GYMNOSPERMS (GYMNOS–NAKED, SPERM–SEED):

Introduction

- Coined the term Gymnosperm by Theophrastus.
- The study of Gymnosperm is called Gymnospermology.
- These are perennial woody plants or ancient seed bearing phanerogamic sporophytic plants without flowers, ovary and fruits. They are popularly called naked seeded vascular plants.

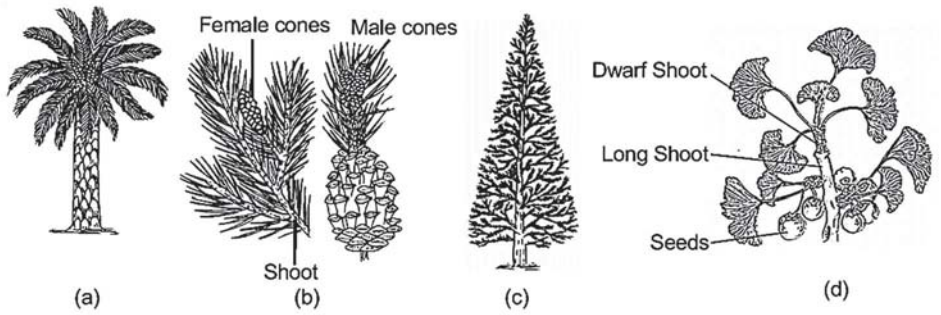


Fig. : Some Gymnosperms :
(a) *Cycas*, **(b)** *Pinus*, **(c)** *Cedrus*, **(d)** *Ginkgo*

Pecific Features

- All gymnosperm are vascular plants. Therefore vascular tissue present i.e. xylem & phloem.
- Xylem lack vessels & phloem lack companion cells.

Exception:-

- Exceptionally in xylem of Gnetum, Ephedra, Welwitschia true vessels are present.
- In gymnosperms vascular bundle is Conjoint-Collateral-Endarch-Open.
- In the vascular bundle cambium is present therefore secondary growth takes place in gymnosperms, so that Gymnosperms are woody plants.
- Most of the gymnosperms are occur as tree from-but some are present as shrub.
  Eg. Ephedra
- One member is specific shrub.
  Eg. Welwitschia (bear two leaves in whole life)
- Some Gymnosperm are liana wood climbers.
  Eg. Gnetum ula

Wood of Gymnosperms is soft is of following types:-

- Manoxylic: Soft wood, vascular tissues with medullary rays, commercially less important.
  E.g. Cycas.
- Polyxylic: With many persistent cambium rings and bundles.
  E.g. Cycas
- Pycnoxylic: Compact wood without or with narrow medullary rays, commercially more important.
  E.g. Pinus.
- Monoxylic: With single persistent cambium ring and bundles. E.g. Pinus

General characters:

Habit and Habitat:

- Gymnosperms include medium-sized trees or tall trees (Sequoia) and shrubs (Ephedra).
- These are found mainly in cold temperate climates but cycads occur in warmer areas.
- The giant redwood tree Sequoia is one of the tallest tree species.
- In India Gymnosperms are found on Himalayan mountains.

Morphological character:

- Root: The roots are generally tap roots.
- Roots in some genera have fungal association in the form of mycorrhiza (Pinus), while in some others (Cycas) small specialised roots called coralloid roots are associated with N_2-fixing cyanobacteria.
- Stem: The stems are unbranched (Cycas) or branched (Pinus, Cedrus / Deodar).
- Leaf: The leaves may be simple or compound.
- In Cycas the pinnate leaves persist for a few years (Perennial leaves).
- The leaves in gymnosperms are well-adapted to withstand extremes of temperature, humidity and wind (Xerophytic adaptation).
- In conifers (e.g. pinus), the needle-like leaves reduce the surface area and their thick cuticle and sunken stomata also help to reduce water loss.

Anatomical character:

- Stem bears eustelic condition.
- Vessels are absent in xylem of gymnosperms except gentiles (e.g. Welwitschia, Ephedra, Gnetum).
- Phloem has sieve cells and albuminous cells and sieve tubes and companion cells are absent.
- Xylem has tracheid but vessels absent.
- Secondary growth occurs in stem and root.
- Bordered pits are present.

Wood of gymnosperms is homoxylous, nonporous and soft.

Life Cycle of Gymnosperm

- In Gymnosperms main plant body is sporophyte (diploid).
- All Gymnosperm are dioecious. I.e. male & female plants are separate, but exceptionally pinus is monoecius.
- All Gymnosperms are heterosporus. At the time of reproduction two types of spores are formed.
  Microspores - Male
  Megaspores - Female
- These two types of spores are formed in different sporangia.
- Microspores are formed in Microsporangia. Microsporangia also term as pollen sac.
- Megaspores are formed in Mega sporangia. Mega sporangia also term as ovule.
- Both type of sporangia are formed on different Sporophyll.
- Microsporangia are formed on Microsporophyll. It is known as stamen.
- Mega sporangia are formed on Megasporophylls. It is known as carpel.
- Both types of Sporophyll are found in groups & form male cone (strobilus) & female cone.

Male cone –

- The strobili bearing microsporophylls and microsporangia are called microsporangiate or male strobili.
- The microspores develop into a male gametophytic generation which is highly reduced and is confined to only a limited number of cells (Cycas - 5 cells and Pinus - 6 cells).
- This reduced gametophyte is called a pollen grain.
- The development of pollen grains take place within the microsporangia.

Female cone –

- The cones bearing megasporophylls with ovules or mega sporangia are called macrosporangiate or female strobili.
- The ovules are borne on megasporophylls which may be clustered to form the female cones.
- The nucellus (2N) is protected by envelopes / integument (unitegmic) and the composite structure is called an ovule or integument mega sporangium.
- The megaspore mother cell (2N) is differentiated from one of the cells of the nucellus.
- The megaspore mother cell divides meiotically to form four megaspores (N) out of which 3 megaspore degenerated.

- One of the megaspores (functional) enclosed within the mega sporangium develops into a multicellular female gametophyte (also known as endosperm) that bears two or more archegonia or female sex organs.
- The multicellular female gametophyte is also retained within mega sporangium / ovule.

Note:

- Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. They remain within the sporangia retained on the sporophytes.
- The development of male gametophyte and female gametophyte take place within microsporangia and mega sporangia respectively.

Pollination

- Pollen grain (Male gametophyte) reach at the Micropyle of ovule by wind.
- Pollination occurs by Anemophily (by air) most commonly in Gymnosperms.

Fertilization

Two types of fertilization take place in gymnosperms
Zoodio - siphonogamy -

- This type of fertilization occurs in lower gymnosperms.
- Male gamete is motile and contained in pollen tube.

Siphonogamy –

- This type of fertilization occur in higher gymnosperms.
- Male gamete is non-motile and transferred to female gamete (egg) by pollen tube.
- After Pollination male & female gametes are fused & form a diploid zygote.
- In gymnosperm single fertilization takes place so that single zygote form through fertilization.
- In Angiosperm double fertilization takes places so that two product are formed after it
  (i) Zygote
  (ii) Endosperm.
- In gymnosperm endosperm form before fertilization so it is haploid but in angiosperm endosperm are formed after fertilization so endosperm of angiosperm is triploid

Development of Zygote

- Embryo formed by the development of diploid zygote.
- After embryo formation ovule term as seed. (Seed□□□Ovule + Embryo)
- Ovule is a mega sporangia.
- Embryo enclosed in ovule because development of spore is endosporic.
- Seeds are not formed in pteridophyta because germination of spore is exosporic i.e. embryo develops outside the sporangia.

Polyembryony

Polyembryony occurs in gymnosperm i.e. a single seed develops many embryo.
There is two type of Polyembryony

Potential polyembryony -

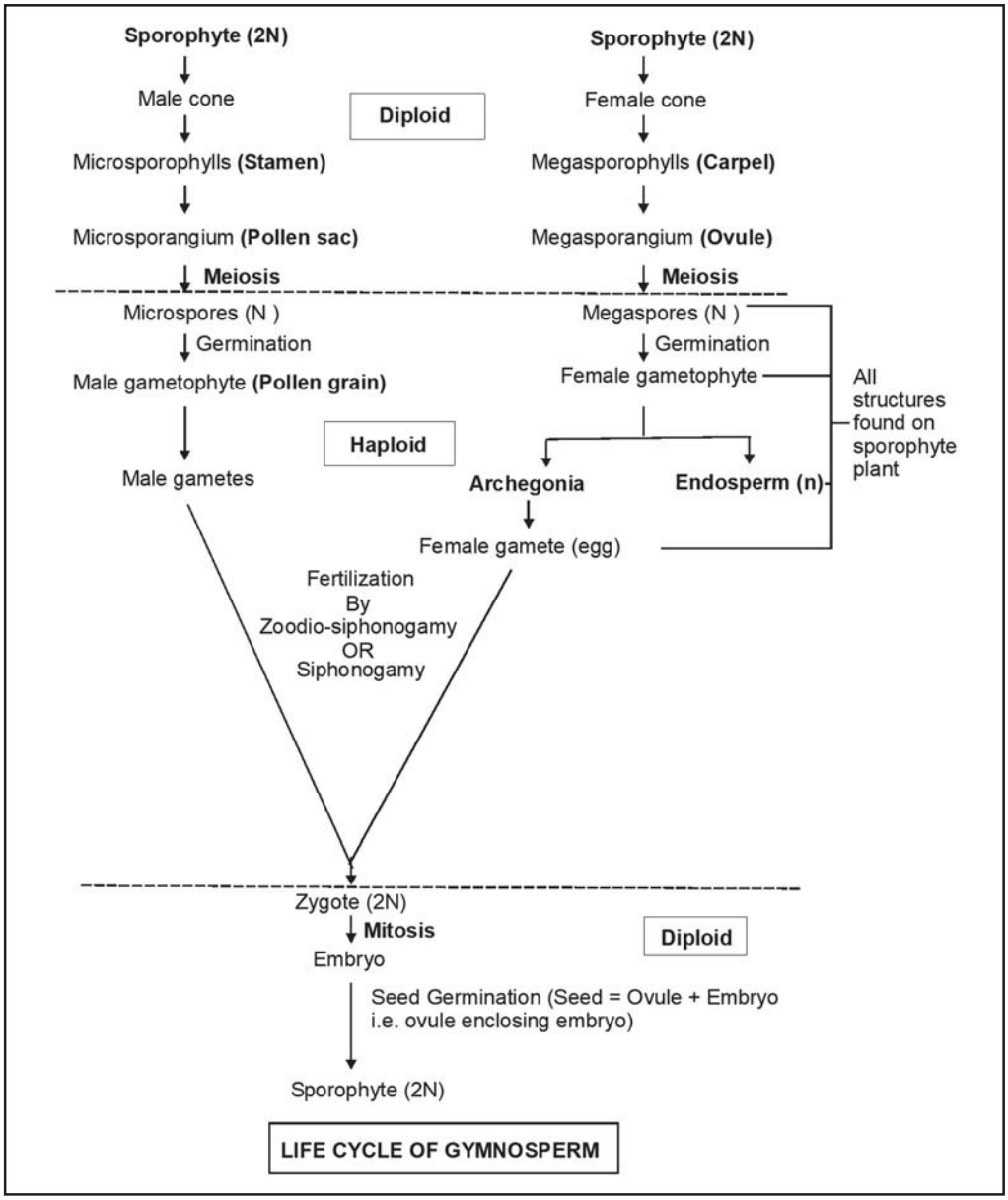
- Many embryo form by fertilization of many archegonia.
  Eg. Cycas -
- Single ovule of Cycas contains two archegonia.
- Fertilization occurs in both archegonia so two zygote form in a ovule, So two embryo form.
- Potential polyembryony is not true polyembryony because a zygote form only one embryo.

Cleavage polyembryony -

- Many embryo are formed by the cleavage in zygote so it is true polyembryony.
  Eg. Pinus
- Embryo enclosed in seed. Seed absorbs water & bursts.
- Now embryo germinate and form a new diploid sporophytic plant.

Life Cycle

- Life cycle of Gymnosperm & angiosperm is diplontic because gametophytic generation is short lived.
- Gametophyte is much reduced & depend on its sporophyte unlike bryophyte and pteridophyte.
- Gametophyte remain within the sporangia on sporophyte.



Important Points to Be Remembered

- Antheridia is absent in gymnosperm & angiosperm i.e. pteridophyte is last group bearing antheridia.
- Archegonia is also absent in angiosperm, so gymnosperm is last group of archegonia.
- Evolution of archegonia starts from liverworts. It is well developed in moss.
- Gymnosperm is last group of it. So in this group it is much reduced.

Archegonia of Liver worts	-	NCC = 4 - 6	VCC = 1	Egg cell = 1
Archegonia of Moss	-	NCC = 6 - 18	VCC = 1	Egg cell = 1
Archegonia of Pteridophyta	-	NCC = 1 -2	VCC = 1	Egg cell = 1
Archegonia of Gymnosperm	-	NCC = Absent	VCC = 1 (Short lived)	Egg cell = 1

- Neck of archegonia of Ephedra is longest
- During evolution Gametophyte becomes reduced & sporophyte becomes well-develop.

Different plant groups		Female sex organ	Male sex organ
Algae	-	Oogonium (mostly), Nucule (Chara)	Antheridium, Globule (Chara)
Bryophyte	-	Archegonium	Antheridium
Pteridophyte	-	Archegonium	All Antheridium
Gymnosperm	-	Carpel, Archegonium	Stamen, Androecium
Angiosperm	-	Carpel, Gynoecium	Stamen, Androecium
Fungi	-	Oogonium Ascogonium (Ascomycetes)	Antheridium Spermatangium (Basidiomycetes)

Economic Importance:

- Source of Wood - e.g. Cedrus deodara (deodar, strongest of all soft wood), Sequoia (red wood tree), Pseudosuga (Douglos fir), Taxodium, Taxus (Yew).
- Food - Sago a kind of starch is obtained from cortex and pith of stem and seeds of Cycas.
- The Roasted seeds of Pinus gerardiana (Chilgoza) are used as dry fruit.
- Seeds of Ginkgo biloba are eaten in china and japan.
- Cedar wood oil is obtained from stem of Juniperus virginiana (Red cedar) and used as immersion oil in oil immersion lens.
- Medicinal use - Ephedrine is obtained from stem branches of Ephedra and used to cure cough, cold, bronchitis, asthma and fever. Taxol is extracted from Taxus baccata (yew) and used in the treatment of cancer.
- Canada balsam is a turpentine extracted from Abies balsamea used in mounting of permanent slides.
- Many Gymnosperms are grown in the gardens as ornamental plants e.g. Cycas, Taxus, Thuja, (Morpankh), Araucaria excelsa (x-mas /Christmas tree), Ephedra, Cupressus, Ginkgo (Pagoda tree / Maiden hair tree), Araucaria imbricate (Monkey's puzzle).

Classification of Gymnosperm

Gymnosperm are classified into Cycadophyta e.g. Cycas and Coniferophyta e.g. Pinus, Ginkgo, Cedrus, Taxus etc.

Cycadophyta

- The plants of this group are megaphyllous or macrophyllous with circinate vernation.
- Presence of Ramenta.
- Male gamete is motile.

Cycadophyta is divided into three orders

Cycadofillicales or Pteridospermae:-

- This order is completely extinct. Plant of this order known as seed fern.

Benettitales:-

- It is also a completely extinct group.
  Eg. Williamsonia - fossil plant
  Note: Its fossils were discovered by Prof. Birbal Sahani

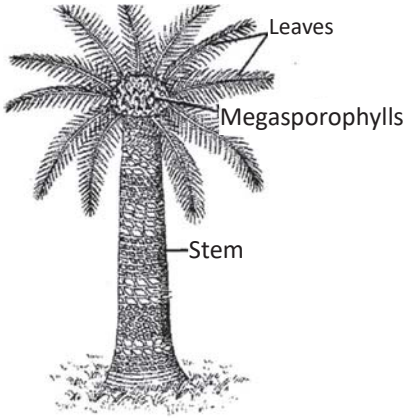
Cycadales –

- Presently living cycadophytes are included in this order.
- All the plants of this group are living fossils.

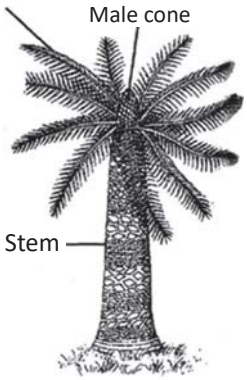
Zamia pygmea	-	Smallest Gymnosperm
Cycas	-	Fern palm or Sago palm Sago is obtained from its stem.

The diameter of its ovules is 7 cm. Its ovule, male gametes, egg and male cone are largest in plant kingdom. In embryo of Cycas two cotyledons are present. In Cycas male gamates are top shaped. In Cycas female cone is absent.

Cycas



Cycas:- (A)female plan



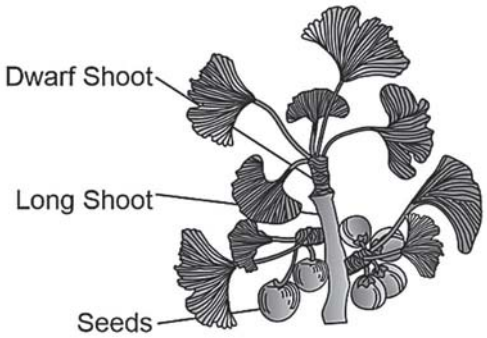
(B)male plan

Coniferophyta

Four orders are included in this group

Ginkgoales

- It is the oldest order of coniferophyta.
- Maximum plants of this group are extinct.
- Only one plant of Ginkgo biloba is present in India (In Manali). Some plants are also present in china.
- Ginkgo biloba - living fossil - It is also known as ''Maiden hair tree''
  Exceptionally Ginkgo biloba belongs to higher gymnosperm but its male gametes are motile and fertilization by Zoodio siphonogamy.



Cordaitales

- It is completely extinct group
  Eg. Cordaites

Coniferales

- Conifers are included in this group.
- It is the largest group of gymnosperm

Eg.

Pinus (Pines)	-	Roots have fungal association (mycorrhiza)
Pinus species	-	A resin ''turpentine'' is obtained from it. Turpentine is used in varnish.
Pinus gerardiana	-	It is known as ''chilgoza pine''
Pinus roxburghii	-	It is known as ''chirpine''
Cedrus	-	It is known as deodar. Wood used in match sticks, Railway sleepers, light furniture, packing case etc
Taxus	-	It is known as Yew tree. An anticancer medicine ''Taxol'' is obtained from its bark.
Taxodium maxicanus	-	The stem of this plant is thickest in the plant kingdom.
Abies balsamea	-	A resin ''Canada balsam'' is obtained from it. It is used to manufacture permanent sildes in biology laboratory.
Juniperus virginiana	-	An oil obtained from this tree-''Cedar wood oil''. It is used as cleansing fluid in biology laboratory. This oil also used in microscope to increase the resolving power. This oil is used as nail polish remover. Wood used in pencil manufacturing Araucaria species
Araucaria excelsa	-	Christmas tree Ornamental plants
Araucaria araucana	-	Monkey puzzle tree
Sequoia species	-	The plants in this genus are heavy. Therefore they are called as father of forest.
Sequoia giganteum	-	It is called "Red wood tree" or Sherman tree, It is the tallest gymnosperm. There is only one tree of this species and that is in California (America)
Met sequoia	-	It is living fossil. This plant is present in China valley.

Gnetales

- They are the most advanced gymnosperms.
- Exceptionally members of this group have vessels in xylem.
- Ovule of this group is bitegmic.
- Archegonia is absent in the members of this group.

Eg. Gnetum

Welwitschia - Two leaves in whole life, pollination by insects.
Ephedra - Exceptionally archegonia is present in Ephedra.
Ephedra - This gymnosperm is commonly found in Rajasthan.
Ephedra is a medicinal plant. Ephedrine (Medicine) is obtained from it.
It is an effective medicine in asthma.
Athletes misuse it, so ephedrine is restricted for them.

Differences between Cycas and Pinus		
S.No.	**Cycas**	**Pinus**
1.	Unbranched stem	Branched stem
2.	Dioecious	Monoecious
3.	Pinnate, spirally arranged leaves	Needle like scally leaves
4.	Coralloid root present	Mycorrhizal roots present
5.	Male gamete motile (Zooido-siphonogamy)	Male gamete non-motile (Siphonogamy)
6.	Manoxylic wood	Pycnoxylic wood
7.	Male gametophyte - 5 cells only	Male gametophyte - 6 cells only
8.	Pollination at 3 cell stage.	Pollination at 4 cell stage.
9.	Megasporophyll contains 1-5 ovule	Megasporophyll contains 2 ovule
10.	Male cone present and Female cone absent	Male cone and female cone present
11.	Pollen grain are without wings.	Seed and pollen grain are winged.
12.	Pollen grain contain 1 prothalial cell.	Pollen grain contain 2 prothalial cell.

Differences between Pteridophytes and Gymnosperm		
S.No.	**Pteridopohytes**	**Gymnosperms**
1	These are found in moist and shady places.	They are xerophytic.
2	Secondary growth is absent.	Secondary growth is quite common.
3	Ovules absent.	Ovules present.
4	Pollen tube is not formed.	Pollen tube is formed.
5	Neck canal cell is found in the archegonium.	It is absent in archegonium.
6	Seed formation does not take place.	Seed formation takes place.