Phanerogams (Spermatophytes)

Phanerogams, or flowering plants (from the Greek *phaneros* = visible and *gamos* = union), refer to all plants whose reproductive organs are visible and grouped at the ends of certain branches of the sporophyte. Additionally, they have the ability to produce seeds, which is why they are also called *Spermatophytes*. Phanerogams are divided into three subgroups: Progymnosperms, Gymnosperms, and Angiosperms.

VI. Progymnosperms (Prespermatophytes)

Progymnosperms represent an extinct or nearly extinct group of vascular plants that occupied an intermediate position between Pteridophytes and true Spermatophytes. Today, only around a hundred species are known, most of which are fossilized remains. Occasionally referred to as Prespermatophytes, seed ferns, or primitive gymnosperms, this group was historically classified among the Gymnosperms due to similarities in their reproductive structures. However, they are now recognized as a transitional lineage. Extant representatives are extremely rare and primarily limited to ornamental cultivation in parts of Asia.

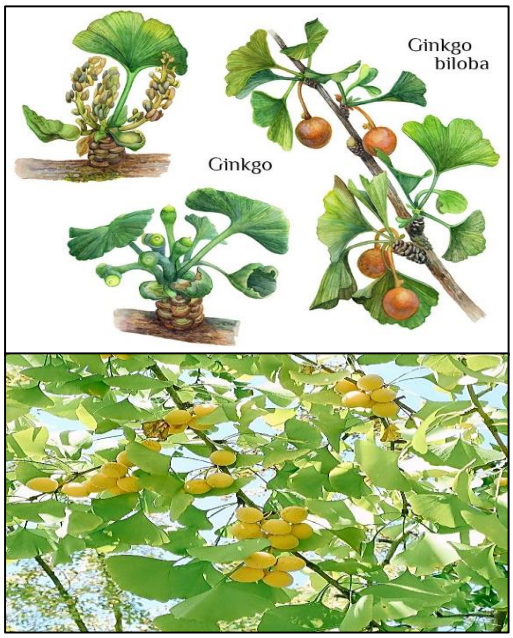

Figure : Ginkgo biloba

Characteristics

- Incomplete seed development: Ovules were protected by integuments but did not develop into true seeds.
- Endosporic female gametophyte: The female gametophyte formed inside the ovule, no longer free-living.
- Nutrient reserves before fertilization: Resources accumulated in the ovule prior to gamete fusion.
- Motile male gametes: Ciliated sperm cells moved passively in a liquid-filled chamber.
- Primitive reproductive structures: Reproductive organs were cone-like but not highly specialized.
- No post-fertilization ovule transformation: The fertilized ovule looked the same as before fertilization.
- Oviparous reproduction: Embryo development began only after the fertilized ovule fell to the ground.

Vegetative structure

- Fern-like habit with large, divided leaves (fronds)
- Vascular tissue with tracheids for water transport
- Dioecious species (separate male and female plants)
- Dichotomous branching of stems and shoots
- Circinate vernation (young leaves coiled like ferns)

Reproductive structures

Dioecious cones; male and female cones are found on separate plants.

Female structures (The ovule)

- Ovules borne on ovuliferous scales grouped in a cone (strobilus)
- Scales resemble small, brownish, sterile leaves
- Each scale bears two rows of naked ovules

Figure : Cycas revoluta female

Male reproductive structures

- Male cones are made of small, modified leaves (stamens) carrying many sporangia on their lower surface.
- Sporangia produce microspores via meiosis, which develop into pollen grains (male gametophytes).
- Each stamen has a filament topped with two pollen sacs (microsporangia).
- Microspores undergo mitosis within thick walls to form a 4-celled pollen grain.
- Pollen grains contain ciliated sperm (antherozoids), which are released into the pollination chamber of the ovule to achieve fertilization.

Figure : Cycas revoluta male

Reproduction

- Haplodiplontic life cycle with dominant sporophyte and reduced gametophytes
- Gametophytes develop on the sporophyte; only male gametophyte (pollen grain) is released
- Female gametophyte (endosperm) remains inside the ovule
- Fertilization is zoidogamous:
    - Ciliated sperm cells swim toward the archegonia in a liquid-filled pollination chamber
    - Liquid originates from the liquefied nucellus, not from external water
- Fertilization still depends on internal water, showing a stage between aquatic and aerial reproduction

Life cycle

Haplodiplontic and digénetic, with a dominant sporophyte

Key differences from Pteridophytes:

1. Ovule is introduced as a naked female reproductive structure (not enclosed in a carpel)

2. Female gametophyte is reduced to a nutritive tissue with 1–2 archegonia
3. Nucellus acts as the megasporangium, protected by integuments
4. Pollen grains (male gametophytes) are airborne, not water-dispersed spores
5. Male gametes are still flagellated spermatozoids, requiring internal water for fertilization
6. Embryo develops using nutrient reserves pre-stored in the female gametophyte
7. The fertilized ovule, not a true seed, is the unit of dispersal

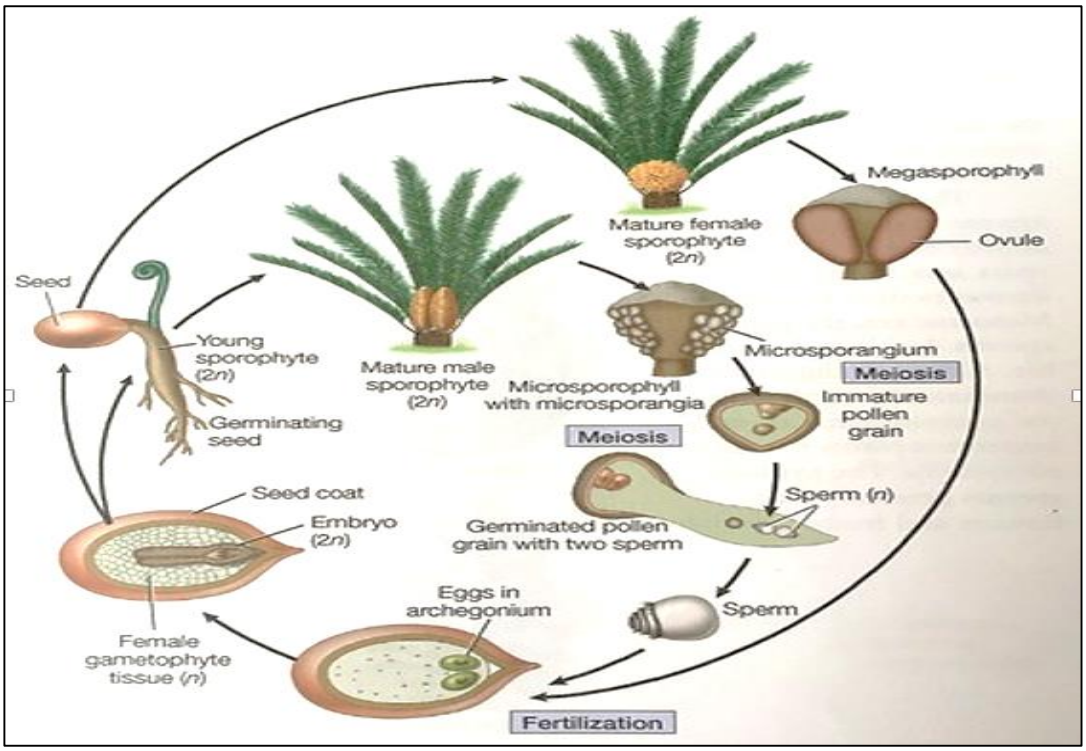

Figure : Cycas life cycle

Classification

1. Cycadophytes

The leaves are pinnately compound and deeply divided, resembling fern fronds. However, the general appearance of the plant is palm-like, with a thick, unbranched trunk topped by a crown of large leaves. The ovules are large and notably rich in starch following fertilization.

Represented by **03** families and **11** genera, Cycadophytes are often referred to as "living fossils." They exhibit large pinnate leaves, a stout trunk, and dioecious reproduction with large, exposed ovules.

Order: **Cycadales**

- **Family**: *Cycadaceae* --------- *Cycas revoluta*
- **Family**: *Stangeriaceae* ------- *Bowenia serrulata*
- **Family**: *Zamiaceae* --------- *Zamia obliqua*

2. Ginkgophytes

In *Ginkgo*, the leaves are truly laminar, fan-shaped, and arranged along the branches in a more typical seed plant fashion. Unlike the frond-like leaves of *Cycas*, *Ginkgo* exhibits a flattened blade morphology, though it retains several primitive features in its reproductive cycle.

This group is represented today by a single extant species, *Ginkgo biloba*, the only surviving member of a once-diverse lineage.

Order: **Ginkgoales**

- **Family**: *Ginkgoaceae* ---------- *Ginkgo biloba*