ENTRI

GYMNOSPERMS GENERAL CHARACTERISTICS

- Some seeds are enclosed in a pod, some in a husk, some in a vessel, and some are completely naked- **Theophrastus.**
- **Goebel**- phanerogams without ovary.
- The term gymnosperm was given by **Theophrastus** in his book "**Enquiry into Plants"**(300 BC).
- It is derived from two Greek words, "**Gymnos**" means Naked and "**Sperma**" means **Seeds**.
- Gymnosperms and angiosperms are two groups of seed plants(Spermatophyta).
- Gymnosperms shows two distinct lines, namely ;

1. Cycadophytes

- Palm like tree habit.
- Unbranched stem.
- Long and large compound leaves.

2. Coniferophytes

- one shaped plant body.
- Tall and profusely branched stem.
- Acicular leaves.

- Of the living and fossil gymnosperms, Cycadales and Ginkgoales are very ancient.
- for this reason and with some other primitive characters, these members are called "**living fossils**".
- Tallest tree known to plant kingdom belongs to gymnosperms- the Red wood plant or Californian sequoia (*Sequoia sempervirens*).
- Smallest gymnosperm is a cycad, *Zamia pygmaea* .
    - Longest living - *Pinus aristata*.

GENERAL CHARACTERISTIC

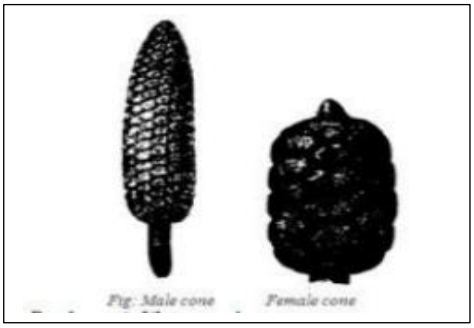
- Gymnosperms are middle sized trees (*Cycas*) to tall trees (*Pinus*) and shrubs (*Ephedra*).
- They are rarely woody climbers (*Gnetum montanum*).
- Herbs are not present in the gymnosperms.
- The most massive (thick) and among the oldest, is *Sequoiadendron giganteum* popularly known as **Redwood tree** or **Father of forest.**
- Usually tap root system is present but in some forms **symbiotic relationship** is found between roots and algae in **coralloid roots** of *Cycas* and between roots and fungi in **mycorrhizal roots** of *Pinus*.
- The stems are aerial, erect, branched (unbranched in Cycas and Zamia) and woody.
- In *Pinus* branches are of two types i.e. **dimorphism**

1. Long shoots or branches of unlimited growth.
2. Dwarf shoots or branches of limited growth.

- Plants may possess one kind of leaves i.e. **monomorphic** or two kinds of leaves i.e. **dimorphic**.
    a. Foliage leaves (evergreen simple or compound).
    b. Scale leaves (minute and deciduous).
- Internal features of roots are like to dicotyledons.
- Vascular cylinder in roots is **diarch** to **polyarch**.
- Xylem is **exarch** and roots show secondary growth.
- Vascular bundles of stems are **collateral**, **endarch**, open and are arranged in a ring.
- Secondary growth is also present.
- Secondary wood may be **manoxylic** (well developed pith and cortex) or **pycnoxylic** (much reduced pith and cortex).
- In cycads (*Cycas*) manoxylic wood is present while in others (*Pinus*, *Taxus*) it is pycnoxylic.
- Xylem lacks vessels and phloem lacks companion cells.
- Secondary vasculature may be monoxylic (single layer of cambium) or polyxylic (several successive layers of cambium).
- **Stomata are present in deep cavities**.
- **Mesarch xylem** and **transfusion tissues** are present.

REPRODUCTION

- Vegetative reproduction is altogether absent in gymnosperms except in *Cycas*.
- *Cycas* do propagate through **bulbils**.
- Sexual reproduction is advanced- **oogamous type**.
- Plants are heterosporous- **microspores** and **megaspores**.
- Both **monoecious** and **dioecious** types of plants are found in gymnosperms.
- In most of the gymnosperms, reproductive organs are arranged in the form of compact cones called as **strobili**.
- Male cones are **microsporangiate** and female cones are called as **megasporangiate**.
- Male cones are short lived and smaller than female cones (except in *Cycas*).
- Female cones are long lived.



- **Microsporangia**
  - are borne on the lower surface of microsporophylls.

- They may be numerous and grouped in **sori** (*Cycas*) or reduced to two (*Pinus*).

❖ **Megasporangia**

- or ovules.
- are **naked** and are borne on the upper surface of megasporophylls.

❖ **Ovules**

- are covered by a **single integument**.
- which is differentiated into **fleshy outer sarcotesta**, **stony middle sclerotesta** and **fleshy inner sarcotesta**.

❖ **Embryo** gets differentiated into **suspensor**, **radical**, **hypocotyl**, **plumule** and **cotyledons**.

❖ **Polyembryony** (development of several embryos in one seed, out of which only one survives) is of common occurrence in *Pinus*.

❖ The zygote is **meroblastic** i.e. only basal part develops into an embryo, whereas upper and middle parts do not participate in embryo formation.

❖ **Endosperm** develops before fertilization and is **haploid**.

❖ The number of cotyledons may be one or two or whorl of many.

❖ Seeds of all gymnosperms except those of *Cycas* and *Ginkgo* undergo a **resting period**.

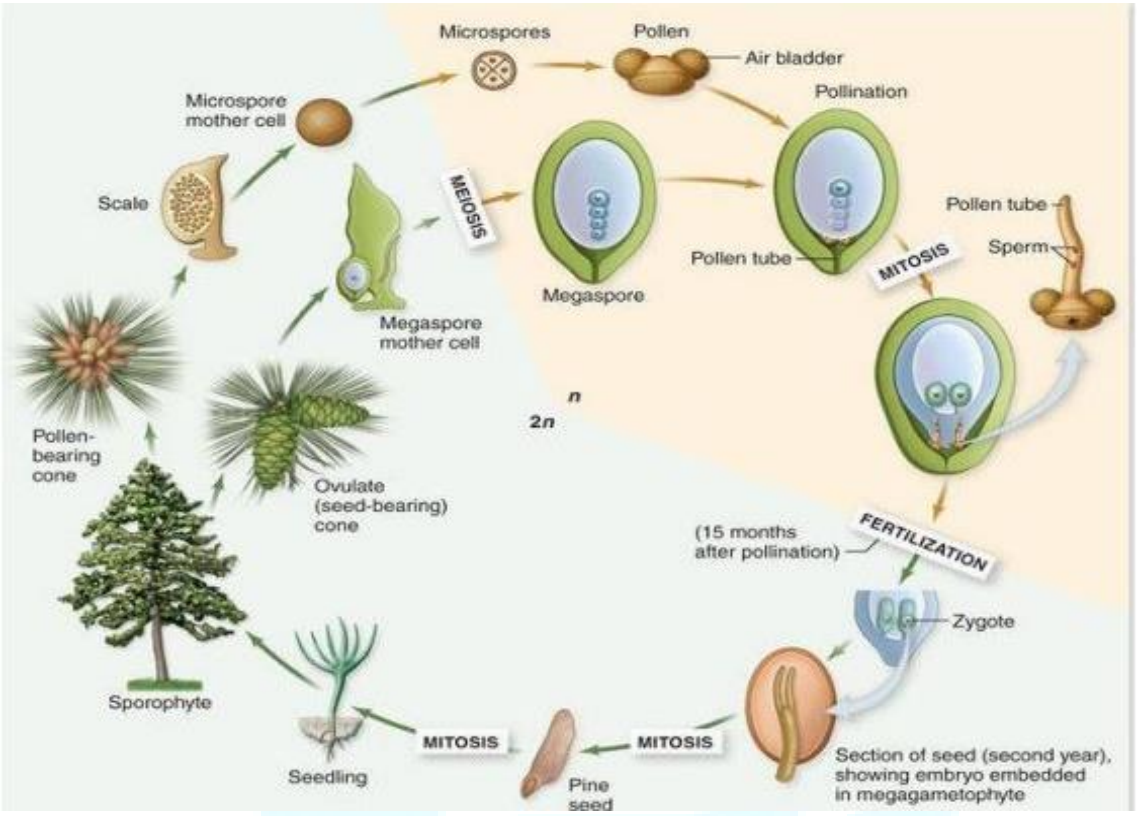
❖ The germination of the seed is **epigeal** (cotyledons come above ground).

❖ The **alternation of generation is heterologous.**

❖ Gametophytic generation (n) is reduced and dependent upon the sporophytic generation.

❖ Sporophytic generation (2n) is dominant and independent.

LIFE CYCLE OF GYMNOSPERMS



CLASSIFICATION OF GYMNOSPERMS CYCADOPSIDA

CLASSIFICATION OF GYMNOSPERMS

THEOPHRASTUS

- The term "GYMNOSPERM" was first used by Theophrastus.
- He wrote a books "HISTORIA PLANTARUM" and "ENQUIRY INTO PLANTS".
- In these books he mentioned "GYMNOSPERM" and "ANGIOSPERM".

ROBERT BROWN(1827)

- Further analysis was made by Robert Brown in 1827.
- He for the first time recognized gymnosperms as a group distinct from Angiosperms due to presence of naked ovules .

BENTHAM AND HOOKER (1862-83)

- Bentham and Hooker considered Gymnosperms equivalent to dicotyledons and monocotyledons .
- They divided them into three groups as;

1. CYCADACEAE
2. CONIFERAE
3. GNETACEAE

- They placed them in between dicots and monocots.

VAN TIEGHEM (1898)

- gave the status of major Divisions to the Gymnosperms.
- Tieghem also divided the spermatophyta (seed plants) in to **two divisions** namely;
    1. GYMNOSPERMS (Astigmate).
    2. ANGIOSPERMS (Stigmata).

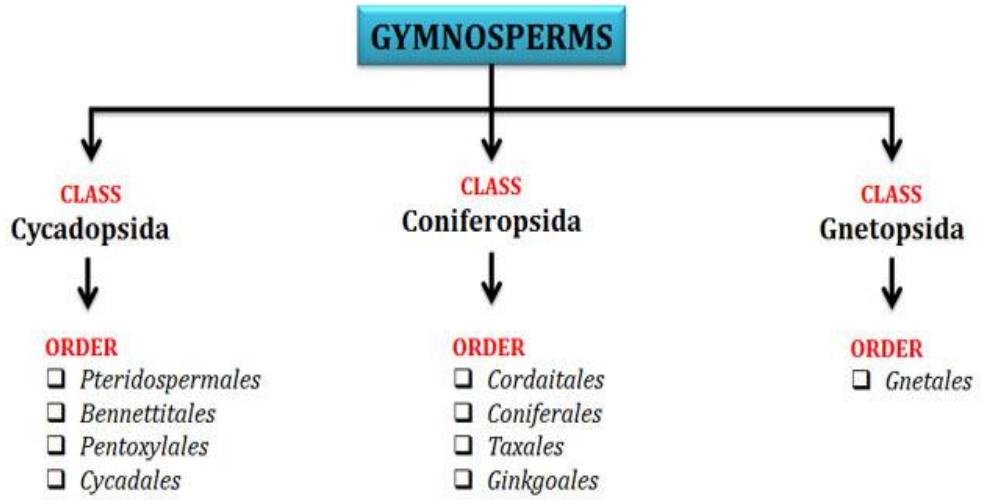
COULTER AND CHAMBERLAIN 1912

- Divided the division Gymnosperm directly into **seven orders** namely;
    1. Cycadofilicales
    2. Bennettitales
    3. Cycadales
    4. Cordaitales,
    5. Ginkgoales
    6. Coniferales
    7. Gnetales

SPORNE (1965)

- Classified gymnosperms into **3 classes, 9 orders and 31 families.**
- The classes include;
    1. Cycadopsida
    2. Coniferopsida
    3. Gnetopsida.

Classification of Gymnosperms by K.R. Sporne (1965)

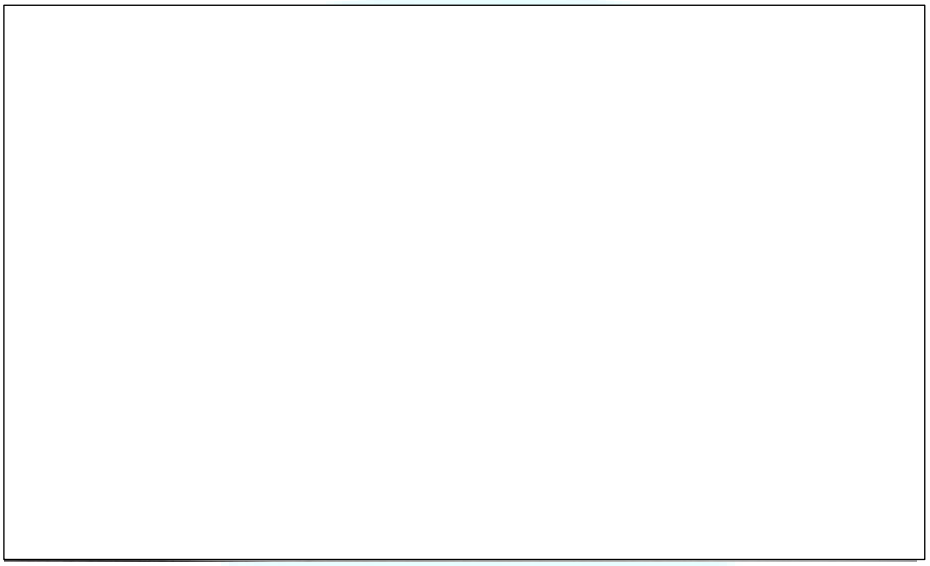


CYCADOPSIDA

GENERAL FEATURES

- Mostly xerophytes.
- The plants are low and palm-like in habit.
- The stem is short, un-branched, columnar and covered with dense persistent leaf bases.
- The leaves are pinnately compound and arranged in a terminal crown.
- The plants grow very slowly but they live for ages.
- Comparatively the pith is large and cortex is broad.
- There is a narrow zone of conducting tissue is present.
- The conducting strand is conjoint, collateral, endarch and open.

- Vascular bundles around the pith separated from each other by medullary rays.
- The cycads are strictly dioecious.
- Except the female strobilus of *Cycas* the sporophylls are arranged in definite cones.
- The ovules are straight and usually sessile.
- Male gametes are motile.



CYCAS

Division : Cycadophyta
Class : Cycadopsida
Order : Cycadales
Suborder: Cycadinae
Family : Cycadaceae
Genus : *Cycas*

GENERAL FEATURES

- Occurs wild or cultivated in tropical and subtropical regions.
- *Cycas* is a palm-like, evergreen plant.
- Stem unbranched, columnar and covered with persistent leaf bases.
- Leaf segment remains circinate within the bud.
- Leaves are dimorphic.
- Female reproductive structures the megasporophylls are not aggregated in cones.
- Ovules borne on the lower margins in ascending order.

ROOTS – MORPHOLOGY

- Roots in *Cycas* are of two types- normal tap roots and coralloid roots.
- Normal tap-roots are positively geotropic, grow deep into the soil and generally possess no root hairs.
- Their function is to fix the plant in the soil and to absorb water and other minerals.

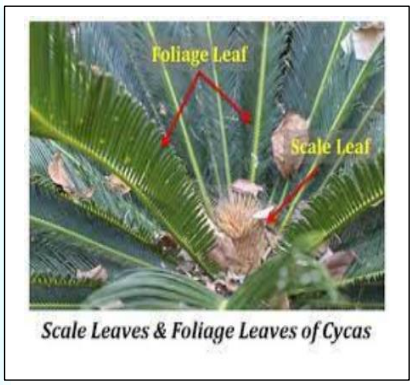
CORALLOID ROOTS

- Apogeotropic Coral like in appearance.
- They divide dichotomously, come out of the soil on the ground surface and are phototrophic in nature.
- Shows symbiotic association with cyanobacteria for nitrogen fixation- *Nostoc*, *Anabaena*.
- Young plants bear more coralloid roots than the older ones.

STEM- MORPHOLOGY

- The stem- thick, woody,un-branched.
- It is tuberous when young but columnar, erect and stout at maturity.
- The aerial part of the trunk remains covered by a thick armour of large and small rhomboidal leaf bases.
- The age of the plant can be calculated by counting the number of crowns of leaves and megasporophylls which are produced every year.
- *Cycas media* is tallest, attaining a height up to 20 metres

LEAVES



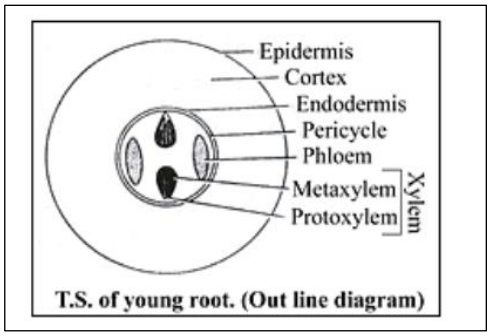
Scale Leaves & Foliage Leaves of Cycas

- Two types of leaves are present in *Cycas*.
- These are green, assimilatory or foliage leaves, and scaly leaves or cataphylls.
- Foliage Leaves or Assimilatory Fronds Green, large, pinnately compound Spiny petiole and large, strong rachis.
- They are produced at the apex of the stem in the form of crown. The rachis bears many leaflets.
- Scaly Leaves or Cataphylls.
- These are dry, brown-coloured, somewhat triangular leaves with their one end pointed.
- They are present at the apex of the stem and remain covered with several ramental hairs

ANATOMY – ROOT

- Young root shows typical structure like that of a dicotyledonous root, shows secondary thickening.

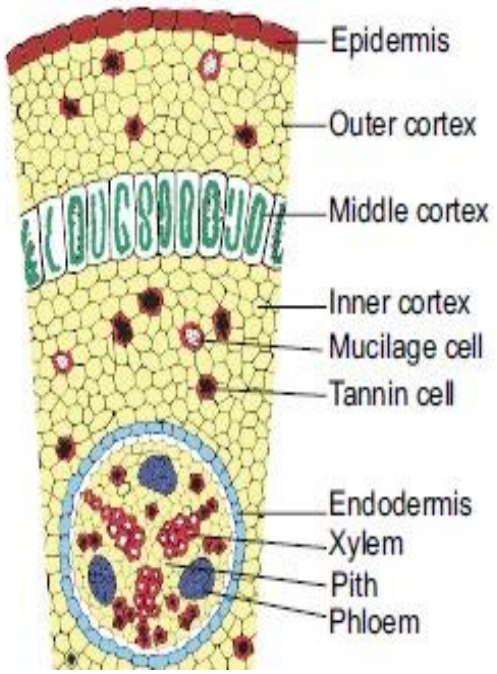
- Outermost layer,epiblema, encloses the parenchymatous cortex.
- Cells of the cortex remain filled with starch, Some tannin-filled cells, mucilage cells are also present.
- Endodermis with casparian thickening.
- Vascular tissue - Radial arrangement
- The roots are usually diarch to tetrarch, rarely polyarch.
- Vessels are absent
- Pith is absent or reduced.



T.S. of young root. (Out line diagram)

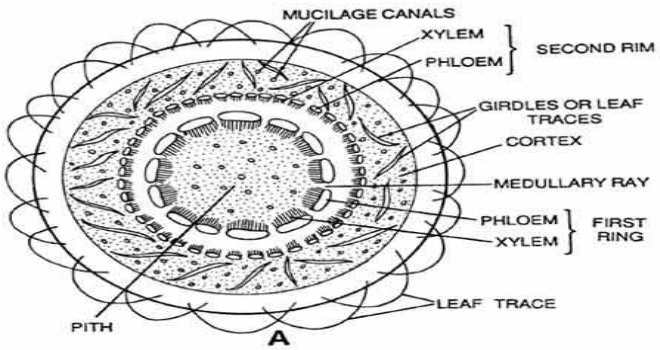
CORALLOID ROOT

- Anatomically, the coralloid roots resemble normal roots except some under mentioned differences:
  - ➢ The secondary vascular tissue in coralloid roots is either totally absent or poorly-developed.
  - ➢ The cortex is wider in comparison with the normal root.
  - ➢ Presence of a greenish algal-zone in the middle of the cortex.



STEM – ANATOMY

- Show irregular outline due to the presence of leaf bases, therefore epidermis is not a continuous layer.
- Broad cortex contains simple and girdle leaf traces
- Numerous mucilage canals, starch grains are present
- Vascular tissues-narrow
- Vascular bundles are open and endarch
- V.B are arranged in ring and separated by medullary rays.
- Pith - large, parenchymatous and having mucilaginous canal And starch grain.



Cycas Stem T.S. Primary Structure

ANATOMY – RACHIS

- Woody and thick
- Hypodermis is sclerenchymatous
- Characteristic feature is omega shaped outline of numerous vascular bundles.

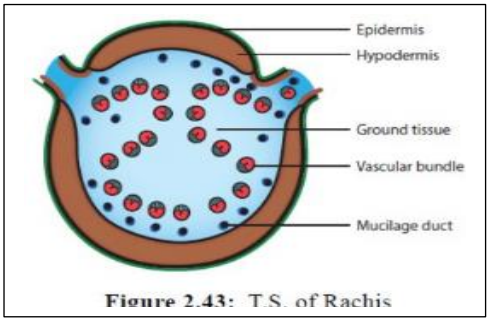
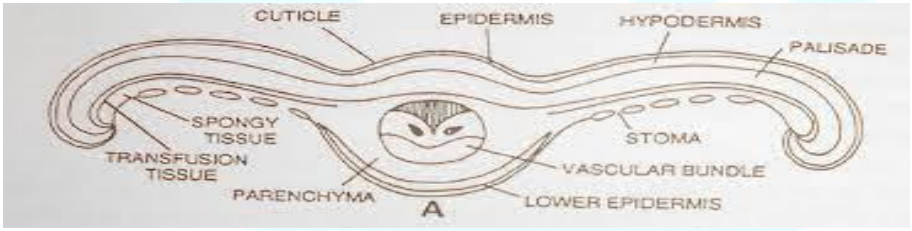


Figure 2.43: T.S. of Rachis

- Each bundle has sclerenchymatous bundle sheath and is open and collateral.

ANATOMY OF LEAFLET

- Leaflet is thicky cutinized and leathery
- Sunken stomata and thickened hypodermis present.
- Well developed palisade layer in mesophyll
- Between the palisade and lower mesophyll layers, there are transversaly running long colourless cells in 3-4 layers extending from mid-rib to near leaf margin -Transfusion tissue.
- Mid rib bundle consist of a broad triangular centripetal xylem and two small patches of centrifugal xylem is present
- Phloem is abaxially placed.



VEGETATIVE REPRODUCTION

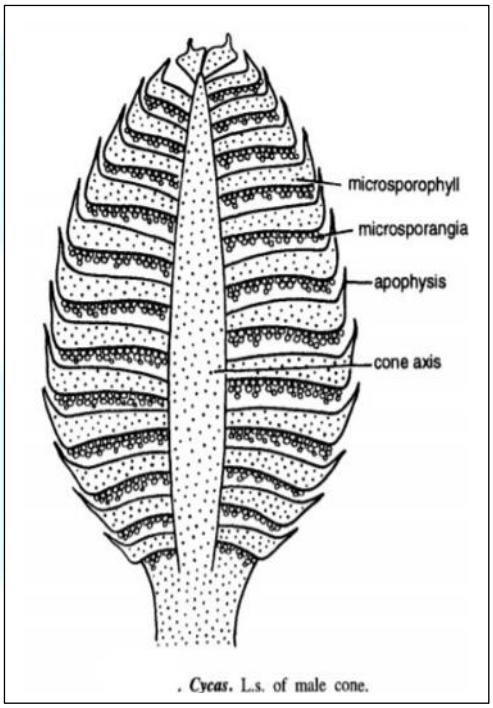
- Vegetative reproduction is by means of bulbils.
- Develop in crevices of scale leaves and leaf bases at the basal part of an old stem.
- Produces new plant on detachment.

SEXUAL REPRODUCTION

- Dioecious plant.
- Male strobilus or cone borne singly at the apex of the trunk.
- Apical shoot apex utilized in the development of male cone, hence branching sympodial.
- Large, conical or ovoid, compact, solitary and shortly-stalked structure.

MICROSPOROPHYLLS

- Numerous micro-sporophylls spirally arranged around the central axis.
- Each microsporophyll is narrow below and broad above terminating into projection – the apophysis.
- Microsporangia confined to abaxial (lower) surface.
- Usually present in sori – each with 2-6 sporangia.
- They contain a large number of haploid microspores (pollen grains).



. *Cycas*. L.s. of male cone.

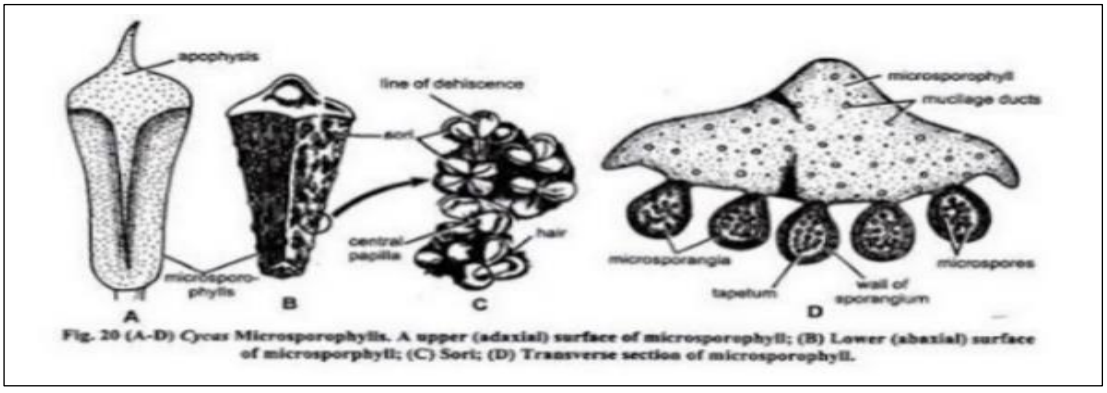
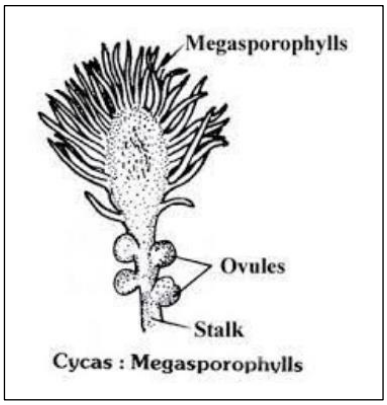


Fig. 20 (A-D) *Cycas* Microsporophylls. A upper (adaxial) surface of microsporophyll; (B) Lower (abaxial) surface of microsporphyll; (C) Sori; (D) Transverse section of microsporophyll.

MEGASPOROPHYLL

- Female plant do not produce definite cones.
- A whorl of spirally arranged megasporophylls arise around the short apex.
- Each megasporophyll resembles the foliage leaf and approximately 10-23 cm.
- Long, lower petiolar part bears the naked ovules on the margins.



Cycas : Megasporophylls

MEGASPORANGIUM

- The megaspore develops in the nucellus by meiotic division and goes on to form female gametophyte tissue.
- 2-3 archegonia are formed in this haploid tissue.
- Egg cell in the venter of archegonia, undergoes fertilization by the motile spermatozoid forming diploid zygote.

STRUCTURE OF OVULE

- Largest ovule (6cms.x 4 cms.) seen in *C.circinalis*.
- Ovules are orthotropous, sessile, ovoid or spherical in shape and unitegmic.
- The thick integument is differentiated in three layers- outer and inner fleshy layers, middle stony.
- The integument remains fused inside with nucellar tissue except at the position where it forms the micropylar opening.
- Ovule is well supplied with vascular bundles

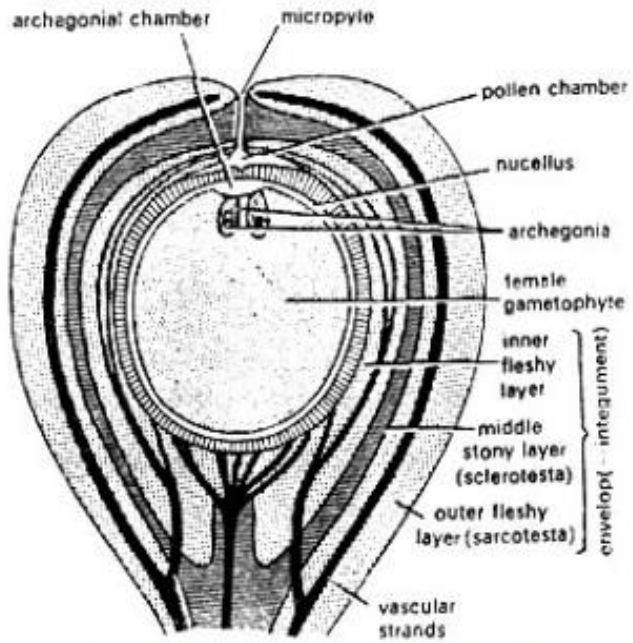


Fig. Structure of ovule LS

POLLINATION

- The pollen grains are carried by wind (Anemophily) and caught by pollination drop secreted by ovule.
- The 3-celled microspores liberate from microsporangia are blown away by wind.
- The pollination drop (ooze) of micropyle. As the ooze dries up, the microspores are drawn into the pollen chamber.
- Pollination is direct.
- Pollen grains take rest for some time in the pollen chamber.

DEVELOPMENT OF MICROSPORE

- During the germination of pollen grain the exine is ruptured and the inner intine comes out in the form a tube like structure known as pollen tube.

- At this time the generative cell divides and forms a larger, upper body cell and smaller, lower stalk cell.
- The pollen tube acts as haustorium to absorb food materials from the nucellus besides as sperm carrier.
- The body cell divides and forms two naked, top shaped, motile, multiciliated antherozoids.
- The cilia are in 4 – 5 spirals.
- The male gametes of Cycas are 180 – 210 μ in size and largest in the plant kingdom.
- The pollen tube apex is ruptured and the male gametes are released into the archegonial chamber.
- Presence of multiciliated male gametes is the fern character shown by Cycas male gametophyte.

FERTILIZATION

- In the archegonial chamber, the tip of pollen tube burst to discharge its contents.
- One of the sperms enters the archegonium.
- When moving towards egg, the sperm lost cilia and cytoplasmic membrane.
- So the fusion of a male nucleus and egg nucleus occurs to form a zygote.
- (2n) It is noted that in *Cycas* fertilization exhibits both siphonogamy (i. e. formation of pollen tube) and zoidogamy (i.e. participation of ciliated male gametes).

EMBRYO DEVELOPMENT

- Embryo development is meroblastic.

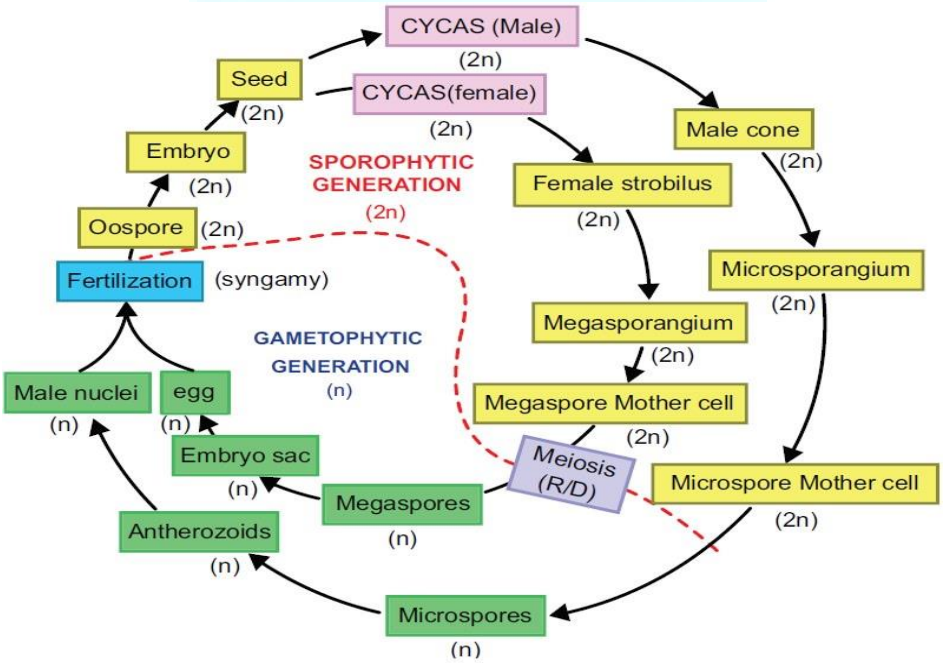
- Proembryo shows upper haustorial part, middle elongating suspensor and the basal meristematic embryonal region.

SEEDS

- A mature embryo is straight and has a short hypocotyl.
- Embryonal axis has plumule at one end and radicle at the other.
- Radicle is covered by coleorhiza.
- Number of cotyledons maybe 2-3.
- Nucellus is completely absorbed in the seed.
- Mature seed is large 2.5–5 cm wide and usually orange or red in colour.
- Germination is hypogeal type.

LIFE CYCLE

- The sexual life cycle of *Cycas* is diplohaplontic.
- It shows heterologous or heteromorphic type of alternation of generations.



CONIFEROPSIDA

GENERAL CHARACTERISTICS

- Mostly evergreen with branched stems, rarely shrubs.
- LEAVES- needle or scale-like/ flattened/spirally arranged.
- The leaves possess xerophytic characters.
- Wood is pycnoxylic.
- Wood without vessels consisting of long tracheids which show bordered pits.
- Resin canals are present.
- The flowers are monoecious or dioecious.
- The female flowers are terminal or lateral surrounded by supporting bracts.
- The male flowers consist of a number of stamens arranged in strobili. The stamens are many, each with 2 to 20 pollen sacs.
- Pollen grains may be winged, e.g : *Pinus*.
- The female flowers are arranged in cones or catkins with the exception of Taxaceae, Cephalotaxaceae and Podocarpaceae.
- Each female flower consists of a bract (sterile) and a scale (fertile).
- The ovules develop on the upper surface of ovuliferous scales.
- The seeds - winged, nut like and with a leathery or woody testa.
- The cotyledons are epigeal and 2-16 in number.
- Polyembryony is quite common.
- They produce non-motile sperms at the time of fertilization.

ENTRI

PINUS

Class: Coniferopsida

Order: Coniferales

Family: Pinaceae

Genus: *Pinus*

MORPHOLOGY

- Indian species are *P. excelsa, P. longifolia, P. gerardiana, P. insularis, P. armandi*.
- Perennial, xerophytic plants appearing pyramidal or conical due to radial branching.
- Branches are dimorphic – long shoots and dwarf shoots (spurs)
- Leaves are dimorphic – Scale leaves and green acicular leaves.
- Male and female cones present on the same plant, hence monoecious

ROOTS

- Plant possesses tap root
- Ectotrophic mycorrhiza is present.
- It is symbiotic association of fungal mycelium on the root's surface
- Helps in absorption of nutrients & protection from pathogens

- Fungal species identified are *Rhizopogon*, *Amanita, Boletus, Entoloma*, etc. – mostly members of Basidiomycetes

STEM

- Erect, tall, cylindrical, woody and branched
- Monopodial branching
- Lower branches longer and horizontal giving the conical shape to the plant
- Branches of unlimited growth are the long shoots
- Arranged spirally around the main trunk

LEAVES

- Scale leaves - thin, brown ,small
- Main function is to protect young buds & conserve water around the branches
- Foliage leaves - long & acicular (needle like)
- Remains green for a number of years (3-10 yrs) hence plants are evergreen

ANATOMY OF ROOT

- Root Resembles typical dicotyledonous root
- Piliferous epiblema bear unicellular root hair (seen only in young roots)
- Broad parenchymatous cortex follows
- Endodermis and pericycle layers seen next
- Vascular tissue is radially arranged in 2-6 groups of xylem and phloem

- This tissue lacks true vessels and companion cells
- Resin canals present in xylem patch making it Y-shaped
- Old roots show secondary growth

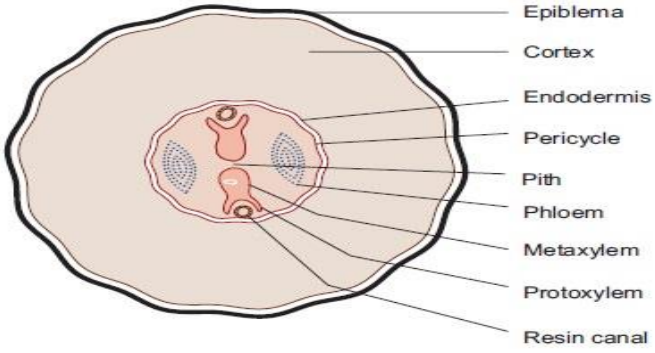


Figure 2.49: T.S. of *Pinus* root

ANATOMY OF STEM

- Stem Typically dicotyledonous stem
- Cuticularized epidermis encloses the lignified sclerenchymatous hypodermal layer below
- Inner cortex is thin walled parenchyma containing chloroplasts and resin canals
- Vascular bundles are conjoint, collateral, endarch , open and form a ring
- Medullary rays are narrow
- Vessels in xylem and companion cells in phloem are absent

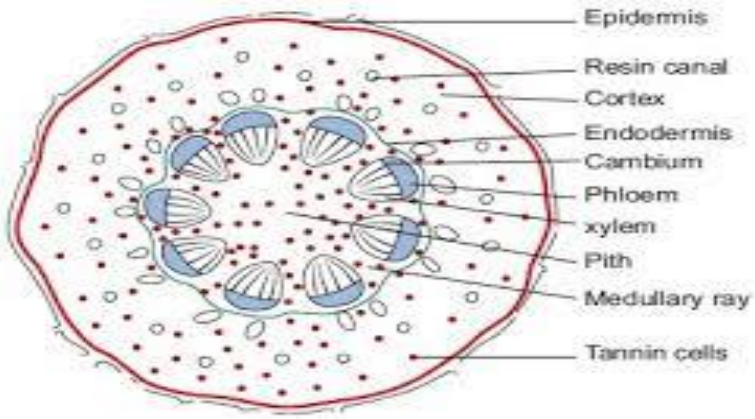
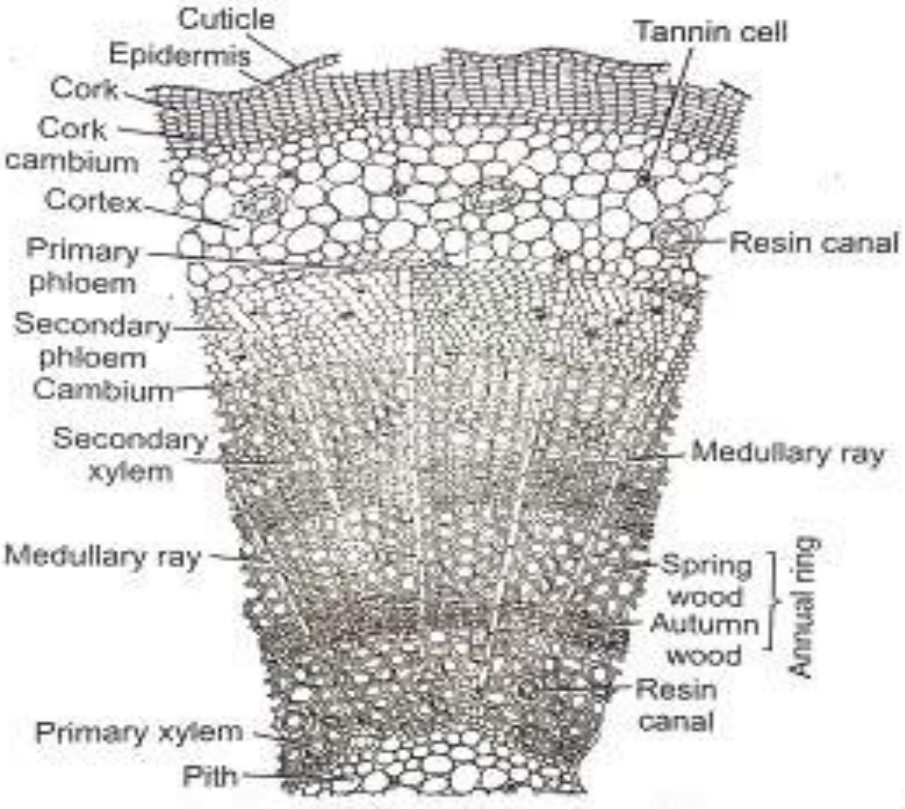


Figure 2.50: T.S. of *Pinus* stem

SECONDARY GROWTH IN STEM

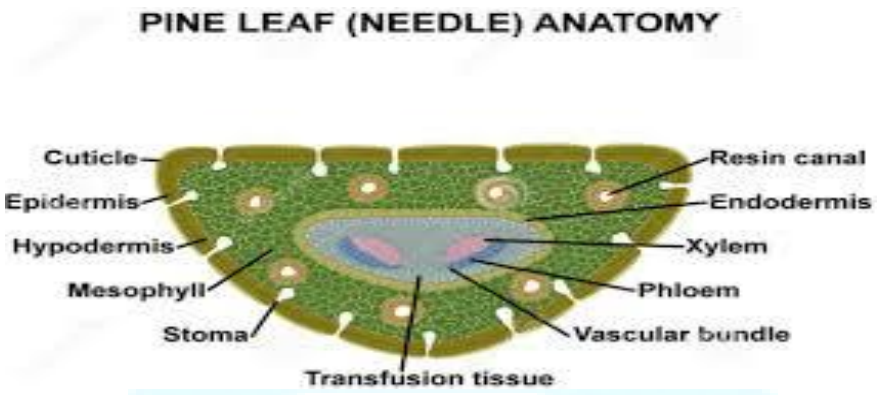
- Ring of vascular cambium develops
- Remains active each year forming spring wood & autumn wood – annual rings
- Important in dendrology for estimation of the age of the plant
- Secondary medullary rays usually uniseriate
- Pinus wood is dense and massive with few parenchyma cells – pycnoxylic
- Cork cambium (phellogen) formed in outer cortical layer
- Forms secondary cortical cells (phelloderm) towards inner side and cork (phellem) on outer side.



ANATOMY OF LEAF

- Leaf Xeromorphic
- *P. longifolia* is trifoliar; so the needle shows triangular outline

- Outermost epidermal layer has thick-walled cells which are cuticularized
- Stomata are sunken
- Hypodermis is sclerenchymatous



REPRODUCTION

- Takes place by means of spores –microspores (male) and megaspores (female).
- Heterosporous
- Monoecious

MALE CONE/STAMINATE CONE

- Borne on the lower branches in the axils of scale leaves.
- Can be seen in clusters just behind the shoot – apex.
- Each cone has spirally arranged microsporophylls
- Two microsporangia are present on the underside of each microsporophyll
- Development of microsporangium is eusporangiate type

- Within the microsporangium, the microspore mother cells undergo meiotic divisions to form haploid microspores

MICROSPORE/POLLEN GRAIN

- It is surrounded by a 3-layered wall
- Exine heavily cuticularized on one side of the microspore
- Middle layer -Exo-intine projected outwards into two large balloon-like air sacs or wings
- Inner layer- Intine is very thin
- Spore germination is in situ
- At the time of dehiscence, huge quantities of microspores form yellow clouds around the pine forests.
- It's called the "Shower of sulphur dust"

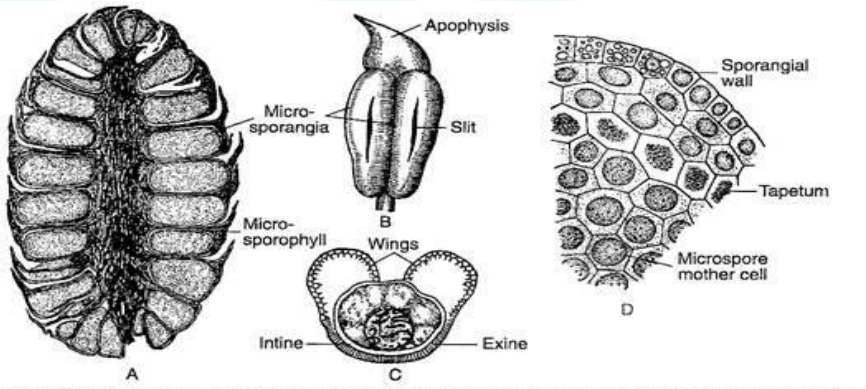
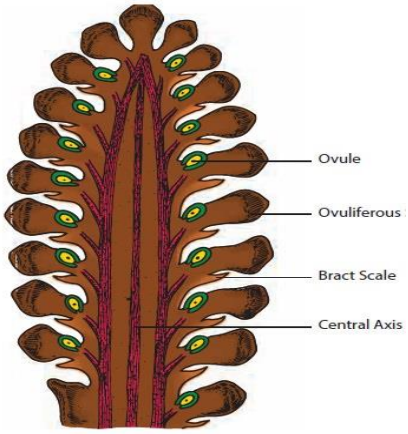


Fig. 1.62 : *Pinus* : A. Median L.S. of male cone, B. A microsporophyll, C. A pollen, D. T.S. of a microsporangium

FEMALE CONE/OVULATE CONE

- Borne on the upper branches of the tree, in axils of scale leaves either singly or in groups of 2-4.
- Each cone consists of central axis bearing spirally arranged ovuliferous scales.

- On young cones a small thin & leathery bract scale can be below the ovuliferous scale.
- Each ovuliferous scale has two ovules on its upper surface.
- Cone on maturity is usually cylindrical.



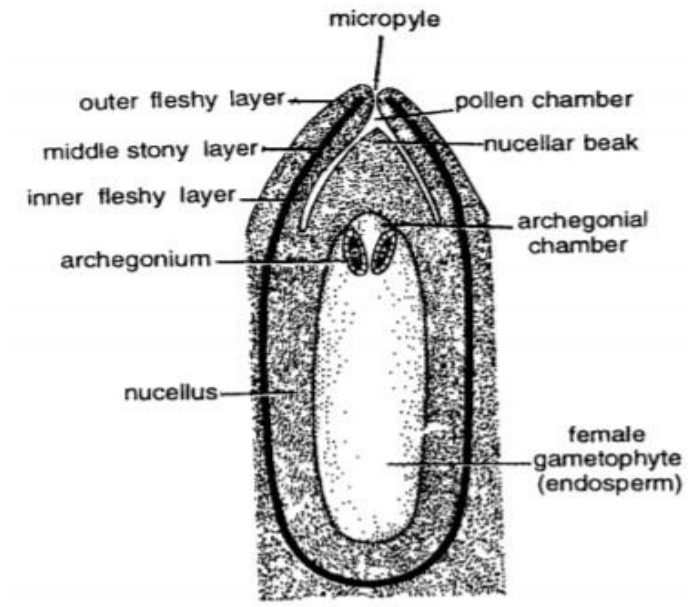
e) L.S. of female cone

MEGASPOROPHYLL

- The ovuliferous scale is thick, large, woody & brownish structure
- More or less triangular in outline – broad, terminal portion is apophysis with its centrally projected area
- Basal portion is narrow and bears two naked, sessile anatropous ovules on its upper surface

OVULE STRUCTURE

- Micropyle of the ovule faces the central axis of the cone
- The single integument is fused to the nucleus except for a short distance near the micropyle
- Embedded in the nucellus ,the archesporial cell divides meiotically to form four megaspores



Pinus. L.s. of ovule.

MALE GAMETOPHYTE

- Early development takes place inside the microsporangium
- Pollen grains are released at the 4-celled stage (2 prothallial, a generative cell and tube cell)
- Pollination is anemophilous and pollen reach the pollen chamber of the ovule through micropyle
- Further development here, results in the formation of pollen tube which carries the two unequal male gametes to the neck of the archegonium
- The released male gametes will fertilize the egg cell resulting in zygote formation

SPOROPHYTE DEVELOPMENT

- Embryo development is meroblastic

- In early stages the embryonal tier of the proembryo splits apart forming 4 apical segments each with its suspensor
- Each of these terminal embryonal cell give rise to a mature embryo, thus Cleavage polyembryony is observed

SEED STRUCTURE

- Seeds are naked (not enclosed in fruit)
- Seeds are winged – the latter being derived from portion of upper surface of the ovuliferous scale
- Outer fleshy layer of ovule disintegrates
- Testa formed from the middle stony layer
- Tegmen is the inner fleshy layer of the ovule
- Nucellus is almost consumed during embryo development.
- Remnants of nucellus , at micropylar end can be seen as reddish papery structure – the perisperm
- The haploid female gametophyte surrounding the embryo forms the oily white kernel (edible part).
- Mature embryo has the radicle towards the micropyle and plumule away from it.
- Plumule is surrounded by 8-14 cotyledons, which are green in colour.
- Germination is epigeal.

LIFE CYCLE

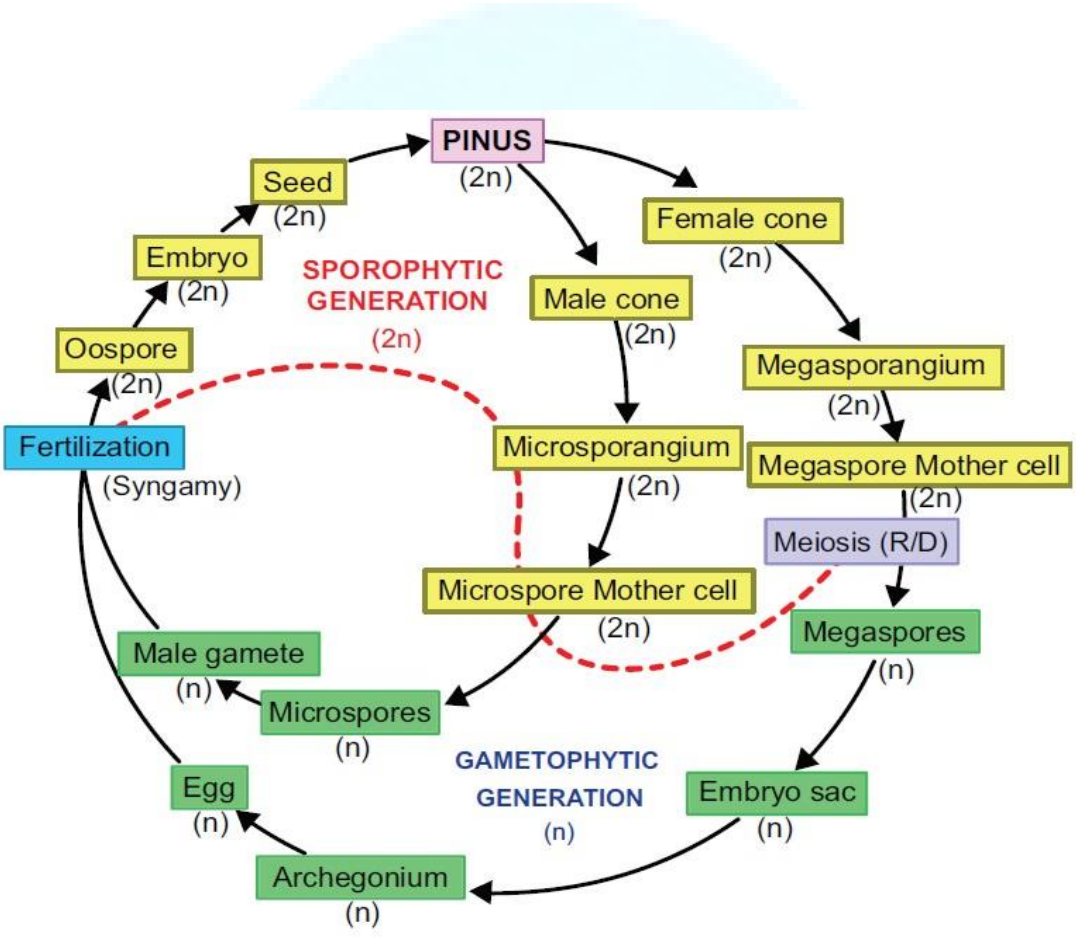


Figure 2.53: Life cycle of *Pinus*