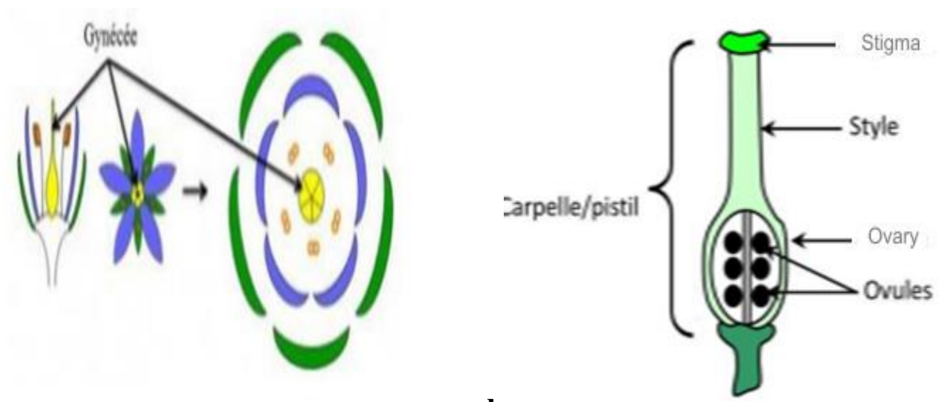


Fig. 63 : The Androecium (a: androecium third whorl. b: Structure of a stamen).

The anther produces pollen, a set of pollen grains which will produce, at the end of their pollen tube, spermatozoa (gametic nuclei); the filament, a sort of stem supporting the anther.

D/The gynoecium or pistil: is the fourth whorl, located in the center of the flower, it is composed of one or more free or fused carpels (female reproductive organ). Each carpel is composed from bottom to top (fig. 64):

- From a swollen and hollow part called **Ovary,** rounded, containing in its cavity or lodge, the ovule **(s).**
- A **style** extending the ovary, a sort of stem (more or less elongated body) supporting the stigma, in which the pollen tube develops during fertilization.
- **From a stigma** covering the style and allowing the pollen to be retained, the stigma, a moist surface with papillae, on which the pollen lands at the time of pollination.

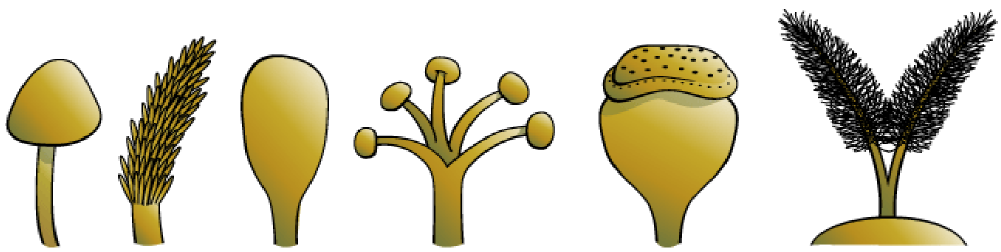


a **b**

Fig. 64 : Gynoecium or pistil

(a: Gynoecium fourth whorl, b: Structure of the carpel).

The style and stigma take different forms (fig. 65)



a b c d e f

Fig. 65 : Styles and stigmata.
(a. capitate, b. linear, c. punctiform, d. discoid, e. papillose, f. feathery).

V.1.2.2 Variation of floral pieces

A/The floral receptacle

It is the terminal part of the axis bearing a flower (floral peduncle). The floral parts are inserted on the receptacle either in a spiral or in circles (whorls) we speak of **cyclic flowers;** if the most external parts are in whorls and the internal ones in a spiral we speak of **hemicyclic flowers** (fig.66).

B/Types of receptacles

The receptacle takes different forms. We can schematically distinguish the receptacle:

(a) **Thalamiflora:** conical or convex in shape

(b) **Caliciflora:** calyx-shaped (concave or cup-shaped)

(c) **Disciflora:** comprising a nectariferous disc

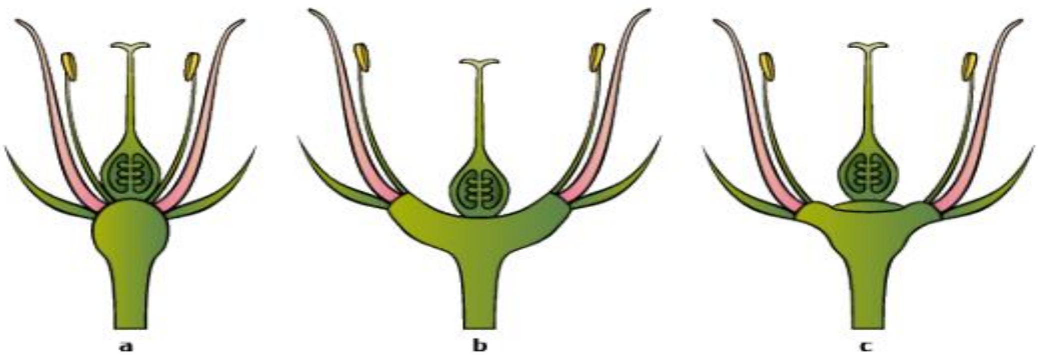


Fig. 66 : Types of receptacles
(a. Thalamiflora, b. Caliciflora, c. Disciflora).
(b.

C/ The perianth

The perianth is composed of the calyx and the corolla. In some flowers, these parts are absent and only the reproductive organs (androecium and/or pistil) remain: we then speak of naked flowers (fig. 67).

(1) **Heterochlamydia**: petals + sepals, when sepals and petals form the perianth

(2) **Homochlamydia**: tepals, when these 2 whorls are difficult to distinguish and they are called tepals, forming the perigone. Found rather in primitive groups.

(3) **Haplochlamydia**: sepals alone, when one of the 2 whorls is caused to disappear. Found rather in primitive groups.

(4) **Achlamydia**: when the perianth is completely absent.

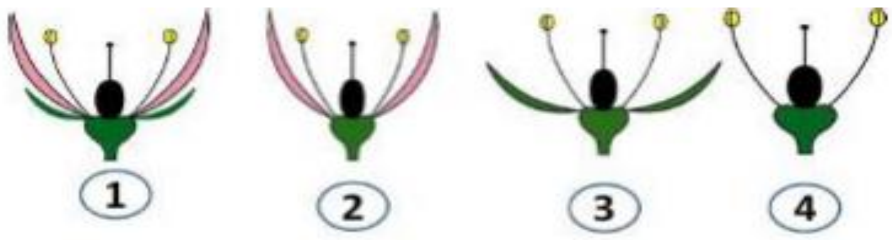


Fig. 67 : Type of perianth.

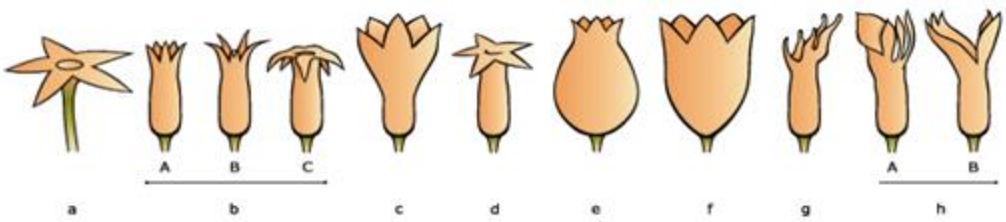
Welding or not of floral parts (sepals and petals)

The floral parts can be free (=dialy) or fused (=syn- or gamo). Gamopetaly is considered an evolution since the animal is then better directed in a tubular flower.

❖ **Relative position of the sepals**

***A dialysepalous calyx** characterizes free sepals.

***A gamosepalous calyx** has sepals fused at the base, forming a more or less long tube (fig. 68).



a-f: actinomorphic calyces g-h: Zygomorphic calyces

a: stellate; b: tubular (A: with erect teeth; B: with spreading teeth; C: with reflexed teeth); c: infundibuliform; d: hypocrateriform; e: urceolate; f: campanulate; g urceolate-bilabiate; h: bilabiate (A: with entire lip and trilobed lower lip; B: with trilobed upper lip and bilobed lower lip)

Fig. 68 : Main types of calyxes

❖ **Relative position of petals**

When the petals are independent, **the corolla is dialypetalous.** They can be attached to each other by their base or welded to other whorls such as the stamens, **the corolla is then gamopetalous** (fig. 69). There are 3 petals per whorl in Monocotyledons and generally 5 in Dicotyledons but different values are not rare (fig.70).

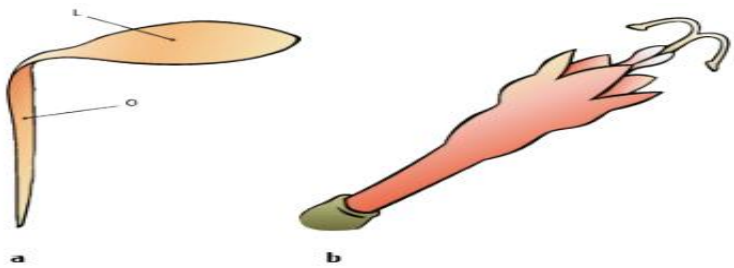


Fig. 69 : Welding of petals: Free petals (a. dialypetalous and fused b. gamosepalous)

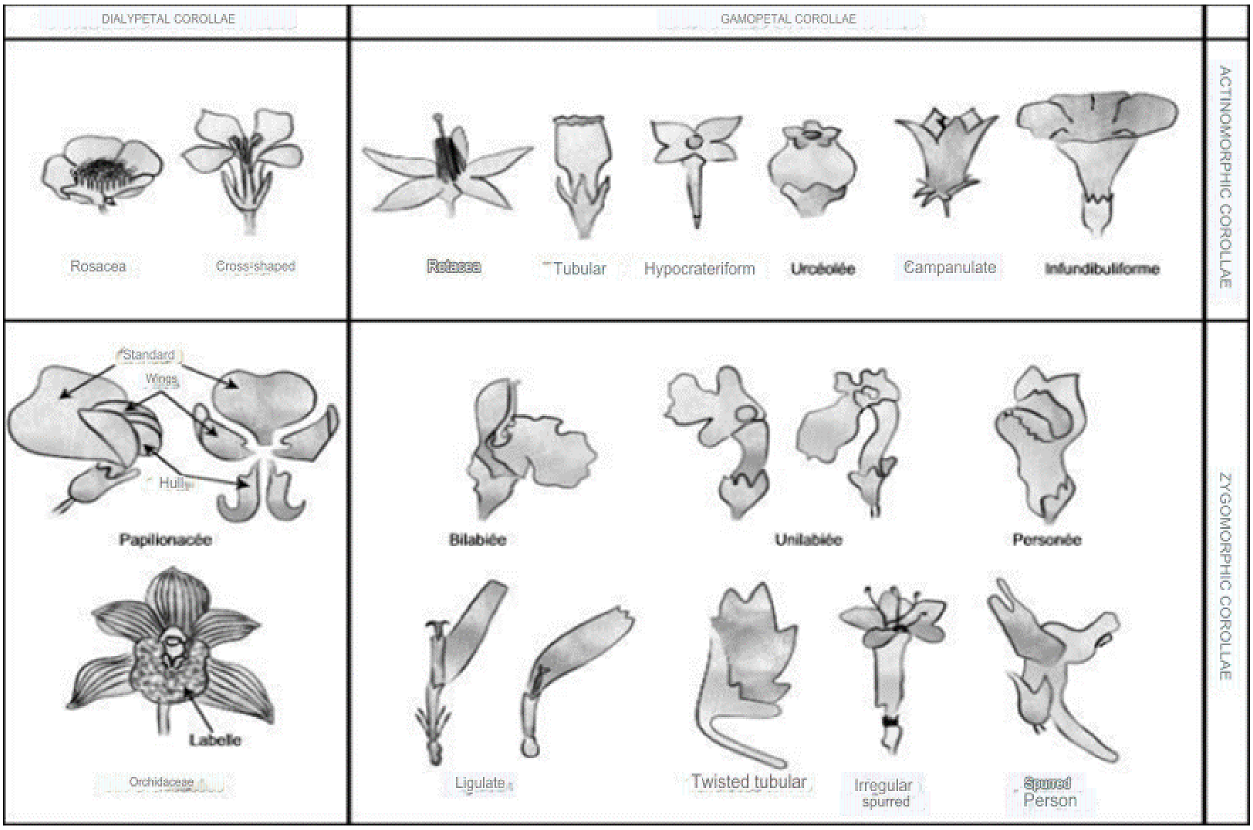


Fig. 70 : Types of corollas.

❖ **Number of floral pieces**

The number of floral pieces per whorl also varies (Fig. 71). Flowers are distinguished

(a)Trimerous or flowers made up of successive whorls of 3 pieces each.

(b)Tetramer

(c) **Pentamer**

(d) Polymer

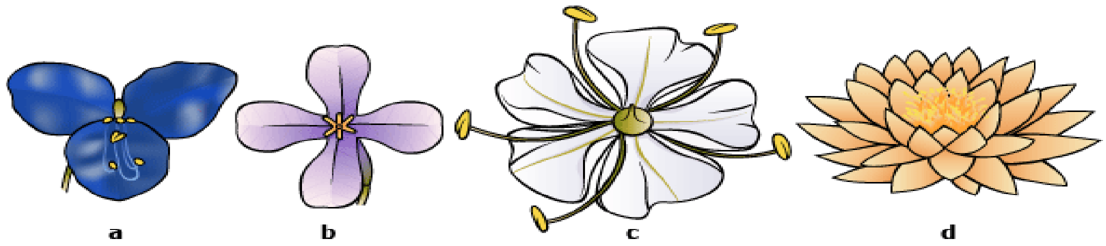


Fig. 71 : Number of floral parts per whorl
(a. trimerous, b. tetramerous, c. pentamerous, d. polymer).

D/ Variation of Androecium

The insertion of the stamens into the receptacle is done in two ways:

*The spiral type

*The whorled type is the most common.

- **Number of stamens**

In the spiral type: the androecium is said

(1) **Polystemone** : the number of stamens is high.

(2) **Diplostemonous:** the stamens are divided into two whorls and the number of stamens in each whorl is equal to that of the pieces in the other whorls.

(3) **Isostemone** : is considered to derive from the previous one by abortion of one of the two whorls.

- **Welding of the stamens**

The stamens can be brought together in bundles (fasciculate stamens), while each keeping an individual filament; in this case, we speak of **polyadelphia** (fig. 72). In some cases, the stamens, then called **monadelphia** , are all welded together by their filament up to a certain height or almost to the top, they form a sort of tube. Sometimes also, we can find on the same flower, a group of welded stamens accompanied by a free stamen; they are then called **diadelphous** (typical case of many families).

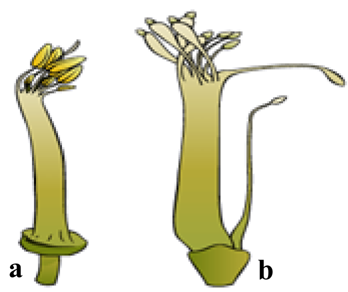


Fig. 72 : Welding of the stamens (a. monadelphus, b. diadelphus).

❖ Anther variation

In the majority of species, the filament is fixed at the base of the anther and the connective is in its extension (fig.73): the anther is said in this case to be innate or **basifixed.** In some cases, the filament is fixed over the entire length of the anther, which is said to be **adnate.** Finally, the connection of the filament can be limited to a point that is often median (**medifixed anther)**, rarely apical (**apicifixed anther**).

Fig. 73 : Position of the anthers.

❖ Release of the pollen grain

Pollen release occurs by dehiscence of the anthers according to different possibilities (fig. 74):

(a) **Longitudinal loculicidal dehiscence:** via a longitudinal slit in the direction of the theca axis.

(b) **Transverse loculicidal dehiscence:** via a slit transverse to the axis of the theca. Rarer case.

(c) **Valvar dehiscence:** opening by small flaps, generally in a lateral position.

(d) **Poricidal dehiscence:** opening by a small hole, generally in an apical position.

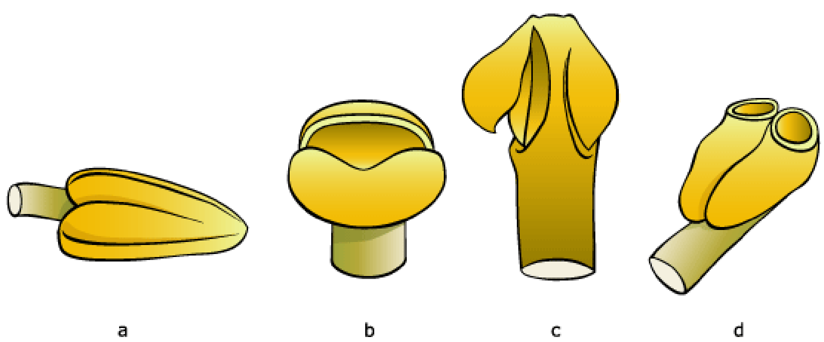


Fig. 74 : Anther dehiscence
(a. longitudinal loculicide, b. transverse loculicide, c. valvar, d. poricide).

E/ Variation of the gynoecium.

The floral receptacle develops differently from one species to another and determines different positions between the gynoecium and the other parts

The gynoecium has several levels of variation (fig.75).

(I) **Hypogynous flowers:** the gynoecium is inserted above the other whorls (superior ovary).

(II) **Perigynous flowers:** sepals, petals and stamens are fused

(III) **Epigynous flowers**: sepals, petals and stamens are inserted above the gynoecium (inferior ovary).

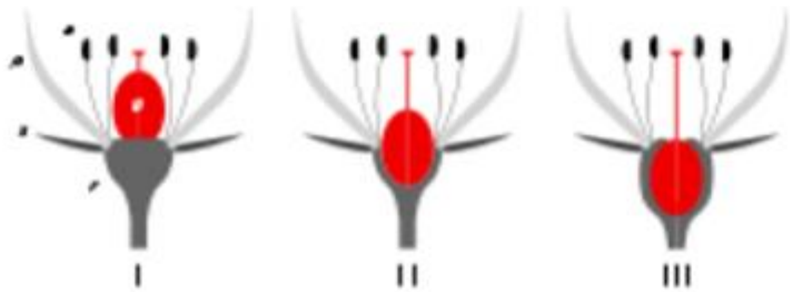


Fig. 75 : Level of variation of the gynoecium

❖ **Degree of carpel fusion**

Depending on whether the carpels are independent or fused and whether each carpellary blade is closed on itself or forms an ovary made up of several blades, the following main types of gynoecium are distinguished:

(1) **Apocarpous gynoecium:** gynoecium formed from independent carpels or a single carpel (unicarpellary gynoecium).

(2) **The coenocarpous or syncarpous gynoecium:** gynoecium formed of partially or totally fused carpels. Several cases can be distinguished (fig. 76):

- **Intimate fusion** of the carpels (so-called coalescent carpels), possibly limited to their base;
- **More pronounced fusion,** with the formation of a single ovary, the styles however always remaining independent;
- **Fusion affecting ovaries and styles:** results in a single ovary and style, but the stigmas remain autonomous, indicating the number of carpels.

- **Complete fusion;** the pistil therefore only comprises an ovary, a style and a stigma.

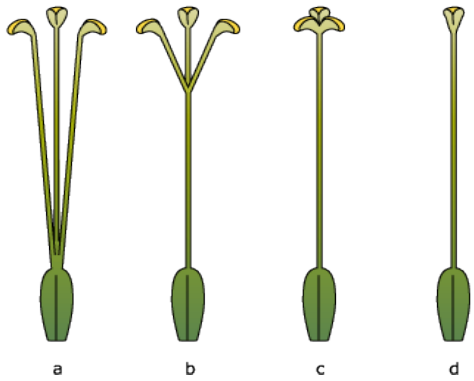


Fig. 76 : Syncarpous gynoecium or (coenocarp)

a) Total union of the ovaries, the styles remain independent, b) Total union of the ovaries, partial union of the styles, c) Total union of the ovaries and the styles, the stigmata remain free, d) Total union of the ovaries, styles and stigmata.

V.1.2.3. Sex of the flower

- **Unisexual flowers:** either male, only stamens (staminate flowers), or female, only a gynoecium (pistillate flowers).
- **Hermaphroditic flowers:** contain both stamens and carpels.
- **Pentacyclic flowers:** five whorls of floral parts (one sepal, one petal, two stamens, and one carpel)

V.1.2.4. Presence of unisexual flowers on the feet of the plant

- **Monoecious plants:** Refers to a plant having unisexual male and female flowers appearing on the same individual, on the same plane.
- **Dioecious plants:** Said of a plant whose male and female flowers are borne on two different plants.

V.1.2.5. Symmetry of the flower

- **Asymmetrical** (=irregular), meaning that the flower does not have any planes of symmetry
- **Zygomorphic** (=regular and bilateral), meaning that the flower only has one plane of symmetry (fig. 77).

- **Actinomorphic** (=regular), meaning that the flower has several planes of symmetry

Actinomorphy plays a role in the classification of flowering plants, characterizing entire families or only certain genera of the same family. The flowers are then called actinomorphic or regular. This radial symmetry exists, for example, in mallows and potatoes (5-fold symmetry), mustard and wallflower (4-fold symmetry), and lilies (3-fold symmetry).

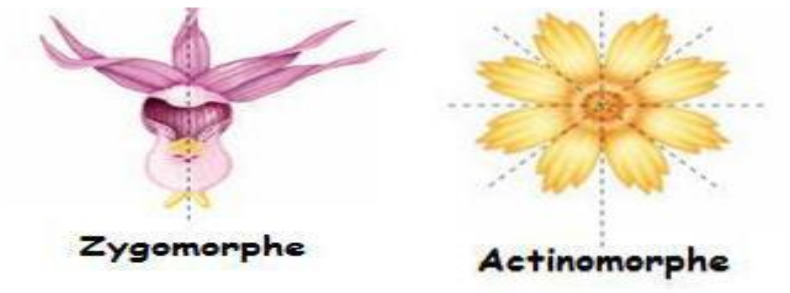


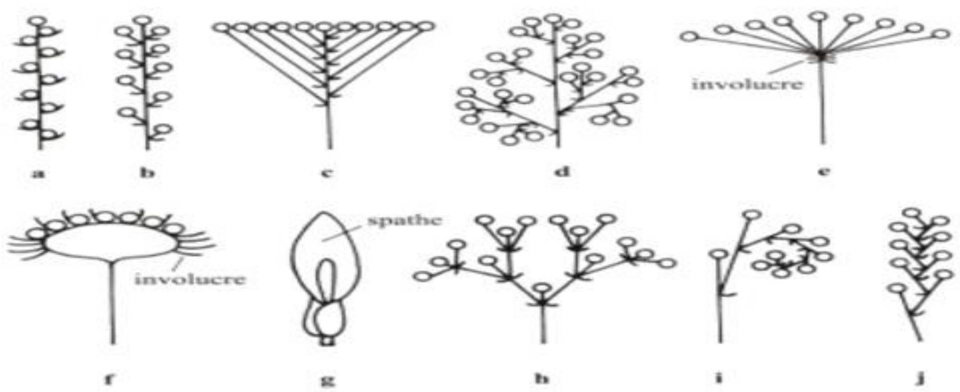
Fig. 77 : Floral symmetry

V.1.2.6. Variations of inflorescences

In many groups, the flowers are solitary. But the flowers are usually grouped in inflorescences

We observe 3 modes of development (fig. 78):

- ✓ Inflorescences **with defined growth (or cymose)**
- ✓ Inflorescences **with indefinite growth**
- **Mixed** inflorescences (undefined axis, defined branches)



a: spike; b: raceme or cluster; e: corymb; d: panicle; e: umbel; f: capitulum; g: spadix with spathe; h: biparous cyme; i: uniparous scorpioid cyme; j: uniparous helicoid cyme

Fig.78 : Types of inflorescences

V.1.3. Floral morphology of an angiosperm: (Diagram and floral formula)

V.1.3.1 Floral diagram

The floral diagram is a schematic representation of the structure of the flower through the different floral parts (calyx, corolla, androecium at the level of the anthers, gynoecium at the level of the placentas) seen from above, in cross section relative to the axis of the stem (fig.79).

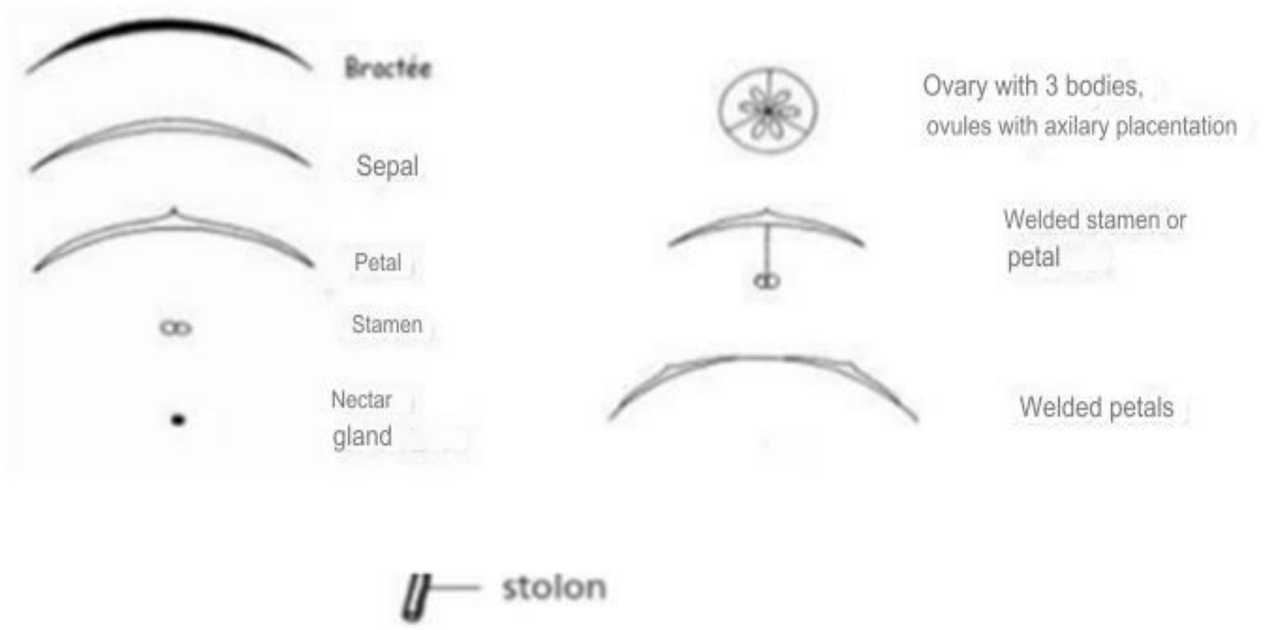


Fig. 79: Representation of the different parts of the flower in a floral diagram.

V.1.3.2. Floral formula

Is a representation of the morphology of a flower in the form of a formula specifying the nature of the parts present, their number, possibly also their arrangement (in one or two cycles for example). The number of floral parts is indicated in a group of acronyms constituting each whorl thus, the letters give the nature of the floral parts:

S : pour sépales,

P : pour pétales,

E : pour étamines,

C : pour carpelle

T : pour tépales.

The numbers show the number of floral pieces. If two or more whorls (or groups) of floral pieces are observed, this can be indicated in the form of an addition: 2+4 E means that there are 6 stamens in all, but 2 from one group and 4 from another (case of Brassicaceae = Cruciferae).

The formula also includes additional information

- Parentheses: to indicate that floral pieces are welded together: ()

Free carpels: Cx
Fused carpels: C(x)

- The line: to specify the position of the ovary. When the line is below the C (carpel sign) is, it is a **superior ovary**, when the line is placed above the C, it is an inferior ovary.

($\underline{C5}$) pour indiquer qu'il s'agit d'un ovaire supère

($\overline{C5}$) pour indiquer qu'il s'agit d'un ovaire infère

- The letter **T:** to designate the **tepals.**
- **The infinity symbol/n** indicates an indeterminate number of pieces or a high number of them. Beyond 12, we note "n"
- **The type of symmetry is represented by:**

⊕ ou ⊗ Pour les fleurs actinomorphes

-|- Pour les fleurs zygomorphes

Some examples of floral diagrams (fig.80).

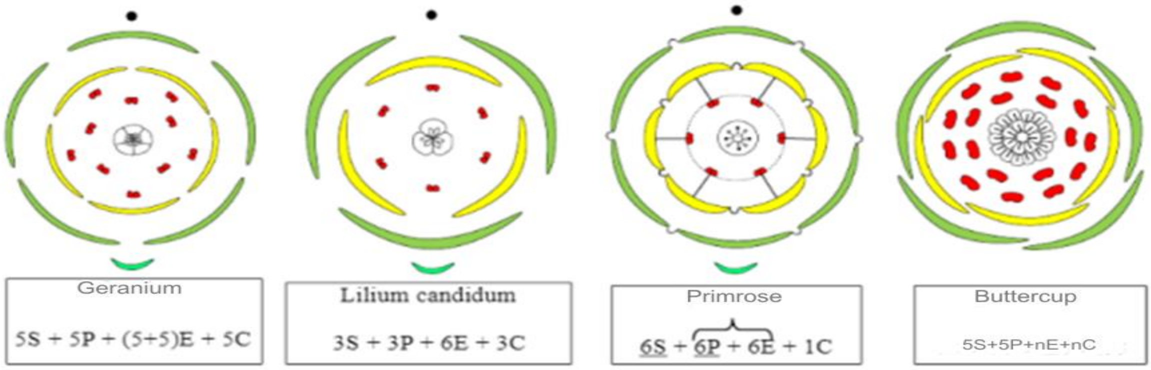


Fig. 80 : Some examples of floral diagrams and floral formulas of some angiosperm species.

V.2. Anatomical Characteristics

*The metaxylem of angiosperms is formed of vessels, sometimes with completely perforated transverse walls.

*The wood of angiosperms contains vessels, conductive elements, but also fibers, cells specialized in support. It is thus called heteroxylated wood, as opposed to the homoxylated wood of gymnosperms, where only the tracheids provide conduction and support.

*Angiosperms have tissues that are conducted by one or more criblovascular bundles.

*Angiosperms are spermatophytes, they share a synapomorphy which is the presence of a bifacial cambium producing, on the internal side, secondary wood or xylem.

V. 3 Chemotaxonomic characters

With the advancement of analytical techniques, there are now many plant groups in which phytochemical data have contributed to significant taxonomic improvements. The presence or absence of a particular phytochemical in a plant as well as knowledge of its biochemical synthesis pathways can be used to assign it a taxonomic position. These chemotaxonomic characters not only allow us to classify Angiosperms, but also to better understand their ecological adaptations and their interactions with other organisms.

V.3.1. The different chemotaxonomic compounds of Angiosperms

Among the main metabolites involved in the chemotaxonomic characters studied in angiosperms are glycosides, alkaloids, volatile oils, flavonoids, plant phenols and terpenoids.

1. Flavonoids

*Types : Flavonols, flavones, anthocyanins.

*Role: Pigments responsible for the coloring of flowers and fruits, involved in pollination and protection against UV rays

*Importance: Flavonoid profiles vary widely among species and can help distinguish families and genera.

2. Alkaloids

*Types: Nicotine (in tobacco), morphine (in poppy: Papaver), caffeine (in coffee).

*Role: Often toxic compounds, used by plants to defend themselves against herbivores.

3. Terpenes

*Types: Monoterpenes, sesquiterpenes, diterpenes.

*Role: Volatile compounds responsible for aromas and flavors, playing a role in interactions with pollinators and defenses. Examples: Essential oils in aromatic plants such as mint (*Mentha).*

4. Organic acids

*Types: Citric acid, malic acid, oxalic acid.

*Role: Contribute to the flavor of fruits and play a role in metabolism. Examples: citric acid in citrus fruits, malic acid in apples.

5. Phenolic compounds

*Types: Phenolic acids, tannins.

*Role: Protection against pathogens, antioxidants and UV rays, influence on flavor and color.

*Importance: Their presence and concentration may vary depending on the species and the environment.

6. Saponins and tannins

*Role: Compounds that can have toxic effects on herbivores and can be used in species classification.

*Importance: Saponin profiles may be specific to certain families.

7. Glycosides

*Types: Flavonoid glycosides, terpene glycosides.

*Role: Compounds that store energy and play a role in defense.

8. Essential oils

*Types: Volatile compounds extracted from aromatic plants.

*Role: Energy sources and volatile compounds responsible for aromas and contribute to flavors and protection against insects.

*Importance: Used in the identification of certain species, particularly in aromatic families.

V.3.2. Main families of Angiosperms studied by chemotaxonomy

In Angiosperms, the most popular families that have been studied through chemotaxonomy are ***Fabaceae. Asteraceae. Lamiaceae. Rosaceae. Apiaceae and Solanaceae***. These families show the richness and diversity of chemical compounds present in angiosperms, which are essential not only for classification but also for understanding ecological interactions and practical applications in agriculture and medicine.

- ***Fabaceae*** (Legumes):

Chemical characteristics: Presence of alkaloids, flavonoids and saponins. Flavonoids are often used to identify subfamilies.

- ***Solanaceae***

Chemical Characteristics: Knowledge of alkaloids such as nicotine and solanine, as well as terpenoids. These compounds are important for determining genera.

- ***Asteraceae*** (Asteraceae):

Chemical characteristics: Presence of flavonoids, essential oils and phenolic acids. Flavonoids are used to differentiate genera within the family.

- ***Lamiaceae***

Chemical characters: Terpenes, flavonoids and essential oils. Volatile compounds are often used for identification.

- ***Rosaceae***

Chemical Characteristics: Flavonoids, tannins and phenolic acids. Flavonoids help establish relationships between subfamilies.

***Apiaceae* (*Umbelliferae*)**

Chemical characteristics: Presence of terpenes and essential oils, as well as phenolic compounds. These characteristics are important for classification.

- ***Cucurbitaceae***

Chemical characters: Cucurbitacins (bitter compounds), flavonoids and saponins, used for identification and study of phylogenetic relationships

Much research has been done on the importance of these compounds in certain families leading to the establishment of phylogenetic relationships. We can cite:

*Singh's study (2016) on glycosides also characteristic of the *Cruciferae*, *Moringaceae*, *Capparaceae* families. As the flavonolic glycosides of Rosa rugosa have proven to be important chemotaxonomic markers for the classification of species in sections *Gallicanae*, *Cinnamomeae*. * His study also on alkaloids provides a contribution in some groups where they are well represented such as the *Apocynaceae* family: the *Plumieroideae* subfamily only includes species with indole alkaloids, but these are absent in *Cerberoideae* and *Echitoideae.* In some cases, chemical criteria allow finer distinctions such as that of the genera Vinca (temperate periwinkles) and Catharanthus (tropical periwinkles), the latter containing very particular "double" alkaloids. Some alkaloids are good taxonomic markers, specific to a species, a genus, or even a tribe (colchicine of the *Liliaceae* - *Wurmberoideae*).

*As we can also cite the work of Ankanna, Suhrulatha and Savithramma in 2012, for chemotaxonomic studies of some important monocots which involves screening secondary metabolites of various monocot plants by different chemical methods and summarizing new concepts of monocot taxonomic ranks. The results revealed that the selected monocot species responded positively to flavonoids, phenols, tannins and steroids. While Sorghum vulgare and *Canna orientalis* showed synergistic chemical constituents and *Commelina benghalensis* showed only two constituents. *Sorghum vulgare* showed maximum number of secondary metabolites, namely flavonoids, glycosides, phenols, lignins, leucoanthocyanins , tannins, fats, coumarins, steroids, emodins and anthocyanins, followed by *Eragrostis tenella*, *Pothos* *scandens , Smilax zeylanica , Zingiber officinalis , Musa paradisiaca , Alliam cepa , Crinum asiaticum Raven, ala madagascarensis , Scilla hyacinthina , Cyperus rotundas , Dracaena perfume, Gloriosa superb, Yucca gloriosa , Cymbopogan citratus , Acorus calamus, Typha angustata, Saccharum officinarum, Caryota urens, Cynodon Orchardgrass*, *Aloe vera , Allium sativum, Chloris barbat , Aristida hirtris , Eleusine coracana, Zea mays, Pandanus fascicularis , Borassus flabellifer , Bambusa arundinacea, Setcreasea purpurea, Commelina benghalensis . Amaryllis vittata, Curcuma longa, Sansevieria roxburghiana and Asparagus raccemosus.* Where they concluded that members of the *Poaceae* family are rich in glycosides, phenols and flavonoids.

V.4. Reproduction

V.4.1. Asexual or vegetative reproduction

* It is relatively less widespread among angiosperms than in other plant branches. It refers to all other means of reproduction where neither gametes nor fertilization are involved and the individuals obtained are strictly identical to those from which they came. In this case, the genetic material of the parents and descendants remains identical. It is a form of natural cloning. It can be done without a particular organ by:

*The fragmentation of the organs of a plant such as the stem or the roots. It can be done naturally (perennial plants) or artificially (by man). The vegetative apparatus of the plant is fragmented, each fragment obtained being able to give a new individual.

*Accidental breakage or necrosis of stems of the mother plant (common in rhizome plants).

*The formation of specialized organs, either by production or fragmentation of organs (bulbs, tubers, rhizomes, etc.) by different processes: Natural **layering, Natural cuttings**, **Bulbils**, **Stolons**, Sucker roots and Tuberous roots or stems. This capacity for vegetative multiplication, resulting from the **totipotency** of the plant cell, is used in the laboratory to multiply in vitro individuals of economic interest (fig.81 and fig. 82).

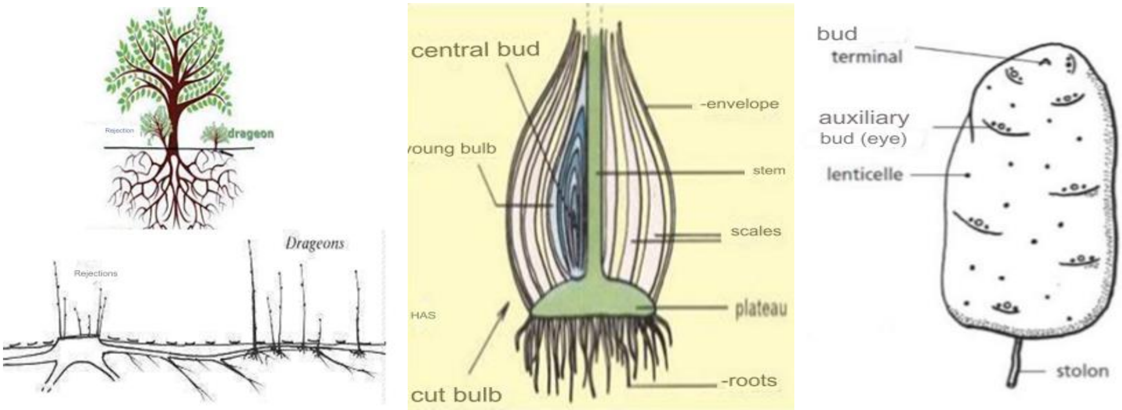


Fig. 81 : Asexual reproduction mode of angiosperms (Natural vegetative multiplication).

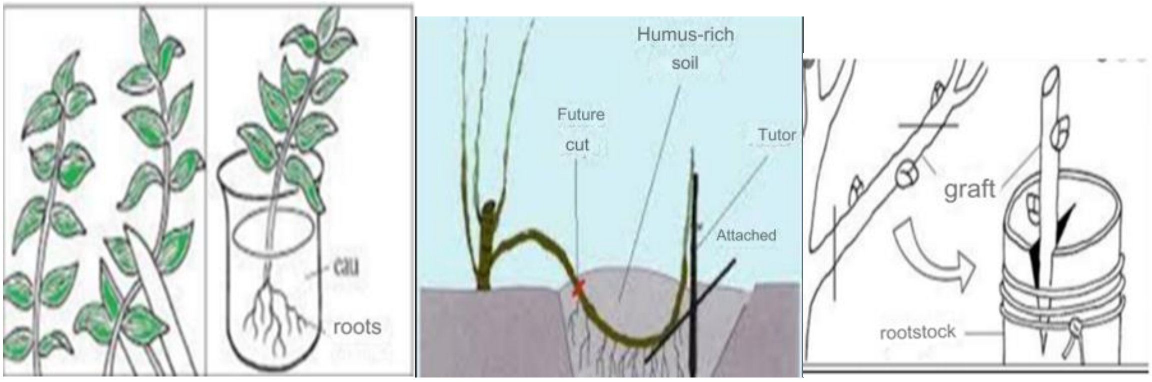


Fig.82 : Asexual reproduction mode of angiosperms (Artificial vegetative multiplication).

V.4.2. Sexual reproduction

Like all plants, Angiosperms exhibit an alternation between two states: the sporophytic state and the gametophytic state. However, this alternation is part of a very unbalanced cycle: the gametophytic phase is very reduced in space and time. The male and female gametophytes correspond respectively to the pollen grain and the embryo sac in Angiosperms.

Gametogenesis is the formation of gametes that enter into the sexual reproduction of plants, it is different depending on the sex of the organ of the flower that produces the gamete.

*If it occurs in the anthers of the stamens, then it will be male gametogenesis (also called **microgametogenesis)**, which is the formation of the pollen grain = the formation of the male gametophyte or microgametophyte and sperm cells = male gametes

* If it is produced in the ovule of the plant, at the base of a carpel, is called female gametogenesis (also called **macrogametogenesis** or **megagametogenesis)**, the female gamete resulting from this gametogenesis will be the oosphere contained in the **embryo sac.**

V.4.2.1. Male gametogenesis or microgametogenesis

The anther is the seat of male gametogenesis leading to the formation of the pollen grain or male gametophyte. It is the innermost layer of the young anther that is at the origin of the microspore mother cells (MMC), future pollen grains. The MMC then undergo meiotic division and each produce 4 haploid cells (microspores), young cells with a large central nucleus (fig. 83).

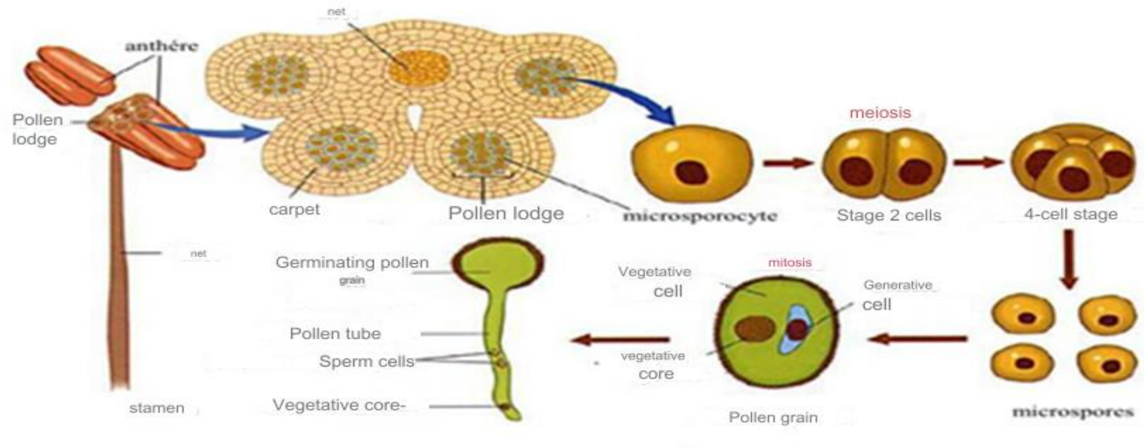


Fig. 83 : Formation of the pollen grain

Each microspore, after division of its nucleus and differentiation, becomes a mature pollen grain, most often bicellular (70% of cases), and generally spherical in structure with a diameter ranging from 7 µm to 150 µm, those which are less than 10 µm are most often considered to be allergenic. It presents:

- An external wall: **The exine:** thick and resistant, can be smooth and ornamented, highly cuticularized, resists most chemical and biological degradation, allowing the pollen to be released into the environment without being damaged. The exine is very thinned in places and thus forms depressions called **apertures** which will allow the emission of the pollen tube which will fertilize the ovule. The number and the shape of the apertures are important taxonomic criteria distinguishing **monocots (monoaperture) from dicots (tripaperture).**
- An internal wall: **The intine,** thin and flexible, of pectocellulosic nature,
- A large cell, which occupies all the internal space, **is the vegetative cell.** It has a nourishing role and intervenes in the germination of the pollen grain.
- A small cell included in the vegetative cell: the generative or spermatogenic cell (fig. 84).

In some cases (30% of cases) the generative cell divides, giving the 2 male gametes before the germination of the pollen grain which is then tricellular.

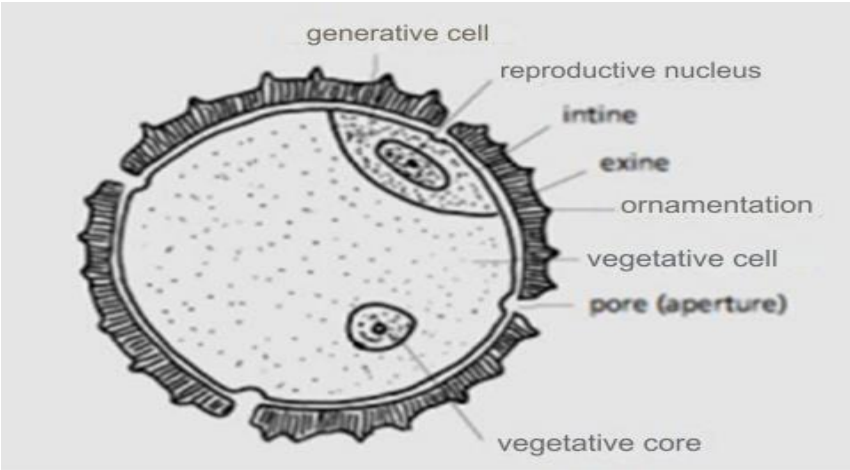


Fig. 84 : Structure of the pollen grain

The surface of the pollen grain varies greatly from one species to another. As an illustration, we encounter four different forms (fig.85).

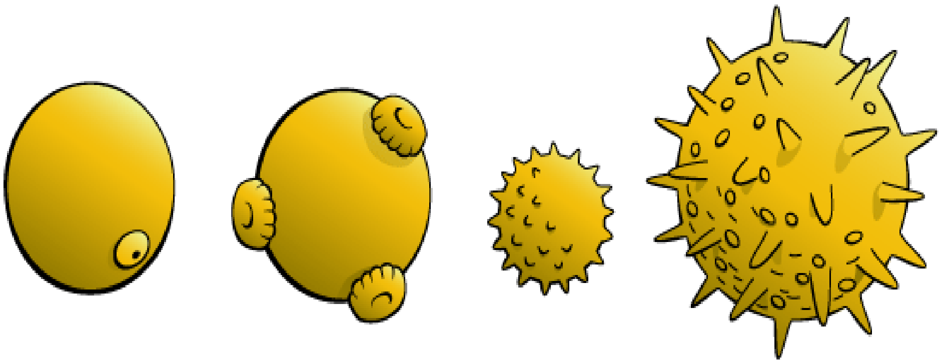


Fig. 85 : Surface of the pollen grain

V.4.2.2. Female gametogenesis or macrogametogenesis

As the very young ovule develops, the megaspore mother cell differentiates. It undergoes meiosis, producing 4 haploid cells or megaspores, of which 3 cells degenerate and 1 cell (fertile cell) will evolve to form the embryo sac. The latter corresponds to the female gametophyte.

❖ **Structure of the ovule**

The ovule, despite its small size, has a relatively complex organization. We distinguish (fig.86):

* **The funiculus:** a sort of cord on the lower side of the ovule, attaching it to the placenta (then the seed after the transformation of the fruit);

* **The chalaza:** point where the conductive bundle of the ovary branches;

* **The nucellus:** internal part of the ovule which contains the embryonic sac;

* **The embryo sac:** female gametophyte which, after fertilization, will house a diploid embryo and a triploid albumen;

* **The integument(s):** envelopes generally numbering of two, one internal and one external

* **The micropyle:** this is the narrow apical opening formed by the integument(s)

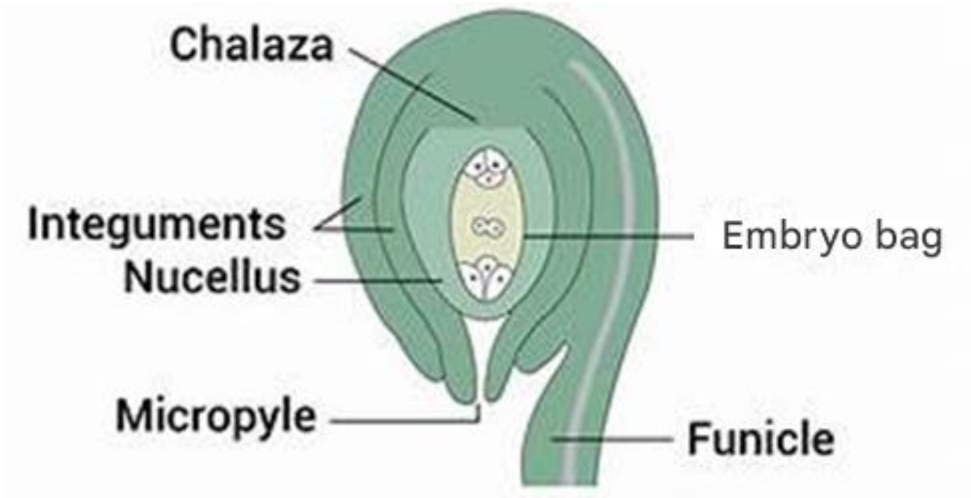


Fig. 86 : Structure of the ovule

We can distinguish three types of ovules (fig 87):

(1) Straight ovules (= orthotropic),
(2) Lying or curved ovules (= campylotropic)
(3) Inverted or reversed ovules (= anatropous)

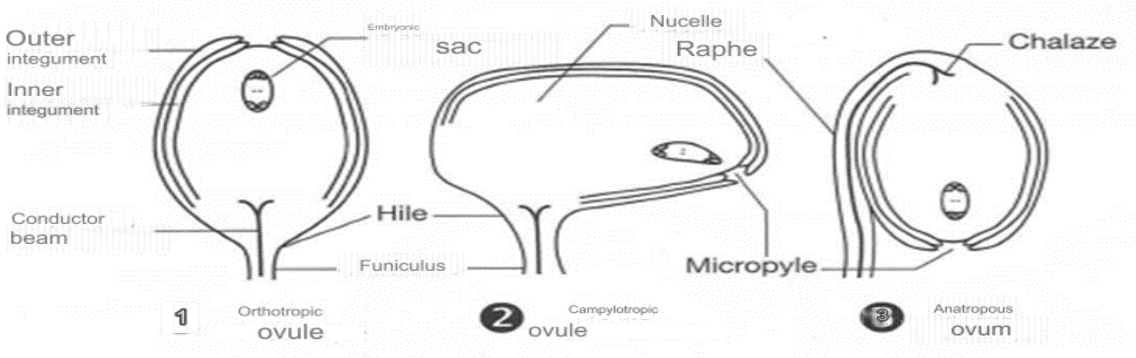


Fig. 87: Diversity of angiosperm ovules

❖ Placentation (or insertion of eggs into the ovary)

The ovule is connected by a funiculus to the tissue supplying the ovule (including conductive tissues) called the placenta. The placentation of an ovary formed by several carpels depends on the position of the placentas on which the ovules develop. This position varies depending on whether the carpels are open or closed.

There are three types of placentation (fig. 88):

(1) Parietal placentation: the fused carpels are open. The ovary has a single cell regardless of the number of carpels. The placentas are located on the periphery.
(2) Axile placentation: the fused carpels are closed. The ovary has several chambers as many as carpels. The placentas are located against the axis of the ovary.
(3) Central placentation: the fused carpels are closed but the septa are not formed or have disappeared. The ovary has only one cell. The placentas are located in the center of the ovary.

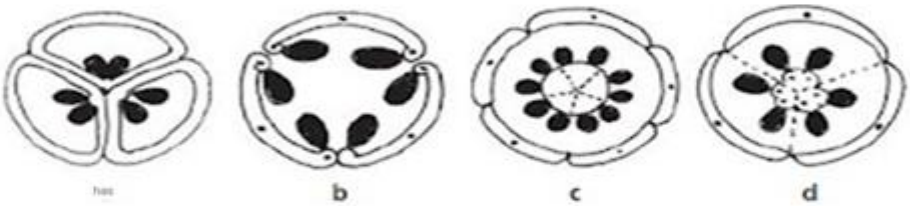


Fig. 88 : Different types of placentation of eggs in the ovary
(a. axial; b. parietal; c. central; d. axile becoming central)

❖ Formation of the ovule

The ovule is produced by a local proliferation of the placenta: a cell mass first rises to form the nucellus; then by divisions, two circular ridges are produced: these are the integuments (T1 and T2). In certain groups of Angiosperms (monocotyledons), a single integument is formed. The integuments grow by gradually covering the nucellus but leaving free a pore giving access to the nucellus, the micropyle. The ovule having reached its maximum size is attached to the placenta by means of a small foot, the funiculus. The integuments and nucellus are fused at the base.

✓ Formation of the embryo sac

Formation of the embryo sac: During the differentiation of the ovule, a cell, most often sub-epidermal, increases in volume and becomes the single archesporial cell (archespore) then the megasporocyte, the latter undergoes meiosis giving 4 haploid cells, the megaspores, which are arranged in a linear tetrad (fig. 89). Most often, the 3 cells closest to the micropyle degenerate and the functional megaspore undergoes 3 waves of successive nuclear divisions leading to the formation of eight haploid nuclei which are divided into groups of four at each of the two poles of the embryo sac. One of the nuclei from each group then migrates towards the center of the cell forming the polar nuclei (coming from the poles).

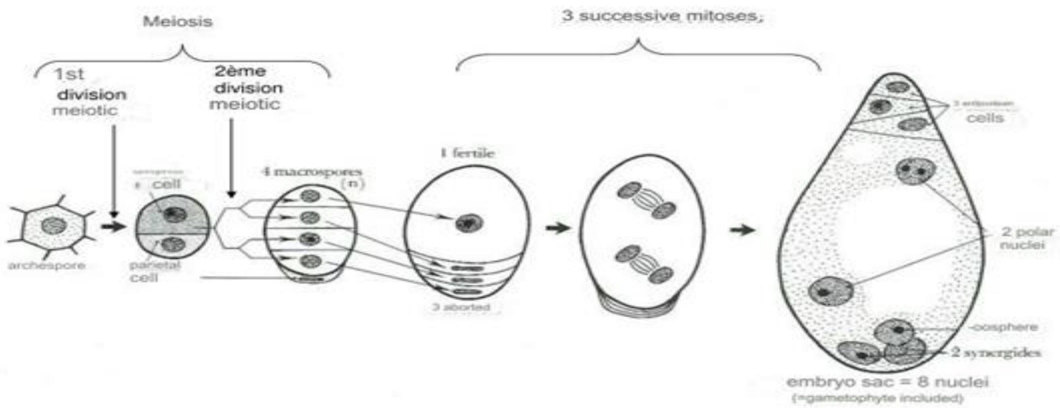


Fig. 89 : Formation of the embryo sac

Cytokinesis (all the modifications of the cytoplasm during cell division) then occurs, completing the formation of the embryo sac which is made up of 7 cells (fig. 90):

* Two synergides;

*The oosphere at the micropylar pole;

*Three antipodes at the opposite pole and

* A large central cell which contains the 2 polar nuclei.

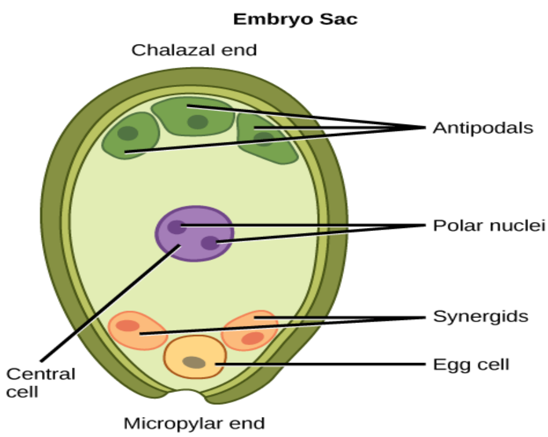


Fig. 90: Structure of the embryo sac.

V.4.2.3. Fertilization

In Angiosperms siphonogamy is the rule, moreover the ovule is not directly pollinated due to the imprisonment of the ovule in a carpel. Fertilization is carried out in several stages: pollination, germination and discharge of the pollen tube.

A/ Pollination

Pollination is the transport of a plant to the stigma of a pistil. It can be direct; this is **self-pollination or autogamy**: the fertilizing pollen comes from the stamens of the same flower or the same individual. It can be crossed; this is **allopollination or allogamy:** the fertilizing pollen comes from a flower of a different individual (fig. 91).

Fig. 91 : Pollination methods of angiosperms (left: autogamy – right: allogamy)

Pollen can be carried by wind, insects, water or by certain animals.

- ✓ **Anemogamy** (= anemophily) is a mode of pollination due to the transport of pollen by the wind.
- ✓ **Entomophily** (= entomogamy) is a mode of pollination due to the transport of pollen by insects.
- ✓ **Water (hydrogamy** = hydrophily), especially in various aquatic plants.
- ✓ Other animals (other **zoogamies** = "zoophilia"): Birds (**Ornithogamy,** like tropical Hummingbirds), Spiders (**Arachnogamy)**...

B/Pollen germination

The pollen grain germinates on the stigma which is covered with papillae by emitting a long pollen tube which exits through one of the apertures (germinal pore). The vegetative nucleus and the two sperm nuclei, resulting from the division of the generative cell, pass into the pollen tube that crosses the stigma, and continues its growth in the style, enters the ovarian cavity and goes to the ovule. There is a chemotaxis that allows the growth of the pollen tube to be directed to the ovule (fig. 92). The pollen tube enters the ovule through the micropyle, and passes through the upper part of the nucellus and arrives in the upper part of the embryo sac where the synergids and the oosphere are located.

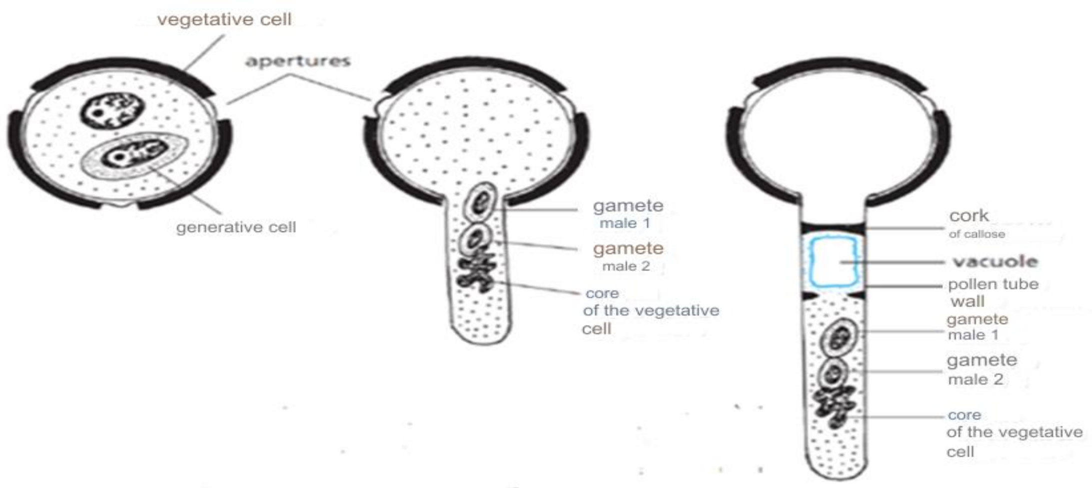


Fig. 92 : Germination of the pollen grain

Pollen germination requires certain conditions that promote this germination, including water, nutrients at the stigma, ambient temperature, and genetic compatibility. Rehydration and germination of pollen, following its deposit on the stigma of a compatible flower. The stigmatic papillae secrete a glycoprotein adhesive mucus (mucilaginous) that retains the pollen grains and is very rich in water. Upon contact, the pollen grain rehydrates, which increases the turgor of the vegetative cell and tends to produce outgrowths at the apertures, areas of least resistance. A single outgrowth persists and is at the origin of the pollen tube

C/Pollen tube discharge

The contents of the pollen tube (the gametes or sperm nuclei and the vegetative nucleus) are discharged into one of the two synergids. There is a close physical association between the two male gametes and the vegetative nucleus: this association is called the male germinal unit because it carries all the nuclear and cytoplasmic hereditary information contained in the pollen. This ensures good synchronization of the arrival of the two male gametes in the embryo sac to quickly ensure double fertilization. Then the vegetative nucleus degenerates (before completing its role). The two male gametes then migrate to their respective targets, the oosphere for one and the polar nuclei of the central cell for the other, then the synergids degenerate (fig. 93). There is also a close association and complementarity between germinal cells (oosphere and central cell) and the synergids, thus defining a female germinal unit.

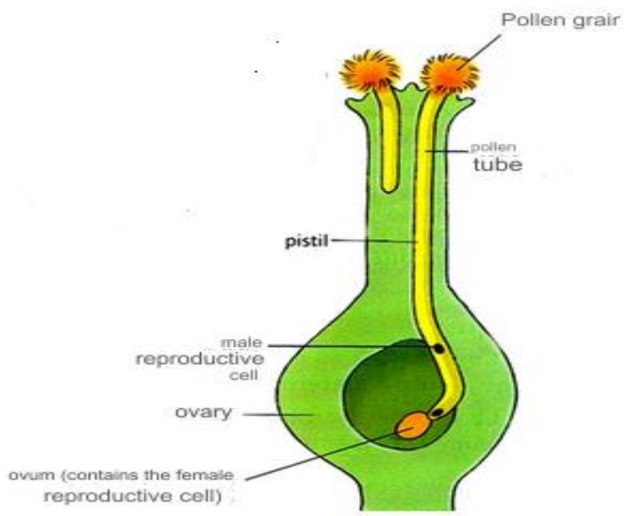
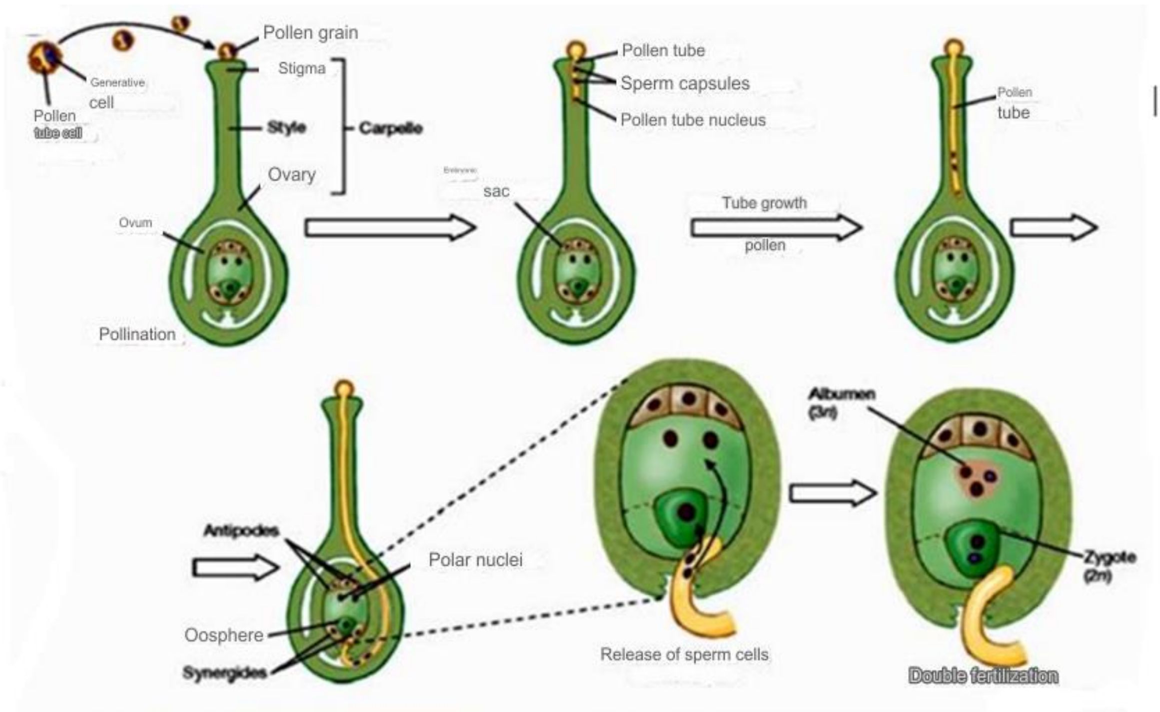


Fig. 93: Discharge of the pollen grain onto the ovule

D/ Double fertilization

One of the male gametes unites with the oosphere to form the main zygote, the other gamete unites with the two polar nuclei and forms the triploid accessory zygote (also called albumen cell). There is therefore formation of two zygotes whose destinies will be different. This double fertilization (fig. 94) is characteristic of Angiosperms.



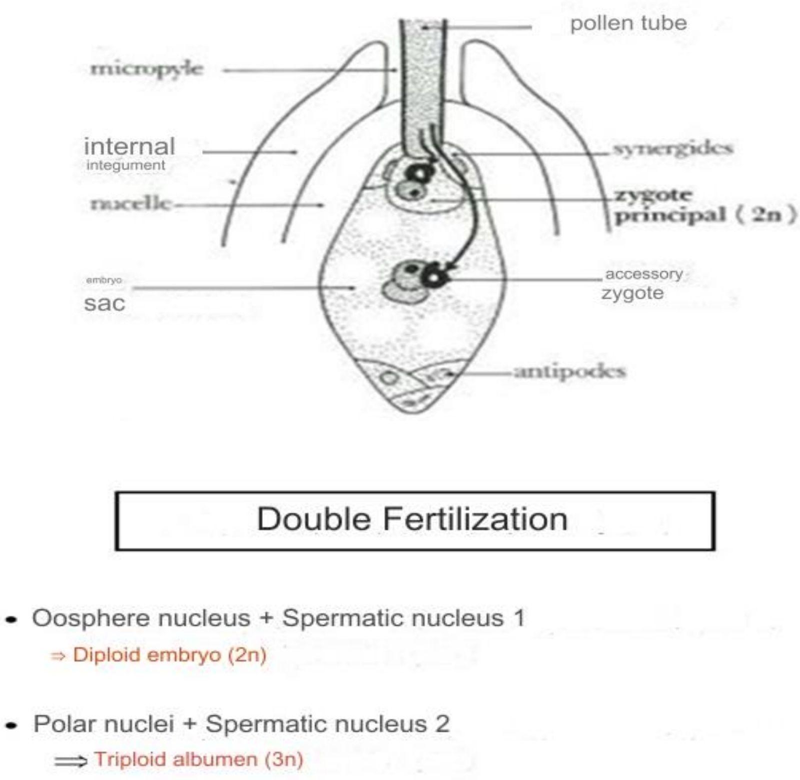


Fig. 94 : Double fertilization in angiosperms

V.4.2.4. Formation of the seed

At the end of the double fertilization, the main zygote will produce an embryo (cell 2n) at the origin of a new plant. As for the cell (3n) albumen digests the remains of the nucellus which it replaces. It ensures the nutrition of the plant during the germination of the seed.

After fertilization, the three antipodal cells and the two synergids degenerate. The main cell (the embryo) undergoes successive mitoses, thus giving rise to the first embryonic structures, radicle, cotyledons (monocotyledon or dicotyledon) and gemmule (terminal bud) (fig. 95). The accessory egg undergoes multiplication to form cell clusters containing nutrients called albumen. Thus, the seed formed undergoes desiccation and enters a phase of slowed life (dormancy) where nutritional and respiratory exchanges are low, allowing it to withstand unfavorable conditions.

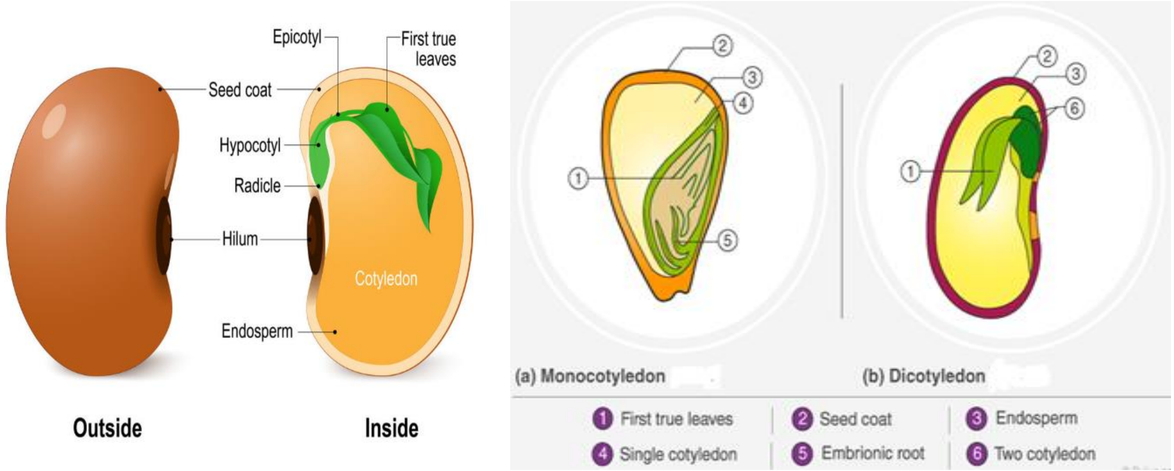


Fig. 95 : Seed structure
(Difference between seeds of a monotyledon and a dicotyledon)

As it develops, the albumen digests the nucellus of the ovule, takes its place and comes to apply itself against the integuments of the ovule, in this case the seed is said to be albuminous. The accumulation of reserve substances occurs either in the albumen when it persists or in the cotyledon(s) when the albumen is consumed by the embryo before the end of the maturation of the seed. The seed is then exalbuminous. A third type of seed exists in certain species where a significant portion of the nucellus persists and constitutes a perisperm where a part of the reserves stored by the seed accumulates: perispermated seed (fig. 96).

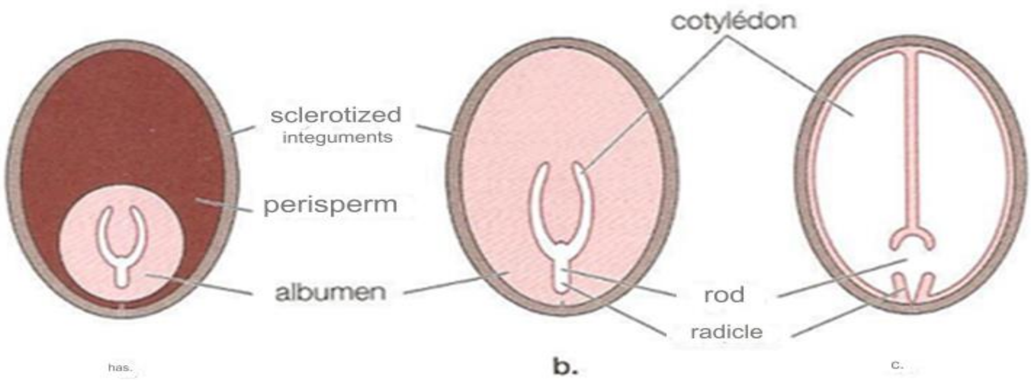


Fig. 96 : The different types of seeds in angiosperms
(a. Perisperm seed; b. Albumen seed; c. Exalbuminous seed)

V.4.2.5. Fruit and fruiting

While after fertilization the ovule transforms into a seed, the ovary becomes a fruit. The fruit contains one or more seeds that it protects.

The fruit is made up of a pericarp which results from the transformation of the wall of the ovary. Before fertilization, the wall of the ovary was made up of a parenchyma covered by an external epidermis and an internal epidermis. These three elements will constitute the three parts of the pericarp of the fruit (fig. 97):

- **The epicarp:** which derives from the external epidermis of the ovary (rind of the fruit);
- **The mesocarp** consists of the median parenchyma of the ovary (flesh of the fruit);
- **The endocarp** corresponding to the internal epidermis of the membranous or horny ovary.

These terms come from the Greek; *peri:* around; *karpos:* fruit; *epi:* outside; *mesos:* in the middle; *endon:* inside

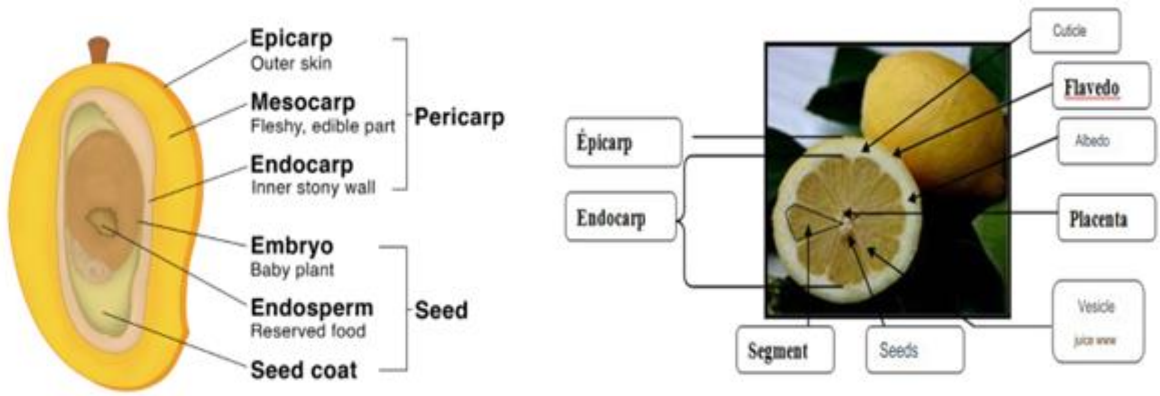


Fig. 97 : Anatomy of a fruit

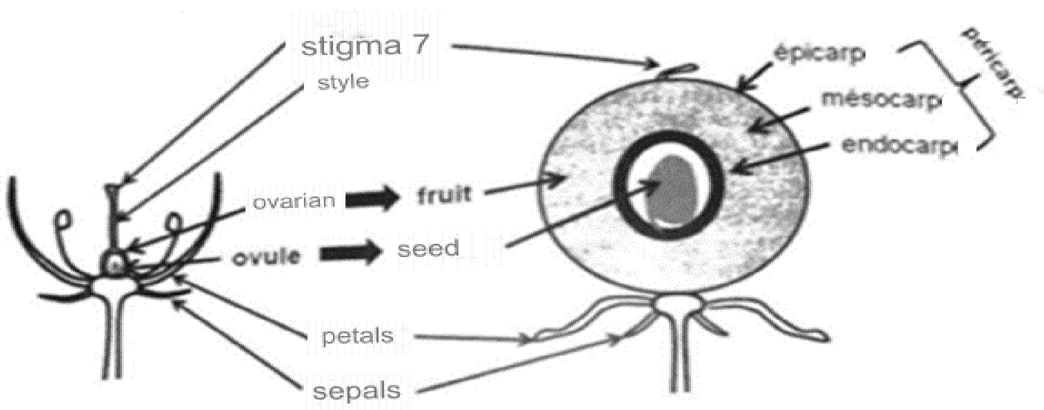


Fig. 98 : Fate of the different floral parts after fertilization

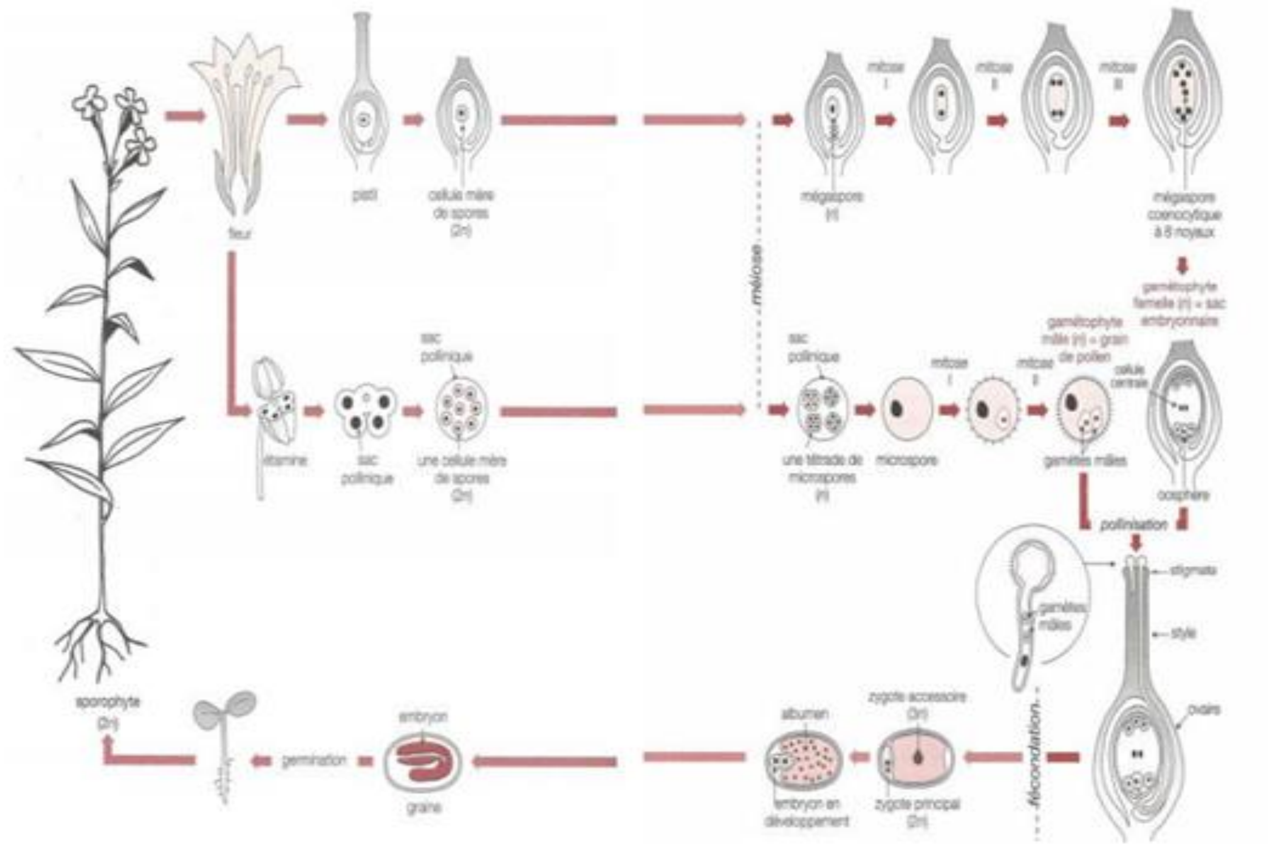


Fig. 99: Development cycle of angiosperms

Fruits are classified into different categories (Fig. 100) according to the number and arrangement of the original carpels, the number of seeds they contain, the nature (fleshy or dry) and the type of opening (dehiscent or indehiscent) of the fruit.

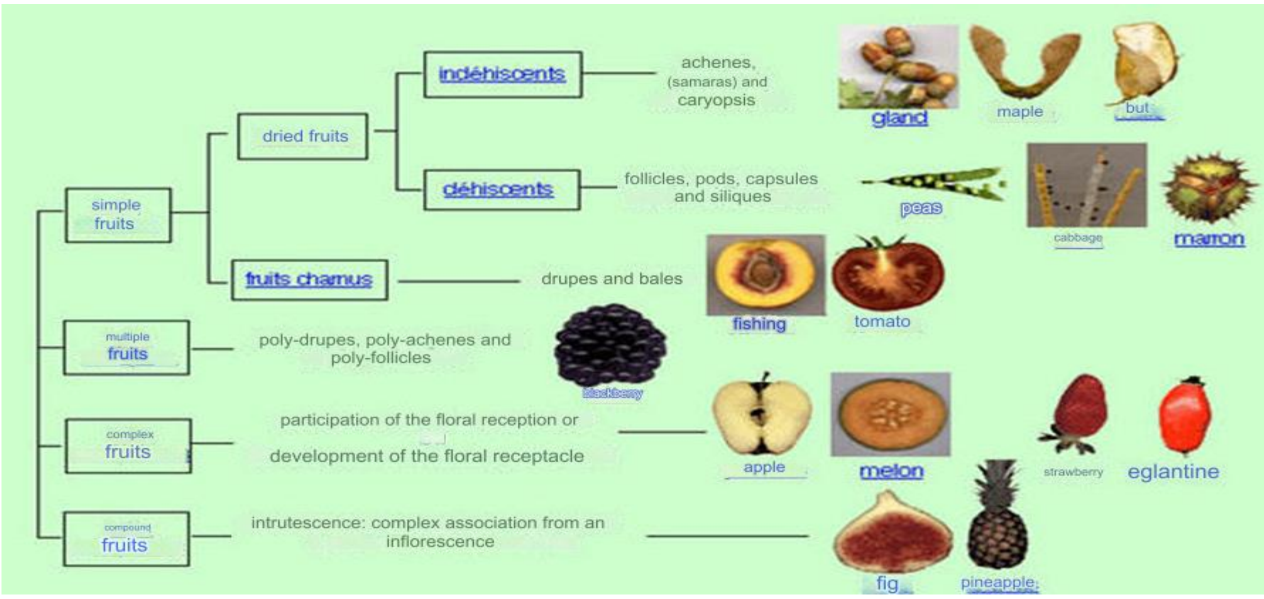


Fig. 100 : Different types of fruits

In some cases, fruiting can occur accidentally, in the absence of pollination and fertilization or seed development; this is called parthenocarpy. Parthenocarpic species produce seedless fruits (bananas, clementines).

V.5. Systematics of Angiosperms

There are several classifications of Angiosperms. The traditional ones include 2 classes: **monocots** and **dicots** (fig. 101) characterized respectively by a single cotyledon and by two cotyledons. This criterion has always been considered first in all ancient and contemporary systems and systematists have tried to capture in each of the two classes the most stable morphological characters. Among them, the criteria of the flower are the most important and are based on their archaic (primitive or plesiomorphic) and evolved (derived or apomorphic) state as indicated below

- Flower (actinomorphic or zygomorphic)
- Ovary (superior or inferior)
- Whorl type (spiral or cyclic)
- Welding of petals (free or welded)
- Number of floral pieces (many or not)
- Seed (albuminous or exalbuminous)

The use of these criteria has led to natural classifications, the most synthetic of which, and which is still widely used, is that of Engler (1924).

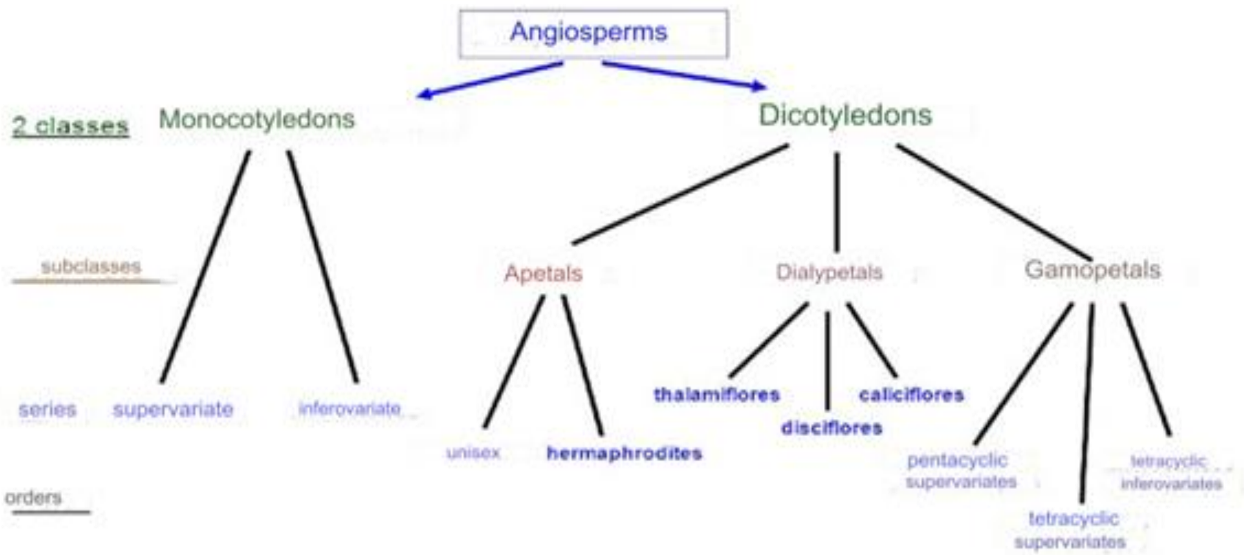
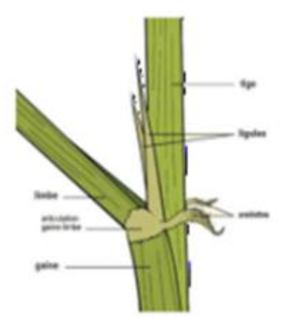
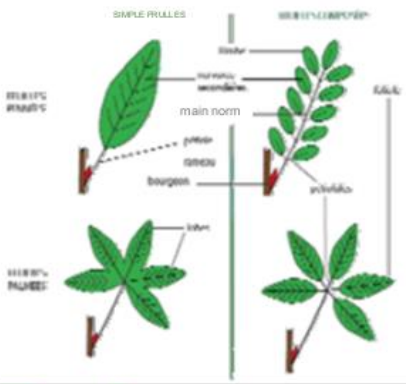
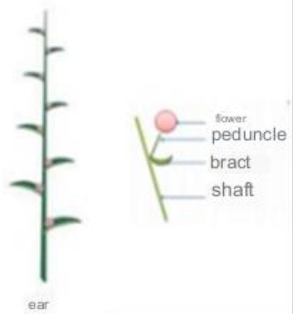


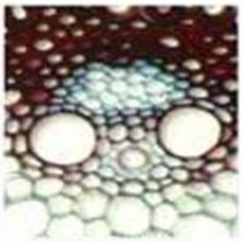
Fig. 101 : Classical systematics of angiosperms

Table 6. Comparison of morphological characteristics between monocotyledons, dicotyledons and Gymnosperms

<table>
<tr><th colspan="3"></th><th>Angiosperms Monocotyledons -</th><th>Angiosperms Dicotyledons</th><th>Gymnospermes</th></tr>
<tr><td colspan="3">Biological type</td><td>Herbaceous perennials (except bamboos)
-The stipe (special case)</td><td>- Herbacées
-Woody</td><td>-Woody</td></tr>
<tr><td rowspan="5">Vegetative apparatus</td><td colspan="2">Stem</td><td>- Rarely branched
- Cylindrical stem (culm) with nodes marked and full.
- Absence of a real trunk
-The stem retains the same diameter throughout its life (no secondary formations)</td><td>-Branched
- Erect, creeping or climbing
-The stem grows in thickness with age</td><td>- Upright which sometimes reaches a very great height and which thickens each year</td></tr>
<tr><td rowspan="4">Leaves</td><td>Petiole</td><td>-Absent in many cases
-Presence of a very developed sheath enveloping the stem, sometimes with a ligule at the junction of the sheath and the blade</td><td>-Present
, Stipules generally well developed at the base of the petiole</td><td rowspan="3">Euphylla (true leaves): leaves reduced to scales, hard and non-chlorophyllous with a very short lifespan.
Pseudophylls (false leaves): very thin, long leaves (needle-like), chlorophyllous, arranged in groups of 2 or 3 at the end of the branches.</td></tr>
<tr><td>Limbe</td><td>-Almost always whole (simple) and elongated</td><td>-Simple or compound (great diversity)</td></tr>
<tr><td>Nervation</td><td>Most often parallel</td><td>-Network (branched), most often pinnate or sometimes palmate</td></tr>
<tr><td>Illustration</td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Root</td><td>Fasciculated root system
</td><td>Taproot system
</td><td>Mixed root system,
(Their roots reach a great length and also take annual secondary formations)
</td></tr>
<tr><td>Reproductive system</td><td colspan="2">Flower</td><td>-Basically trimer (parts florals organized in multiples of three: 3 sepals, 3 petals, 2 x 3 stamens, 3 carpels)
- spike inflorescences (sessile flowers directly inserted on the axis of the inflorescence)
</td><td>-Flowers. Tetrameres or Pentameres (floral parts organized in multiples of four or five)
-Inflorescences in clusters or derived from clusters
</td><td>-Flowers (cones) generally unisexual monoecious, some dioecious times

</td></tr>
</table>

Table 7. Comparison of anatomical characteristics between monocotyledons and dicotyledons

DICOTYLEDONS			MONOCOTYLEDONS
Presence of a cambium framed by secondary wood and phloem or cambium at least present. Presence of a periderm with phellogen and secondary suber (cork). Sometimes absent in annual plants. Absent in leaves	 Libero-woody bundle. with secondary liber wood and cork  stem limited by secondary cork	 Libero-woody bundle of couch grass without cambium  Root limited by its primary tissues	Absence of cambium therefore no secondary tissues. Primary tissues on the surface of the adult organ (epidermis, rhizoderm or exodermis).
Diameter growth ensured by the cambium and secondary conductive tissues which appeared very early. In perennial stems, it renews itself every year.	 Vine stem	 Tradescantia stem	Limited diameter growth; size of diameter dependent on primary tissues. Bundles numerous from the outset, or by subsequent primary histogenic activity.

As early as 1993, a collective of botanists (APG: *Angiosperm Phylogeny Group*) proposed a new classification based on the sequencing of chloroplast, mitochondrial and nuclear genes. Molecular data led to a subdivision of Angiosperms correlated with the number of pollen apertures (fig.102). The separation of the two old classes on the basis of the number of cotyledons (Monocotyledons or ***liliopsida*** / dicotyledons or ***Magnliophyta***) is no longer accepted.

The APG III classification (2009) is the third version of the botanical classification phylogenetics of angiosperms established by *Angiosperm phylogeny Group* (APG) (fig.103). It is a revision and update of the flowering plant families of the APG II phylogenetic classification (2003) , again updated with the APG IV phylogenetic classification (2016) .

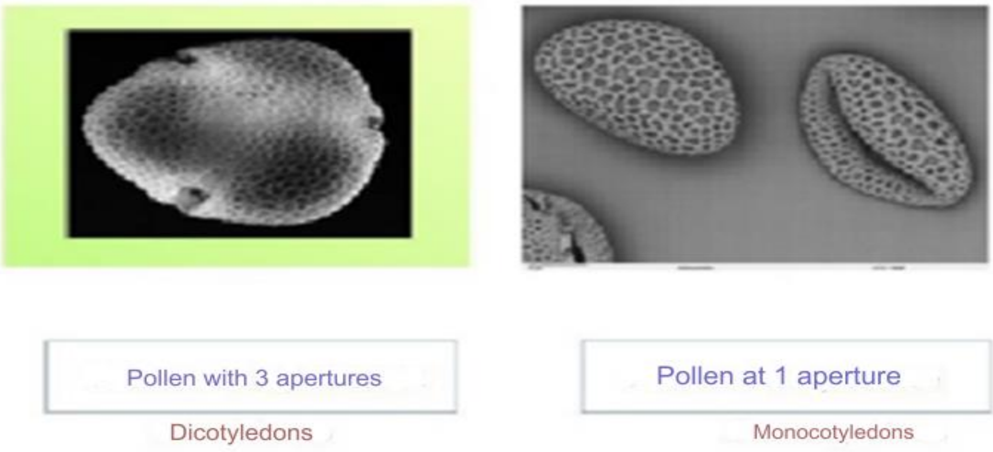


Fig.102: The number of apertures of the pollen grain

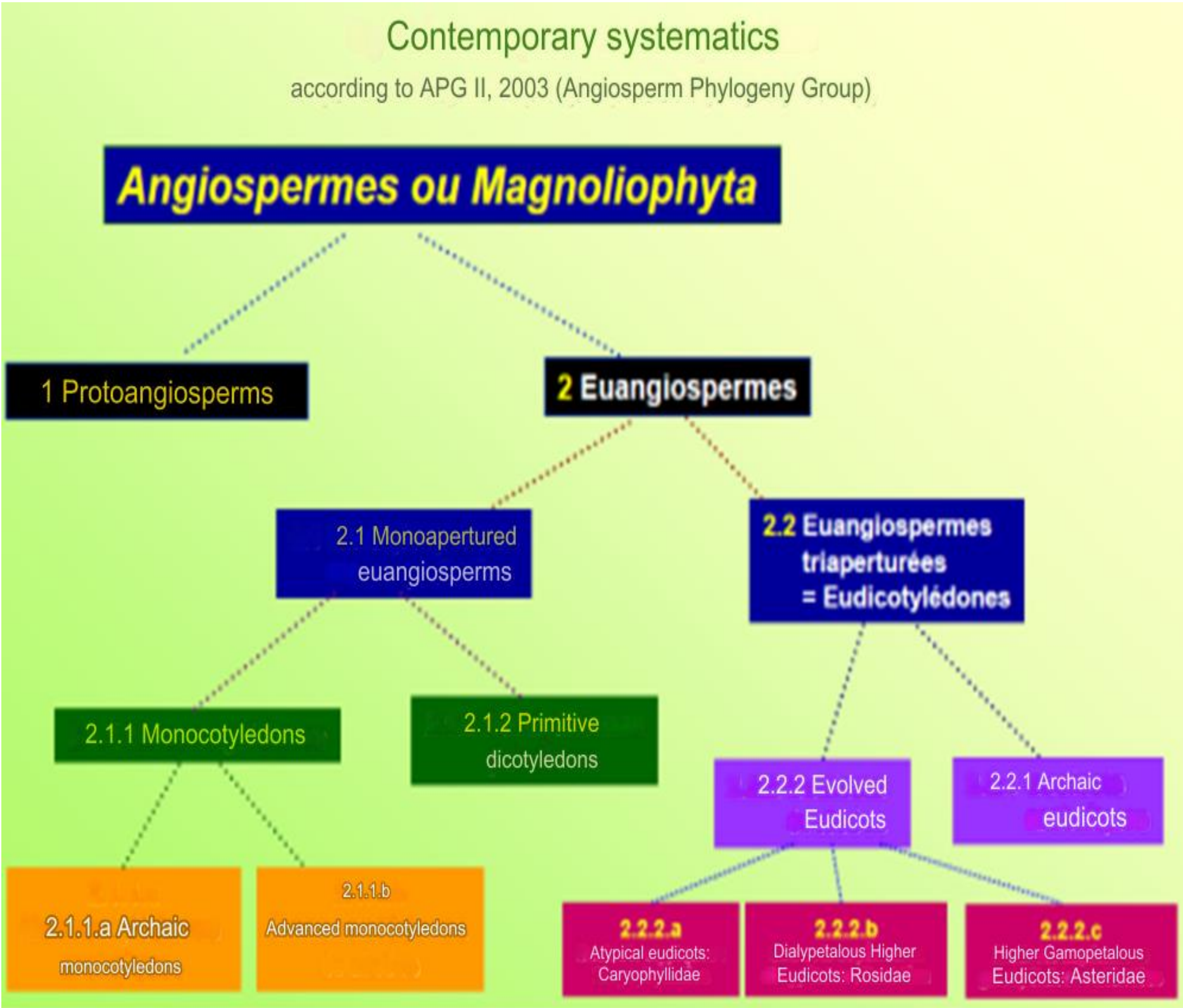


Fig. 103: Phylogenetic classification of angiosperms.

V.5.1. Different Phylum of Angiosperms

Angiosperms include 56 Orders, 445 Families, 250,000 to 300,000 described species, Algeria: More than 3,139 species 750 species are endemic or sub-endemic (fig.104).

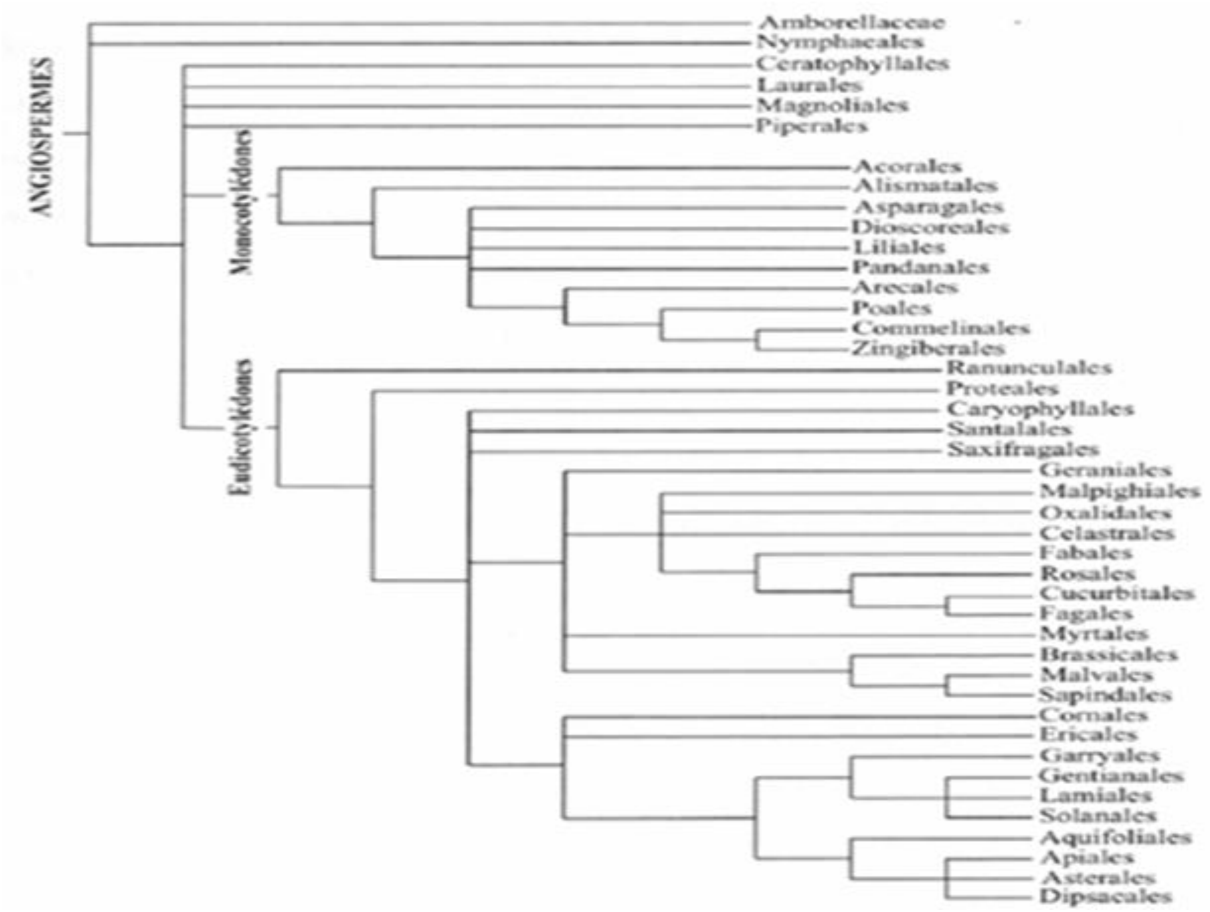


Fig. 104 : Organization of angiosperms (APG 2003)

1. **PROTOANGIOSPERMS also called Paleoherbs**

    -Incomplete welding of the carpels, closed by a secretion
    -Aquatic plants or shrubs (175 species)
    -Most often spiral insertion of floral pieces

a. Order 1: ***Emborellales***: 1 family and 1 species: ***Amborella trichopoda***

b. Order 2: ***Nympherales****:* former class. Dicotyledons Dialypetals Thalamiflora

Nymphaeaceae family (Aquatic plants: 58 species).

Example: ***Nymphea alba*** (white water lily)

c. Order 3: ***Austrobayleyales***: Illicium verum (star anise)

2. EUANGIOSPERMS (perfectly closed carpels):

2.1. MONOAPERTURED EUANGIOSPERMS

- Pollen with a single aperture
-Trimerous flowers
-Apetalous or with perianth formed of tepals
-Sometimes spiral insertion of floral pieces

2.1.1. Monocotyledons or Liliopsids

2.1.2. Primitive Dicotyledons or *Magnoliidae*

2.1.1. Monocotyledons or Liliopsids (52,000 species)

- Flower type 3 (trimer)
- 1 cotyledon only
- Stem rarely branched
- No secondary formations in stem and root
- Liberoligneous bundles scattered in the stem
- Fasciculate type roots
- Generally, no true leaves: Phyllodes or Cladodes often with parallel venation.

2.1.1.a. Archaic monocotyledons

2.1.1.b. Advanced monocotyledons

2.1.1.a. Archaic monocotyledons: flowers often aperiantheous

Order of *Acorales
Order *Alismatales

* **Order *Acorales***

➢ Family ***Acoraceae*** (former class Monocotyledons Superovaries)

- (2-4 species)
- Spadix with spathe
-Presence of scalariform tracheids in the wood
-Rhizome of certain varieties used in perfumery (Essential Oils).

* **Order *Alismatales***:

➢ Family ***Araceae*** (former class Monocotyledons Superovarieae)

-> 4,000 species
- Tropical regions,
- Very numerous ornamental species
- Simple spadix with membranous spathe
- Leaves often more or less triangular
- Fruit: berry

- Toxic by saponosides and very irritating due to the presence of calcium oxalate raphides

- Undergrowth
- Perennials by tuber
- Leaves appearing in autumn (***Arum italicum***) or in spring
- Spadix (approx. 8-10cm) - Ended by a sterile yellowish "club" (***Arum italicum***) or brownish (***Arum maculatum***), with spathe
- Fruits: red berries on spikes (from May to October)
- Toxic and irritant - Adapted to pollination by flies
- Unpleasant odor
- Heat release at the base of the spadix

2.1.1.b. Advanced monocotyledons

- Trimerous flowers, often well developed
- Tepaloid perianth.

Order of *Arecales
Order of *Poales
Order of *Asparagales
Order of *Liliales
Order of *Dioscoreales

Order of *Arecales

➢ Family ***Arecaceae***: (former class. Monocotyledons Superovaries)

- 2000 species
- Hot regions
- Stem formed by the base of fallen leaves, uniform diameter from base to top = stipe
- Leaves in terminal bouquet
- Branched spadix
- Trimerous or dimerous (3 pieces or 2 pieces per floral whorl)
- Fruit: drupe or berry
- Very great economic importance
  *Food (date palm, coconut tree)
  * Oil (oil palm)
  * Fibers (raffia, rattan, vegetable horsehair)

Example: Date palm (***Phoenix dactylifera***) Coconut tree (***Cocos nucifera***)

Order *Poales

- Family ***Poaceae:*** (former class Monocotyledons Superovaries)

  - > 10,000 species
  - Cosmopolitan family (the most widespread on the surface: prairies, steppes, pampas, savannas, etc.)
  - Annual or perennial herbaceous plants (rhizome)
  - Hollow stem with nodes and internodes: culm (woody in bamboos)
  - Narrow, ribbon-like "leaves", with parallel venation, distichous - Inflorescence: single-flowered or multi-flowered spikelet protected by 2 glumes, each flower has 2 glumes and 2 glumellules.
  - Spikelets grouped in ears or panicles.
  - Fruit: caryopsis rich in starch
  - Very great economic importance (Food species (cereals)

Example: Rice (***Oryza sativa***) 25% of cereals,
Wheat (several species of the genus ***Triticum***), 30% of cereals
Some fiber species: ***Alfa Stipa tenacissima*** (paper), esparto ***Lygeum spartum***

Order of *Asparagales

- Family of ***Alliaceae***: (former class. Monocotyledons Superovaries, F of Liliaceae)

  - 800 species
  - Characteristic odor -Compact inflorescence
  - Small flowers
  - (3+ 3) T + (3+3) E + 3C
  - Superior ovary
  - Fruit: capsule
  - Genus ***Allium*** (700 species)

Example: Garlic (***Allium sativum***), Onion (***Allium. cepa***), Leek (***Allium porrum)***

- Family ***Asparagaceae***: (former class. Monocotyledons Superovaries, F of Liliaceae)
  - -160 species
  - Horizontal or vertical rhizome
  - Fruit: berry in general - "Leaves": linear cladodes

Example: Asparagus (***Asparagus stipularis***)

- Family ***Ruscaceae***: (former class. Monocotyledons Superovariaceae, F of Liliaceae)

  - 475 species
  - Leaves arranged in spirals or in 2 rows
  - Fruit: generally, berry (sometimes drupe)

Example: Little holly (***Ruscus aculeatus***)

- Family ***Amaryllidaceae***: (former class. Monocotyledons Inférovaries)

  - 800 species
  - Perennial by bulb or rhizome
  - Large flowers with corundum
  - (3+ 3) T + (3+3) E + 3C
  - Inferior ovary - Ornamental
  - Irritants (calcium oxalate raphides)
  - Bulbs often toxic (alkaloids), confused with edible bulbs

  Example: Narcissus (***Narcissus cup***)

- Family ***Iridaceae*** (former class. Monocotyledons Inférovaries)

  - > 1800 species
  - Herbaceous, perennial by rhizome, tuber or bulb
  - (3+3) T + 3 E + 3C
  - Inferior ovary
  - Petaloid stigmata
  - Sometimes zygomorphic (gladiolus)
  - Fruit: capsule

  Example: Garden iris (***Iris germanica***)

- Family ***Orchidaceae***: (former class: Inferovariate Monocotyledons)

  -> 20,000 species (around 47 in Algeria)
  - Terrestrial, epiphytes, parasites, …
  - Generally, 2 ovoid tubercles in terrestrial species
  - Symbiosis with fungus (Rhizoctonia)
  - 3S+3 P or (3+3) T
  - Zygomorphic dialytepal perianth

Generally, only 1 fertile stamen, pollen grouped together - Most often in 2 pollinia united by the sticky retinaculum

Example: Vanilla (***Vanilla planifolia***)

****Order of Liliales***

****Colchicaceae*** family

* ***Melanthiaceae*** family

* ***Liliaceae*** family

- ***Colchicaceae*** family (former class. Monocotyledons Superovariaceae, F of Liliaceae)

  - > 250 species
  - Fruit: capsule
  - Leaves in 2 rows or more or whorled
  - Wet meadows
  - Perennial by full bulb
  - Extending into the ground
  - Leaves + capsules in spring
  - Very toxic: alkaloids (colchicine, antimitotic)
  - Treatment of acute gout attacks

Example: Colchicum (***Colchicum autumnal***)

- Family ***Melanthiaceae***: (former class Monocotyledons Superovariaceae, F of Liliaceae)

  - < 200 species
  - Leaves often persistent, with sheathing base
  - Branched inflorescence (cluster type)
  - Blackish rhizome (worm atrum = all black)
  - Alternate leaves: bases of the leaves nested forming a pseudo -full stem
  - Terminal inflorescence of whitish flowers
  - Fruit: capsule
  - Very toxic: alkaloids

Example: Verâtre, Varaire (***Veratrum album***)

- Family ***Liliaceae*** (str s.) (anc. class. Monocotyledons Superovariaceae, F of Liliaceae)

  -635 species
  - Herbaceous, perennial plants
  - Large flower
  - (3+ 3) T + (3+3) E + 3C
  - Superior ovary, trilocular, axile placentation
  - Fruit: capsule

Example: Tulips (***Tulipa sylvestris***)

***Order of Dioscoreales**

- Family ***Dioscoreaceae***: (anc.class. Inferovariate Monocotyledons)

- > 800 species
- Woody stem, often liana
- Full sheet
- Reduced flowers
- Fruit: capsule or berry
- Yam family (consumed in tropical regions)

Example: Tamier, battered woman's herb (***Dioscorea communis***)

2.1.2. Primitive Dicotyledons or *Magnoliidae*

- 2 cotyledons
- Monoaperated pollen
- Indistinct calyx and corolla (tepals) or absent
- Trimerous flower or spiral arrangement

Order of the *Magnoliales

*** Order of the *Laurales***

Order of *Magnoliales

- Family ***Magnoliaceae*** (former class. Dicotyledons Dialypetals Thalamiflora)

-230 species
- Shrubs or trees from tropical or subtropical regions
- Large flowers, biperianthose or with free petaloid tepals on a spiral
- Elongated floral receptacle (thalamus)
- Numerous stamens and numerous carpels on a spiral
- Variable fruit

Order of *Laurales

- Family ***Lauraceae***: (former class. Dicotyledons Dialypetals Thalamiflora)

- 2500 species
- Shrubs or trees
- Single leaves
- Hot regions
- Small flower -3S + 3P + (3+3+ 3) E + 1C
- Sepaloid petals
- Fruit: berry (sometimes drupe)
- Essence cells (aromatic plants)

Example: Bay laurel or noble laurel Cinnamon trees, Avocado trees.

2.2. EUANGIOSPERMES TRIAPERTURED EUDICOTYLEDONS

- 2 cotyledons
- Pollen with 3 apertures (except exceptions!)
- Increase in thickness by secondary structures
- Complete leaves (blade and petiole)
- Flower type 5 (pentamer), sometimes 4 (tetramer) rarely 3 (trimer)

2.2.1. Archaic eudicotyledons

2.2.2. Advanced eudicotyledons

2.2.1. Archaic eudicotyledons

- Often tepaloid perianth
- Frequent dialycarpy

Order of *Ranunculales

****Ranunculaceae*** family

*Family ***Papaveraceae***

➢ Family ***Ranunculaceae*** (former class Dicotyledons Dialypetals Thalamiflora)

- > 2500 species
- Temperate and cold regions, often humid environments Very heterogeneous family
- Herbaceous plants, alternate leaves, often very cut
- Perianth of nS (petaloids) in spiral with 5S + 5P in whorls
- Often whorled perianth and stamens and carpels on a spiral:
- Hemicyclic flower
- Numerous stamens (polystemone androecium)
- From n to 3 Free carpels *if n C: fruits = achenes *if 3-5C: fruits = follicles
- Often toxic (alkaloids, cardiotonic heterosides)

Example: Aconitum napel ***(Aconitum napellus***)

➢ ***Papaveraceae*** family: (former class. Dicotyledons Dialypetals Thalamiflora)

- 760 species including 100 Papaver
- Herbaceous plants from temperate to cold regions
- Dimerous flowers (sometimes trimerous)
- 2S + (2+ 2) P + (n+n) E + (n or 2) C
- Deciduous sepals

- Meristemonous androecium (large number of stamens per branching of the filaments)
-"Open" fused carpels: unilocular ovary, parietal placentation
- Fruit: capsule (pseudo silique when 2 C)
- Very many very small seeds
- Latex rich in alkaloids

Example: Opium poppy (***Papaver somniferum***) Poppies (***Papaver hybridum***)

2.2.2. Advanced eudicotyledons

Dialy or gamopetalous most often (sometimes apetalous)

2.2.2.a. Atypical Eudicotyledons: *Caryophyllidae*

2.2.2.b. Higher Eudicotyledons Dialypetals: *Rosidae*

2.2.2.c. Eudicotyledons Superior Gamopetals: *Asteridae*

2.2.2.a. Atypical Eudicotyledons: Caryophyllidae original characters:

- Perisperm
- Curved embryo
- Imperfect ovules

Both primitive and evolved characters

Order of *Caryophyllales
Order of the *Santalales

***Order Caryophyllales**

- ➢ ***Amaranthaceae*** family
- ➢ ***Caryophyllaceae*** family
- ➢ ***Polygonaceae*** family
- ➢ ***Cactaceae*** family

- ➢ Family ***Amaranthaceae*** (including ex-Chenopodiaceae) (former class. Dicotyledons Apetals Hermaphrodites)

- > 2000 species
- Herbaceous plants, often halophilic
- Contracted inflorescences of small flowers
- 2-3C, unilocular ovary, 1 ovule only
- Fruit: achene
- Betalains: some used as food coloring, for example:

- Beetroot Red (E 162)

Example: Beetroot (***Betta vulgaris***)

➢ Family ***Cactaceae*** (former class. Dicotyledons Dialypetals Caliciflora)

- 1500 species
- Origin: desert regions of tropical America
- Large, regular flowers, most often isolated
- Fruit: berry - Perfect adaptation to the desert climate
- Cylindrical or spherical stem: limited evaporation
- Water reserves
- Leaves reduced to thorns (stem: photosynthesis)
- "Succulent plants" or "fat plants"

Example: Prickly pear (***Opuntia ficus-*** indica)

➢ Family ***Caryophyllaceae*** (former class. Dicotyledons Apetals Hermaphrodites)

- 2200 species
- Herbaceous plants with knotty stems
- Leaves (= phyllodes) opposite
- Biparous cymes - Flower: 5S + 5P + (5+5) E + 5 to 2C
- Fruit: capsule

Example: Corn cockle (***Agrosthemma githago***)

➢ Family ***Polygonaceae***: (former class. Dicotyledons Apetals Hermaphrodites)

- 1100 species
- Perennial herbs with tuberous underground organs, sometimes vines or trees
- Knotty stems
- Leaves with ochrea
- Sepaloid or tepaloid perianth with (3+3) or 5 pieces
- Flower: (3+3) or 5T + (3+ 3) E + 3 or 2C
- Fruit: trigonal achene (persistent S)

Example: Edible rhubarb (***Rheum rhaponticum***)

➢ Family ***Santalaceae*** (former class. Dicotyledons Apetals Unisexuosa)

- 1000 species
- Herbaceous or woody plants
- Parasites or hemi-parasites

Example: Mistletoe (***Viscum album***)

2.2.2.b. Higher Eudicotyledons Dialypetals: Rosidae -Dialypetals

- Floral pieces in whorls
- Different calyx and corolla
- Pentamers (sometimes tetramers)

Order of *Rosales
Order of *Fabales
Order of *Cucurbitales
Order of *Malpighiales
Order of *Brassicales
Order of *Malvales
Order of *Sapindales

Order of *Rosales

****Rosaceae*** family
* ***Rhamnaceae*** family
* ***Moraceae*** family
* **Cannabaceae** family

➢ Family ***Rosaceae*** (former class. Dicotyledons Dialypetals Caliciflora)

- 3500 species
- Mainly temperate regions
- Heterogeneous family: herbaceous plants, bushes, trees
- Isolated, stipulated, simple or compound leaves
- Frequent calculus
- Various inflorescences: isolated flowers, clusters, spikes, corymbs, etc.
- Corolla with 5P, rosaceous
- Numerous stamens, 10-50 (polystemony)
- Carpels isolated or concrescent with the floral receptacle
- Variable fruit:
    * If few carpels (1-5): follicles or drupes
    * If numerous carpels: achenes
- The floral receptacle sometimes participates in the formation of a "false fruit":
- Fleshy receptacle bearing the achenes: strawberry
- Urn-shaped receptacle enclosing the achenes: rose bush (hip)
- Receptacle welded to the ovary: apple, pear
- Some medicinal species, many foods species
- (Fruit trees), very numerous ornamental species (including rose bushes)

Examples: Rose (***Rosa canina***) Raspberry (***Rubus idaeus***) Wild strawberry (***Fragaria vetch***).

- ***Rhamnaceae*** family: (former class. Dicotyledons Dialypetals Caliciflora)

  - >900 species
  - Woody plants with simple leaves
  - Flowers type 4 or 5
  - Hollow floral receptacle with nectar disc at the bottom
  - Dried fruit or drupe

Example: sedra ***(Ziziphus lotus***)

- Family ***Moraceae***: (former class. Dicotyledons Apetals Unisexuosae)

  -1100 species - Woody plants
  - Spike-shaped inflorescences
  - Fruit: drupe or achene
  -Laticifers

Example: Fig tree (***Ficus carica***) Mulberry trees (***Morus alba*** and ***Morus nigra***)

- Family ***Cannabaceae*** (former class. Dicotyledons Apetalous unisexual)

  - Formerly 2 genera (Humulus and Cannabis) and 2 species
  - Currently (APG II): 11 genera (170 species)
  - Herbaceous or woody plants

Example Cultivated hemp (***Cannabis sativa***).

Order of *Fabales

- ***Fabaceae*** family: (former class. Dicotyledons Dialypetals Caliciflora), Fabaceae or Legumes

  - 19,400 species
  -Variable port: tree grass, liana
  - Compound leaves stipulated (except Cercids)
  - 5S + 5P + (5+ 5) E + 1C
  - Zygomorphic or actinomorphic flower
  - Fruit: pod (= vegetable).

Most Fabaceae live in symbiosis with bacteria of the genus Rhizobium capable of fixing atmospheric nitrogen.

-3 or 4 subfamilies depending on the authors

- Subfamily ***Cercidae***
- Subfamily ***Caesalpinioideae***
- Subfamily ***Mimosoideae***
- Subfamily **Faboideae** (= ***Papilionoideae,*** often ***Papilionaceae***)

- Subfamily ***Faboideae*** (= ***Papilionoideae***, often ***Papilionaceae***)

-13,900 species
- Annual or perennial herbs, shrubs, trees, vines
- Alternate leaves, pinnately compound, stipulate (stipules sometimes transformed into spines or replacing the leaves)
- Inflorescence: cluster in the shape of an ear, umbel or capitulum
- Zygomorphic flower called papilionaceous

Order *Cucurbitales

➢ ***Cucurbitaceae*** family (former class. Dicotyledons Gamopetals Inferovaries). Tetracyclics)

- 850 species
- Warm regions (2 native species)
- Creeping or climbing plants thanks to tendrils
- Leaves generally palmately lobed
- Flowers generally gamopetalous, sometimes dialypetalous
- 5E + or
-Welded by their filaments or by their anthers
- 3C generally with hypertrophy of the placentas
- Fruit: berry,

Example: zucchini (***Cucurbita moschata***) melon (***Cucumis melo***)

Order of *Malpighiales

****Euphorbiaceae*** **family**

****Hypericaceae*** **family**

➢ ***Euphorbiaceae*** family: (former class. Dicotyledons Dialypetals Thalamiflora)

- > 5700 species
- Herbaceous or woody plants, sometimes cactiform
- Variable inflorescence
- Unisexual flowers with reduced or no perianth
- Fruit: capsule
- Presence of laticifers (latex canals): several species produce rubber

Example: Castor oil plant (***Ricinus communis***)

➢ Family ***Hypericaceae***: (former class. Dicotyledons Dialypetals Thalamiflora)

->550 species - Herbaceous or woody plants
- nE: meristemonous androecium, stamens in 3 or 5 bundles

-Pockets and secretory ducts

Example: St. John's Wort (***Hypericum perforatum***)

Order of *Brassicales

- Family ***Brassicaceae*** (former class. Dicotyledons Dialypetals Thalamiflora)

  - 4000 species
  - Temperate and cold regions
  - Herbaceous plants with simple alternate leaves
  - Cluster type inflorescence
  - Dimer flowers: (2+2) S + (2+2) P + (2+4) E + 2C
  - Tetradynamous androecium - Unilocular ovary then divided into 2 chambers by a "false partition"
  - Fruit: silique or silicle, of varied shape
  - Plants rich in sulfur compounds (glucosinolates)

Example: Mustard (***Sinapis arvensis***), ***Brassica oleracea***. var. ***botrytis***: cauliflower

Order of *Malvales

- ***Malvaceae*** family: (former class. Dicotyledons Dialypetals Thalamiflora)

  -> 4200 species

According to APG includes a certain number of "old families"

* Malvaceae (mallow, marshmallow, cotton, hibiscus),
*Tiliaceae (lime tree),
*Bombacaceae (baobab),
* Sterculiaceae (cocoa tree), etc.

- Herbs, shrubs or trees
- Stipulated sheets
- Often palmate venation
- Presence of mucilages (mixtures of polysaccharides)
- Fruit: capsule most often (sometimes berry, schizocarp, etc.)

Example: Wild Mallow (***Malva sylvestris***)

Order of *Sapindales

- ***Rutaceae*** family: (former class. Dicotyledons Dialypetals Disciflora)

  - 1000 species
  - Woody plants from warm regions
  - Fruit: follicle or berry
  - Secretory cells and pockets

Example: Fetid Rue (***Ruta chalepinsis***), lemon tree, orange tree, grapefruit tree, etc.

2.2.2.c. Higher Eudicotyledons Gamopetals: Asteridae

- Gamopetals
- Floral pieces in whorls
- Pentamers (sometimes tetramers)
- Differentiated calyx and corolla

Order of *Ericales
Order of *Gentianales
*** Order of *Lamiales***
Order of the *Solanales
Order of *Apiales
*** Order of *Dipsacales***
*** Order of *Asterales***

Order of *Ericales

➢ ***Ericaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Pentacyclics).

-3000 species
- Temperate or cold regions, acidic soils
- Woody plants (shrubs or shrubs), with simple leaves, often persistent.
- Regular flower type 4 or 5
- Corolla often urn-shaped -8-10 E (sometimes 4-5)
- Horned anthers, pollen in tetrads
- 4-5C, multilocular ovary, superior.
- Fruit: capsule (sometimes berry)

Example: Strawberry tree or strawberry tree (***Arbutus unedo***), Heathers (***Erica arborea***)

Order of *Gentianales

****Gentianaceae*** family
****Apocynaceae*** family
****Rubiaceae*** family

➢ ***Gentianaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Tetracyclics)

- 900 species
- Mountains of temperate and cold regions

- Herbs with opposite leaves (or in a rosette at the base)
- Inflorescences: contracted cymes.
- Type 5 (sometimes 4), 2C
- Superior, unilocular ovary.
- Fruit: capsule

Example: Yellow gentian (***Gentiana lutea***)

➢ ***Apocynaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Tetracyclics)

-Very variable port: grasses, shrubs, trees, often vines, sometimes succulent plants.
- Opposite or whorled leaves
- Presence of laticifers
- Gamopetalous corolla, often with additional appendages
- Flowers most often pentamerous, sometimes tetramerous.
- 2 carpels giving 2 follicles containing hairy seeds

Example Oleander (***Nerium oleander***)

➢ ***Rubiaceae*** family: (former class. Dicotyledons Gamopetals -Inferovaries Tetracyclics)

-Native species: herbaceous plants with square stems
- Exotic species: trees, vines, epiphytes
- Simple, opposite leaves, with stipules sometimes as large as the leaves
- Pentamerous or tetramerous flowers, 2 carpels
- Fruit: variable

Example: Coffee tree (***Coffea arabica*** and ***Coffea canephora***, var ***robusta***)

***Order of Lamiales**

__Lamiaceae__ family
__Verbenaceae__ family
__Plantaginaceae__ family
__Family Scrophulariaceae__

➢ ***Lamiaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Tetracyclics)

-Square stem, opposite decussate leaves
- Zygomorphic gamopetalous corolla forming 2 lips
- Androecium didynamyum (sometimes only 2E Sage, rosemary)

- Gynaeceum: 2C, 2 compartments then partitioning giving 4 compartments
- Fruit: tetrachene (with persistent calyx)
- Plants very rich in essences (secreting hairs) containing Phenolic compounds (e.g. thymol) and especially terpenic compounds (menthol, camphor, etc.)
- Very great interest in phytotherapy and in cooking (antioxidant activity).

Example: Common sage (***Salvia officinalis***), Lavender (***Lavadula latifolia***)

- ***Verbenaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Tetracyclics)

  - Grasses, vines or trees
  - Often secretory hairs
  - Gamopetalous flowers, bilabiate zygomorphic

Example: White broth or Mullein (***Verbascum thapsus***)

Order of *Solanales

****Solanaceae*** family
****Boraginaceae*** family

- ***Solanaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Tetracyclics)

  - Herbs or shrubs with alternate leaves.
  - Biparous cymes + or - modified (sometimes isolated flowers)
  - Persistent or accrescent calyx
  - Variable corolla: rotaceous, funnel-shaped, more or less narrow or campanulate
  - Flower type 5, 2C (sometimes 5 to 10, ex tomato)
  - Fruit: berry or capsule.
  - Particular richness in alkaloids

Example: Food Solanaceae: potato (fruit: toxic berry, we eat the underground stem full of starch) * tomato, * eggplant, * pepper, * chilli peppers Tobacco, Nicot herb, petun …. (***Nicotiana glauca***)

- ***Boraginaceae*** family: (former class. Dicotyledons Gamopetals Superovaries Tetracyclics)

  -2000 species
  - Rough hairy grasses
  - Isolated leaves often decurrent
  - Scorpioid cymes
  - Corolla of variable shape

- Flower type 5, 2C - 2 ovules per carpel, divided into 2 by septum giving ovary with 4 chambers
- Fruit: tetrachene (sometimes fleshy fruit)

Example: Borage (***Borago officinalis***)

Order of *Apiales

****Apiaceae*** family
****Araliaceae*** family

➢ Family ***Apiaceae***: (former class. Dicotyledons Dialypetals Caliciflora)

- 3000 species
- ***Apiaceae***, ***Umbelliferae***
- Hollow and grooved stem
- Very cut alternate leaves, developed sheath
- Inflorescence: simple or compound umbel
- Small flowers, type 5
- 2C: diakene fruit
- Very homogeneous family

Example: ***Apium graveolens***

➢ ***Araliaceae*** family: (former class. Dicotyledons Dialypetals Caliciflora)

- 700 species
- Plants, most often tropical regions
- Simple umbels
- Flower type 5, 2C
- Fruit: drupe or berry

Example: Ginseng: ***Panax ginseng***

Order of *Dipsacales

* ***Caprifoliaceae*** family
* ***Adoxaceae*** family

Order of *Asterales

➢ Family ***Asteraceae***: (former class. Dicotyledons Gamopetals Inferovaries Tetracyclic) Example ***Compositae***, ***Asteraceae.***

- 23.600 species
- Cosmopolitans
- Plants most often herbaceous, but also woody species, twining species as well as succulent species (deserts)
- Leaves most often alternate
- Flower type 5 but 2C
- Reduced calyx: simple rim, scales or bristles
- Gamopetalous corolla either regular in tube: floret, or ligulate: half-floret (sometimes bilabiate)
- Flowers gathered in a characteristic compact inflorescence: the capitulum

Example: Marigold (***Calendula arvensis***) Artichoke (***Cynara scolymus***), Chrysanthemum (***Chrysanthemum grandiflorum***)

Glossary

A

Actinomorphic : adj. (gr. Aktinos, ray and morphé, form). Character of a flower whose parts of the successive whorls are arranged symmetrically with respect to the axis of the flower.

Adaxial : adj. (lat. axis, axle). Describes the upper (or ventral) part of a leaf.

Adventitious : adj. (lat. Adventicius, supplementary). Said of a plant originating from another country which colonizes a territory without having been knowingly introduced there. Also said of an "undesirable" plant species, present in a culture of another species, this one desired.

Airy : adj. (lat. air and ferre, to carry). Said of an element of plant structure (notably a gap) which contains air.

Agame : adj. (from a, privative and from the gr. gamos, marriage). Characteristic of plants capable of propagating without having to resort to the processes of fertilization.

Albumen : m.n. (Latin word, egg white). Reserve tissue of a seed destined, sooner or later, to be consumed by the embryo. The nucleus of each cell has a triple set of chromosomes.

Aleurone : f.n. (gr. aleuron, flour). Aleurone occurs in spermatophytes only in the form of grains. It is a reserve substance made up of nitrogen compounds, and located in many seeds/Born from the dehydration and fragmentation of vacuoles, it is therefore a figurative content of the cell which contains them.

Almond: f.n. (lat. amandula, almond. In angiosperms, this term designates the seed contained in a kernel.

Allogamy: f.n. (gr. allos, other and gamos, marriage). Pollination of a flower by pollen released by the stamens of a flower carried by another individual, but of the same species, variety or cultivar.

Alternation : f.n. (lat. alternare, to alternate) Succession of haploid and diploid phases due to the inevitable, fertilization and chromatic reduction when a plant knows the sexual processes of reproduction. We also say "alternation of generations".

Alternates : adj. (lat. alternus, alternate). Arrangement of various pieces which are placed alternately, and not opposite each other.

Androecium : m.n. (gr. andros, man; oikia, house) set of male fertile parts of a flower grouped most often in a whorl (e).

Androgyny : f.n. (gr. andros, man; gynê, woman;). Characteristic of a plant which has, at the same time, on the same subject, male flowers and female flowers.

Anemophilous : adj. (gr. anemos, wind; philos, friend). Describes the pollination of flowers when it is carried out thanks to the transport of pollen by the wind and to certain morphological arrangements of the female parts which make them particularly receptive.

Angiosperms : f.n.pl (gr. aggeion, capsule; sperma, seed). Important group of higher plants characterized by the possession (at the level of their flowers) of an ovary enclosing one or more ovules, which organs (following a double fertilization) will respectively become a fruit containing one or more seeds.

Antheridium : f.n. (gr. antheroids, flower). Male compartment within which the male gametes (or antherozoids) are developed.

Antherozoid : m.n. (gr. anthéros, flowered; zoôn, living being. It is the male gamete in plants. It is a cell that is most often ciliated or flagellated and, consequently, mobile. The term spermatozoon is also used.

Aperianth : adj. (gr. a, privative; peri, around; anthos, flower). Said of a flower which does not have any part of a normal perianth (and therefore neither sepals nor petals).

Apetalous : adj. (gr . a, privative ; petalon, petal). Describes a flower that has only one whorl of protective parts. It is then considered that it is the petals (the corolla) that are missing, and therefore that only the sepals (the calyx) are present.

Arboreous : adj. (lat. arbor, tree). Said of a plant formation with a predominantly herbaceous plant, simply punctuated, from time to time, by the presence of a few scattered trees.

Arborescent : adj. (lat. arborescere, to become a tree. Having the size and shape of a tree

Archegonium : m.n. (gr. arkhaios, ancient; gynê, woman). This is the female compartment, most often bottle-shaped, at the level of the belly of which the female fertile cell or oosphere is located.

Archegoniates : m.n pl. (gr. arkhaios, ancient; gynê, woman). Set of all plants whose female gametangia are archegonia.

Asexual : adj. (lat. a, privative; sexus, sex). Refers to a mode of propagation that does not come from sexuality.

Association : f.n. (lat. associare, to associate). Grouping of plants growing in given ecological conditions, which explains that an association has a floristic composition which reflects a common background of species that we will qualify as characteristics of the plant association. Among them will also cross certain species not strictly linked to the association considered but which are quite often encountered there and we will call them **companion species** . Finally, we will note the unexpected presence of some species, rather linked to other conditions, to other associations: these will be **accidental species** .

Autogamy : f.n. (gr. autos, oneself; gamos, marriage). Fertilization of a flower by its own pollen. There is therefore self-pollination.

Auxins : f.n.pl (gr. auxanos, to grow). Chemical compounds secreted in privileged areas of a plant and which act powerfully, even at very low doses, on the growth of cells of still young tissues.

Axile : adj. (lat. axis, axle). Type of placentation corresponding to a multicarpellate ovary whose different carpels are first closed (each for itself) then welded together. The ovules are therefore arranged in "2" daughters along the central axis of the ovary ("n" designating the number of carpels at the origin of the gynoecium).

Axillary : adj. (lat. axilla, armpit). Which is located in the armpit of an organ (branch, leaf, bract).

B

Basipetal : adj. (gr. basis, base; petere, to gain). Refers to the direction of evolution of a phenomenon (flowering wave for example) when it propagates from the top of an organ towards its base.

Berry : f. n. (lat. bacca, berry). Fleshy fruit with seeds whose pericarp is, if it is a popular plant species, completely edible. We distinguish between inferior berries and superior berries according to the relative position of the ovary in the flower from which they are derived.

Biennial: adj. (lat. bi, twice; annus, year). A plant is biennial if it completes its cycle only through a development encroaching on two calendar years.

Bilabié : adj. (lat. bi, twice; labrum, lip). Said of a calyx or corolla whose parts are welded in two lots which each constitute a lip.

Binomial nomenclature : f.n. (lat. nomenclature, action of calling someone by their name). Designation of plants universally accepted since Linnaeus, its initiator, around 1750. It consists of: using Latin; juxtaposing two words, one to designate the genus, the other to specify the species. The name of the genus always begins with a capital letter; the name of the species, always with a lowercase letter. To this binomial it is appropriate to attach the initial (or the abbreviation of the name) of the first descriptor of the species.

Biotic : adj. (gr. bios, life). Describes everything that concerns life or conditions its maintenance or development. We therefore commonly speak of biotic conditions, of biotic index.

Bipinnate : adj. (lat. bi, twice; penna, pinna). Said of an organ whose branching is twice pinnate.

Bract : f.n. (lat. bractea, metal leaf). Leaf (whose morphology and size is generally very different from the other leaves of the plant in question, in the axil of which a bud has differentiated a flower or an inflorescence.

Bulb: m.n (lat. bulbus, bulb). Organ most often underground, place of accumulation of reserves for the plant. Its stem, very short, flattened (the plate of the bulb) supports one or more buds to be surrounded by more or less deformed leaf parts and differentiates towards the ground adventitious roots. We distinguish, according to the morphology of their leaves quite fleshy in general.

Bulbils: f.n.pl (lat. bulbus, bulb). Very effaced propagation organs in certain plants for which they ensure natural cuttings. Each bulbil in slow motion, rich in reserves, is normally made up of a short, swollen axis, surrounded by imbricated leaves. Bulbils form in the axils of leaves depending on the species.

C

Caliciflora : f.n.pl. (lat. calyx, calyx; floris, flower). Series of families of dialypetalous dicotyledonous plants whose representatives have flowers) concave floral receptacle, in the shape of a more or less pronounced calyx (sacred vase).

Calicle : m.n. (lat. calyx, calyx). This term is used to designate, at the level of the flower of certain angiosperms, an involucre of green parts, comparable to the sepals but doubling them externally in a whorl alternating with the real calyx.

Calyx : m.n (lat. calyx, calyx). Set of the most external parts of the perianth (or sepals) with an eminently protective role. When the perianth only includes a single whorl of parts, they are considered to be those of the calyx, even if these parts are brightly colored.

Cambium : m.n. (Latin word). These are special layers of cells whose purpose is to generate secondary tissues within organs. The external generative layer (or subero-phellodermic layer) differentiates cork (or suber) on the outside and phelloderm on the inside. The internal generative layer (or libero-ligneous layer) produces secondary liber on the outside and secondary wood on the inside.

Campylotropic : adj. (gr. kamptos, curved; tropos, tower). Said of an angiosperm ovule arched in such a way (in relation to its funicle) that the micropyle is, as a result, in a lateral position, and that the path: hilum, chalaza and micropyle, follows a pronounced curve.

Capillary : adj. (lat. capillaris, capillary). Said of certain fine formations like hair.

Carina : f.n (from the Genoese carena, or from the Roman carina, keel). This term applies especially (in the plant world) to the two lower petals welded together on the corollas of flowers.

Carpel : m.n. (gr. karpos, fruit). In all plants with ovules, these are carried on, and sometimes enclosed in specialized leaves for female use. In angiosperms, the carpels of each flower are more or less welded together and the whole is closed and constitutes the pistil or gynoecium of the flower with the ovule(s) inside.

Cauline : adj. (lat. caulis, stem). Which attaches to the stem or which belongs to the stem.

Chalaza : f.n. (gr. Khalaza, small intestine). This term is used to designate the precise level where, on the periphery of the ovule, the vascular elements that irrigate it diverge. The relative position of the chalaza in relation to the hilum and the micropyle in the ovule makes it possible to define three types of ovules (orthotropic, anatropic and campylotropic).

Chemotropism : m.n. (gr. Khemeia, chemistry; tropos, turn). Growth orientation taken by certain plant organs under the influence of chemical agents. Depending on whether it has attraction or repulsion, we speak of positive chemotropism or negative chemotropism.

Chitin : f.n. (gr. Chitôn, tunic). Organic compound, heteroside based on acetyl-glucosamine and containing proteins), flexible, quite widespread in the animal world, but which is also found in the skeletal wall of some plants.

Chlamydosperms : f.n.pl. (gr. Khlamys, coat; sperma, seed). Group of archegoniates intermediate between Gymnosperms and Angiosperms. They are also called Preangiosperms. It is by some of their anatomical and floral characters that they are truly intermediate.

Cluster : f.n. (germ. Krappa, hook). Indefinite inflorescence (a bud occupies the apex) with a centripetal flowering wave, whose flowers staggered along the axis, in an alternate arrangement, are pedunculated. The oldest flowers, blooming first, are therefore at the base of the cluster.

Coleoptile, Coleorhiza : m.n. / f.n. (gr. Koleos, case; ptil, light feather; rhiza, root). Small single-layered cases covering, respectively, the gemmule and the radicle of embryos and nascent seedlings of Poaceae. The coleoptile is well known for its ability to react to auxins. The gemmule and the radicle do not take long to pierce these seeds during their growth.

Collenchyma : m.n. (gr. Kolla, glue; enkhuma, substance). Support tissue whose cell walls are very thick (either on all sides, or locally and, in this case, tangential) thanks to a supernumerary deposit of cellulose. Collenchyma cells retain their punctuations and therefore their possibilities of exchange: collenchyma is therefore a living tissue.

Collar : m.n. (lat. Collum, neck). Transition zone between the root part and the cauline part of a higher plant. At its level there is a significant anatomical redistribution of the conductive tissues.

Conductor : adj. (lat. Conducere, from cum, with; ducere, to lead). Describes a tissue whose function is the transport of sap. This notion concerns wood (xylem) for raw (ascending) sap and phloem for elaborated (or ascending) sap.

Cone : m.n. (lat. Conus, cone). Male flower or female inflorescence of Gymnosperms. Each male cone is made up of an axis around which are inserted numerous scaly stamens supporting pollen sacs on their lower surface.

Conifer : m.n. (lat. Conus, cone; ferre, to carry). Important group of woody species in the world of Gymnosperms characterized by their needle-like or scale-like foliage; their female inflorescences in cones with ovules then seeds, naked; their secretion of resin.

Cork : m.n. (lat. levius, light material). Secondary tissue in spermaphytes, consisting of cells with walls rich in suberin, which leads to their early death by making them impermeable to water and gases. It is therefore a mechanical and heat protective tissue.

Corolla: f.n. (lat. Corolla, small crown). This term designates the set of petals of a flower. The corolla, located inside the calyx in flowers with a complete perianth, plays a protective role for the reproductive parts, just like the sepals.

Cotyledon: m.n. (gr. Kotulédon, cavity, small cup). Designates, at the level of the embryo of spermaphytes, the primordial leaf(s). The number of cotyledons is variable: only one in monocots. Two in dicots; up to 10 to 12 in gymnosperms. During germination, the cotyledons efficiently supply the young developing seedling by emptying themselves of their reserves.

Culm : m.n. (lat. Calamus, culm). Hollow stem of ***Poaceae***, except at the nodes where diaphragms meet, and made very strong by the development of a ring of supporting tissue.

Cultivar : m.n. (French abbreviation of “cultivated variety”). Each designates the very numerous new races, ornamental, fruit, medicinal, silvicultural, etc. obtained by breeders and propagated by them using seeds or by multiplication, while retaining their own characteristics.

Cuttings : f.n. (old fr. bouter, pousse). Action which consists of using cuttings to propagate a species vegetatively. Cuttings are very commonly practiced using various angiosperms.

Cutting : f.n. (old fr. bouter, pousse). Fragment of plant capable of regenerating the organs it lacks, and thus reconstituting an entire plant capable of continuing its perfectly autonomous development.

Cyme : f.n. (gr. Kuma, flow). Defined and therefore centrifugal inflorescence whose apex is cut by a flower, the oldest.

D

Deciduous : adj. (lat. cadere, to fall). Said of the foliage (or each leaf) of a plant destined to fall during the year, after having fulfilled its function, which normally happens as the bad season approaches. This term is sometimes applied to floral pieces that fall prematurely.

Dehiscence : adj. (lat. dehiscere, to open). This term refers to the fission of any part of a plant that opens spontaneously at maturity. The dehiscence of an anther can, depending on the position of the openings that allow the dispersion of pollen.

Desiccation : f.n. (lat. desicare, to dry out). Elimination of the water initially contained in the tissues of an active plant organ. This results in more or less severe dehydration which can sometimes lead to cellular deformations and movements linked to fluctuations in atmospheric humidity.

Dialycarpellate : adj. (gr. dialucin, to separate; Karpos, fruit). Said of the gynoecium of a flower whose carpels are not fused together.

Dialycarpic : adj. (gr. dialucin, to separate; Karpos, fruit). Group of thalamiflorous dialypetalous dicotyledons whose flowers possess, in addition to numerous stamens, independent carpels.

Dialypetals : adj. (gr. dialucin, to separate; skepé). Cover; petalon, petal). Said of the calyx of a flower whose sepals are free (they can be detached one by one).

Dicotyledons : f.n.pl. (gr. di, two; kotulêdon, small cup, cavity). Phanerogamous plants Angiosperms whose increase in diameter of the stems and roots results from the activity of cambiums. The seed contains an embryo) two cotyledons.

Digenetic : adj. (gr. di, two; gennetikos, generation). Describes a reproductive cycle in which the spores, on the one hand, and the gametes on the other, are at the origin, respectively, of well-represented haploid individuals and diploid individuals. There is therefore clearly a succession of two generations in the cycle.

Dioecious : adj. (Gr. di, two; oikos, habitat). Said of plant species capable of sexuality, but in which a single individual differentiates only male gametes, or only female gametes.

Disciflora : f.n.pl. (gr. diskos, disk; lat. florem, flower). Series of families of Dialypetalous Dicotyledons whose representatives have flowers provided with a receptacle supporting a nectariferous disk.

Dominance : adj. (lat . dormire, to sleep). Type of slowed life which results in the fact that an organ (even though placed in conditions conducive to its growth) does not evolve. Only microclimatic and/or physiological conditions.

Drupe : f.n. (lat. drupa, ripe olive). Fruit, fleshy with a stone. The pericarp is represented by the epicarp (the skin of the fruit), the mesocarp is the flesh and the endocarp, sclerotized, constitutes the stone. The seed, unique, or almond is located in the stone.

E

Egg : m.n. (lat. ovum, egg). Often called a zygote by biologists, the egg, in the plant kingdom, is a cell with a double set of chromosomes resulting from the fusion of two gametes (one male and the other female) fusion involves that of the cytoplasms and those of the nuclei. Depending on the species, the egg can either undergo meiosis immediately and generate tetraspores, or develop into a diploid individual (called the diplotte or sporophyte).

Embryo : m.n. (gr. embruon. foetus). Usually diploid formation, derived from the evolution of the egg born from fertilization.

Embryo sac : In Angiosperms this name refers to the female gametophyte at the heart of the ovule. It is a very small mass of 7 cells with 8 haploid nuclei: 3 uninucleate antipodes, 2 uninucleate synergids, 1 uninucleate oosphere and 1 vegetative cell with two nuclei. The embryo sac is derived from a diploid cell of the nucellus that has undergone meiosis and then an additional mitosis (hence the 8 haploid nuclei).

Endocarp : m.n. (gr. endon, inside; karpos; fruit). Innermost part of the pericarp of a fruit. When the endocarp of a fleshy fruit is sclerotized.

Endoderm : m.n. (gr. endon, inside; derma, skin). Cellular layer with an important physiological role (in the control of absorbed substances) which, in vascular plants, delimits the bark (at the limits of the central cylinder). The cells of the endoderm are often reinforced by secondary deposits of suberin on the four faces adjacent to the other endodermal cells.

Endosperm : m.n. (gr. endon, inside; sperma, seed). In gymnosperms, this term designates the haploid reserve tissue resulting from the development of the female prothallus, itself born from the meiosis of a cell of the original nucellus. The endosperm also developed early by consuming almost all of the nucellus.

Epigynous : adj. (gr. epi, on; gunê, female). Literally in Angiosperms: particular arrangement of the other floral parts which appear to be inserted on the ovary of the flower. In this case the ovary is therefore below the rest of the flower: it is said to be inferior. When all the floral parts (perianth, androecium) are arranged in this way, the flower itself is said to be epigynous or with an inferior ovary.

Evergreen : adj. (lat. semper, always; virens, green). Qualifier given to woody plants that keep their green foliage throughout the year (which means that the progressive replacement of the leaves has not taken place).

Exalbuminous : adj. (lat. ex, out of; albumen, Latin word). Said of an angiosperm seed whose embryo (diploid) has consumed all the albumen (triploid) during maturation. The ripe fruit therefore contains seeds without albumen.

Exine : f.n. (gr. exo, outside). External layer of the skeletal wall of the pollen grain, interrupted by pores, often richly decorated with ridges, furrows, meshes, striations, etc. and allowing the pollen of different species to be distinguished.

F

Family : f.n. (lat. famillia, family). Systematic grouping of plant genera that are brought together by common characteristics. Sometimes the genera are indisputably very close and the family is said to be homogeneous.

Female : adj. (lat. femella, female). Refers to anything of the female sex. In plants, the female gamete is generally larger than the male gamete and tends very quickly to become immobile while waiting for the arrival of the male gamete.

Fertilization : f.n. (lat. fecudare, to fertilize). Phenomenon observed for the first time in France by Thuret in 1885 in Fucus. Classically: genesis of an egg through the union of two gametes (one male, the other female). The male gamete in plants is called an antherozoid, while the female gamete is called an oosphere.

Filament : m.n. (lat. filum, filament). Thinned part of a stamen which is attached to the floral receptacle (or welded to the corolla) and supports the anther. The filament can be more or less long, more or less hairy, more or less flattened.

Fleshy : adj. (lat. Carnutus, fleshy). Said of organs that are somewhat swollen and of a fairly soft consistency.

Foliaceous : adj. (lat. foliaceus, foliaceous). Qualifier which applies to any organ having the appearance of a leaf.

Foliar : adj. (lat. folium, leaf). Describes that which relates to the leaf. Ex: leaf parenchyma, leaf necrosis (under the influence of a pathogen or a pollutant).

Floral diagram : A diagram showing the relative arrangement of all the parts of a supposed flower cut by a hypothetical transverse plane that would meet all the parts. The floral diagram also shows any welds between parts and the intimate structure of the ovary.

Floral formula : Numerical representation of the composition of a flower. The capitals S, P, E, C respectively designate the Sepals, Petals, Stamens and Carpels of the flower.

Fruit : m.n. (lat. fructus, fruit). Organ derived strictly from the female parts of a fertilized flower. As soon as double fertilization has taken place, the term fruit must be substituted for that of ovary. The fruit contains as many seeds as the ovary contained ovules (if all have been fertilized). The diversity of fruits is very great, according to the botanist, based mainly on the superior or inferior character of the ovary from which they derive.

Funicle : m.n. (lat. funiculus, small cord). Thin, threadlike formation that connects the ovule to the wall of the ovary at the placenta.

G

Galbule : f.n. female cone of some Gymnosperms whose carpels, few in number, become fleshy and welded into a globular and juicy whole fallaciously undermining a berry.

Gametangium : m.n. (gr. marriage; aggeion; capsule). Compartment developed during sexual differentiation by Cormophytes and characterized, early on, both by its structure and by its role. The central part of the gametangia evolves alone into gametes.

Gamopetals : adj. (gr. gamos, marriage; petalon, petal). Said of corollas whose petals are more or less completely welded together, which constitutes an evolved characteristic.

Gamosépales : adj. (gr. gamos, marriage; skepe; cover). Said of a calyx whose sepals are welded together.

Gemmule : f.n. (lat. gemma, bud). Refers, at the seed level, to the bud of the embryo which will develop, during germination, into a leafy shoot (the first axis of the plant). It is therefore the top part of the seedling, the one which will generate the entire aerial part of the plant. It is at its base that the cotyledon(s) are inserted.

Germination : f.n. (lat. germination, germination). Resumption of the active life of a plant after a period of rest of variable duration in the form of diaspores (spore, propagule or seed).

Glume : f.n. (lat. gluma, glume). Each of the 2 scarious parts that protect the spikelet in a Poaceae inflorescence. The glumes contribute to forming the chaff, or residue of the threshing of Cereals.

Glumella : f.n. (lat. gluma, glume). Each of the 2 scarious parts that protect each flower of a spikelet of Poaceae. The glumes, like the glumes, contribute to forming the chaff, or residue of the threshing of Cereals.

Grain : m.n. (lat. granum, grain). This term refers to various plant productions which have in common only their relative smallness.

Gymnosperms: f.n..pl (gr. Gymnos, naked; sperma, seed). Important group of higher plants characterized by their seeds elaborated naked from the ovules supported by carpellary leaves grouped in cones. Gymnosperms are almost all large, woody plants. Many morphological, histological, biological characteristics separate them from Angiosperms.

Gynece : m.n. (gr. gunaikeion, from gunê; woman). The gynoecium is the set of carpels, whether fused or not, of the flower of Spermaphytes (or seed plants).

H

Hermaphrodite : adj. (Gr. hermaphrodite, non-mythical). Said of a plant species in which each individual is capable of producing gametes of both sexes at the same time. This ability does not mean that self-fertilization is possible, or effective (fertile).

Hologamy : f.n. (gr. holos, whole; gamos, marriage). Particular mode of fertilization found in fungi and algae and characterized by the simultaneous fusion of the entire contents of the two complementary gametocysts.

Hilum : m.n. (lat. hilum, hile). A small, distinct colored area on the surface of a sheath usually indicates the precise location where the funicle connected to the ovule.

Hybrid : adj. (lat. hybrida, metis). Plant born sexually, from the crossing between two parents belonging to two different species or even to different genera.

Hypogynous : adj. hypo, below; gunê, woman). Said of a floral piece which appears to be inserted below the ovary, or that its ovary is superior.

I

Inferior : adj. (lat. inferior, lower). Describes the ovary of a flower and the fruit derived from it when it is located below the level of insertion on the receptacle of the other floral parts. The flower itself is said to be epigynous.

Inflorescence : f.n. (from lat. inflorescere). Set of flowers grouped on the same axis in a Spermaphyte. In Angiosperms, depending on whether the axis is occupied or not by a flower, the inflorescence is said to be definite (or centrifugal) or indefinite (or centripetal).

Integument : m.n. (lat. tegere, to cover). Although this term can be used to designate any covering, it is used much more regularly in the following sense. Protective envelope of the ovule in Prespermaphytes and Spermaphytes.

Internode : m.n. (lat. inter, between; nodus, node). Portion of stem between two successive nodes.

Intine : f.n. (lat. intimus, interior). Cellulosic inner layer of the skeletal wall of the pollen grain. It is this which distends when the pollen grain "germinates" on the surface of the female parts of the flower, thus constituting the pollen tube and will lead the male gametes home in the process of siphonogamy.

K

Kitten : m.n. (lat. Cattus, cat). Type of inflorescence common in the main forest woody species. It is a spike) flexible axis and a centripetal inflorescence whose flowers, unisexual, are sessile or very briefly pedunculated. There are male catkins and female catkins.

L

Lanceolate : adj. (lat. lancea, lance). Said of an organ (leaf in particular) in the shape of a narrow spearhead, tapered at both ends.

Leaf : f.n. (lat. folium). Fundamental organ of many plants characterized by its limb (green blade with a stimulating role) often extending a petiole which is then inserted on the stem of the plant. The morphological diversity of the leaves is considerable. Their arrangement on the stem responds to a specific plan which is translated by the mathematical data of phyllotaxis. Most of the leaves have bilateral symmetry.

Leaf blade : m.n. (lat. limbus, fringe). This term is used to designate the widened part of a leaf or a floral part (which is only a modified leaf). The privileged seat of photosynthesis, the leaf blade is, in principle: acicular or scaly in Gymnosperms; ribbon-like in many Monocotyledons; wide and more or less cut, compound in dicotyledons.

Leaflet : f.n. (lat. foliolum, small leaf). Each of the divisions of a compound leaf, which can be, for example, trifoliolate, multifoliolate.

Liber : m.n. (lat. liber, tree bark). Elaborate sap-conducting tissue, characteristic of vascular plants. Its characteristics differ depending on the systematic groups considered (Gymnosperms, Preangiosperms and Angiosperms). It is an essentially celluloso-pectic tissue for its walls and not very resistant.

Ligule : f.n. (lat. ligula, tongue). Leaf appendage which differentiates in Poaceae on the upper surface of the blade, at its connection with the sheath enclosing the culm.

Lobe : m.n. (gr. lobos, lobe). Rounded and shallow division of the blade of a leaf or a frond or a thallus.

Loculicide : adj. (lat. loculus, lodge; coedere). Mode of dehiscence of a capsule when the opening occurs at the level of the dorsal vein of each of the carpellary leaves which are at the origin of this capsule.

Lodge : f.n. (lat. from the Frankish laubja, lodge). At the level of the androecium: half of the anther of a stamen, itself comprising two pollen sacs. At the level of the Gynoecium: each of the cavities delimited within the ovary by partitions of the various carpels constituting this ovary, when these partitions have not disappeared during development.

M

Maturation : f.n. (lat. maturare, to ripen). Succession of morphological and physiological transformations which restore an organ to be able to fulfill its functions. In the case of fruit, the size, color, flavor and its resistance to penetration are the essential data which allow it to be considered ripe or not.

Meristem : m.n. (gr. meristos, to share). Tissue consisting of a set of cells that have remained embryonic, cells that are substantially isodiametric, with a thin skeletal wall and a high ratio of the volume of the nucleus compared to that of the entire cell, capable of dividing at a sustained rate, generating, after differentiation of the cells produced, the specialized tissues of adult organs.

Mesophyll : m.n. (gr. meso, middle; phullon, leaf). The mesophyll constitutes, at the level of the blade, the middle part of the leaf, between the epidermis. It is a palisade parenchyma under the upper epidermis in a mealiferous parenchyma, or lacunate in contact with the lower epidermis.

Micropyle : m.n. (gr. mikros, small; pulê, door). Small discontinuity of the integument(s) surrounding the ovule, allowing the passage of the pollen tube towards the embryo sac, in order to ensure fertilization.

Monadelphous : adj. (gr. monas, unit; adelphos, brother). Said of an androecium in which all the stamens are fused, partially or totally, to form a single bundle.

Monocarpic : adj. (Gr. monos, one only; karpos, fruit). Said of a plant that flowers only once and dies either during the year following germination: the plant is then an annual monocarpic or after several years of vegetative life: the plant is then a perennial monocarpic.

Monocotyledons : f. n. pl. (gr. monos, alone; kotulêdôn. cavity, small cup). Phanerogamous plants Angiosperms of which: the stem and the root are almost always) devoid of cambiums and therefore of secondary formations; the leaf is almost always provided with parallel veins; the flower is built on type "3"; the pollen grain has only one germination pore; the seed contains an embryo with a single cotyledon.

Monoecious : adj. (Gr. monos, alone; oikos, habitat). Said of a plant species in which each individual is bisexual in the sense that it can produce gametocysts or gametangia of each of the two sexes, either mixed, side by side, or on separate branches.

Mycorrhiza : f.n. (gr. mukés, mushroom; rhiza, root). Symbiotic association between certain fungi and the underground parts of various plants, almost always chlorophyllous.

N

Natrices : f.n. (lat. natrix, to swim). Describes a flowering plant in which the germinal tube of the pollen grain tears and releases ciliated male gametes which, by their beating of cilia, reach the oosphere to be fertilized, at the level of the female gametophyte.

Needle : f. n. (lat. acucula, fir needle). One of the two types of leaves of conifers. The needles are characterized by their narrowness and their more or less pointed end.

Nerve : f.n. (lat. nervus, nerve). Location of the conductive elements (wood and phloem) at the level of a leaf blade (typical or modified as are the floral parts), a frond or a phylloid.

Depending on their preeminence, we distinguish between 1st order ribs , 2nd order ribs and nerviols.

Node : m.n. (lat. nodosus, knotty; knot). This word designates, on a stem, each of the levels of insertion of leaves or divergence of branches.

Nucellus : m.n. (lat. nucula, small nut). Indehiscent fruit, with a single cell containing a single seed, and with a very hard wall. Sometimes we speak of nucellus to designate each of the parts constituting a composite dry fruit.

O

Orthotropic : adj. (gr. orthos, straight; tropos, tower). Said of an angiosperm ovule symmetrical with respect to an axis which would extend the funicle. As a result, the hilum, the chalaza and the micropyle are aligned. We then say that the ovule is straight.

Ovary : m.n. (lat. ovarium, from ovum; egg). Basal part of the Gynoecium. Born from the welding of the carpels, or from the closure of the carpel if it is unique. The ovary contains the ovules whose arrangement within it corresponds to the notion of placentation. After fertilization the ovary becomes the fruit and the fertilized ovules develop into seeds. Within the flower the position of the ovary is variable in relation to the other parts.

Ovule : f.n. (lat. ovum, egg). Macrosporangium contained in the ovary in Angiosperms, connected to the wall by a funicle and differentiating within it the female gametophyte (or embryo sac). After fertilization the ovule will develop into seeds. In Gymnosperms and prespermaphytes, the ovule remains exposed on the female fertile leaves or carpels.

P

Palmate : adj. (lat. palma, palm of the hand). Said of a leaf blade divided into segments which all meet at the top of the petiole, like the fingers of the hand are all linked to the palm.

Panicle : f.n. (lat. panicula, panicle). Indefinite inflorescence (and therefore ending in a bud) and derived from the spike in that the flowers, isolated or grouped in spikelets, are here pedunculated.

Papilionaceae : adj. (lat. butterfly, butterfly). Describes the very particular corolla in the Fabaceae or Papilionaceae family. The 5 sepals of the flower are very differentiated: one, covering, is the standard; two others, free and lateral, are the wings; the last two, lower, included between the wings more or less welded together, constitute the keel.

Parietal : adj. (lat. parietis, wall). Type of placentation corresponding to a unicarpellate ovary bearing ovules only at the level of the suture which closes the carpel; or to a pluricarpellate ovary whose different carpels have confronted each other then welded together by their margins without each having previously closed on itself.

Paripinnate : adj. (lat. par, pair; penna, feather). Said of a pinnate compound leaf which does not have a terminal leaflet. The number of leaflets is therefore even.

Parthenocarpy : f.n. (gr. parthenos, virgin; karpos, fruit). Development of an ovary into a fruit without there having been fertilization of the ovules. The result will therefore be a parthenocarpic fruit without seeds. This is a relatively frequent phenomenon, obligatory or accidental depending on the case.

Pentacyclic : adj. (gr. penta, five; kuklos, circle). Characterizes a flower composed of 5 whorls of floral parts (1: calyx; 2: corolla; 3 and 4 stamens; 5: gynoecium). Several orders of gamopetalous dicotyledonous Angiosperms are grouped, thanks to this common characteristic; under the name of Pentacyclic Gamopetales.

Perennial : adj. (lat. vivax, which has vitality). Describes a plant that lives more than one year by persisting through its vegetative system. This can be maintained by: an aerial part and an underground part simultaneously present; or by underground perennial organs only, in which case these are bulbs, tubers or rhizomes.

Perianth : m.n. (gr. peri, around; anthos, flower). Set of protective parts of the flower: calyx + corolla if the perianth is complete; calyx alone if the flower is monochlamydated.

Pericarp : m.n. (gr. peri, around; karpos, fruit). Wall of the fruit (which was, before fertilization, the wall of the ovary) which often allows the superposition of 3 distinct structures to be recognized: the epicarp, on the outside; the mesocarp, in the middle; the endocarp, towards the center of the fruit). Depending on the particularities of each of these 3 structures, the fruit falls into a distinct category (the most common of which are: the berry, the drupe, the capsule and the achene).

Pericycle : m.n. (gr. peri, around; kuklos, circle). Cellular layer whose location is very precise in the root and in the stem: it is the most external of the layers of the central cylinder (or stele), which it therefore separates from the bark. It is at this level that the ramifications of the root are initiated.

Perigynous : adj. (Gr. peri, around; gunê, woman). Said of a series of floral parts which appear to be inserted around the ovary. By extension, when all the floral parts are inserted on the edge of the depressed receptacle, protecting the gynoecium which has remained free within it, the flower is called perigynous.

Perisperm : m.n. (gr. peri, around, sperma, seed). The perisperm of a seed is made up of the diploid tissue of the nucellus of the ex-ovule, in the rare case where this tissue has not been prematurely lysed by the albumen and the embryo born from the double fertilization.

Petal : m.n. (gr. petalon, petal). Each of the normally colored parts of the corolla of an Angiosperm flower. The petals may be absent in apetalous flowers; present or free in dialypetalous flowers; present and fused in gamopetalous flowers. By their color, shape and size, the petals contribute enormously to the beauty of flowers.

Petaloid : adj. (gr. petalon, petal). Said of an organ which mimics a petal, by shape and/or by coloring.

Petiole : m.n. (lat. petiolus, small foot). Basal, narrow and often subcylindrical part of certain leaves (called petiolate leaves) which therefore serves as an intermediary between the blade and the stem, traversed by the conductive tissues which irrigate the blade at the level of the veins.

Phanerogams : f.n.pl. (gr. phaneros, apparent; gamos, marriage). Higher plants differentiating the flowers clearly visible and especially in the sense of sexuality.

Pinnate : adj. (lat. penna, feather). Describes a compound leaf or frond whose leaflets (for leaves), or pinnae (for the frond) are arranged on each side of the main axis of this leaf or frond like the barbs of the feather.

Phyllotaxis : f.n. (gr. phyllon, leaf; taxis; order, arrangement). Arrangement of leaves on the stem of a plant.

Phylogeny : f.n. (lat. phylum, lineage; genesis, birth). History of the development of a group of plants representing a systematic unit,

Phylum : f.n. (Latin word). Group of plants belonging to more or less important and vast systematic units (races, species, genera and families) showing real links of filiation between them.

Pistil : m.n. (lat. pistillus, pestle). Set of the ovary, style and stigma. We can also say: set of carpel synonymous with Gynoecium.

Pivot : adj. (obscure origin of the word pivot). Said of a main root (or pivot) very dominant in relation to apparently practically insignificant rootlets, and ensuring by itself the anchoring of the plant and often the storage of reserves.

Placenta : f.n. (Latin word meaning cake). Area of the carpellary wall at the level of which the funicle that connects the ovary to the ovule is inserted. It is at the level of this tissue that the nutrients necessary for the growth of the seed derived from the ovule will transit following the fertilization of the latter.

Pod : f.n. (uncertain origin). Dry fruit, in principle dehiscent, derived from a unicarpellate ovary containing two alternating rows of seeds and opening at maturity into two valves thanks to two fission lines: one dorsal (at the level of the main vein), the other sutural (at the level of the fusion of the original carpel).

Pollen : m.n. (lat. pollen, flour flower). Microscopic production released by the anthers of the stamens through various dehiscence processes. The ornamentation of the pollen grains allows their identification and allows a real morphological classification.

Pollen sac : At the level of the anther of a stamen, each of the masses of mother cells of pollen grains at which meiosis will therefore take place is called a pollen sac. In principle, there are two per stamen of Gymnosperms and four per stamen of Angiosperms.

Pollen tube : m.n. (lat. tubus, tube; pollen, flour flower). Production of the pollen grain that has reached the surface of the stigma and corresponds to an extraordinary evagination of its intine through one of the pores of its exine. In Angiosperms, this tube therefore crosses the stigmatic tissue, travels through the style and most often heads towards the micropyle of one of the ovules in the ovary to produce it.

Pollination : f.n. (lat. pollen, flour flower). Pollination, or the transport of pollen from male parts to female parts, mainly involves: wind (anemophilous); animals (zoidophilous); water (hydrophilous) and man (for certain plants of economic interest).

Polycarpic : adj. (gr. Polys, numerous; karpos, fruit). In terms of gynoecium: synonymous with dialycarpellous. In terms of fructification: said of a necessarily perennial plant which flowers and fructifies several times during its life. This flowering took place either regularly each year, or at greater intervals, or without interruption.

Polypetalous : adj. (gr. polys, numerous; petalon, petal). This term, which applies to a corolla made up of several parts free from each other, is a synonym, quite rarely used, of dialypetalous, which is more common.

Polyploidy : adj. (gr. polys, numerous; eidos, resemblance). Character of a cell possessing more chromosomes than the usual diploid stock (2n).

Polysepalous : adj. (gr. polys, numerous; skepé, cover; petalon, petal). This term applies to a calyx made up of several pieces, free from each other.

Preangiosperms : f.n.pl. (gr. before; aggeion, capsule; sperma, seed). Small group of Phanerogams, they associate in particular with the vascularization and floral organization plans, characters of Gymnosperms and Angiosperms. The ovules are clearly protected, totally enclosed. The seeds which derive from them are then surrounded by the accrescent fleshy bracts.

Prephanerogams : f.n.pl. (Gr. pre, before; phaneros, apparent; gamos, marriage). See Prespermaphytes.

Prespermaphytes : f.n.pl. (gr. pre, before; sperma, seed; phuton, plant). Group of vascular archegoniates which elaborate ovules but physiologically cut themselves off from them before they have been fertilized. Older than the Phanerogams, these plants are still characterized by: their primitive anatomy; their dichotomy; their frequent filicoid fronds; their constant diecy and especially by their zoidogamy.

Pteridospermales :f.n.pl. (gr. pteron, wing; sperma, seed). Commonly called seed ferns (which is a doubly excessive approximation) these prespermaphytes were abundant in the Upper Devonian and Carboniferous. They had the shape of tree ferns with Cycas-type fronds.

R

Radicle : f.n. (lat. radiatus, radicle). It is the first root developed by a plant at the level of its embryo and which normally appears when a seed begins to germinate. A distinction is made between the root and the radicle.

Receptacle : m.n. (lat. receptare, to receive). Enlarged and variously deformed upper part of the floral peduncle.

Resinous : m.n. (lat. resina, resin). Another name for Gymnosperms alluding to their almost universal ability to produce resin. Resinous trees often grow faster than hardwoods and are therefore frequently preferred to them.

Rhizome : m.n. (gr. rhiza, root; homos, similar). Underground, perennial stem, full of nutrient reserves, emitting over the years aerial shoots, scaly leaves and adventitious roots.

S

Scale : f.n. (germ. Skalja, tile). This term is used to designate organs that are only related by their general and coarse morphology (short, foliar, leathery formation).

Scutellum : m.n. (lat. scutum, shield or escutcheon). Refers to the small cotyledon of Poaceae embryos which is flattened and depressed against the voluminous albumen rich in reserves.

Seedling : f.n. (lat. planta, plant). Young plant still included in the seed and which will develop its organs by using the reserves of this seed during germination. We usually recognize three parts of the seedling: gemmule, stem and radicle.

Seed : f.n. (lat. granum, grain). Product of the evolution of a fertilized ovule. In Gymnosperms, the seed contains an embryo and a large endosperm. In angiosperms, due to double fertilization, the young seed contains an embryo, an albumen and a perisperm.

Self-fertilization : f.n. (pref. autos, oneself; lat. fecundare, to fertilize). Sexual phenomenon involving male and female gametes produced by a single individual.

Sepal : m.n. (gr. sképé, cover; petalon, petal). Each of the parts, normally green, of the calyx of an Angiosperm flower.

Sepaloid : adj. (Gr. sképé, cover; petalon, petal). Said of a floral piece (generally a petal) which mimics a sepal (most often because it returns to the green color).

Sessile : adj. (lat. sessilis, sessile). Describes any organ (leaf, flower, etc.) without a petiole or peduncle, which is therefore inserted directly onto the axis.

Sheath : f.n. (lat. vagina, sheath). Base of the petiole of a leaf more or less tightly embracing a segment of stem.

Shrub : m.n. (lat. arboriscellus, shrub). Woody plant less than four meters high, branched from the base and therefore devoid of a trunk.

Shrub : m.n. (lat. arbustum, shrub). Woody plant less than seven meters tall, but otherwise offering all the characteristics of a tree.

Siphonogamy : f.n. (gr. siphôn, siphon; gamos, marriage). Intimate process of fertilization in Phanerogams (Angiosperms and Gymnosperms) characterized by the path of male gametes to the female prothallus by taking the germinal tube of the pollen grain which leads them to the direct contact of the female cells to be fertilized. The male gametes are therefore not released and their transport justifies that Phanerogams are still qualified as Vectors.

Species : f.n. (lat. species, species). A notion that seems obvious but one of the definitions of which "collection of individuals that resemble each other more than each other and reproduce identically to themselves" remains very difficult to handle.

Spermaphytes : m.n.pl. (gr. sperma, seed; phuton, plant). Group of Gymnosperms and Angiosperms or plants, respectively, with naked seeds and seeds enclosed in a fruit. It is the development of these seeds which gives them precisely an indisputable originality.

Spike : m.n. (lat. spica, point). Centripetal (indefinite) inflorescence whose flowers, or groups of flowers (spikelets) are arranged along the rigid axis of the spike (the rachis) and are sessile.

Spikelet : m.n. (lat . spica, spike). This term designates each constituent element of an ear composed of Poaceae.

Spine : m.n. (gr. rhachis, spine; dorsal). This term designates an axis supporting often reduced parts of a Poaceae spike which supports the spikelets in excavations which are staggered along the length or the axis of the cone of a Resinous is sometimes called rachis.

Sporangium : m.n. (gr. spora, seed; aggeion, vase). Organ consisting of a fertile central zone of a sterile peripheral part (mono or pluristrate), which is the seat of the development of spores through meiosis. Only Archegoniates develop sporangia. Those of Phanerogams are located at the level of the anther of the stamens (microsporangia), for the male sex; at the level of the ovule, or macrosporangium for the female sex.

Sporophyte : m.n. (gr. spora, seed; phuton, plant). In the context of cycles linked to sexual reproduction, the sporophyte always derives from fertilization. It is the individual producing spores. Preponderant phase of the reproductive cycle of certain lower plants and all higher plants.

Stamen : f.n. (lat. stamina, stamen). From prespermaphytes to Angiosperms, this is how each of the floral parts of the androecium is designated as a microsporophyll, generating pollen through the meiosis undergone by the mother cells located in the pollen sacs.

Starch : m.n. (gr. amylon: a, privative and mulê. millstone: which can be obtained without covering with a millstone. Reserve carbohydrate (polyholoside) produced by photosynthesis, extremely common in the form of intracellular grains or amyloplasts. It is found in particular in abundance in roots, stems, tubers, seeds.

Starchy : adj. (gr. amylon, which is not ground). Said of an organ or tissue rich in starch.

Stigma : m.n. (lat. stigma, mark). Terminal part of the Gynoecium in Phanerogams Angiosperms. In general the stigma is papillose and viscous and constitutes a surface adapted to the reception and retention of pollen grains. Depending on the species, the stigma can be pointed, globular, spoon-shaped, feathery, bifid, etc.

Stipe : m.n. (lat. stipes, stem). Organ of a plant that mimics by its shape and function the trunk of a woody plant, but which has neither its size nor its structure. The presence of a stipe is recognized in arboreal monocotyledons. In angiosperms, the stipe appears as a cylindrical axis marked by the scars of fallen palms. Its anatomical structure is totally distinct from that of a trunk.

Stipules : f.n.pl. (lat. stipula, small stem). Small appendages, membranous, foliaceous, or spiny, which are found at the point of insertion of the leaf on the stem, on either side of this insertion. The stipules are sometimes deciduous, sometimes persistent.

Style : m.n. (gr. stulos, column). Part of the Gynoecium and ends with the stigma or pollen-receiving surface. The style is more or less long, straight or arched, simple or digitate, depending on whether the carpels constituting the Gynoecium are perfectly joined or more or less independent (at least at the level of this style).

Subshrub : m.n. (lat. subtus, under; arboriscellus, shrub). Term which designates a woody plant whose size does not exceed or hardly exceeds that of many herbaceous species. Commonly a subshrub reaches only a few dm. in height.

Superior : adj. (lat. superus, from superior, to suspend). In Angiosperms, this term designates an early differentiation of the sporophyte, from the first divisions of the zygote, born from the fertilization of an oosphere; the suspensor is there, early distinct from the embryo proper.

Synergides : f.n. (gr. syn, with; energia, energy). This term designates the two cells of the embryonic sac of Angiosperms which flank the oosphere at the micropylar pole of this sac.

T

Taxon : m.n. (gr. taxis, arrangement). General name to designate any systematic unit of whatever rank it was, up to and including the family. The most common are: genus, subgenus, species, variety and form.

Taxonomy or Taxonomy : f.n. (gr. taxis, arrangement; nomos, law). Study of the principles which must govern the designation and classification of living beings using taxa and paying particular attention to the morphology of individuals.

Tendril : f.n. (lat. viticula, vine tendril). Aerial organ capable of winding around a support and giving the entire plant a relatively erect shape.

Tepals : m.n.pl. (gr. combination of the words petals and sepals). Perianth parts of an Angiosperm flower which all resemble each other in shape, color and whether they belong to the calyx (sepals) or the corolla (petals).

Thalamiflora : adj. and nf (gr. thalmus, bed; flos, flower). Characterizes the floral organization of various Angiosperms which have a thalamus along which the points of insertion of the floral parts are staggered. The thalamiflora are considered to represent a series of families of relatively primitive Dialypetalous Dicotyledons.

Thalamus : m.n. (gr. thalamus, nuptial layer. Flat floral receptacle, rounded or stretched into a column in the Dicotyledons Dialypetals Thalamiflora. When it supports both androecium and gynoecium, the thalamus is said to be androgynophore but if it supports only the Gynoecium; it is said to be gynophore.

Tigelle : f.n. (lat. tibia, flute). At the level of the embryo of higher plants, this term designates the small stem which supports the cotyledon(s) and the outlines of the first leaves (gemmule) grouped in a small terminal bud.

Tiller : m.n. (gr. tallos, branch). Each of the ramifications that arise at the collar of a plant and gradually form a tuft. It is thanks to the appearance of its tillers (stage of development called tillering) that each wheat plant has several parallel culms, the most vigorous of which will one day end in an ear.

Tracheid : f.n. (gr. trakheia, rough). Conductive element of the Wood of Gymnosperms and of very young woody formations of Angiosperms. These are imperfect vessels whose constituent cells have preserved all their walls.

Tree : m.n. (lat. arbor, tree). Woody plant at least seven meters high, characterized by the possession of a main stem (or trunk), which branches into a crown.

Trifoliate : adj. (lat. tri, three; folium, leaf). This qualifier applies to leaves subdivided into 3 leaflets.

Trimerous : adj. (gr. tri, three; meros, part). Classical character of the flowers of Monocotyledons which are made up of successive whorls of 3 pieces each.

Tuber : m.n. (lat. tuberculum, tuber). Swollen organ, of a cauline nature, generally underground, belonging to a vascular plant and at the level of which the plant stores reserves.

U

Unilocular : adj. (lat. unus, one; Frankish laubja, locule). Said of a Gynoecium whose ovary is (originally, or as a result of the later regression of the intercarpellary septa) with a single locule.

Uninervated : adj. (lat. unus, one; nervus; nerve). Character of an organ which has only one rib.

Uniovulated : adj. (lat. unus, one; ovum, egg). Character of an ovary (or of each of the ovarian cells) which contains only one ovule.

Uniparous : adj. (lat. unus, one; paria, pair). Said of a cyme inflorescence of which only one lateral branch develops (on one side of the main axis consequently).

Unisex : adj. (lat. unus, one; sexus, sex). In Prespermaphytes and Spermaphytes: said of an individual (or a simple flower) which has only one sex.

Urceolate : adj. (lat. urceola, small wineskin). Said of a calyx, a corolla, or a set of tepals whose parts are welded together and whose narrowed throat of the cup thus formed makes the resulting set resemble a bell.

V

Valvary : adj. (lat. valva, door leaf). Arrangement of floral elements including the bud such that the parts of the same whorl (and in particular the petals) are contiguous but without overlapping each other.

Variety : f.n. (lat. variare, to vary). Subdivision of a species which groups together individuals belonging indisputably to this species, but which reveal in common one (or several) character (s) which the other representatives of the species do not possess.

Vectors : f.n.pl. (lat. vector, conductor). In phanerogams, the pollen tube "carries" the two male gametes "home".

Vegetable : m.n. (lat. legumen, vegetable). Beyond the meaning acquired by this term in everyday life, we must remember the original meaning: dry fruit, dehiscent by two cracks which allow it to open into two valves. It is the word pod which took over from the word vegetable in the botanical vocabulary.

W

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Whorl : m.n. (lat. verticillus, whorl). This term designates each of the sets of parts inserted on an axis at the same level. It can be the leaves on a stem or the sepals, petals, stamens or even the carpels on a floral receptacle which are whorled.

Winged : adj. (lat. ala, wing). Said of an organ which has differentiated one or more wings

Wood : m.n. (low lat. bosci, wood). Tissue that conducts raw sap, characteristic of vascular plants. Depending on the systematic groups considered (pteridophytes, gymnosperms, prephanerogams and angiosperms) its characteristics differ. It is a tissue that groups together living cells and dead cells.

X

Xerophytes : f.n.pl. (gr. xeros, dry; phuton, plant). Plants capable of living in conditions of severe drought.

Xylem : m.n. (gr. xylon, wood). Conductive tissue, synonym of Wood. Primary xylem derives from the apical meristem, while secondary xylem results from the activity of the deep cambium, or libero-ligneous generative layer.

Z

Zoidogamy : f.n. (gr. zôn, animal; gamos, marriage). Intimate process of fertilization in Prespermaphytes, characterized by the release of male gametes, ciliated, capable of moving by beating of cilia to reach the oosphere and unite with it.

Zygomorphic : adj. (gr. zygos, couple; mophê, form). Said of a flower whose symmetry (most often bilateral) is not axial, the usual case. It therefore accepts a single axis of symmetry.

Zygote : m.n. (gr. zugôtos, joint). Cell resulting from the union of two gametes (or sometimes of two gametocysts, if there is hologamy). Zygotes, classically diploid, are also called eggs. They mark, in the reproduction cycles of plants, the beginning of the diplophase.

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