Spermatophytes or Phanerogams (*Seed Plants, Flowering Plants*)

Modern spermatophytes are represented by approximately 250 000 to 300 000 species, the vast majority of which are angiosperms (flowering plants), while the remaining group consists of gymnosperms (around 1000 living species).

General characteristics

- These are seed-bearing plants that produce ovules.
- They are called phanerogams because they have visible reproductive organs; i.e., they are flowering plants.
- They are terrestrial plants (*Embryophytes*) with ovules that develop into seeds after fertilization.
- They are cormophytes, meaning they possess differentiated organs: stems, leaves, and roots.
- They are tracheophytes, i.e., vascular plants with xylem and phloem.
- The ovule contains a reduced haploid gametophyte that produces the female gamete, the oosphere. This entire structure remains dependent on the sporophyte, a condition known as complete endoprothallia.
- Spermatophytes are the most advanced and best-adapted plants for terrestrial life.
- The unit responsible for species dispersal and survival in spermatophytes is a diploid sporophyte, known as the seed.
- The leafy plant we observe is the sporophyte, which develops the sexual organs.
- Male gametes, carried by pollen grains, land on the stigma and reach the female gametes, which remain attached to the sporophyte.
  Thus, fertilization occurs on the sporophyte, resulting in a diploid zygote, which develops into a seed that ensures the dispersal and preservation of the species.
- In spermatophytes, the haploid gametophyte stage is highly reduced and lives as a parasite on the sporophyte.
- Fertilization does not occur in water, unlike in more primitive plants.

Spermatophytes are divided into two major groups:

- ***Gymnosperms***
- ***Angiosperms***

VII. Gymnosperms

Modern gymnosperms are mainly represented by conifers. Their life cycle is characterized by a long vegetative phase, compared to a shorter reproductive phase.

Figure : Gymnosperm species

1. Vegetative structure

- Gymnosperms are all woody plants (trees and shrubs).
- Their developmental cycle spans several years, and they can be very long-lived. Their life cycle is slow, with growth and reproduction spread out over many years.
- They typically have a conical or pyramidal growth form, due to strong apical dominance.
- Branches are often arranged in whorls or pseudo-whorls.
- Leaves are small, either:
    - Needle-shaped (e.g., in pines), or
    - Scale-like (e.g., in cypresses).
- Leaf arrangement may be alternate, opposite, or whorled.
- In most species, leaves are evergreen (persistent), which is why these trees are commonly known as evergreens.

- The two sexes are usually found on the same plant (monoecious), though they are rarely separate (dioecious, e.g., the yew).
- These are xerophytic plants, adapted to dry mountain environments. They have :
    - A thick cuticle,
    - Few stomata, often hidden in sunken crypts,
    - A very reduced leaf surface area.
- Generally, they do not regenerate shoots from the stump after being cut.

- They secrete resin, and typically possess a secretory system (resin canals), which gives them their distinctive scent, hence the common name "resinous trees" or "resinous conifers".
- Their wood is homoxylous, meaning it is composed of a single type of conductive element: Tracheids with bordered pits (areolate pits).

2. Reproductive structures

Gymnosperms are generally monoecious (e.g., pines), with both male and female cones borne on the same plant. However, some species, such as yews, are dioecious.

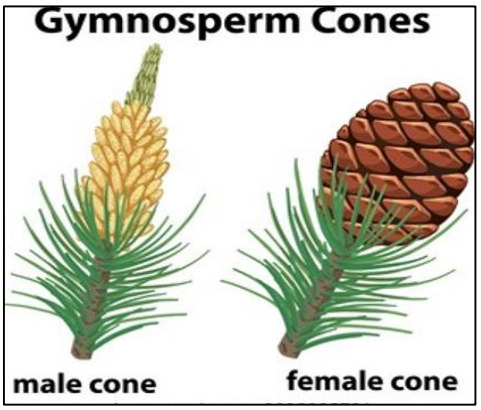

Figure : Gymnosperm cones

- The sexual organs are grouped into unisexual cones (either male or female), both found on the same individual in monoecious species.
- At maturity, they produce woody cones (cones, strobili, or galbuli), which gives rise to the name conifers.
- They have naked ovules (exposed, without protective ovary).
- The female gametophyte (embryo sac) is multicellular, typically consisting of seven cells, including the egg cell.
- The male gametophyte is also multicellular, composed of three cells, including two male gametes.
- The male reproductive organs are composed of sporangiferous leaves (scales) or stamens, bearing microsporangia (pollen sacs) that contain microspores (pollen grains).
- The female reproductive organs (ovules) are naked and may originate from stem tissues. They are generally located on the dorsal surface of scales, which together form the female cone.
- These scales are functionally equivalent to carpels in angiosperms but never fully close to form a protective chamber around the ovules.
- Ovules in gymnosperms are unitegmic, meaning they have a single integument layer.

3. Reproduction :

- Gymnosperm reproduction is sexual.
- Pollination is always anemophilous, i.e., carried out by the wind.
- The haploid prothallus (or endosperm) acts as the nutrient reserve for the developing embryo.
- The processes of fertilization and embryogenesis are long and extended. For example, in pine trees, multiple generations of female cones can be observed on the same branches.
- At first, the scales of female cones are small and spread apart, allowing pollen to enter freely.
- Later, the scales enlarge and close, protecting the ovules as they develop into seeds.
- Typically, the cones become woody (as in pines and cypresses), and later open by desiccation, releasing their seeds.

- Exceptionally, cones may become fleshy, like the berry-like structures in junipers.
- In yews, there is no true cone. Instead, a fleshy red outgrowth (called an aril) develops around the fertilized ovule.

Fertilization by siphonogamy :

- Fertilization occurs via siphonogamy, a process found in some gymnosperms and in all angiosperms.
- The pollen grain produces non-flagellated male gametes, which are delivered to the archegonia through a pollen tube.

Note:

Siphonogamy is a mode of fertilization in seed plants in which the pollen tube delivers the male gametes either into a synergid cell (in angiosperms) or near the egg cell within the archegonium (in gymnosperms). This process contrasts with zoidogamy, where motile sperm swim to the egg in water.

In angiosperms, double fertilization also occurs, where one male gamete fertilizes the egg, and the other fertilizes the central cell to form the endosperm.

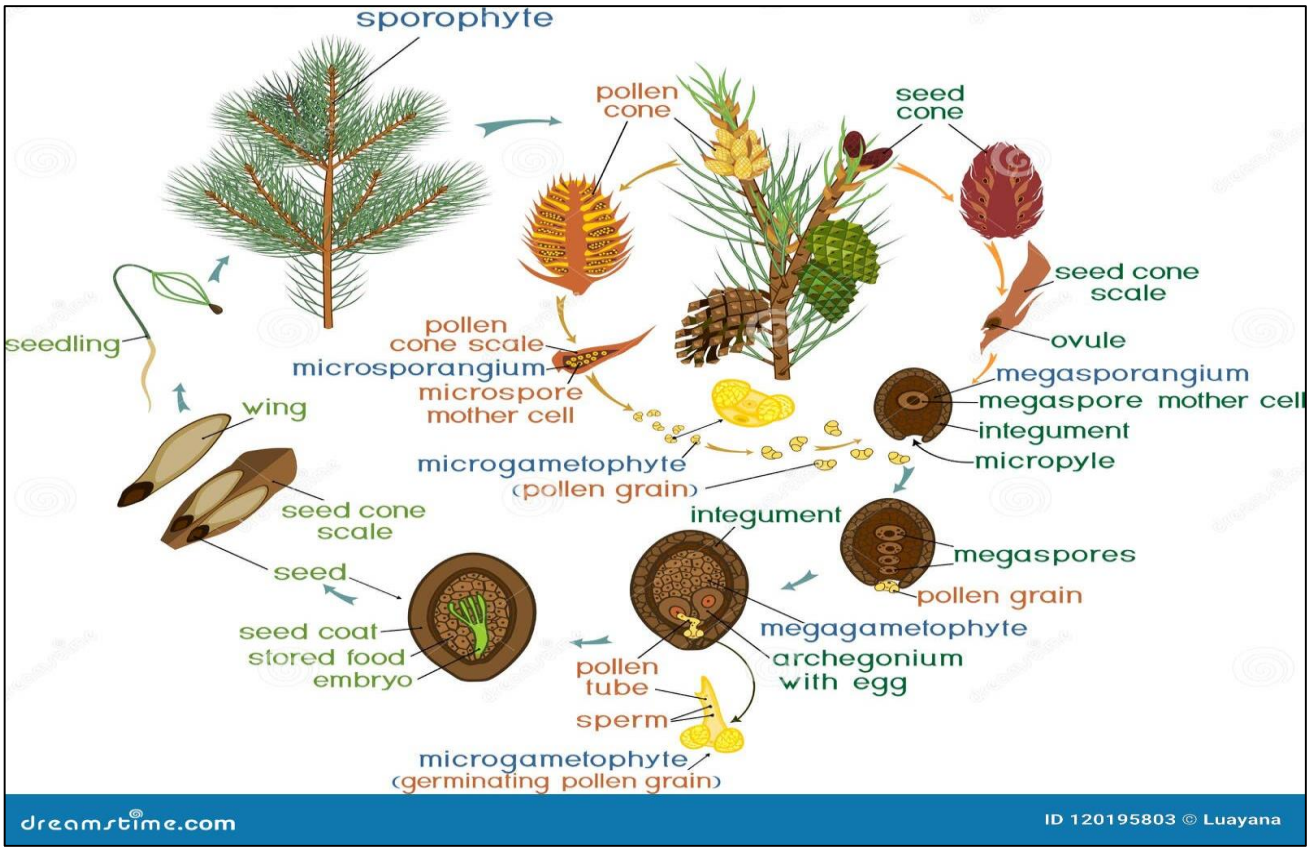

Figure : Gymnosperm life cycle

Example of gymnosperms

***Pinus halepensis* Mill.**

Figure : Pinus halepensis

1. Generalities:

Scientific name: *Pinus halepensis* Mill.
Common name: Aleppo Pine

- Medium-sized evergreen conifer
- Height: typically 15–25 meters, rarely up to 30 m
- Lifespan: up to 200 years
- Bark: grayish and flaky in young trees, becoming reddish and cracked with age
- Leaves: needle-like, in pairs (fascicles of 2), slender and flexible
- Cones: ovoid-conical, woody, 4–12 cm long, opening after 2–3 years or by fire

2. Natural distribution and habitat

- Native to the Mediterranean Basin:
  - Southern Europe (Spain, France, Italy, Greece)
  - North Africa (Algeria, Tunisia, Morocco)
  - Middle East (Lebanon, Palestine, Syria)
- Typical habitat:
  - Dry, rocky, and calcareous soils
  - Altitude: sea level to ~1000 m
  - Highly tolerant of poor, degraded, and salty soils
  - Grows well on south-facing slopes with full sun

3. Ecological Characteristics

a) Xerophytic adaptations (drought resistance):

- Small leaf surface area (needles)
- Thick cuticle and sunken stomata
- Needles persist for several years to conserve nutrients

b) Pioneer species:

- One of the first species to colonize degraded land after disturbance (fires, overgrazing)
- Plays a key role in ecosystem restoration and soil stabilization

c) Fire ecology:

- Fire-adapted: cones can be serotinous, opening after exposure to high heat
- After fire, seeds are released rapidly, allowing fast regeneration

4. Reproduction and life cycle

- Monoecious: male and female cones on the same tree
- Pollination: by wind (anemophilous)
- Male cones release pollen in spring
- Female cones are fertilized and take up to 3 years to mature
- Seeds are winged, dispersed by wind or gravity

5. Biological importance

- Provides:
  - Habitat and cover for wildlife
  - Resin and timber (limited use due to soft wood)
  - Soil protection and erosion control
  - Carbon sequestration in drylands

Figure : Pinus halepensis forest

6. Ecological concerns

- In some areas, considered invasive due to its aggressive colonization
- Monospecific stands reduce biodiversity if unmanaged
- Susceptible to pests: *Tomicus destruens*, *Thaumetopea pityocampa* (pine processionary moth)

7. Human uses

- Reforestation of degraded Mediterranean lands
- Landscaping and windbreaks
- Resin extraction in traditional industries
- Used in forest fire research due to its ecological plasticity