

VIVEKANANDA COLLEGE
THAKURPUKUR
KOLKATA-700063

NAAC ACCREDITED 'A' GRADE



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Name of the Teacher: Mrs. Rinku Halder Sahu
Name of the Department: Botany (Morning)

GYMNOSPERMS

- ***INTRODUCTION***

One crucial step in the evolutionary history of all plants was the development of seeds. Seeds provide a viable means for dispersal of offspring without the need for water. They're a far more efficient way of dispersal and allow plants to exist away from direct sources of water.

The term gymnosperms (gymnos = naked; sperma = seed) was introduced by Theophrastus in 300 BC to describe plants with unprotected seeds. According to Goebel gymnosperms are phanerogams without ovaries.

The phanerogams or Spermatophyta (sperm = seed; phyton = plant) or seed plants are those plants which reproduce by means of seeds, not spores.

Gymnosperms are the vascular plants where seeds are not enclosed within an ovary (opposite to an angiosperm or flowering plants where seeds are enclosed by mature ovaries or fruits). In these plants the ovules are borne naked on the surface of the megasporophylls, which are often arranged in the cones.

Fossil records indicate that the **gymnosperms must have evolved** approximately 300 million years ago **from non-seed producing ancestors of the extinct division of Progymnospermophyta**

which were fern-like in appearance (form a bridge between pteridophytes and angiosperms).

Gymnosperms were dominant plants over the earth's surface during the **Jurassic and cretaceous periods of the mesozoic era**. At present about 83 genera and approximately 790 species of living gymnosperms are distributed throughout temperate, tropical and arctic regions of the world.

Distinguishing Features of Gymnosperms:

- ***External Features of Gymnosperms:***

1. Gymnosperms are predominantly **woody plants**, represented by trees, shrubs or rarely climbers.

2. They are usually **xerophytic**, some of them are deciduous while others are evergreen. *Sequoia sempervirens* (California or Coast redwood) is probably the **tallest living tree** reaching a height nearly 112 m and attaining a growth of 15 m. **Smallest gymnosperm** is *Zamia pygmaea*.

3. **Plant body is sporophytic** and can be **differentiated into root, stem and leaves**.

4. Generally the plants possess a well developed tap root system. In some gymnosperms the roots show symbiotic relationship e.g.,

coralloid roots of *Cycas* with algae and mycorrhizal roots of *Pinus* with fungi.

5. Stem is erect, woody and branched (unbranched in *Cycas* and tuberous in *Zamia*). Presence of **leaf scars on the stem** is the characteristic feature of gymnosperms.

6. The arrangement of the **leaves** on the stem may be spiral or cyclic. They may be of one kind (**monomorphic**) or two kinds (**dimorphic, foliage leaves and scale leaves**). Foliage leaves are green, simple, may be small (microphyllous e.g., *Pinus*) or large (megaphyllous e.g., *Cycas*). Their main function is photosynthesis. Scale leaves are present around the reproductive structures and apex. They are mainly protective in nature.

- ***Internal Structure of Gymnosperms:***

1. The roots are diarch to polyarch.

2. In stem a **well-developed vascular system** is present in the form of vascular bundles. The vascular bundles are open, endarch and are arranged in a ring.

3. **Secondary growth takes place** in the gymnosperms and there is the formation of annual rings.

4. The **xylem is composed of tracheids with border pits** and xylem parenchyma.
5. Secondary wood is of two types: **manoxylic** (porous and loose due to presence of large amount of parenchyma and broad medullary rays e.g., *Cycas*, useless commercially) and **pycnoxylic** (compact and hard due to less amount of parenchyma and narrow medullary rays e.g., *Pinus*). Bordered pits may be uniseriate or multiseriate.
6. Like pteridophytes, in the wood **xylem vessels and fibres are absent** (except in Gnetales).
7. Phloem is composed of sieve tubes and phloem parenchyma. **Companion cells are completely absent.**
8. Leaves are characterised by the presence of **thick cuticle and sunken stomata.**
9. Mesophyll tissue may be differentiated into palisade tissue and spongy parenchyma e.g., *Cycas* or remain undifferentiated e.g., *Pinus*, *Cedrus* etc.
10. **Lateral veins are absent** in most of the gymnosperms. So, the **translocation of the nutrients** takes place **with the help of transfusion tissue.**

- ***Reproduction in Gymnosperms:***

1. It is of two types: **vegetative and sexual, reproduction.**
2. Vegetative reproduction takes place by the formation of **bulbils or adventitious buds** which develop on the stem in the axil of the scale leaves e.g., *Cycas*.
3. Gymnosperms are **heterosporous** and sexual reproduction is **oogamous type**. In living gymnosperms the reproductive structures are arranged in the form of **strobili or cones** (except the ovulate structures of *Cycas*).
4. Plants may be monoecious (e.g., *Pinus*) or dioecious (e.g., *Cycas*).
5. **Usually the cones are monosporangiate** (unisexual) but in certain members e.g., *Ephedra* **bisporangiate** (bisexual) cones have been reported.

- **Male Cones:**

6. Male cones consist of many **microsporophylls** (stamens) arranged on the central axis.
7. Microsporophylls bear **microsporangia** (pollen sacs) on the abaxial (lower) side.

8. Sporangial development is **eusporangiate** (develop from a group of cells).

9. Meiosis occurs in microspore mother cells and **haploid pollen grains** (male gametophytes) are developed.

10. During the development of male gametophyte only one (e.g., *Cycas*) or two (e.g., *Pinus*) prothallial cells are formed.

11. **Pollen tubes** act as **sperm carriers** only in higher forms (e.g., *Pinus*, *Ephedra*) whereas in the lower forms it acts as **haustorium** (e.g., *Cycas*).

12. **Pollen grains may be smooth** (e.g., *Cycas*) or **winged** (e.g., *Pinus*).

➤ **Female Cones:**

13. Female cone is the aggregation of **megasporophylls** (carpels) which bear **megasporangia (ovules)**.

14. **Ovules are naked** or not enclosed inside the ovary because the ovary wall is absent.

15. Ovules are orthotropous and are covered by a single integument (unitegmic e.g., *Cycas*) or two integuments (bitegmic e.g., *Ephedra*).

An additional covering in the form of aril or cupule is also present outside the integument.

16. The single integument is differentiated into three layers: outer fleshy (outer sarcotesta), middle stony sclerotesta) and inner fleshy layer (inner sarcotesta).

17 In young ovules meiosis occurs and **4 haploid megaspores** are produced.

18. **Three megaspores degenerate and one functional megaspore** forms female gametophyte (monosporic) or endosperm.

19. **Endosperm is haploid because it develops before fertilization.**

20. Female gametophytes bear **archegonia**.

21. The number of archegonia is variable. In *Gnetum* only one, in *Pinus* two and in *Cycas* more archegonia develop. The archegonium in *Gnetum* is represented by ovum only.

22. Each archegonium has a single egg and a ventral canal cell. **Neck canal cells are absent**. In some members e.g. *Cycas* venter canal cell is also absent.

- **Pollination:**

23. The microspores are liberated in various stages of development of male gametophyte e.g., they are liberated at 3-celled stage in *Cycas*. 4-celled stage in *Pinus* and 5-celled stage in *Ephedra*. Except in *Cycas* and *Ephedra* the male gametes are non-motile.

24. Pollination is **anemophilous** i.e., brought about by wind.

25. Pollen grains come in direct contact with the ovule. They are deposited in the pollen chamber where they germinate.

- **Fertilization:**

26. It is **siphonogamous** i.e., takes place with the help of pollen tube, Water is not essential for fertilization.

27. An **oospore is formed after fusion of male and female gametes.**

- **Embryogeny:**

28. The development of **embryos is meroblastic** i.e., only a part of the zygote (basal) develops into an embryo.

29. There are free nuclear divisions in the early stages of embryo development of embryos (except *Gnetum* and *Welwitschia*). Later it

gets differentiated into upper (**haustorial**), middle (**supensorial**) and basal (**embryonal**) cells.

30. Polarity is endoscopic with the shoot end directed away from the micropyle.

31. **Polyembryony** is observed in some members of gymnosperms e.g. *Pinus*. Several embryos develop due to fertilization of more than one egg or by the division of the zygote (**cleavage polyembryony**) but only one embryo attains maturity.

32. A **true fruit** like that of angiosperms **is absent** in gymnosperms. It is because of the absence of ovary.

33. The ovule after embryo formation turns into the seed. The instruments of the ovule act as seed coat.

34. Number of cotyledons varies in different members, they are two in *Cycas* and many in *Pinus*. These become green while still enclosed within the seed.

35. ***The seeds represent three generations:***

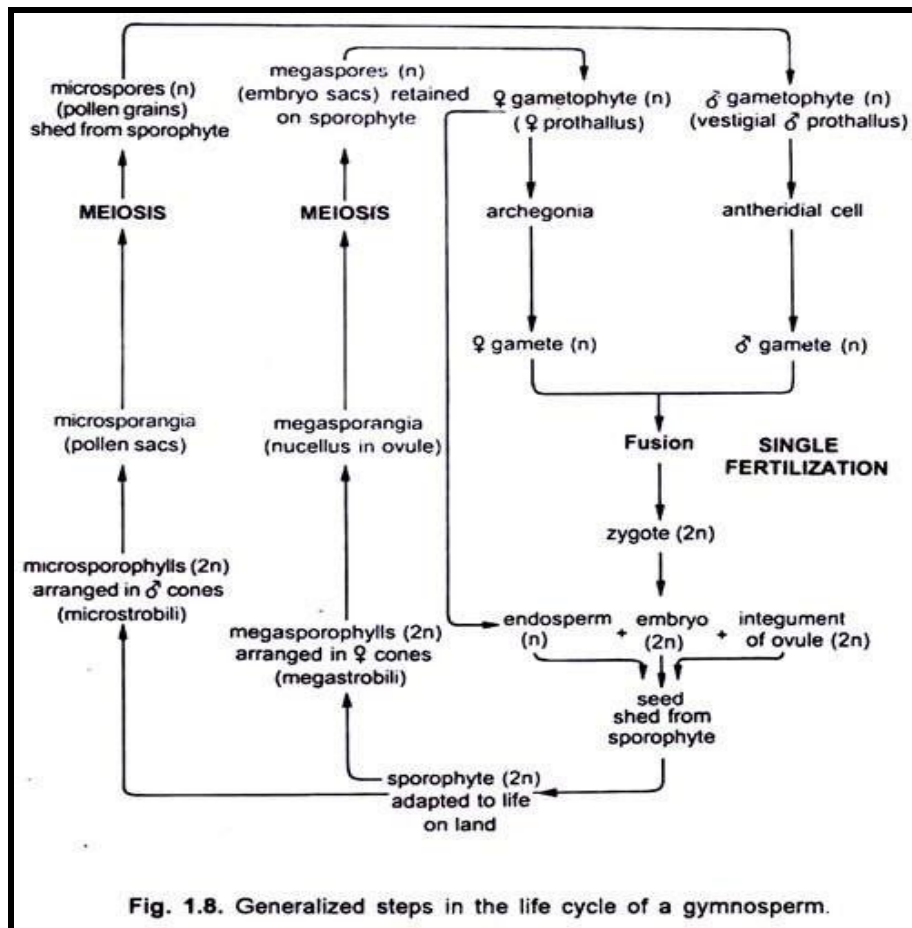
(i) Integuments and nucellus represent the parent sporophytic phase.

(ii) Endosperm represents the gametophytic phase.

(iii) Embryo represents the new sporophytic phase.

36. Gymnosperms show **distinct alternation of generation**. The sporophytic or diploid phase is dominant, long lived and independent while the gametophytic or haploid phase is short lived and is dependent on gametophytic phase.

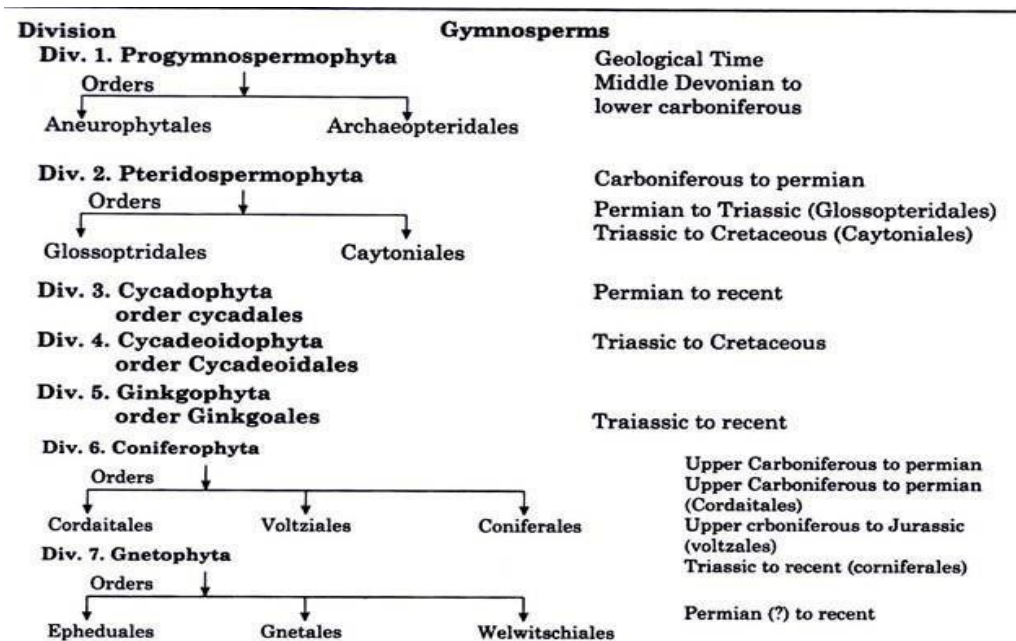
Generalized pattern of life cycle in gymnosperms is depicted in Fig.



Classification of Gymnosperms:

In older times gymnosperms were kept among angiosperms. It was Robert Brown (1827) who first of all recognised these plants due to the presence of naked ovules and placed them in a distinct group called gymnosperms. Bentham and Hooker (1862-83) in their 'Genera Plantarum' placed this group in between dicotyledonae and monocotyledonae.

The classification of gymnosperms is quite controversial because several genera and a few orders like the cordaitales and cycadeoidales are known only in fossil states. Attempts have, however, been made from time to time to classify them. **Classification of gymnosperm by Gifford and Foster (1989)** has been given here.



Examples of different genus belong to different divisions are as follows:

DIVISION 1: PROGYMNOSPERMOPHYTA

Eg: *Archaeopteris*

DIVISION 2: PTERIDOSPERMOPHYTA

Eg: *Lyginopteris*

DIVISION 3: CYCADOPHYTA

Eg: *Cycas*

DIVISION 4: CYCADEOIDOPHYTA

Eg: *Williamsonia*

DIVISION 5: GINKGOPHYTA

Eg: *Ginkgo biloba*

DIVISION 6: CONIFEROPHYTA

Eg: *Pinus*

DIVISION 7: GNETOPHYTA

Eg: *Gnetum*

