B. SC. SEMESTER-II

BOTANY PAPER I

(PALAEOBOTANY, PTERIDOPHYTES, GYMNOSPERMS AND SOIL ANALYSIS)

UNIT-III: Gymnosperms:

1. Gymnosperms: General characteristics, Classification (Steward, 1982). Economic Importance

2. Fossil Gymnosperms: *Cycadeoidea* flower

3. Life cycle of: *Cycas* and *Pinus.*

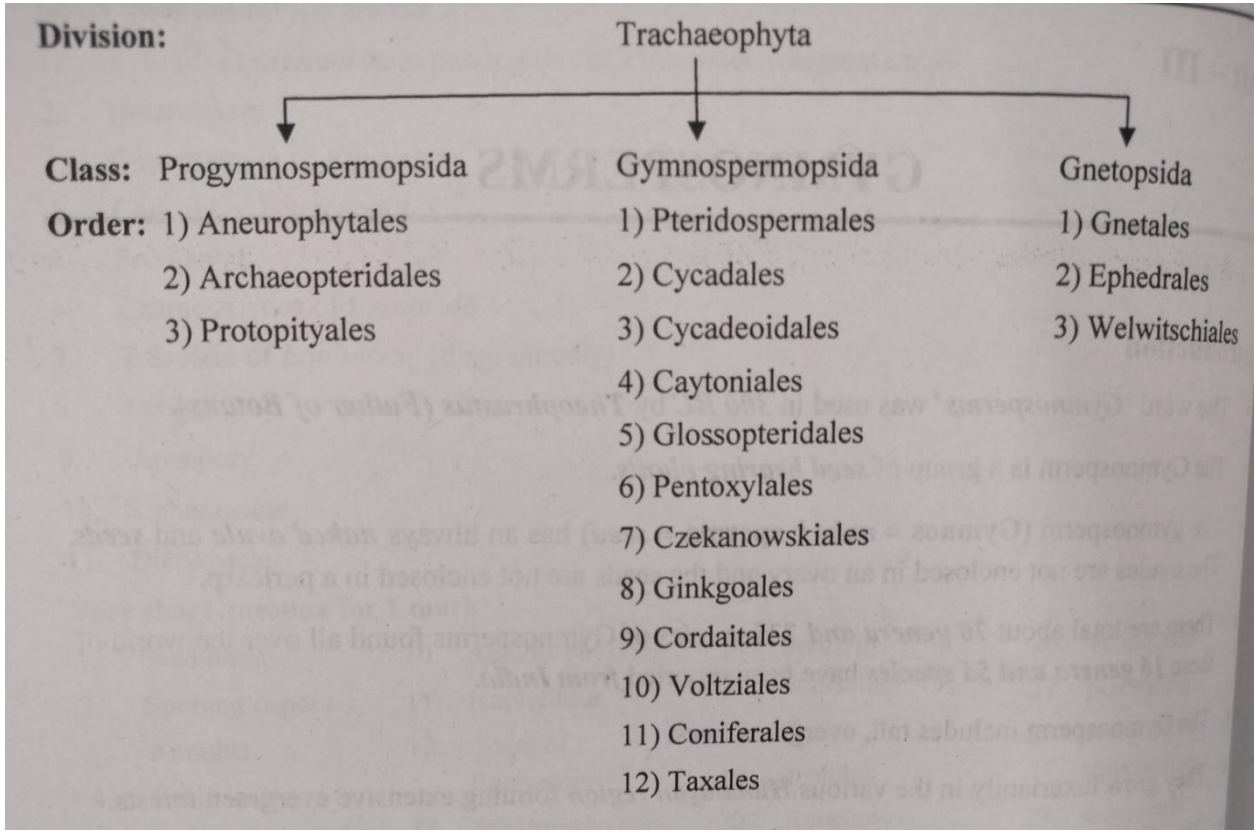
1. Gymnosperms: General characteristics

- They do not produce flowers.
- Seeds are not formed inside a fruit. They are naked.
- They are found in colder regions where snowfall occurs.
- They develop needle-like leaves.They are perennial or woody, forming trees or bushes.
- They are not differentiated into ovary, style and stigma.Since stigma is absent, they are pollinated directly by the wind.
- The male gametophytes produce two gametes, but only one of them is functional.
- They form cones with reproductive structures.The seeds contain endosperm that stores food for the growth and development of the plant.
- These plants have vascular tissues which help in the transportation of nutrients and water.
- Xylem does not have vessels and the phloem has no companion cells and sieve tubes.

Classification (Steward, 1982).

Stewart proposed a system of classification of gymnosperm according to stewart the division tracheophyta has been divided into three classes i.e progymnospermopsida, gymnospermopsida and gnetopsida . Classes further divides into order. Some of the orders are extinct.

The outline of a system of classification of Gymnosperm is as follows:



Economic Importance

1.Gymnosperms are a good source of food. Seeds of these non-flowering plants are widely used as an edible species, used for producing various food products. These plant species include: *ginko*, *pinus*, *cycas*, etc.

2.A few species of gymnosperms are a good source of starch and are also used in the production of sago. It serves as major staple food for lowland or indigenous peoples.

3.In certain parts of America and in other lowland regions, the leaves of these plant species are soaked and eaten as a green leafy vegetable.

4.The different species of non- flowering plants are widely used in the production of wine and also on other food products.

5.Other than the food, gymnosperms are widely used by the pharmaceutical industry for the production of various medicines, which are effectively used to treat infectious disease and other allergies including cold, cough, asthma, bronchitis, etc.

6. Taxus, a genus of coniferous trees is well known for the drug taxol. This is an anticancer drug, which is used in the treatment of different cancers and is prepared from the bark of the Taxus tree.

7. Different species of *Cycas* plants are used in the treatment of different diseases and also in the production of different hair care products, including oil, lotion, shampoo, etc.

8. There are a few species of non-flowering plants, which are widely used as ornaments for decoration purposes. For example- fern.

9. Oil extracted from the barks, wood and other parts of the plants are used in the cosmetics industries in the production of perfumes, room fresheners and other fragrance spray.

10. Other than the food and medical applications, a few of these non-flowering plants are widely grown in gardens, parks and in other places as these plants possess beautiful ornamental leaves.

2. Fossil Gymnosperms: *Cycadeoidea* flower

CLASSIFICATION

Division : Cycadeoidophyta
Order : Cycadeoideales
Family : Cycadeoidaceae
Genus : *Cycadeiode*

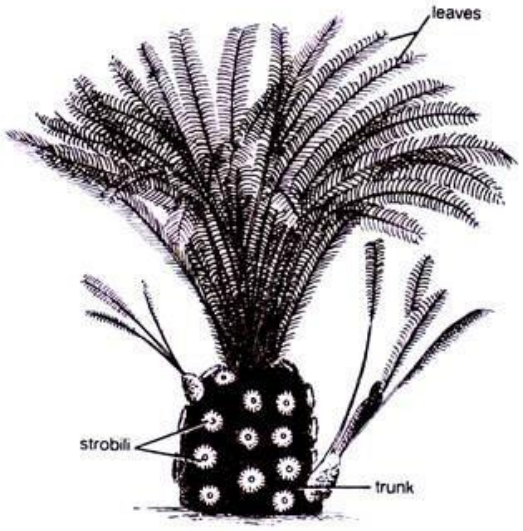


Fig. 6.1. *Cycadeoidea dacotensis*. External features. (after Macbride)

Introduction:

- Cycadeoidea, also called Bennettites by several European palaeobotanists is represented by about 30 species.
- The name Cycadeoidea was put forward in 1827 for petrified trunks from Isle of Portland.
- Though Bennettites is still employed for plant fossils from the Isle of wight, *cycadeoidea* is now the valid name of the genus.
- It has been reported from upper Jurassic to upper Cretaceous rocks of America, India, Russia and several European countries.
- It occurs in the form of a large number of petrifactions in different parts of the world

2. Morphological Features of Cycadeoidea:

- The Cycadeoid trunks were short, stout, spherical to sub-spherical and unbranched or branched.
- The trunks and leaves of many of its species show remarkable resemblance with those of living Cycads.
- Some of the species were short while others (*Cycadeoidea jenneyana*) attained a height of 3 to 3 .6 metres.
- The trunk generally attained a diameter of about 50 cm, and had many, persistent, rhomboidal leaf bases.
- A compact crown of Cycad-like, large, pinnately compoun was present at the apex.
- The leaflets had many parallel veins.

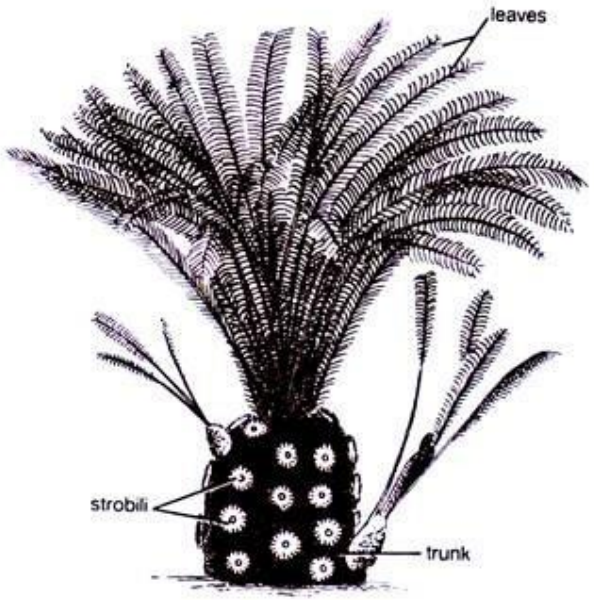


Fig. 6.1. *Cycadeoidea dacotensis*. External features. (after Macbride)

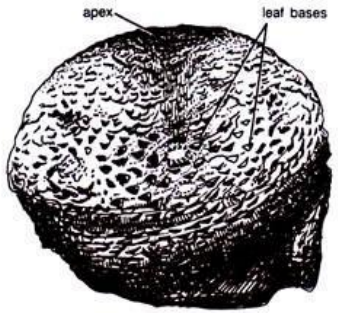


Fig. 6.2. *Cycadeoidea colossalis* showing almost completely spherical stem. (after Wieland).

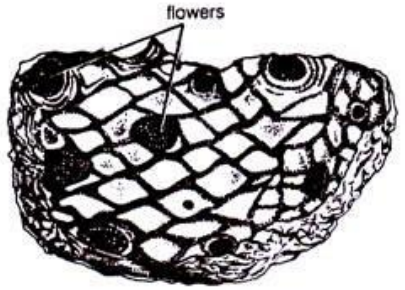


Fig. 6.3. *Cycadeoidea gibsonianus*. Tangential section through leaf base and flowers.

3. Anatomy of Cycadeoidea:

- The stem was roughly circular or oval in outline.
- It remained covered by heavy armour of leaf bases.
- The epidermis was not very distinct.
- The cortex was parenchymatous and possessed many mucilage canals and leaf traces.
- Many conjoint, collateral, open and endarch vascular bundles constituted the primary vasculature of the stem.
- A large centrally located pith was present.
- The xylem and the pholem have been studied in detail by Wieland (1906) Most of the tracheids were rectangular in shape.

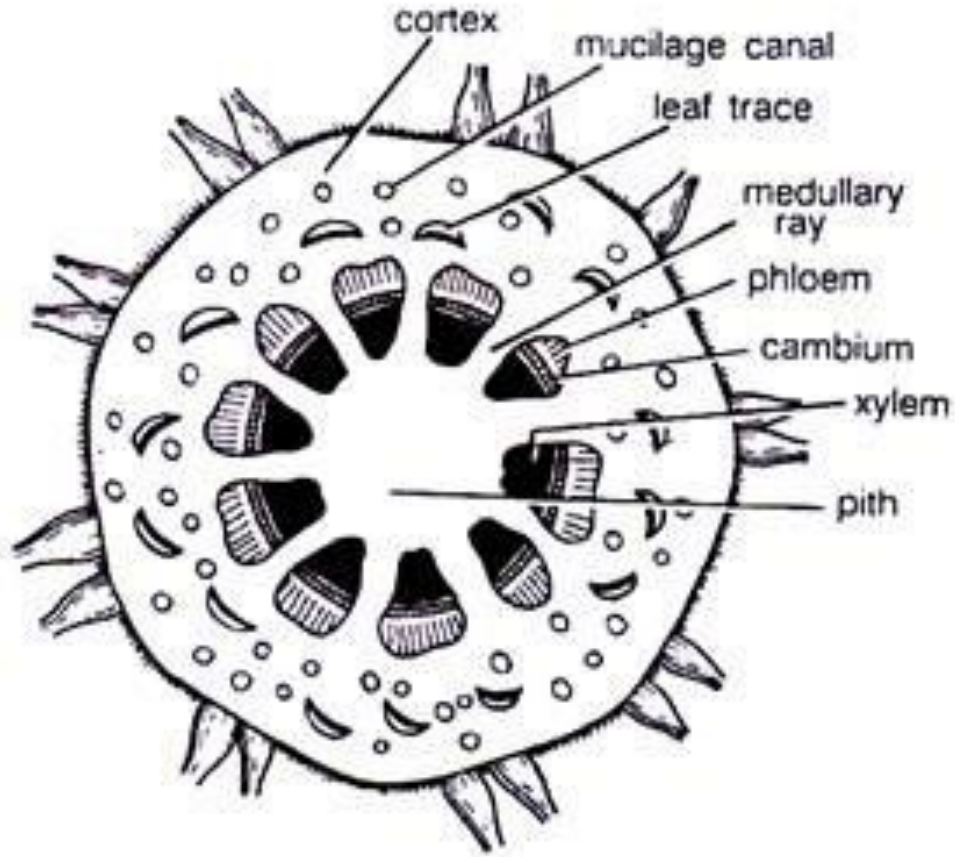


Fig. 6.4. *Cycadeoidea*. Diagrammatic representation of T.S. stem showing primary structure.

- They were scalariform.
- The tracheids of protoxylem were spiral.
- The secondary xylem and the secondary phloem were traversed by secondary medullary rays, which were either uniseriate or bi-seriate.
- Cambium was clearly visible.
- A leaf trace developed singly from the primary vascular strand.
- It divided into many mesarch strands upon entering into the cortex.
- At the place of its origin the leaf trace was C-shaped.

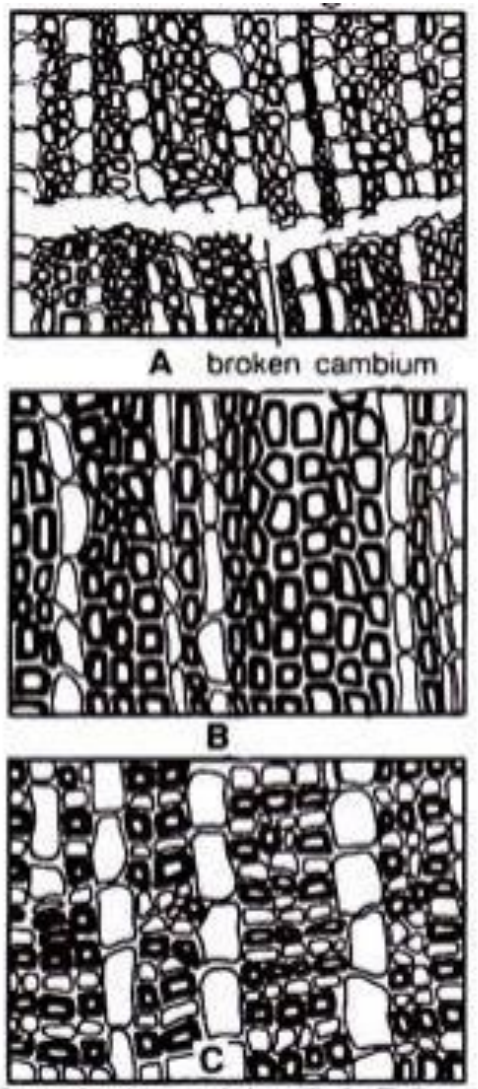


Fig. 6.5. *Cycadeoidea wielandii*. A, T.S. stem passing near cambium; B, T.S. secondary wood; C, T.S. phloem showing thin-walled and thick-walled tracheids. (all after Wieland).

4. Reproductive Organs of Cycadeoidea:

- The Bennettitalean reproductive organs are designated as “flowers “.The flower buds in the plants were present in the axil of leaf bases.

- As many on 500 flower buds were present on a single trunk in species such as Cycadeoidea dartonii (Monanthesia dartonii). In several species of Cycadeoidea all the flower buds were present on a trunk at almost the same stage of development.

- Some palaeobotanists believe that such a plant might have flowered only once during its lifetime. Except a few species (e.g. C. wielendii) the flowers in Cycadeoidea were bisexual. Hermaphrodite flower developed on a short pedicel.

- They were surrounded by as many as one hundred bracts, which were hairy and protective. Flowers in different species were of different size. In Cycadeoidea dartonii they attained a length of about 2 cm and a diameter of about 1.5 cm while in C. dacotensis each flower was about 8 cm long and 3 cm in diameter.

- In C.dacotensis the lower two-third portion of the floral axis had about 100-150 bracts. A whorl of stamens was present above the bracts.

- Each stamen was pinnately branched and each pinna had a double row of purse-shaped sporangia.

- Each sporangium resembled with a synangium. A conical floral axis was present just above the whorl of stamens. The entire compact structure resembled with a strobilus.

5. Microsporophyll in Cycadeoidea:

- According to Wieland (1906, 1916), the androecium or pollen-bearing region consisted of about 20 pinnate, microsporophyll's.
- These were somewhat fixed or united at the base.
- Bean-shaped pollen capsules were arranged in two rows on each pinna of the sporophyll.
- These microsporophyll's remained folded round the gynoecium when young, but probably at maturity they expanded.
- Delevoryas (1963), however, opined that the microsporophyll's never expanded.
- He further concludes that synangia-bearing structures, described as pinnae by Wieland (1906), were similar to the trabeculae.
- These trabeculae established a connection between outer and inner walls of the androecium.
- Pollen capsules or synangia were borne along these trabeculae.
- Several (20-30) pollen sacs or microsporangia were present in a pollen capsule or synangium.
- The wall of a synangium consisted of outer palisade-like, thick-walled cells followed by thinwalled layer and then a tapetum.
- The tapetum was not clearly demarcated.
- The pollen grains were oval in shape and measured up to 68 fi in length. Multicellular pollen grains in *Cycadeoidea* have been reported

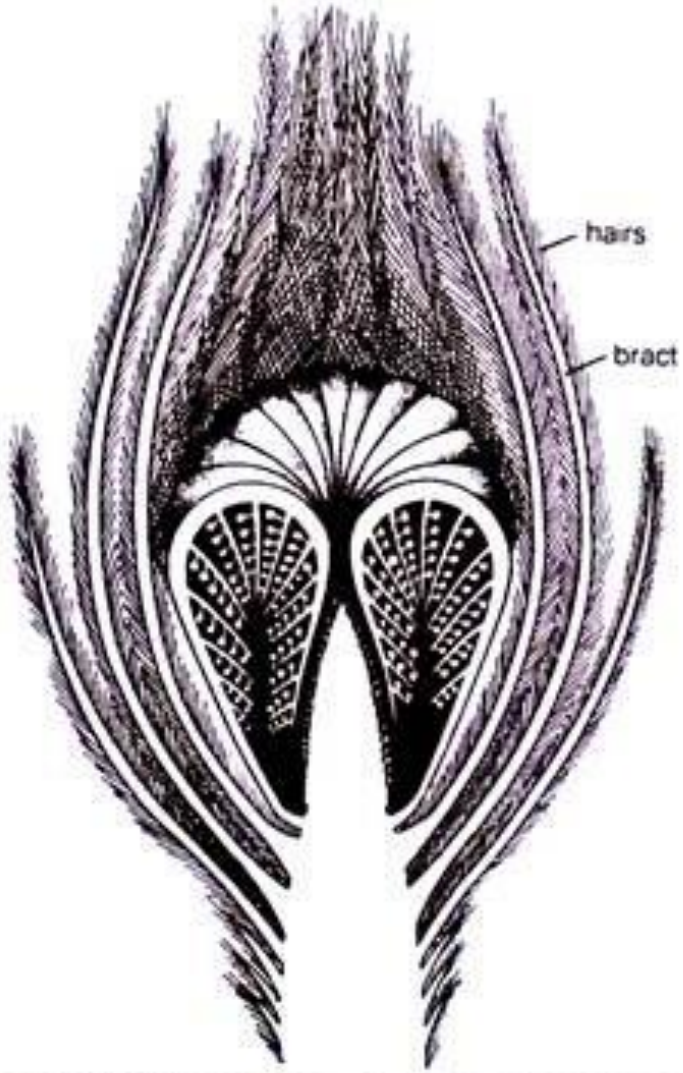


Fig. 6.6. *Cycadeoidea*. Diagrammatic representation of unexpanded strobilus. (after Wieland, 1906)

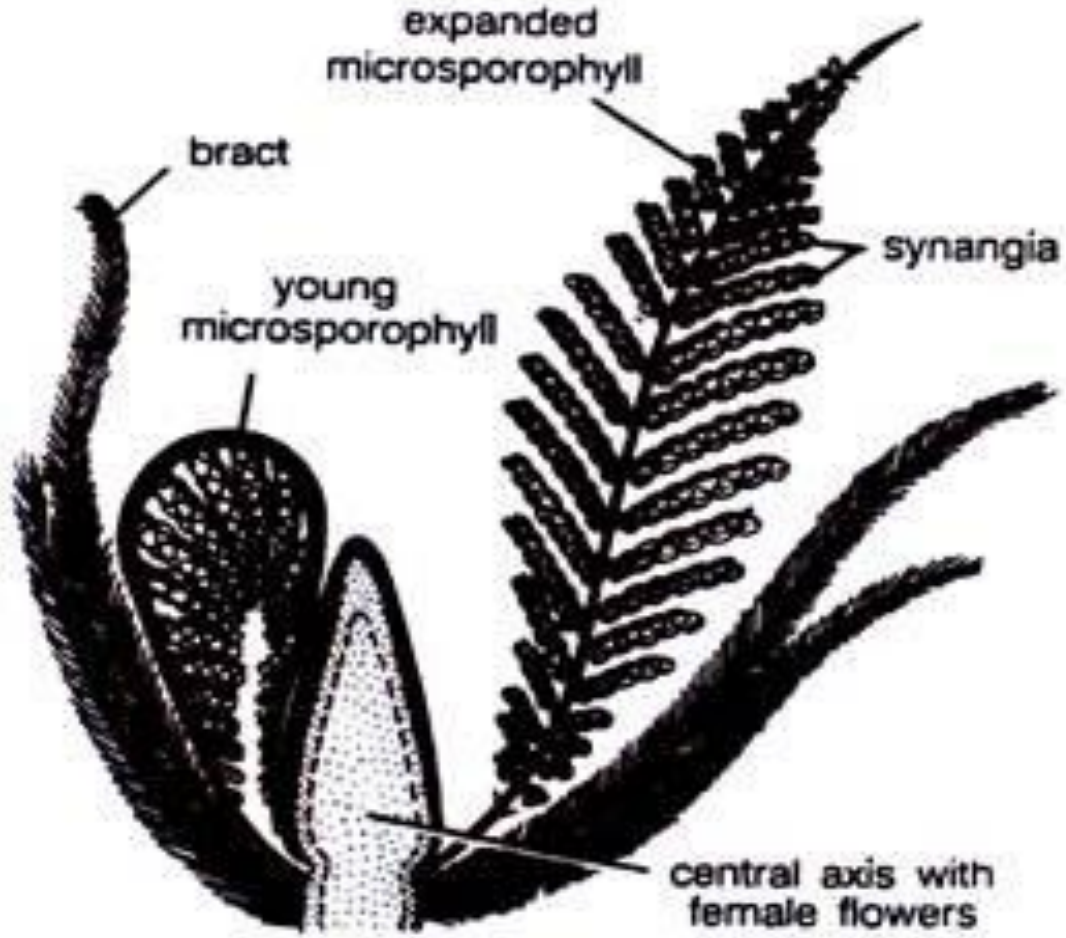


Fig. 6.7. *Cycadeoidea dacotensis*. Apical part with expanded and curved microsporophylls and a central conical axis. (after Wieland).

6. Gynoecium of *Cycadeoidea:*

- The gynoecium receptacle was spherical or conical in shape.
- Hundreds of the stalked ovule along with an approximately equal number of inter-seminal scales were present on the receptacle.
- Each ovules was about 1 mm in length.
- The integument of the ovule was fused with the nucellus, except at the apex.
- The ovule was orthotropous with a long micropylar beak.
- A pollen chamber and a nucellar beak was present in each ovule .
- The seed was somewhat elongated or oval in shape and possessed two cotyledons .
- Crepet and Delevoryas (1972) reported a linear tetrad in the nucellar region of *Cycadeoidea.*

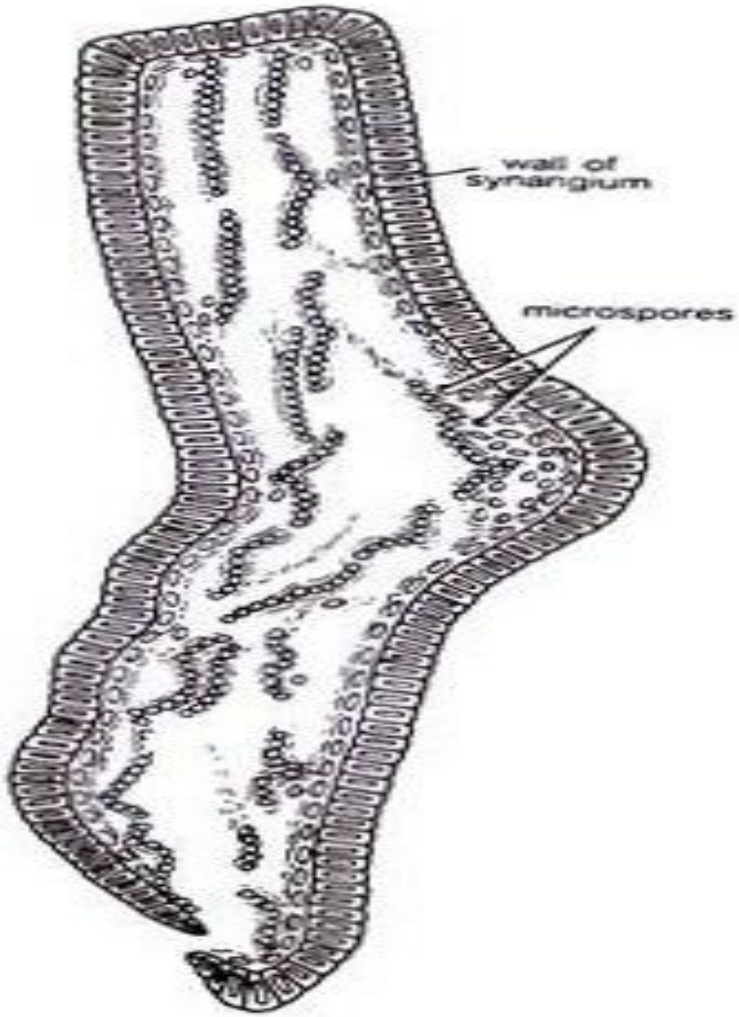


Fig. 6.9. *Cycadeoidea dacotensis*. T.S. of a synangium. (after Wieland, 1906).

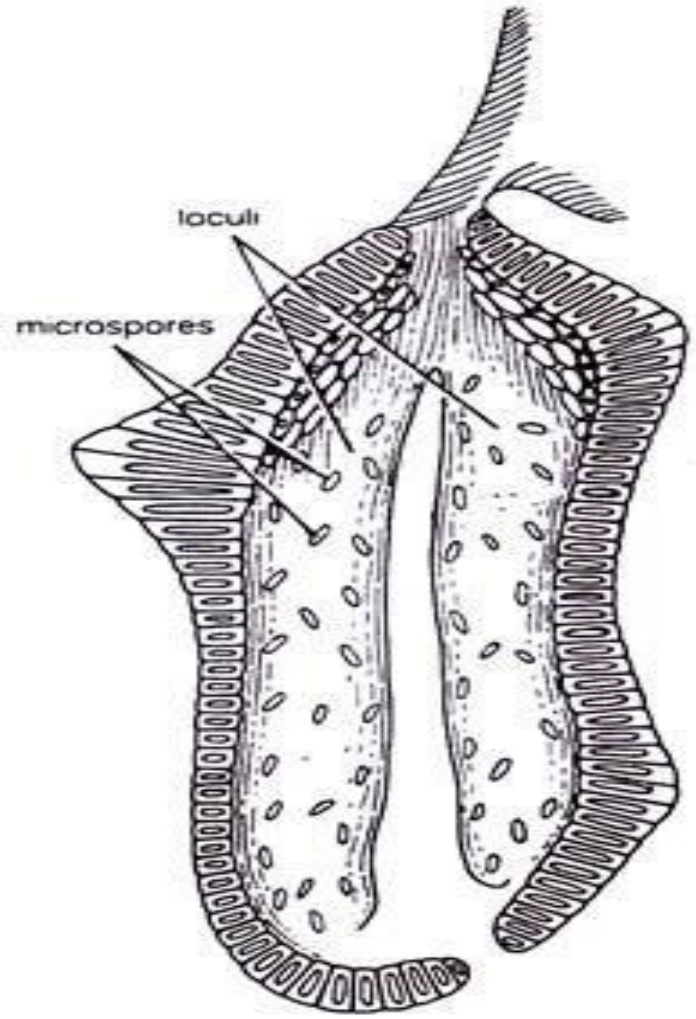


Fig. 6.8. *Cycadeoidea dacotensis*. L.S. sporangium showing stalk and two loculi with microspores. (after Wieland, 1906).

The life history of genus *Cycas* :

Systematic Position of *Cycas*:

Division: Gymnospermae
Class: Cycadopsida
Order: Cycadales
Genus: *Cycas*

Distribution of *Cycas:*

- Several species of the genus *Cycas* have been found widely distributed from Madagascar to Japan including Australia.
- The genus includes about sixteen species which are found wild or cultivated in the tropical and sub-tropical regions of the world.
- In our country they are distributed in the Andaman and Nicobar Islands, Tamil Nadu, Nepal, Sikkim, Bengal and Assam.
- About five species have been reported from various parts of our country.

- The species found in our country are: (important) *Cycas revoluta*, *C. beddomei*, *C. circinnalis*, *C. rumphii* and *C. pectinata*.
- In general, the plants are low and palm-like.
- The normal size of the plant ranges from 4 to 8 feet in height.
- Cycas media is the tallest species upto 20 feet in height.
- The stem is un-branched, columnar and covered with persistent leaf bases.
- The leaves are pinnately compound and aggregated in internal crown.

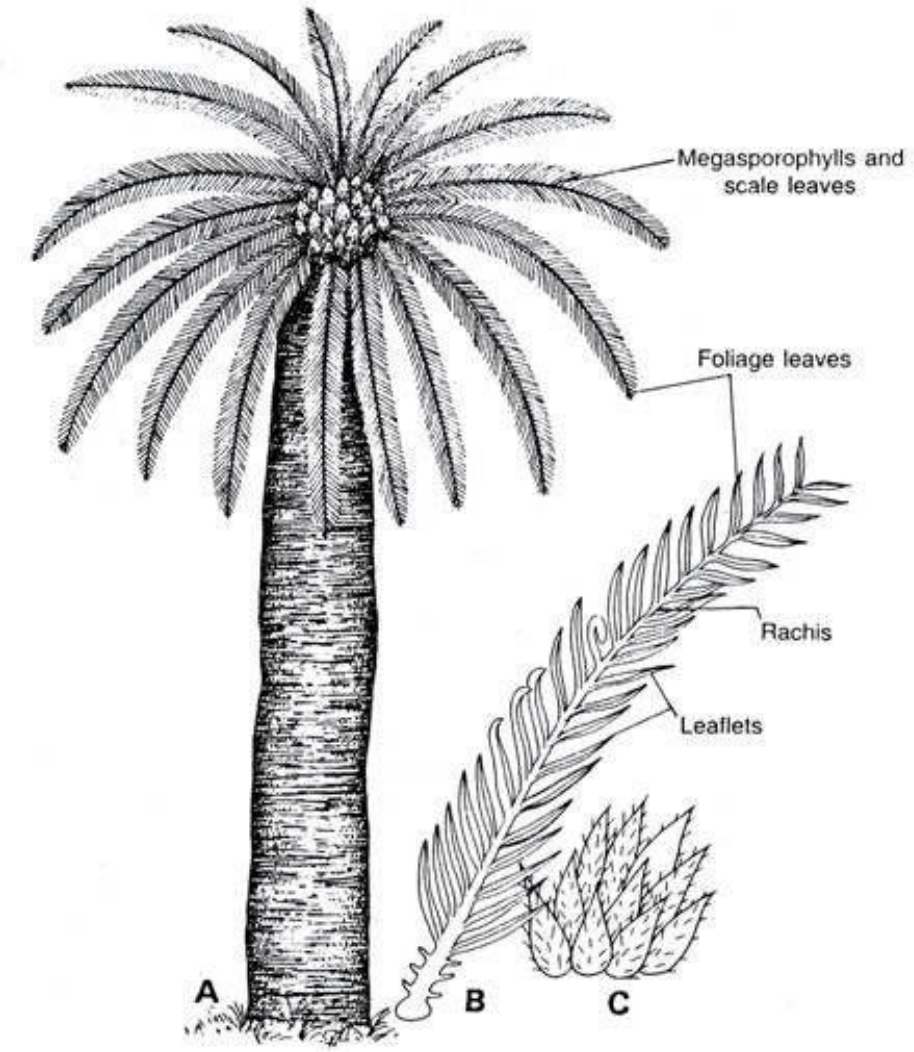


Fig. 3.6. *Cycas*. External structure. A, a female plant of *Cycas revoluta;* B, leaf of *C. revoluate;* C, scale leaves of *C. revoluta*.

External Morphology of *Cycas*:

- *Cycas* is perennial, slow growing evergreen plant and is referred as living fossil because it occurs as a fossil e.g., *C. fusiana*.
- It looks like a palm tree.
- Its main plant body is sporophytic, diploid, dominant and can be differentiated into three parts – roots, stem and leaves.
- Tallest species of *Cycas* is *C. media* with 20 feet height.

1. Roots:

- They are of two types – normal and coralloid roots.
- Normal roots grow deep into the soil and form tap root system.
- Later it is replaced by adventitious roots.
- The function of these roots is to fix the plant in the soil and to absorb water and other minerals.
- From the normal roots develop some small lateral apogeotropic branches near the ground surface.
- These lateral roots get infected with bacteria, fungi as well as algae.
- The entry of these organisms is said to be responsible for the characteristic, swollen, knob like or coral like appearance and hence, these roots are called as coralloid roots or corallorhiza.
- These roots have minute pores (lenticels like) which are respiratory in function (aeration).
-
- Root cap and root hairs are absent in coralloid roots.

2. Stem:

- It is thick, erect, woody, aerial and usually unbranched (caudex).
- Branching is rare and it is due to injury or development of adventitious buds.
- Surface of the stem is rough due to the presence of persistent woody leaf bases.
- These leaf bases form thick armour around the stem.
- In the armour are distinctly visible the alternating bands of large and small rhomboidal leaf bases.
- Larger ones are of foliage leaves and smaller ones are of scaly leaves and megasporophylls in the female plant.
- The leaf bases are spirally and compactly arranged with each other.
- At the top is present a crown of leaves.

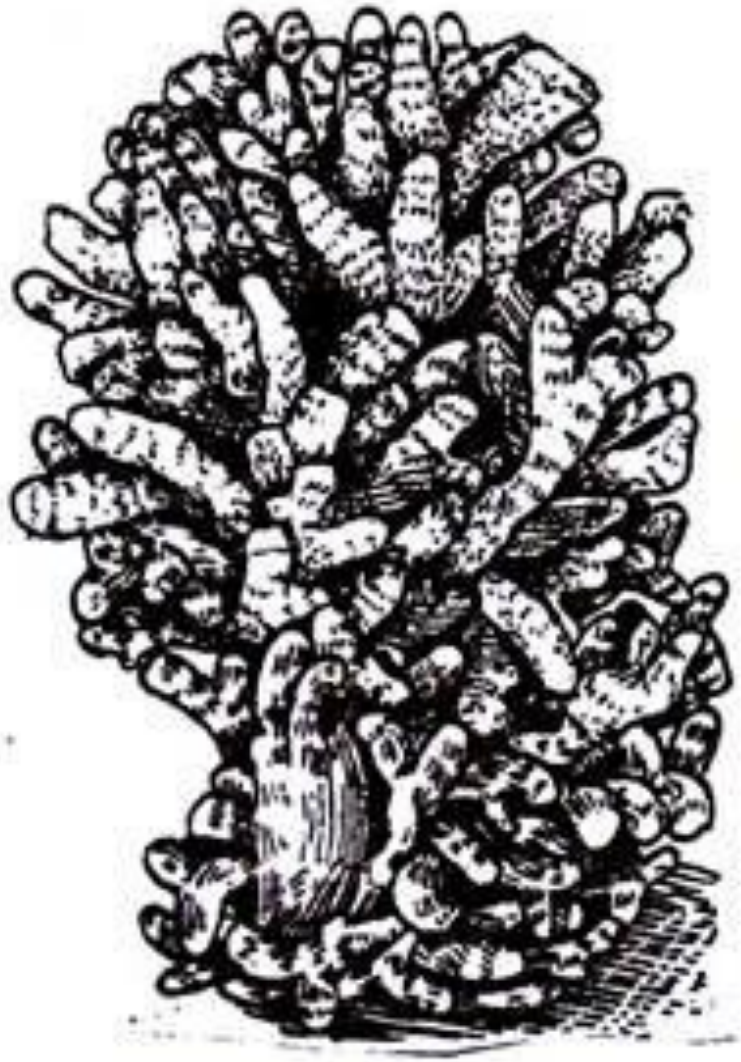


Fig. 2. *Cycas*. Coralloid roots.

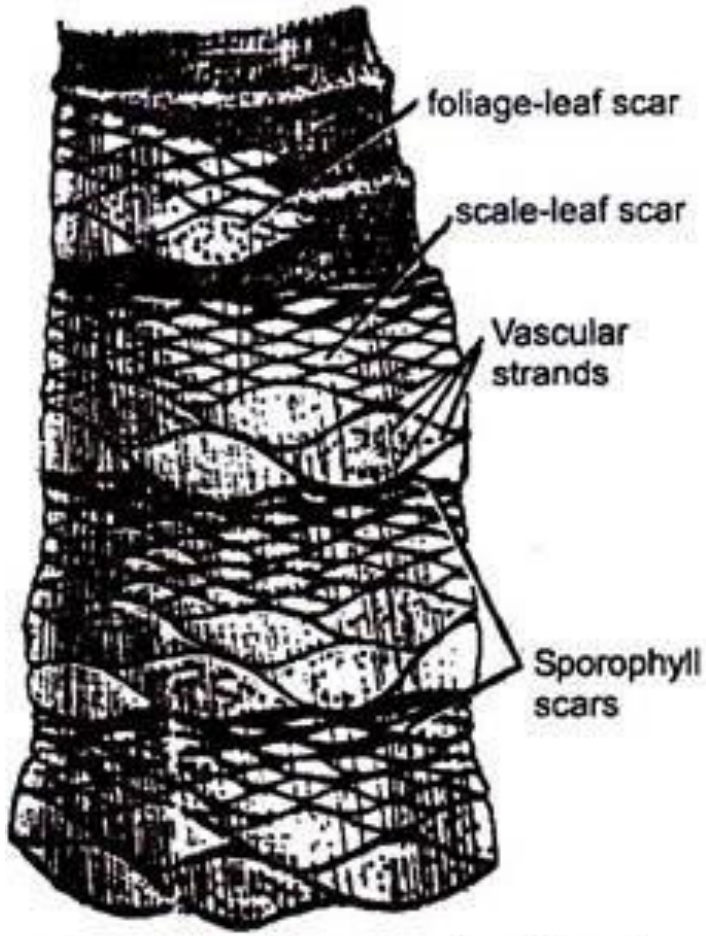


Fig. 4. *Cycas*, Stem showing alternate bands of larger foliage leaf bases and smaller scaly leaves and megasphorophyll bases.

3. Leaves:

Leaves are dimorphic i.e., of two types – scale leaves and foliage leaves.
Both these types of leaves form a crown at the top of the stem.

(a) Scale leaves:

- These are small, dry, brown, triangular structures with a thick covering of brown hairs or rameta.
- These leaves alternate with green foliage leaves.
- These leaves protect the shoot apex and reproductive structures.

Fig. 3. *Cycas*. A scale leaf

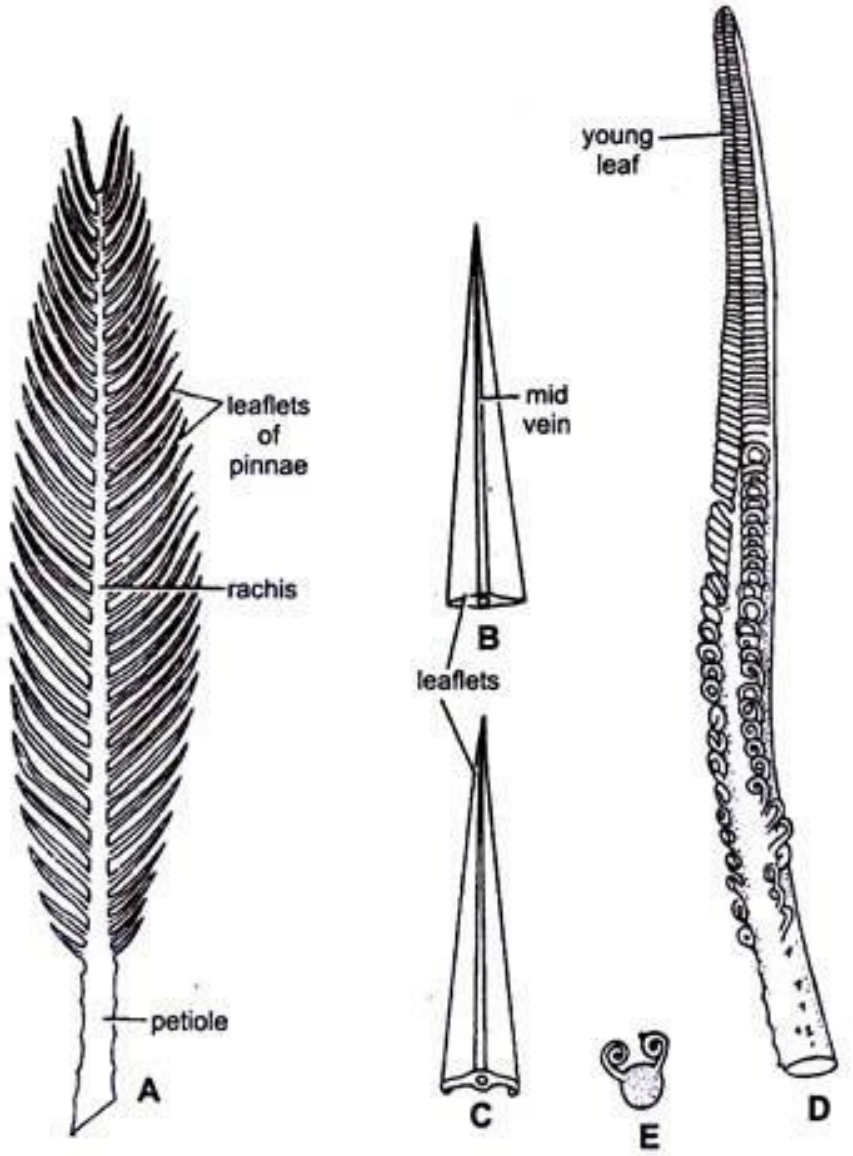


Fig. 6. (A-E) *Cycas*. (A) External features of a normal foliage leaf; (B) Flat leaflet of *C. rumphii*, (C) Revolute leaflet of *C. revoluta*, (D, E) Young foliage leaf showing circinate vernation of leaflets.

(b) Foliage leaves:

- These leaves are also produced in a crown at the apex of the stem. A single foliage leaf is pinnately compound.
- It is unipinnate and paripinnate. Each leaf has 80-100 pairs of leaflets which are arranged on both the sides of adaxial groove of the rachis in opposite or alternate manner.
- The rachis is spiny below with the sheathing leaf base. These spines are modified leaflets.
- Each leaflet is leathery in texture, sessile elongated, ovate or lanceolate in shape and has entire margin with acute apex.
- Each pinna or leaflet contains a midrib without lateral veins. Margins of the pinnae are flat but sometimes they are curved downwards and inwards (revolute) which give the plant a specific name C. revoluta.
- Young leaves have circinately coiled leaflets which are also covered by hairs or ramenta like those of ferns (important) The “vernation is circinate in the midrib and pinnules of *Cycas.*
- Leaves, when young, have circinately coiled pinnae like those of ferns.
- Very young parts of *Cycas* are also covered by fern-like hairs or ramenta.

Internal Structure of *Cycas:*

1. Root:

(i) Normal root:

Its internal structure is exactly similar to that of dicot root.
It is circular in outline and can be differentiated into epiblema, cortex and vascular tissue.

a. Epiblema:

- It is the outermost limiting layer and consists of single layer of thin walled cells.
- Some of its cells give rise to root hairs.

b. Cortex:

- Epiblema surrounds the multilayered zone of thin walled parenchymatous cortex with numerous intercellular spaces.
- The cells of the cortex are filled with starch.
- Some tannin cells, mucilage cells and sometimes sphaeraphides (calcium oxalate crystals) are also present in the cortex.
- The innermost layer of the cortex forms the endodermis which is characterised by the presence of casparian strips.

c. Vascular tissue:

- Endodermis is followed by multilayered parenchymatous pericycle.
- Vascular bundles are radial. Xylem is diarch and exarch i. e., protoxylem is towards the periphery).
- The protoxylem consists of spiral tracheids whereas the metaxylem consists of scalariform thickenings.
- Vessels are absent.
- Alternating with the protoxylem groups are present phloem cells consisting of sieve tubes and phloem parenchyma.
- The companion cells are completely absent.

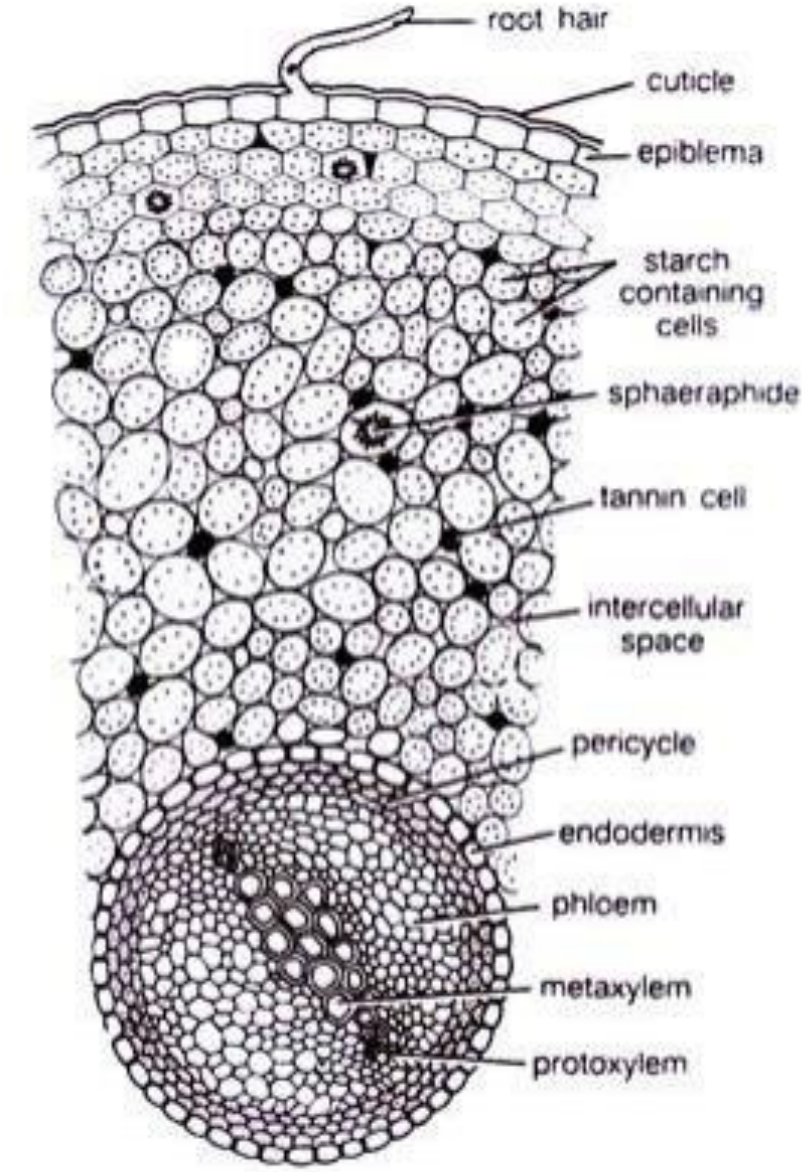


Fig. 8.16. *Cycas revoluta* T.S. normal root (*Young*)

(ii) Coralloid Root:

The transverse section of the coralloid root is similar to that of normal root and it can be differentiated into epidermis, cortex and vascular tissue.

a. Epidermis:

- In young root, it is similar to normal root.
- However, in old root the outermost tissue is periderm.
- It consists of 2 to 5 layers of dead cells.

b. Cortex:

- The cortex is wider in comparison with the normal root.
- A greenish algal zone is present almost in the middle of the cortex and divides it into outer cortex and inner cortex.
- The algal zone consists of loosely co blue green algae (*Anabaena cycadae*, *Nostoc punctiforme*, *Oscillatoria Pseudomonas radicicola*) and some fungi.
- The main function of these roots is nitrogen fixation due to the presence of cyanophycean members.
- Endodermis is similar to normal root.

c. Vascular tissue:

- Endodermis is followed by multilayered parenchymatous pericycle.
- Vascular bundl Xylem is triarch and exarch.
- Secondary growth is very rare or absent.
- No secondary xylem or secondary phloem are developed although cork and cork cambium are present.

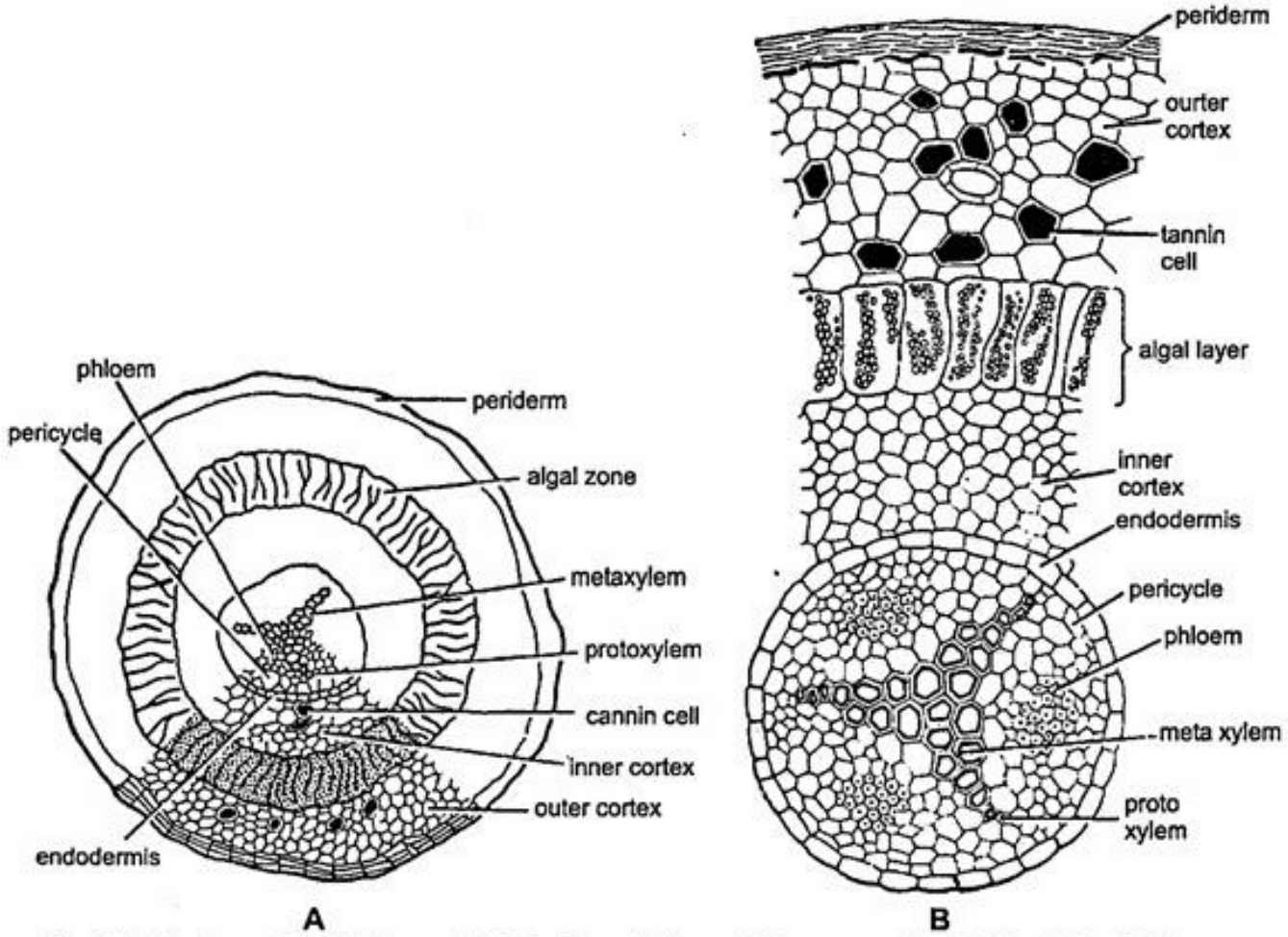


Fig. 9 (A, B). *Cycas.* Coralloid root (A) T.S. of Coralloid root (diagrammatic), (B) T.S. of Coralloid root (a portion cellular)

2. Stem:

A transverse section of young stem is similar to dicot stem. It is irregular in outline due to persistent leaf bases. Internally, it can be differentiated into epidermis, cortex and vascular cylinder.

a. Epidermis:

- It is the outermost layer of the stem.
- It is made up of compactly arranged thick walled cells.
- Epidermis is ruptured due to the armour of persistent leaf bases.

b. Cortex:

- Epidermis encloses the cortex.
- It forms the major portion of the stem.
- It is composed of parenchymatous cells which are filled with large number of starch grains.
- These starch grains are the source of sago starch.
- Therefore, C. revoluta is popularly known as sago palm.
- Scattered in the cortex are various mucilage canals.
- Each mucilage canal is lined by many radially elongated epithelial or secretory cells. which secrete mucilage.
- These canals are connected with those of the pith with the help of the medullary rays.
- The innermost layer of cortex is endodermis. It is not distinct.

c. Vascular Cylinder:

- The vascular cylinder is surrounded by not very conspicuous pericycle.
- Like dicot stems vascular cylinder consists of many conjoint, collateral, open, endarch vascular bundles arranged in a ring (ectophloic siphonostele).
- The xylem consists of tracheids and Xylem parenchyma.
- Vessels are absent.
- Outside the xylem is the phloem which consists of sieve tubes and phloem paraenchyma.
- Companion cells are absent.
- The Xylem is separated from the phloem with the help of primary combium.
- The cells of the primary cambium are brick shaped.
- The cells lying in between the vascular bundles form the medullary rays.
- These are parenchymatous and connect the pith with the cortex.
- Each medullary ray is one celled wide and 1 to 20 cells long.

d. Pith:

- In the centre of the stem is present large canals leaf traces massive pith consisting of parenchymatous cells which are rich in starch (sago starch).
- A large number of mucilage canals are also present, which are exactly similar in structure with the mucilage canals present in the cortex.

e. Leaf Traces and Girdle Traces:

- The leaf traces are scattered in the cortex of the stem and constitute the vascular tissue of the leaves from the main vascular cylinder.

Secondary growth:

- It is a slow process.
- At first a complete ring of cambium is formed by the development of interfascicular combium in between the adjacent vascular bundles.
- The cambium cuts off secondary xylem on the inner side and secondary phloem on the outer side.
- Tracheids consist of multiseriate bordered pits.
- This cambial ring is short-lived and new cambial ring is formed every year in the pericycle of the cortex.
- Wood formed by this method (more than one) cambium ring is polyxylic and manoxylic (large amount of parenchyma is cut off in the xylem

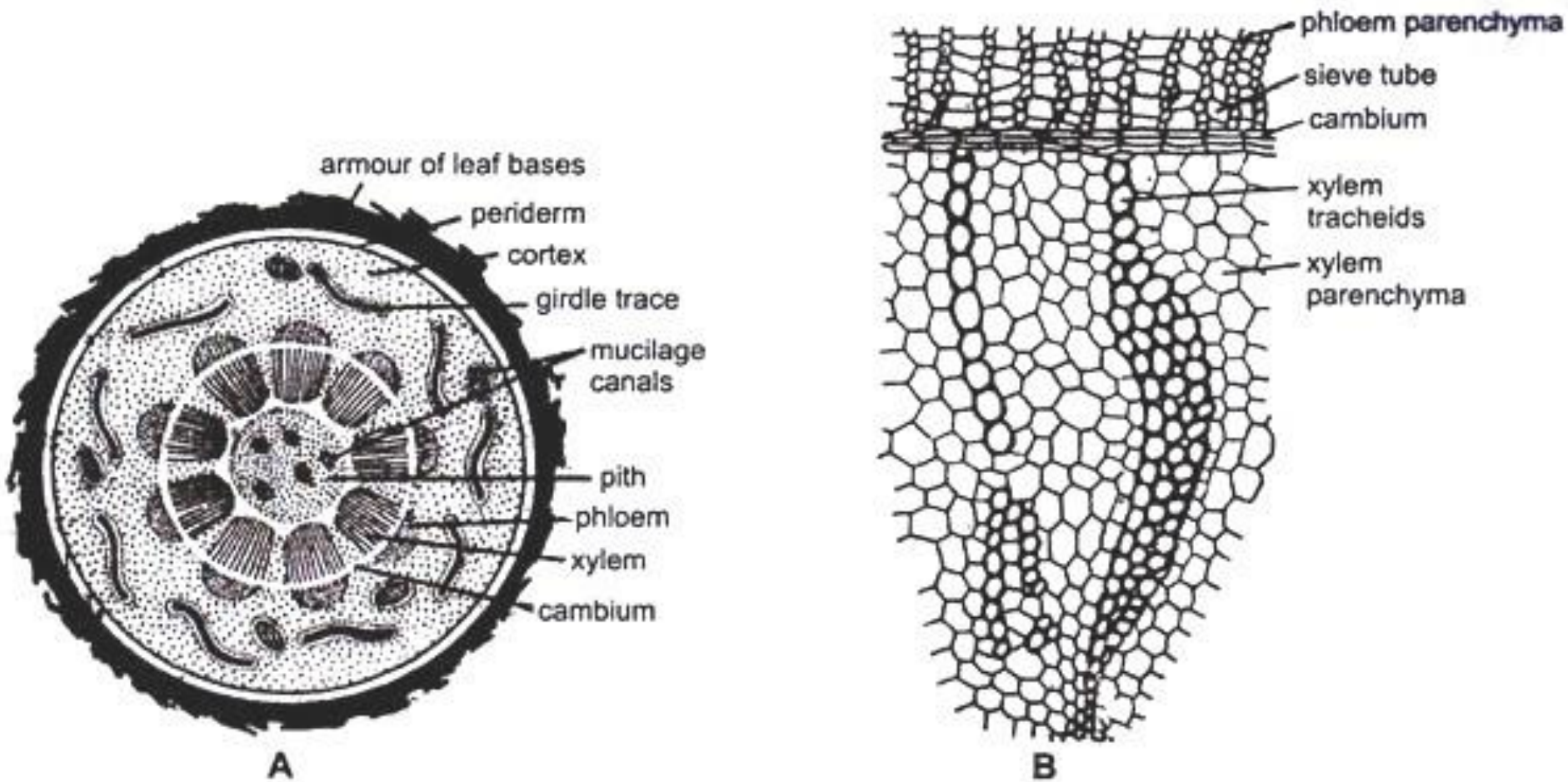


Fig. 11 (A, B) *Cycas.* (A) Diagrammatic representation of T.S. of young stem; (B) A part of vascular bundle.

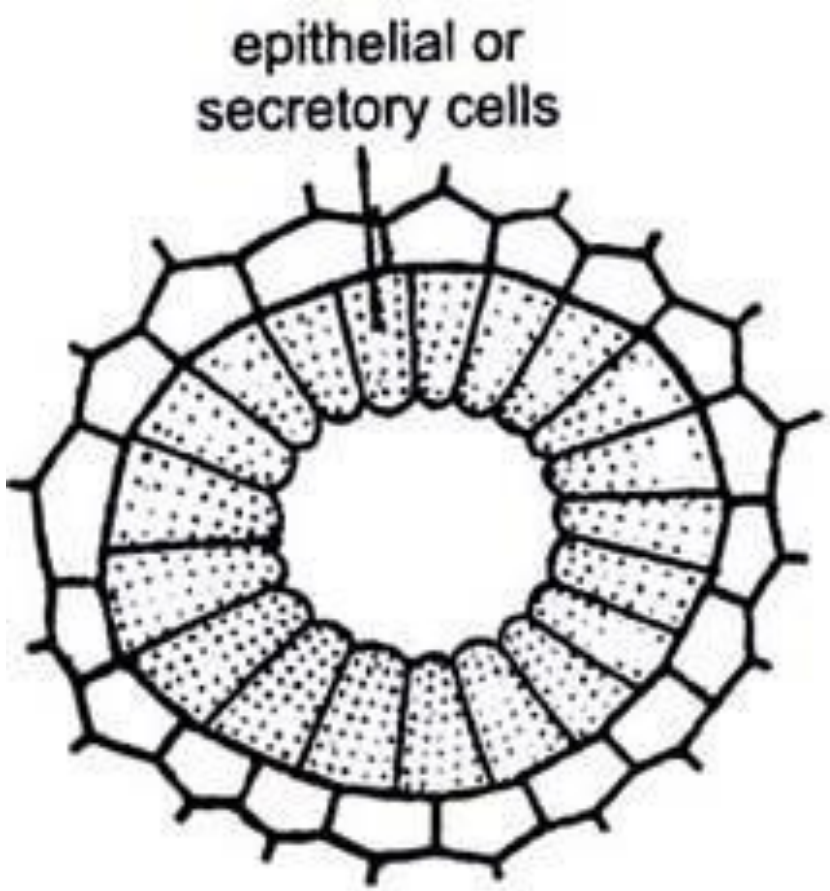


Fig. 10. *Cycas.* A mucilage canal

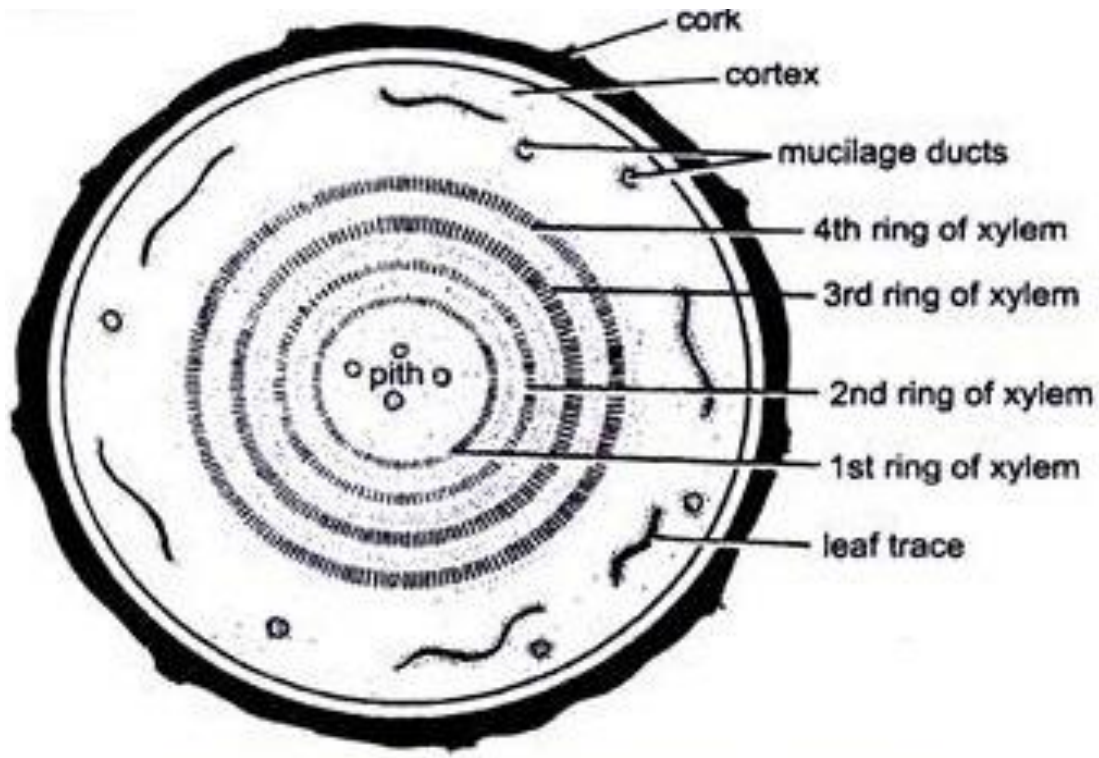


Fig. 13. *Cycas.* T. S of old stem (diagrammatic)

6. Leaflet:

The leaflet of Cycas is dorsiventral and hypostomatic (the stomata are present at the lower surface only).
In a transverse section the leaflet can be differentiated into a swollen midrib portion and two lateral wings. Its internal structure is as follows:

a. Epidermis:

- It is the outer most single layer made up of squarish cells.
- The upper epidermis is complete whereas the lower epidermis is interrupted by several sunken stomata present in the region of the wings.
- The upper and lower epidermis is covered by a thick layer of culicle.

b. Hypodermis:

- Below the epidermis occurs the thick walled sclerenchymatous hypodermis.
- It is single layered in the region of blade but in the region of mid rib it becomes 2-3 layered thick.
- Two to five layers of sclerenchymatous cells are also present above the lower epidermis only in the region of the mid rib.
- It helps in checking the rate of transpiration and protects the tissue from excessive heat.

c. Mesophyll:

- A well-developed mesophyll tissue is present in the leaflet.
- It is differentiated into palisade tissue and spongy parenchyma.
- Palisade tissue is present in the form of continuous layer below the sclerenchymatous hypodermis.
- Spongy parenchyma present only in the wings directly above the lower epidermis.
- It is made up of loosely arranged oval cells filled with chloroplast.
- These cells have many intercellular spaces filled with air.

d. Vascular bundle:

- A single large vascular bundle is present in the mid rib region of the leaflet.
- It is surrounded by a single layer of sclerenchymatous cells, known as bundle sheath.
- The vascular bundle is conjoint, collateral, open and diploxylic.
- Xylem is present towards the dorsal surface and phloem is present towards the ventral surface.
- Xylem and phloem are separated by a non-functional strip of cambium.
- Centrifugal xylem is represented by two small groups on either side of the protoxylem.
- The remaining space of the vascular bundle is filled with thin walled parenchymatous cells.

e. Transfusion tissue:

- Groups of tracheidal cells, separated by some parenchymatous cells, or directly in contact with the centripetal xylem, the bundle sheath are present in the leaflet. It is called primary transfusion tissue.
- The cells of this tissue are short and wide with are reticulate or bordered pitted walls.
- A zone is present on either side of the midrib between the palisade and spongy layers.
- It is three layered and is composed of elongated colourless cells.
- These cells run paralled to the leaf surface from the midrib to the margin.
- This zone is called accessory transfusion tissue or secondary transfusion tissue or hydrostereom or radial parenchyma. On either side of the leaflet it is connected with the primary transfusion tissue present around centripetal xylem of the vascular bundle.
- Primary and secondary transfusion tissue help in the lateral conduction of water.
- The presence of transfusion tissue is to compensate for the unbranched condition of the midrib and it probably serves as a later conducting channel of water.

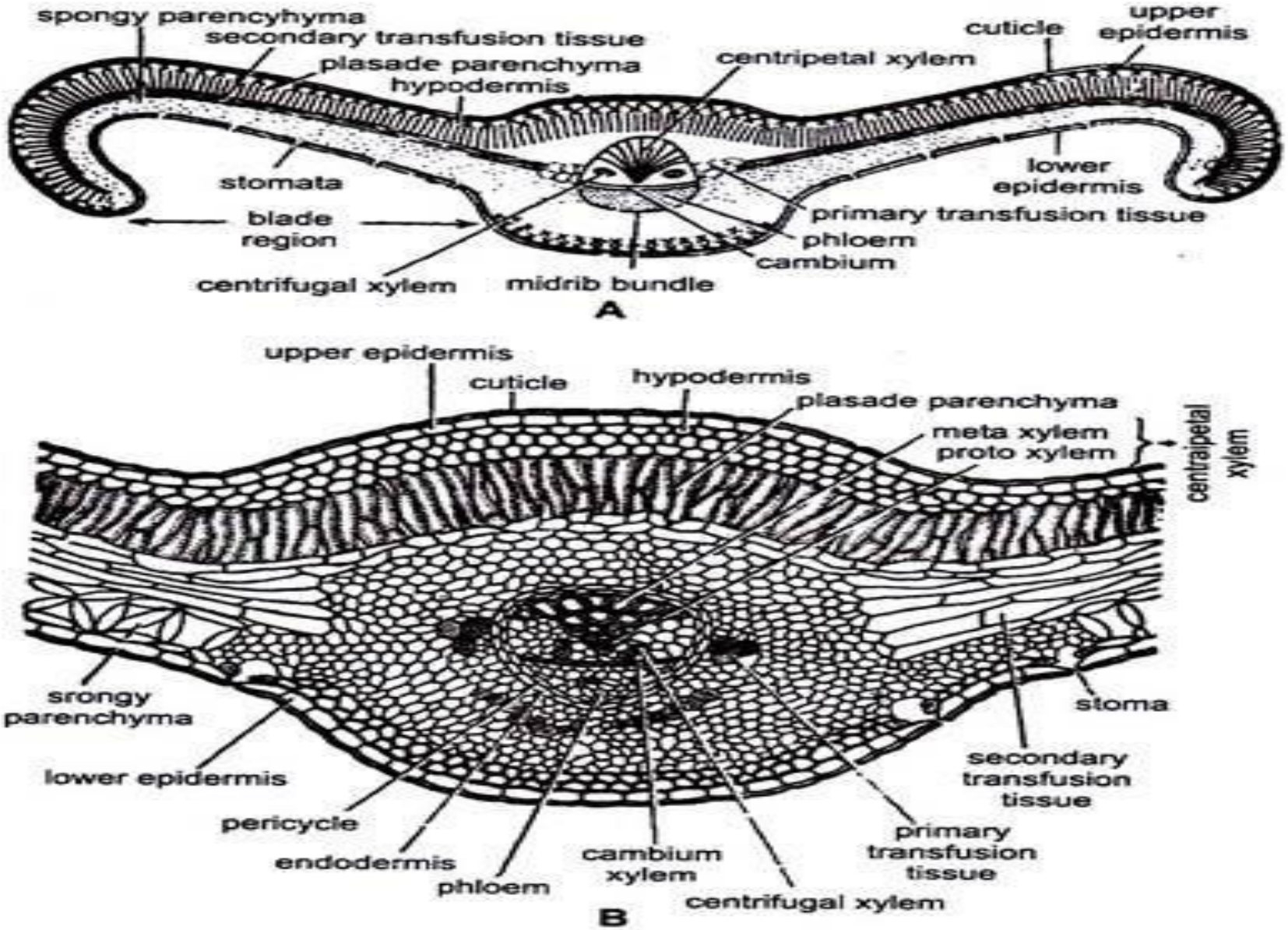


Fig. 16 (A–C). *Cycas.* **Transverse section of leaflet (A) diagrammatic; (B) A protion from the mid rib is magnified**

Reproduction in Cycas:

- Cycas reproduction by two method – Vegetative and Sexual

1. Vegetative reproduction:

- It is the simplest method of reproduction.
- It takes place by the formation of bulbils or adventitious buds.
- These buds develop on the stem in the axil of the scale leaves.
- A bulbil is an oval structure, broad at the base and pointed at the apex.
- It consists of dormant stem in the centre covered by numerous brown scaly leaves.
- On detachment from the stem, a bulbil starts to germinate by producing many roots from the lower side and a leaf towards the upper side.
- A bulbil from male plant will develop only into male plant while the bulbil from the female plant will form only female plant because cycas is strictly dioecious

1. Vegetative reproduction in *cycas*

2. Sexual Reproduction:

- Sexual reproduction in *Cycas* is oogamous (the female gamete i.e., egg cell is significantly larger than the male gamete and is non-motile).

- *Cycas* is sporophytic and strictly dioecious i.e., male and female sex organs are borne on separate plants.

Male Reproductive Organs:

- Male plant Cycas produces every year a single male cone at its apex.
- In the formation of the male cone the apical meristem is used up, and therefore, the growth of the stem checked for some time but later an apical meristem is formed at the base of the cone, which pushes that on one side so that the growth of the stem is resumed again.
- Such growth of the stem is called sympodial.
- The male cone is largest in the plant kingdom (approximately 500 cm or more in length).

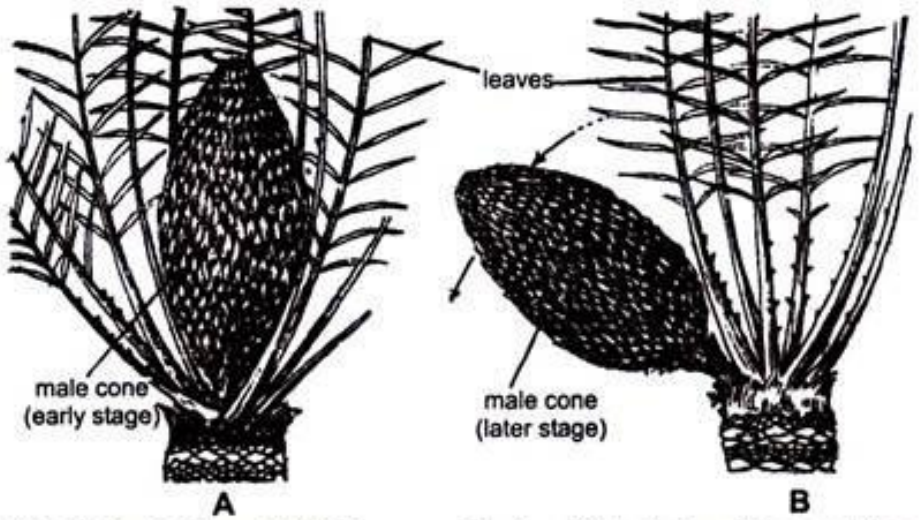


Fig. 18 (A, B). *Cycas*. (A) Male cone at the top, (B) Apical meristem pushing the cone on one site.

Male Cone:-

- Male cone is ovoid or conical and grow up to 1.5 m.
- It has a central axis or cone axis surround by compactly and spirally arranged micro-sporophylls.
- Each microsporophyll has adaxial (upper) and abaxial (lower) surfaces.
- The adaxial surface is ridge like with sterile apophysis at the apex. The adaxial surface contains numerous microsporangia in group of 3-6 called sori.
- Each microsporangium filled with numerous haploid microspores or pollen grains

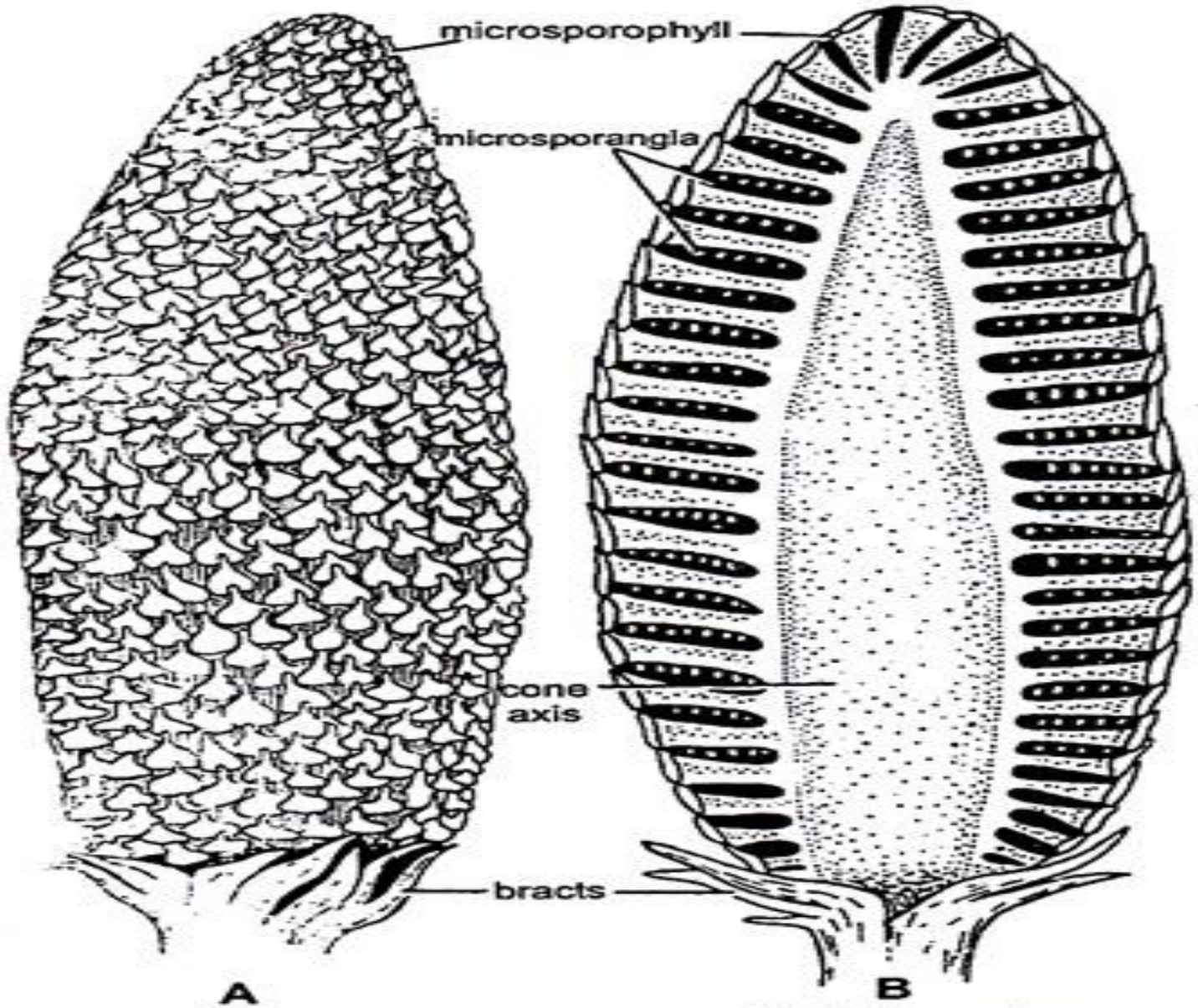


Fig. 19. (A-B). *Cycas.* Male cone (A) Entire male cone, (B) L.S. of male cone

Microsporophylls:-

- Microsporophylls are flat, leaf-like and woody structures with narrow base and expanded upper portion. The upper expanded portion becomes pointed and is called apophysis.

- The narrow base is attached to the cone axis. Each microsporophyll contains thousands of microsporangia in groups called sori on abaxial (lower) surface.

- Development of sporangium is of Eusporangiate type. The spore mother cell undergoes meiosis to produce halpoid microspores.

- Each Microsporangium bears large number of microspores or pollen grains. Each sporangium is provided with a radial line of dehiscence, which helps in the dispersal of spores.

- Each microspore (Pollen grain) is a rounded, unicellular and uninucleate structure surrounded by outer thick exine and an inner thin intine. The microspore represents the male gametophyte.

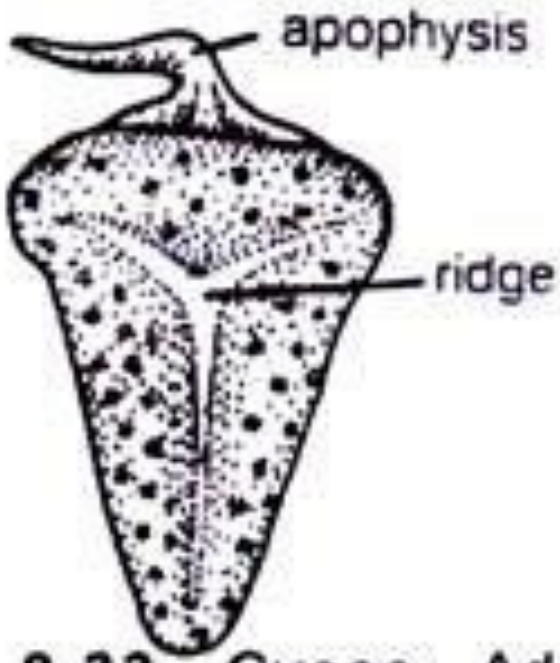


Fig. 8.33. *Cycas*. Adaxial surface of a microsporophyll.

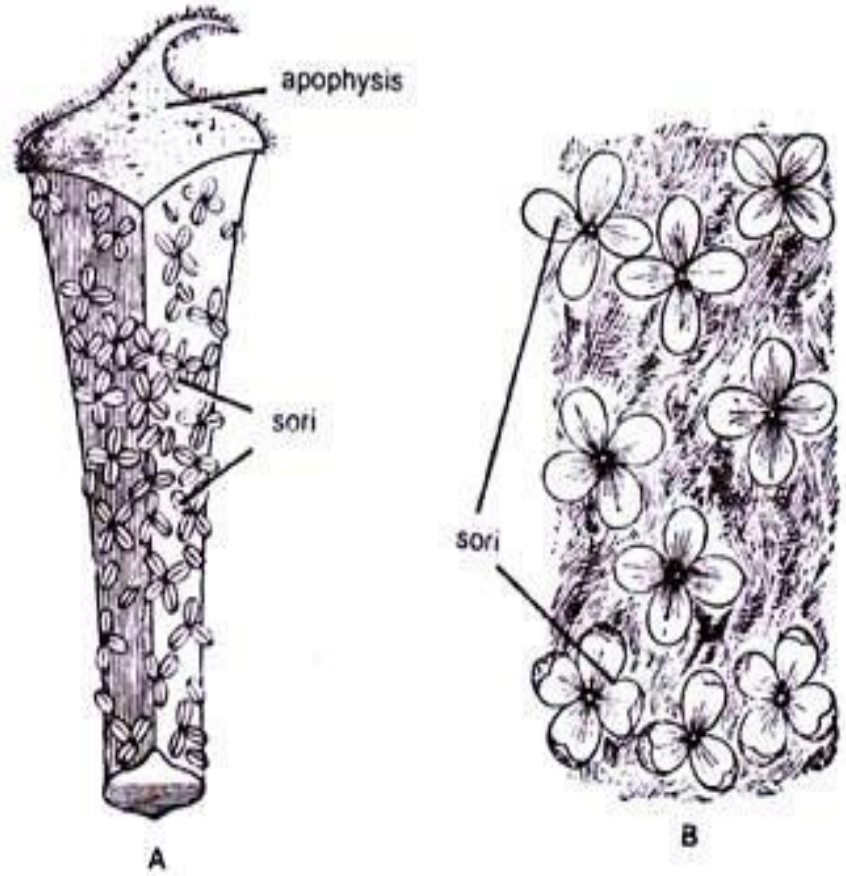
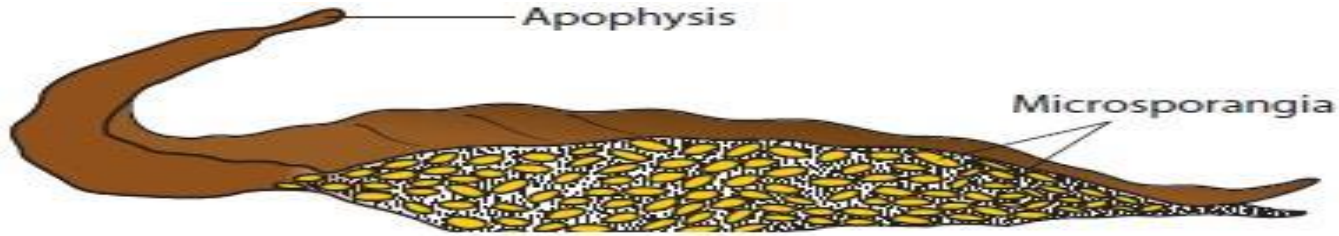
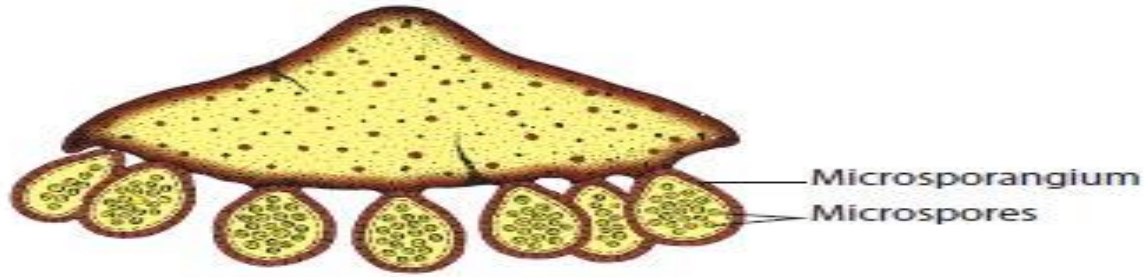


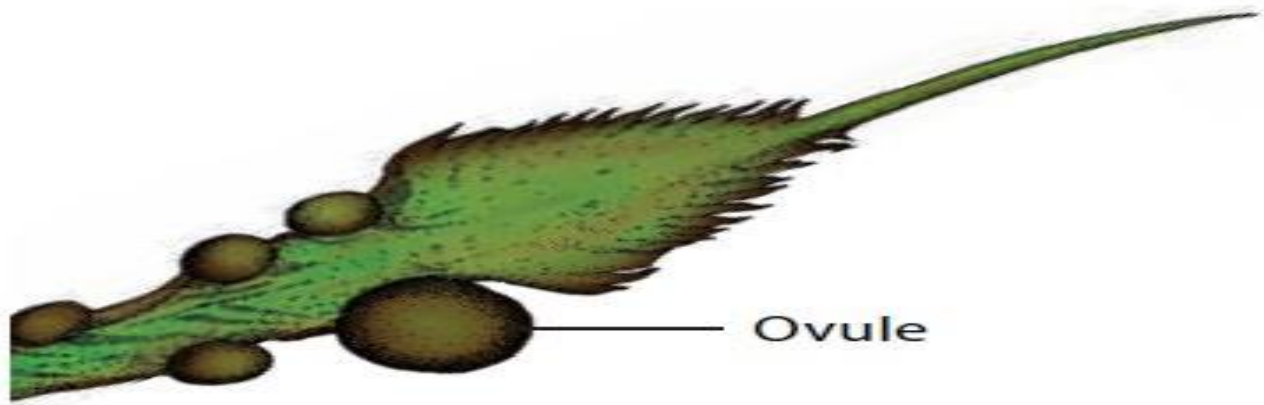
Fig. 8.34. *Cycas*. A, Abaxial surface of a microsporophyll; B, Groups of microsporangia (sori) enlarged.



b) A microsporophyll enlarged



c) T.S. of Microsporophyll



d) Megasporophyll

Figure 2.45: Reproduction in *Cycas*

Female Reproductive Organs:

- Female reproductive organs are megasporophylls.
- Each female plant every year produces numerous megasporophylls in acropetal succession above each crown of foliage and scaly leaves.
- There is no female cone formation.
- The number of the megasporophylls is much more than the number of the foliage leaves on the stem.
- During the formation of the megasporophylls the apical meristem is not used up like that of male cone and therefore, the growth of the stem continues, and thus in female plant growth is monopodial.

Structure of Megasporophyll:

- Each megasporophyll (carpel) is regarded as a modified leaf.
- It is about 12.7 cm to 25.4 cm long and can be divided into 3 parts: upper leafy portion, middle ovule bearing portion and lower stalk.
- Ovules are formed on the lateral side of the middle portion. The upper portion is pinnate and each pinna is tapering to a point.
- Two lateral rows of ovules are present on the lateral side of the middle portion.
- In Cycas there is a great variation regarding the pinnate character of megasporophyll and the number of ovules per sporophyll as a result of which in various species of Cycas gradual reduction in megasporophylls can be traced.
- The megasporophylls of *C. revoluta* are pinnate whereas those of *C. circinalis C. rumphii* and *C. beddomei* are ovate lanceolate structures. In *C. pectinata* and *C. siamensis* they are orbicular or rhomboidal structures.

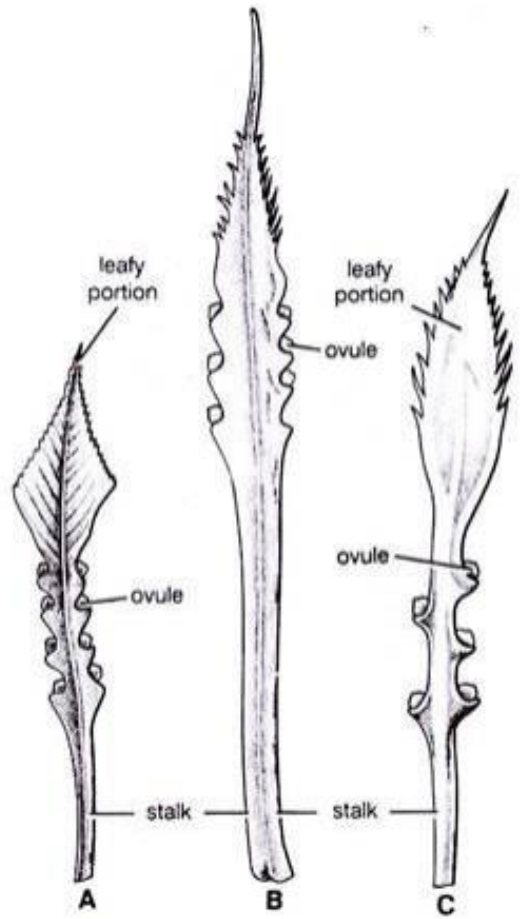


Fig. 8.42 Megasporophylls of *Cycas*. A, *C. circinalis;* B, *C. rumphii;* C, *C. beddomei*.

Structure of ovule (megasporangium):

- The ovules are sessile and are borne laterally on the stalk.
- The ovules of *Cycas* are largest in plant kingdom (7 cm long in C. thoursaii, 6 cm long x 4 cm diameter in *C. circinalis*) and can be seen by naked eye.
- The ovule is green when young and is covered by hairs.
- At maturity its colour changes to orange and hair also fall off.
- The ovules are orthotropus (short and straight) and unitegmic (with one integument).
- The integument is very thick and consists of three distinct layers:

(i) Outer, green or orange fleshy layer called outer sarcotesta

(ii) Middle, yellow stony layer called sclerotesta and

(iii) Inner fleshy layer or inner sarcotesta.

- The parenchymatous tissue inside the integument is called nucellus.
- The integument encloses all the nuclellus except at one point.
- This point or opening is called micropyle.
- Just below the micropyle, the cells of the nucellus form the nuc
- Some of the cells of the nucellar beak dissolves and forms a structure called pollen chamber.
- Just below the micropyle, the cells of the nucellus form the nuc
- Just below the pollen chamber is present an archegonial chamb
- Micropyle leads into the pollen chamber.
- Just below the floor of the archegonial chamber 3-6 archegonia towards the micropylar end.
- The ovule is supplied by three vasular traces.
- The central vascular trace enters the chalazal end of the nucellu
- The inner and outer vascular traces divide into two each, supplies the outer fleshy layer and the inner fleshy layer.
- Thus, the outer and inner fleshy layers receive the vascular supply but the middle stony layers get no vascular supply.

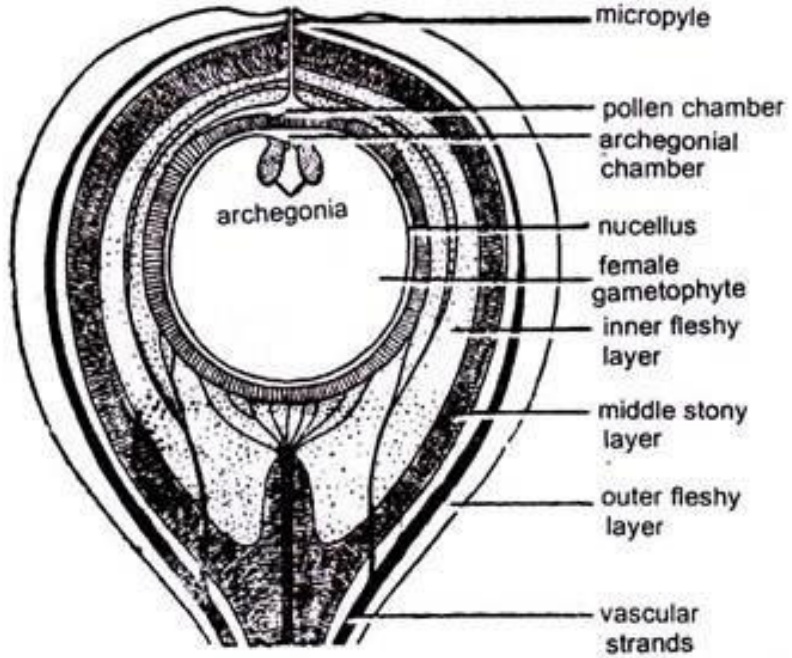


Fig. 8.43 *Cycas*. L.S. ovule showing two archegonia and female gametophyte.

Pollination:

- The pollination is anemophilous.
- The cells of nucellar beak present in the pollen chamber disintegrate and form a viscous fluid.
- This fluid is cohesive in nature.
- This fluid oozes out of the micropyle and collects in the form of a pollination drop.
- The pollen grains present in the air current at their 3-celled stage, are entangled in the pollination drop.
- Gradually the pollen drop dries up and the pollen grains are sucked into the pollen chamber through micropyle.
- Further drying of this drop seals up the micropyle.
- Pollen drop helps in collecting the pollen grains at the micropyle in all gymnosperms.

Fertilization:

- At the time of fertilization, the nucellar tissue between the pollen chamber and the archegonial chamber disorganise and simultaneously the venter canal nucleus also disintigrates.
- The pollen tube reaches the archegonial chamber.
- The tip of the pollen tube ruptures releasing two male gametes and fluid contents.
- Due to this archegonial chamber becomes moist and the sperms move freely in it with the help of cilia.
- Only a single sperm enters violently in each archegonium through neck.
- Only the male nucleus of the sperm fuses with the egg nucleus to form a zygote or oospore (2x).
- The fertilization in *Cycas* takes place with the help of motile sperms.
- This process is known as zooidogamy.
- It is accompanied by pollen tube formation, a phenomenon known as siphonogamy.
- Sometimes more than one sperm enter the archegonium but the male nucleus which first reaches near the nucleus fertilizes the egg. Rest male nuclei degenerate. It is called polyspermy.

Embryogeny:

- The fertilized egg, zygote or oospore is the first cell of the sporophyte.
- The zygote contains dense cytoplasm and a large nucleus.
- It enlarges in size and finally forms the embryo.
- In this whole process one year time is utilised.
- The nucleus moves at the base and starts dividing by free nuclear divisions to form about 256 free nuclei.

Structure of seed:

- After fertilization, the ovule is transformed into seed.
- The nucellus and the inner layer of integument are used up as nourishment by developing embryo.
- The mature seed appears as orange-red or reddish brown structure.
- It comprises the following structures:

a. Testa or seed coat: It is formed by the outer brightly coloured fleshy layer and the middle layer of the integuments.

b. Micropyle: It is present in the form of small opening.

c. Endosperm: Inner to the seed coat lie the wall tissues called endosperm. The cells store a large amount of food material.

d. Embryo: Embedded in the endosperm lies the embryo. It consists of two cotyledons, plumule and The embryo remains suspended in the endosperm by a long spirally coiled suspensor.

- Thus, a mature seed of *Cycas* represents three parts It is formed by the integument and represents parent sporophytic generation.
- Endosperm: Represents the gametophytic generation.
- Testa is sweet in taste and emits pleasant odour The two characteristics i.e red colour and pleasant odour are responsible for their zoochorus (orinthochorous) dispersal.
- Seeds remain viable for not more than a few months.
- Under suitable conditions the seed starts germination.
- It absorbs water and embryo expands.
- The expansion of the embryo breaks open the hard seed coat.
- The coleorhiza protrudes out and is pierced by the growing radicle which grows down and forms the tap root or primary root.
- The cotyledons do not come out of the seed coat but they absorb food from the endosperm for the growing embryo which matures in due course of time.

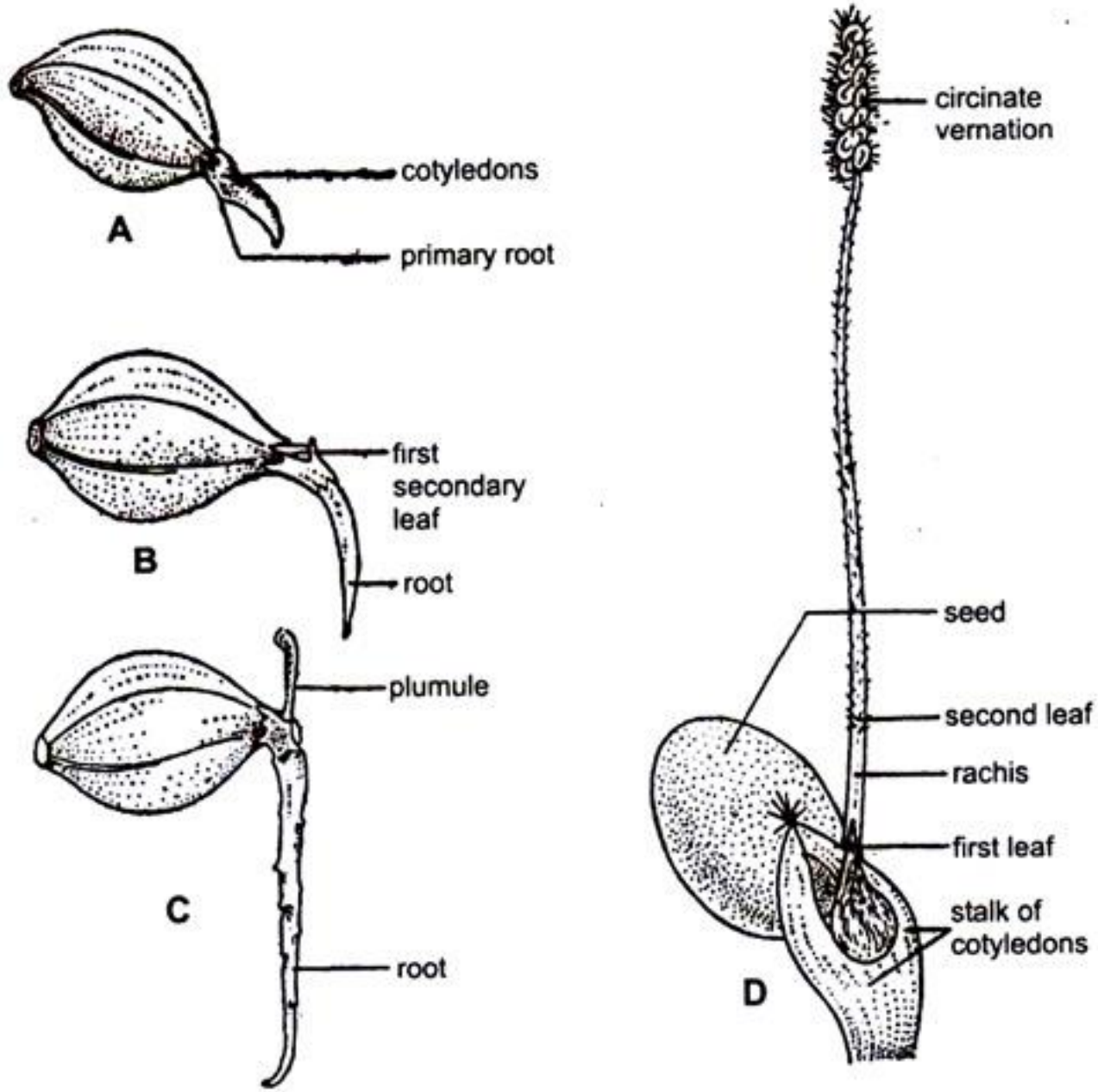


Fig. 32. *Cycas.* Germination of seed.

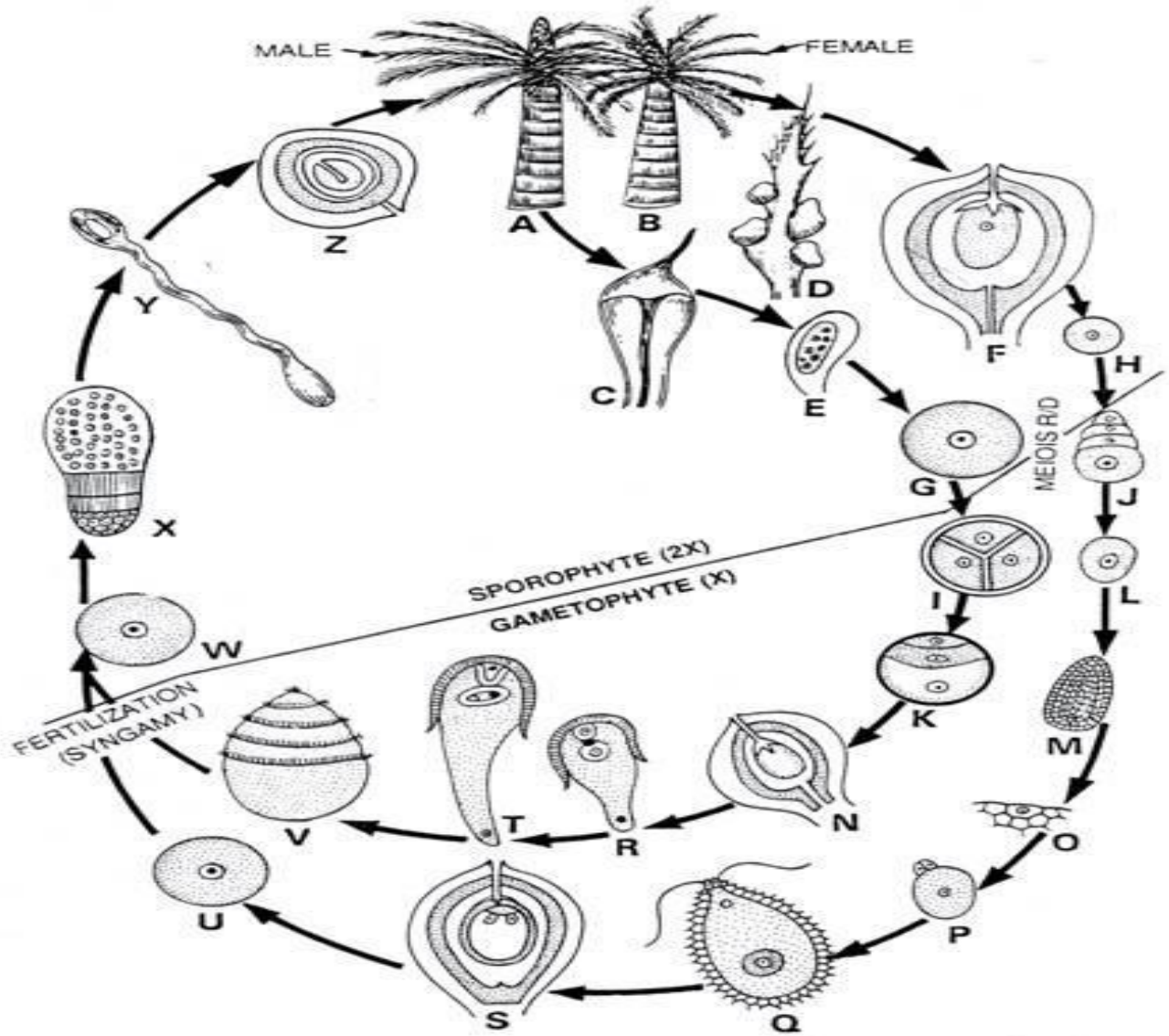


Fig. 3.51. *Cycas* sp. Diagrammatic life-cycle, A, male plant; B, female plant; C. microsporophyll, D, female strobilus; E, microsporangium; F, ovule; G, microspore mother cell; H, megaspore mother cell; I, microspore tetrad; J, megaspore linear tetrad; K, male gametophyte; L, megaspore; M, female gametophyte; N, ovule; O, archegonial initial; P, young archegonium; Q, mature archegonium; R, geminating pollen; S, germinating pollen in pollen chamber; T, geminating pollen; U, egg; V, spermatozoid; W, oospore; X, young embryo; Y, embryo; Z, seed.

3. Life cycle of : *Pinus*

Distribution and Occurrence

- *Pinus* are coniferous, evergreen resinous trees which are popularly known as pine.
- They belong to the family Pinaceae under order Coniferales of class Coiniferosida.
- Different species of the genus Pinus are distributed throughout the temperate and sub-alpine regions of Northern Hemisphere where they form dense forests of evergreen trees. They can grow up to 80 (260 ft) meters in height.
- The tallest pine tree is ponderosa pine which can grow about 81.79 m (268.35 ft) tall.
- They are long lived plant and can live up to 1000 years or more under favorable conditions
- There are about 120 species of pine tree throughout the world. They are widely distributed in the hills

Sporophyte of *Pinus*:

- *Pinus* is a tall evergreen tree giving rise to a series of widespread horizontal branches.
- In each year, a whorl of branches is produced in the axil of scale leaves.
- The branching is restricted to the upper part of the stem, thus giving the tree a pyramid-like appearance.
- The main stem is cylindrical and covered with scaly bark.
- The branches are dimorphic, bearing two types of shoots: long shoots and dwarf shoots, or spurs or brachyblasts.
- *Pinus* exhibits two types of leaves, the scale leaves and the green acicular foliage leaves called needles.
- The plant has a tap root system which becomes elongated at maturity and possesses strong lateral roots.
- The plants are monoecious where the male and female cones are borne on separate branches in the same plant.

External morphology of *Pinus*:-

- The body has three parts: root, stem and leaves.
- The plants bear well developed tap root system.
- The stem is stout, branched and pyramidal in shape with recemose branches.

Root:-

- A strong tap root system is present in young plant which may persist or roots develop and become stronger adventitious roots with increasing age.
- The roots can grow on rocks or hard ground and spread over a large area.
- The lateral roots are well developed with insufficient root hairs.
- Often a branch roots are infested with mycorrhizal fungus and hence it is called the mycorrhizal root.

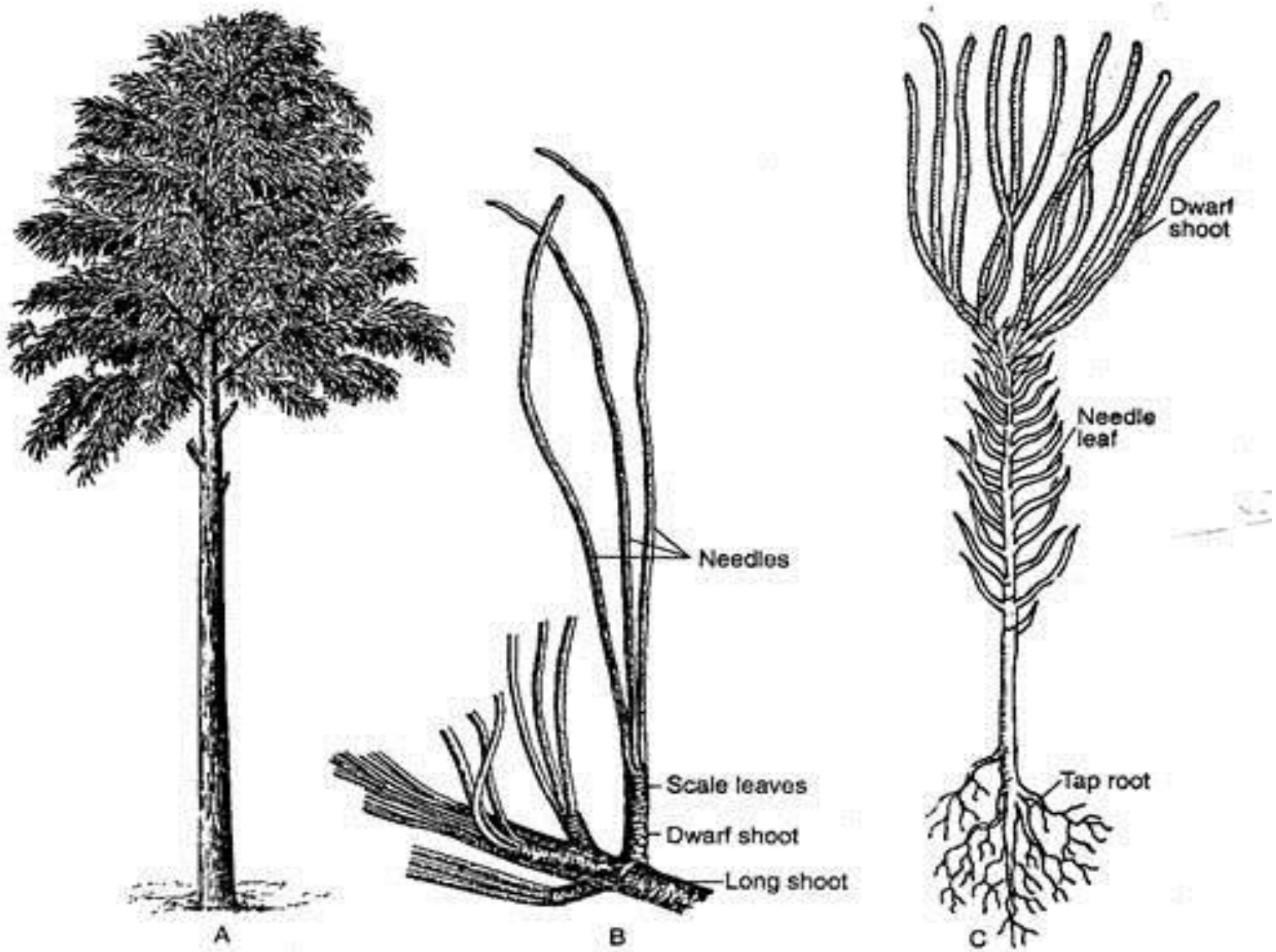


Fig. 1.57 : A. A *Pinus* tree, B. Long shoot and dwarf shoots of *Pinus*, C. A *Pinus* seedling

Stem:-

- The stem is erect, stout, cylindrical and pyramidal shape with dimorphic branches.
- The branches are restricted in the apical region.
- The stem is covered with bark.

There are two types of branches:

- The long shoot of unlimited growth and
- The dwarf shoot of limited growth.

The long shoot of unlimited growth:-

The main branches or long shoots have an unlimited growth with scale leaves which are found below the dwarf shoots and the needle like foliage leaves are present exclusively at their terminal ends.

The dwarf shoot of limited growth:-

- The dwarf shoots develop in the axils of scale leaves on the main branches, which are without apical buds.
- It is about 1 -2 cm long with one or two scale leaves.
- The dwarf shoot also contains foliage leaves.
- In this case, a dwarf shoot with its foliage leaves is known as spur.

Leaf:-

The pine tree bears two types of leaves:-

The scale leaves:-

- Both long and dwarf shoots bear scale-leaves and fall off as the branches attain maturity.
- These leaves are small, brownish in color and membranous with protective structures.

The foliage leaves:-

- The dwarf shoots bear foliage leaves.
- The leaves are long, green, simple, needle-like with photosynthetic structures.
- They develop in clusters at the apex of the dwarf shoots and can form the spur.
- Their number varies from 1-5 in different species.

A spur is called unifoliar if only one leaf is present at the apex of the dwarf shoot, bifoliar if two leaves are present, trifoliar if three leaves are present, and so on.Some of the species with different types of spurs are as follows:-

(i) *Pinus monophylla*-unifoliar (having only one needle);

(ii) *P. Sylvestris*-bifoliar (having two needles);

(iii) *P. Gerardiana*-trifoliar (having three needles);

(iv) *P. Quadrifolia*-quadrifoliar (having four needles).

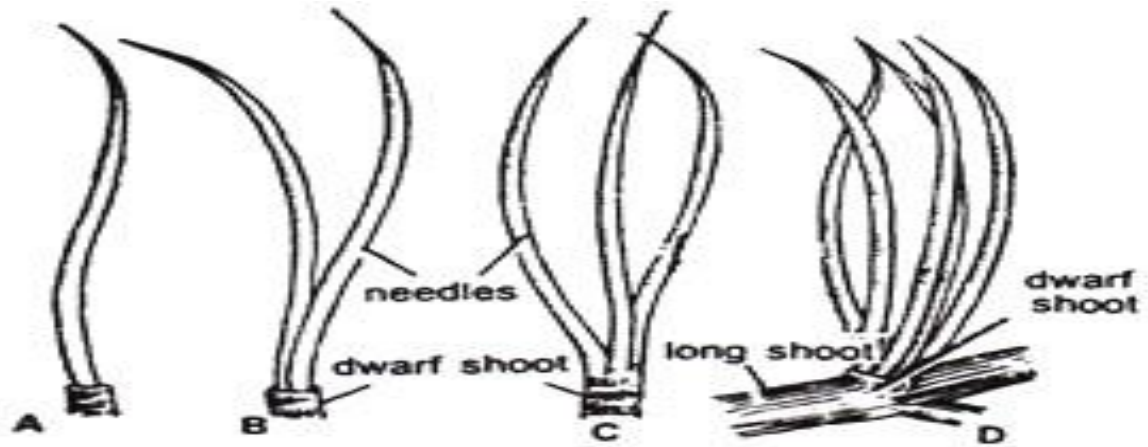
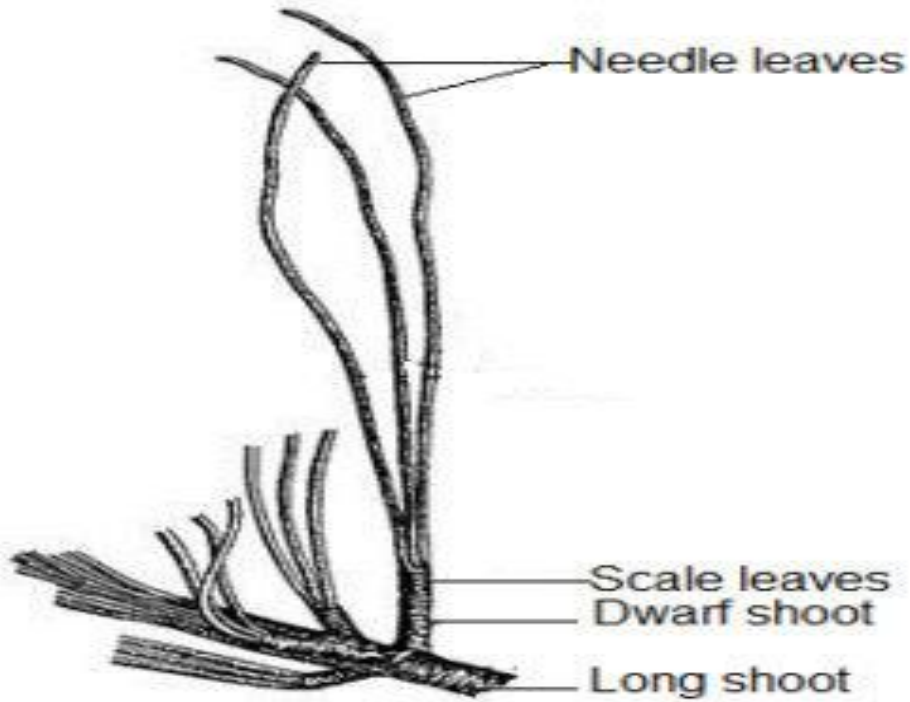
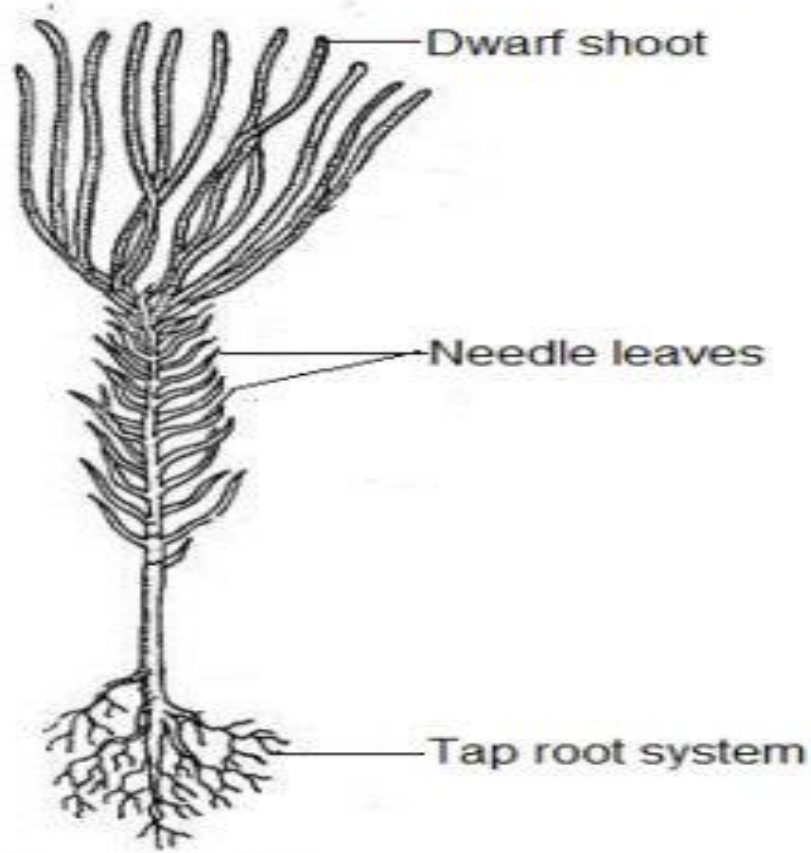


Fig. 28. *Pinus. Spurs of different species. A, Monofoliar (Pinus monophylla); B, Bifoliar (P. sylvestris); C, Trifoliar (P. gerardiana); D, Pentafoliar (P. wallichiana).*



Shoots & leaves of *Pinus*



Young Plant

T.S of 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.

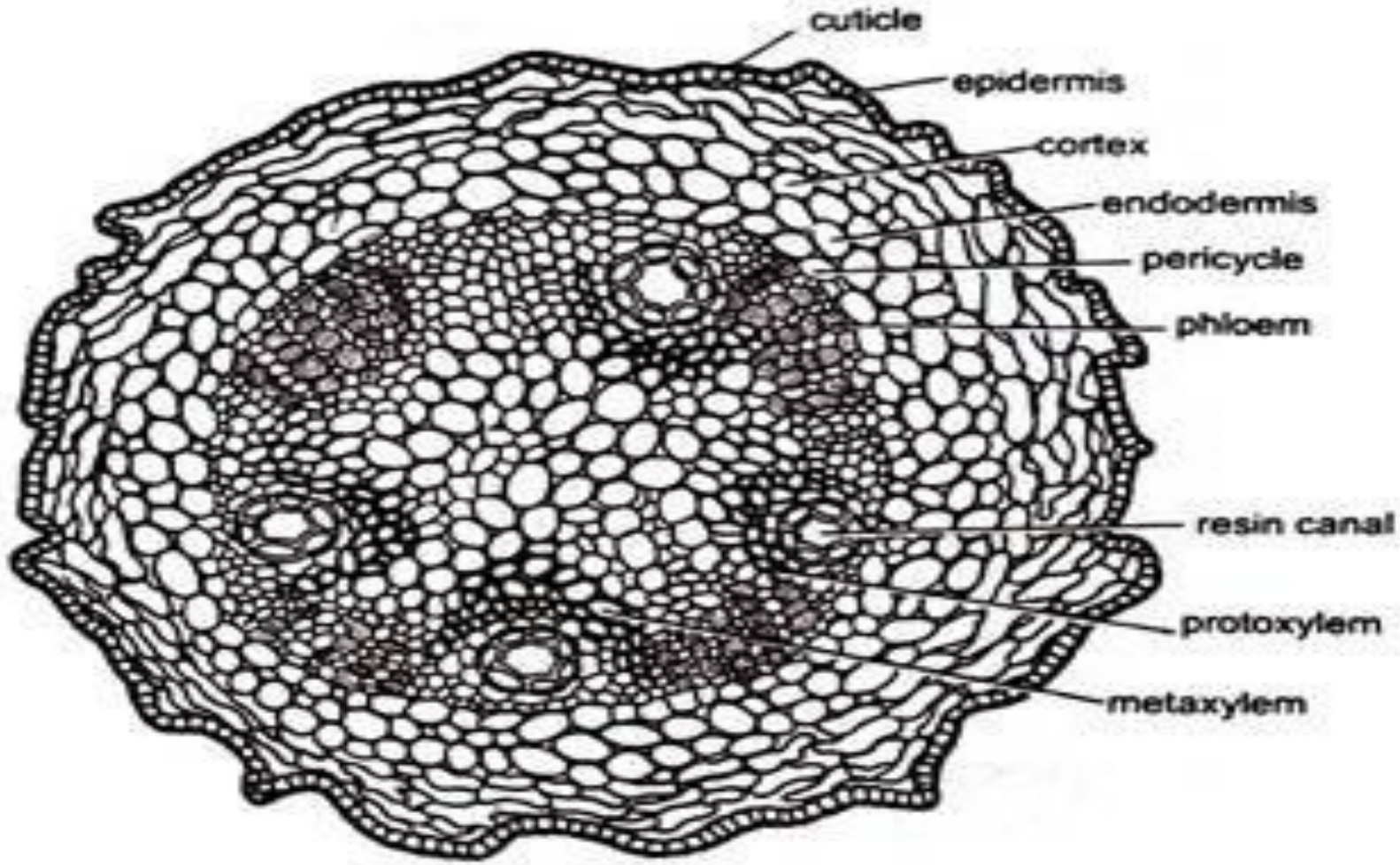


Fig. 29. Pinus. T.S. young root (diagrammatic).

T.S. Old Root Showing Secondary Growth:-

- On the outer side are present a few layers of cork, formed by the meristematic activity of the cork cambium.
- Cork cambium cuts secondary cortex towards inner side.
- Many resin canals and stone cells are present in the secondary cortex, the cells of which are separated with the intercellular spaces.
- Below the phloem patches develop cambium, which cuts secondary phloem towards outer side and secondary xylem towards inner side.
- Crushed primary phloem is present outside the secondary phloem .
- Many uniseriate medullary rays are present in the secondary xylem.
- Primary xylem is the same as in young roots, i.e., each group is bifurcated (Y-shaped) and a resin canal is present in between the bifurcation.

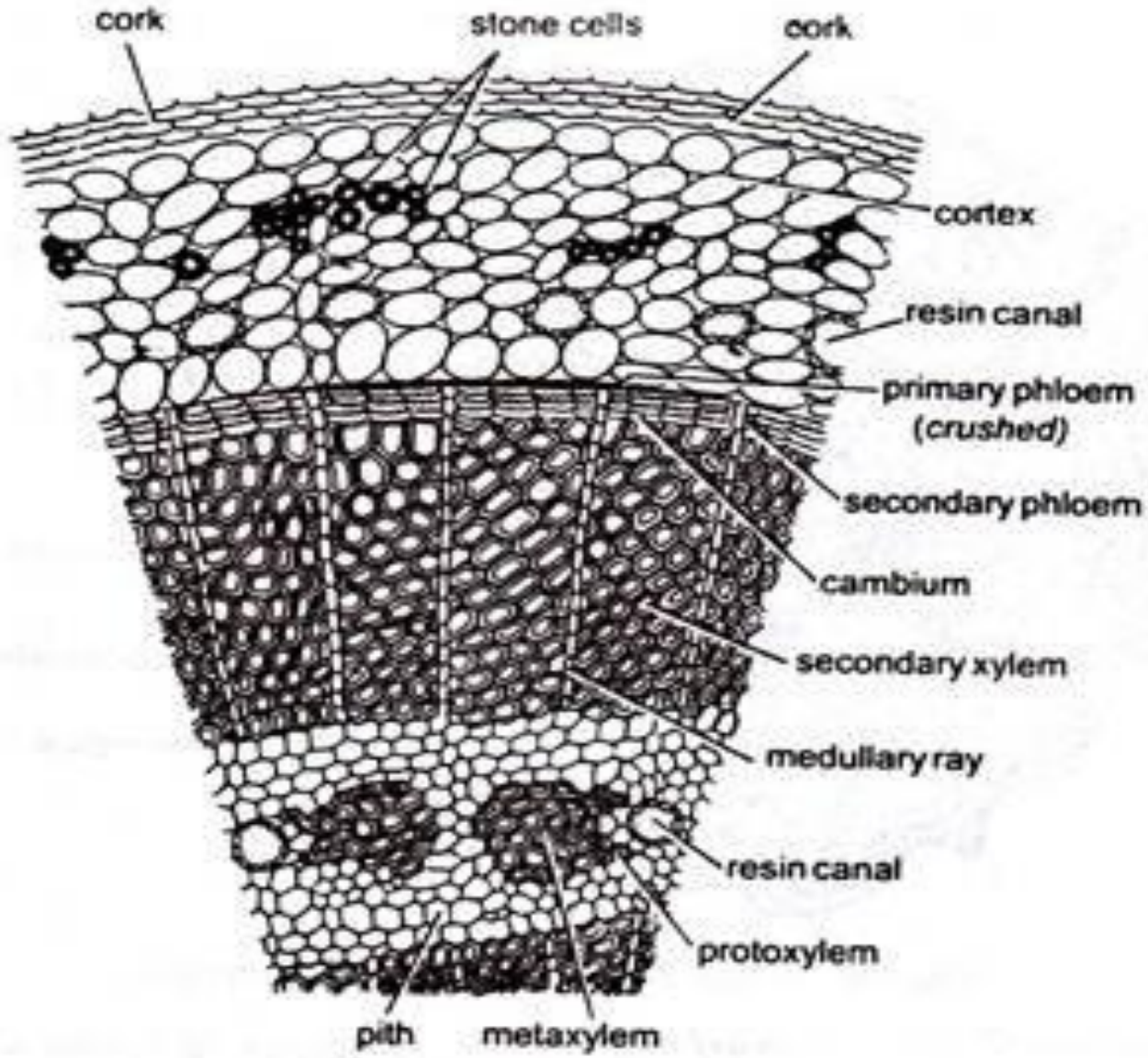


Fig. 30. *Pinus. T.S. old root.*

T.S of Stem

- **T.S. Long Shoot (Young):-**

- Many leaf bases are present on the stem, due to which it appears wavy in outline.
- Outermost single-layered, thick-walled epidermis is heavily cuticularized and followed by multilayered cortex.
- A few outer layers of cortex are sclerenchymatous, and some inner layers are parenchymatous.
- In the inner layers of cortex are present many resin canals.
- The stele is eustelic or polyfascicular endarch siphonostele.
- Vascular bundles are conjoint, collateral, open and endarch, and resemble greatly with that of a dicot stem. 5-10 vascular bundles are arranged in a ring.

- Endodermis and pericycle are indistinguishable.
- Narrow xylem rays connect the cortex and pith.
- Endarch xylem consists of only tracheids.
- Phloem is present on the ventral side and consists of sieve cells, sieve plates, phloem parenchyma and some albuminous cells.
- Intrafascicular cambium is present in between the xylem and phloem.
- Many leaf traces are also present.
- A small parenchymatous pith is present in the centre of stem.

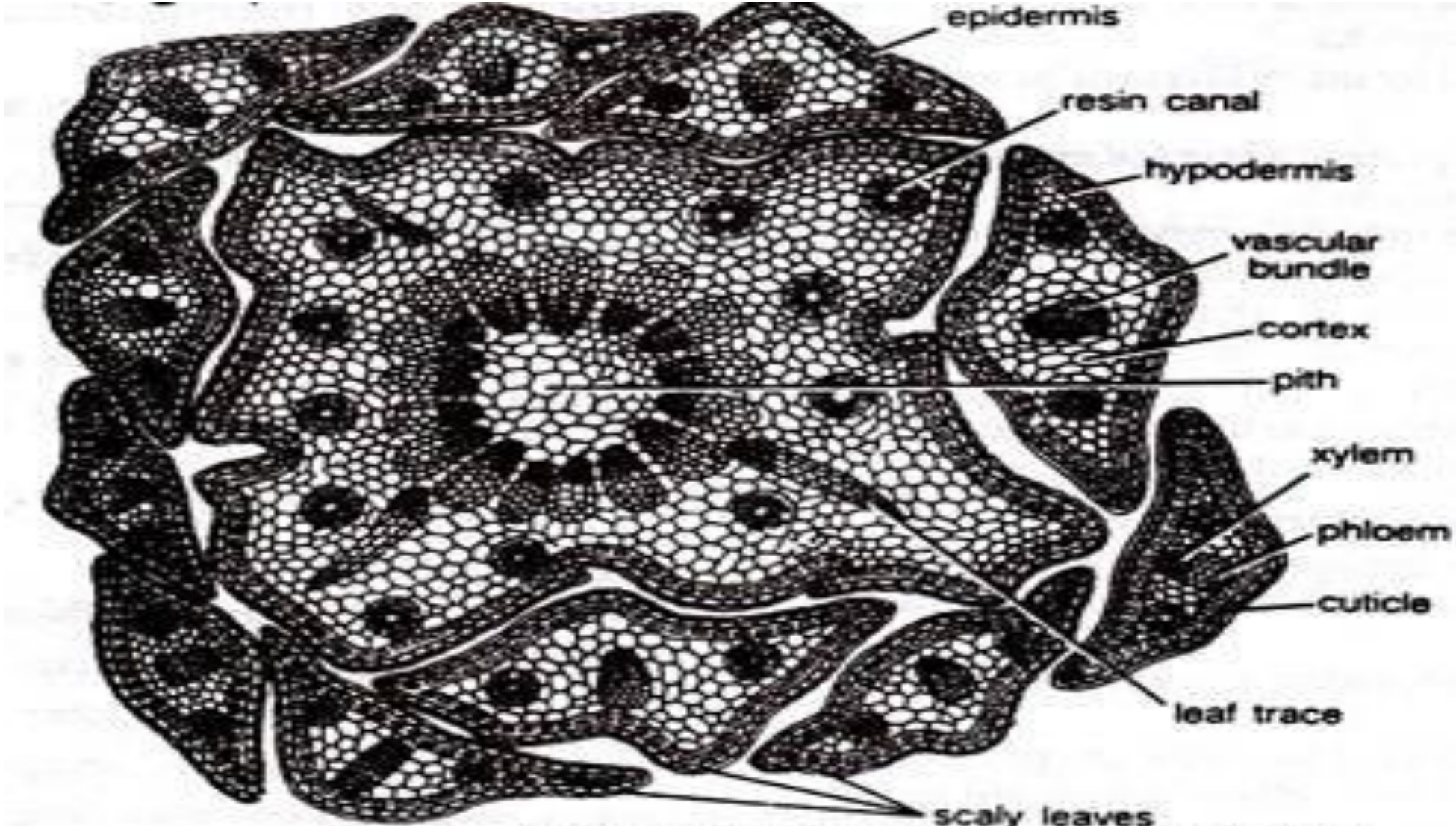


Fig. 31. Pinus roxburghii. T.S. long shoot (young).

T.S. Long Shoot (Old):-

- Secondary growth, similar to that of a dicotyledonous stem, is present in the old stem of Pinus.
- Cork cambium cuts cork towards outer side and a few layers of secondary cortex towards inner side.
- Many tannin-filled cells and resin canals are distributed in the primary cortex.
- Cambium cuts secondary phloem towards outer side and secondary xylem towards inner side .
- Primary phloem is crushed and pushed towards outer side by the secondary phloem.
- In the secondary xylem, annual rings of thin-walled spring wood (formed in spring season) and thick- walled autumn wood (formed in autumn season) are present alternately.
- Such a compact wood is called pycnoxylic (Age of the plant can be calculated by counting the number of these annual rings).
- Below the secondary xylem are present a few groups of endarch primary xylem.
- Some of the medullary rays connect the pith with the cortex and called primary medullary rays while the others run in between secondary xylem and secondary phloem and called secondary medullary rays.
- Central part of the stem is filled with the parenchymatous pith.
- Resin canals are present in cortex, secondary xylem, primary xylem and rarely in the pith.

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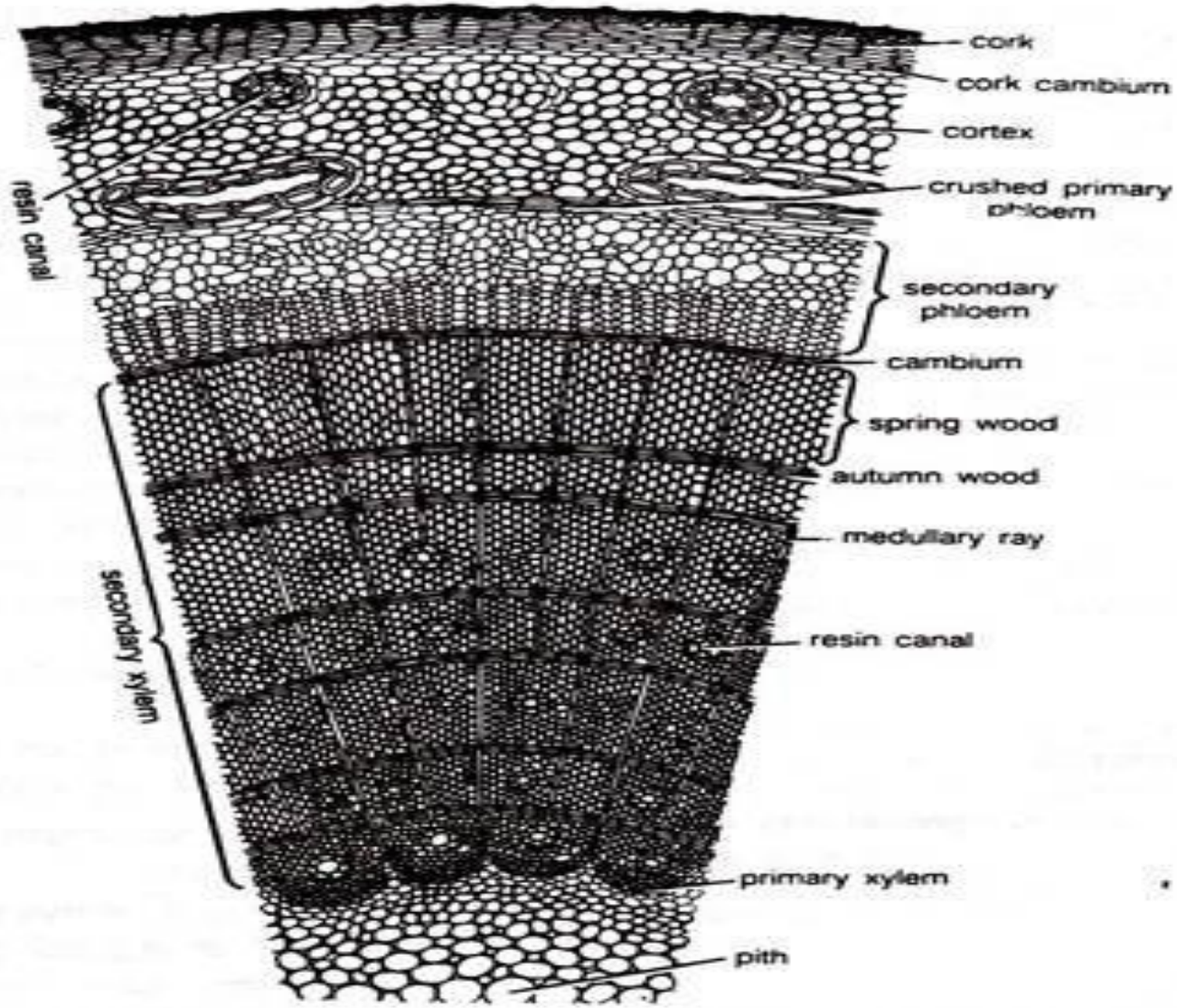


Fig. 32. Pinus. T.S. of a two-year old long shoot.

Tangential Longitudinal Section (T.L.S.) of Wood:-

- In T.L.S. The longitudinal section is cut along the tangent of the wood.
- Following structures are visible:-
- Bordered pits and medullary rays are present in sectional view.
- Each border pit is enclosed by a pit chamber bounded by a pit membrane and contains a centrally located swollen torus .
- Tracheids are composed of rectangular cells. Middle lamella is very clear.
- Many uniseriate medullary rays are present.
- In the xylem region medullary rays contain a centrally located starch cell surrounded by tracheidial cells.
- Albuminous cells are also present in medullary rays in phloem region.
- Pith is absent.

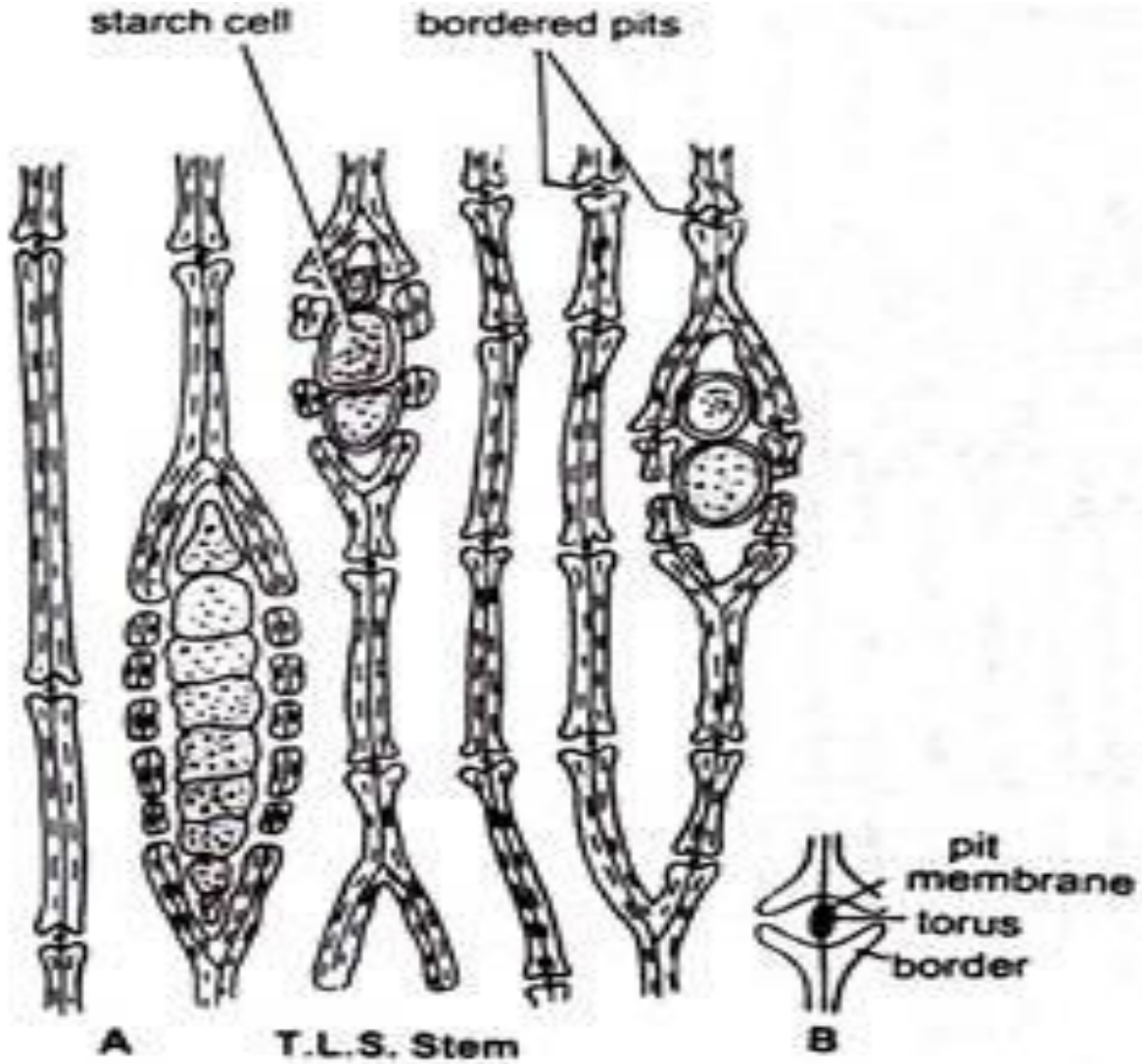


Fig. 33. Pinus. A, T.L.S. wood (a part); B, A magnified bordered pit.

Radial Longitudinal Section (R.L.S.) of Wood:-

- In R.L.S., the stem is cut along the radius, and so the pith is also visible.
- Following other details are visible:-
- It is bounded externally by cork, cork cambium, secondary phloem and crushed primary phloem.
- Uniseriate medullary rays run horizontally.
- In the xylem region thick medullary ray cells are surrounded by ray tracheids.
- Thin-walled ray parenchyma is also present.
- Xylem is separated from phloem with the help of cambium.
- Albuminous cells are present in medullary ray in the phloem region.
- Phloem consists of sieve tubes, sieve plates and phloem parenchyma. Pith is present.

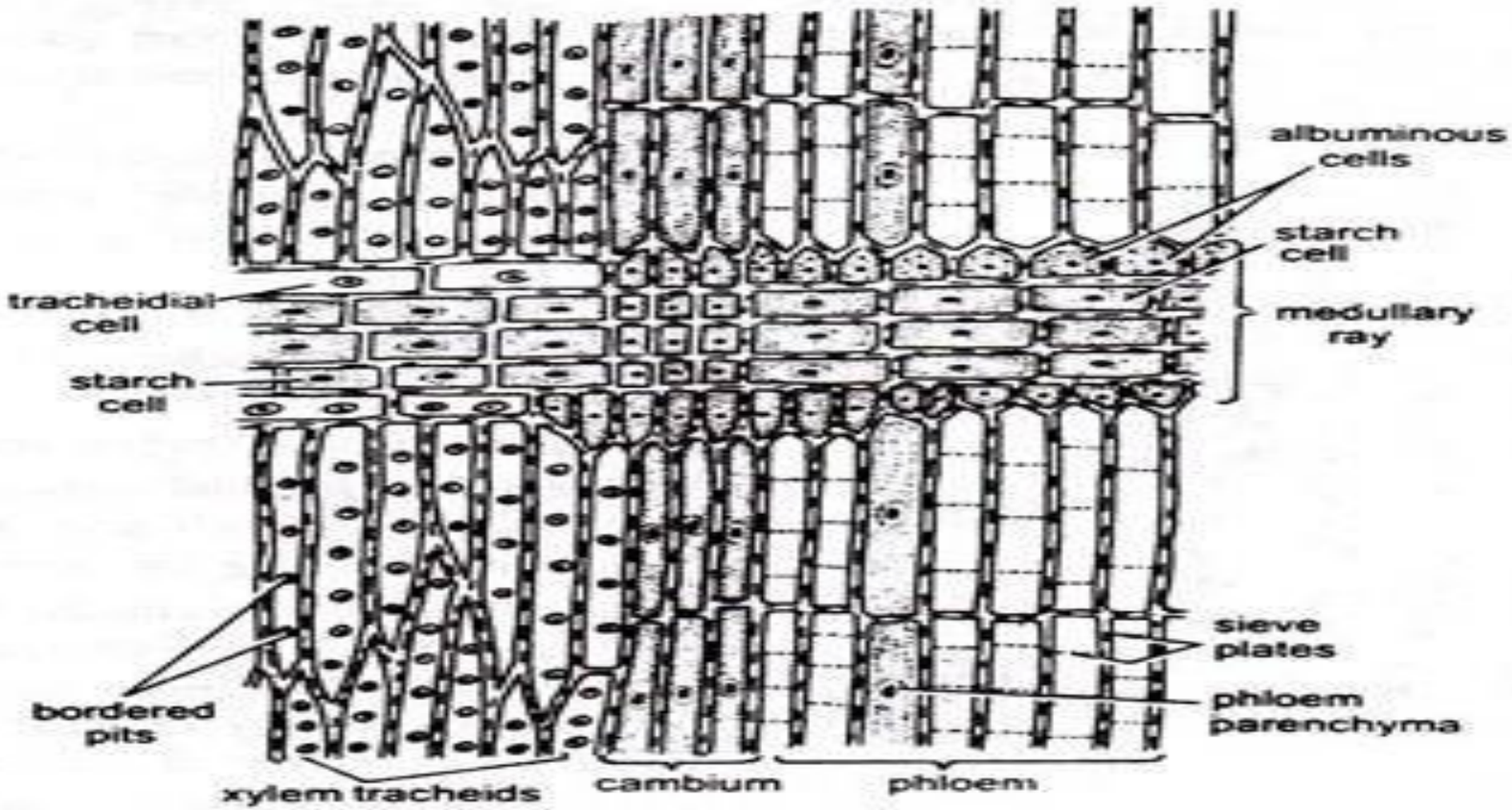


Fig. 34. Pinus. R.L.S. Stem.

T.S. Dwarf Shoot (Young):-

- It is exactly similar to that of T.S. Of young long shoot except following differences:-
- The number of the resin canals present in the cortex is not indefinite but generally six.
- Though it is variable in different species.
- The number of the vascular bundles is also generally six. However, it is also variable in different species.
- Pith in dwarf shoot is comparatively smaller than the long shoot.
- Structure of the vascular bundles is same, i.e., conjoint, collateral, open and endarch.

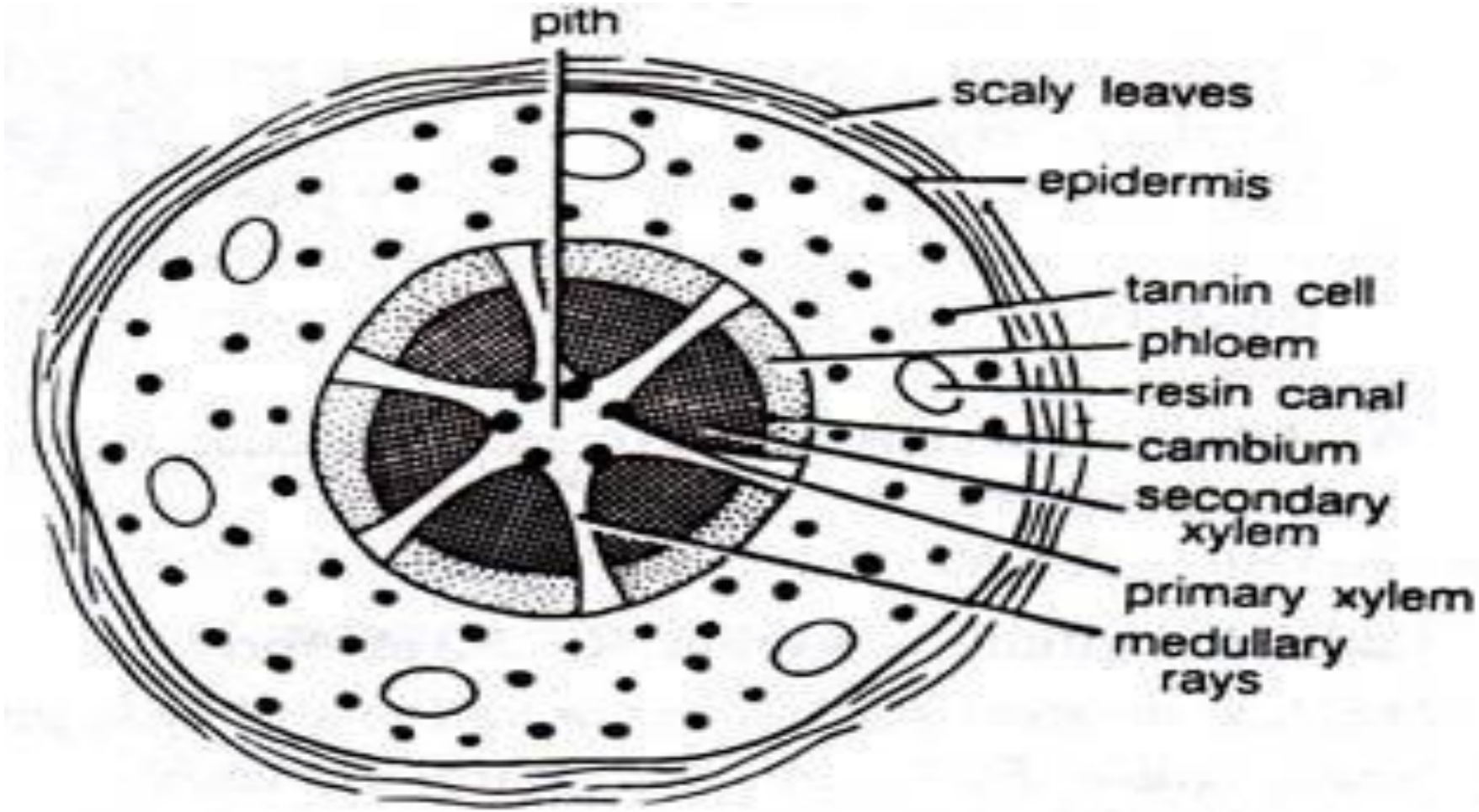


Fig. 35. Pinus. T.S. dwarf shoot.

T.S of Leaf

T.S. Needle (Foliage Leaf):-

- It is circular in outline in Pinus monophylla, semicircular in P. Sylvestris and triangular in P. Longifolia etc.
- Outermost layer is epidermis, which consists of thick-walled cells. It is covered by a very strong cuticle.
- Many sunken stomata are present on the epidermis.
- Each stoma opens internally into a substomatal cavity and externally into a respiratory cavity or vestibule.
- Below the epidermis are present a few layers of thick-walled sclerenchymatous hypodermis. It is well-developed at ridges.
- In between the hypodermis and endodermis is present the mesophyll tissue.
- Cells of the mesophyll are polygonal and filled with chloroplasts. Many peg-like infoldings of cellulose also arise from the inner side of the wall of mesophyll cells.

- Few resin canals are present in the mesophyll, adjoining the hypodermis. Their number is variable but generally they are two in number.
- Endodermis is single-layered with barrel-shaped cells and clear casparian strips.
- Pericycle is multilayered and consists of mainly parenchymatous cells and some sclerenchymatous cells forming T-shaped girder, which separates two vascular bundles . Transfusion tissue consists of tracheidial cells.
- Two conjoint and collateral vascular bundles are present in the centre.
- These are closed but cambium may also present in the sections passing through the base of the needle.
- Xylem lies towards the angular side and the phloem towards the convex side of the needle.

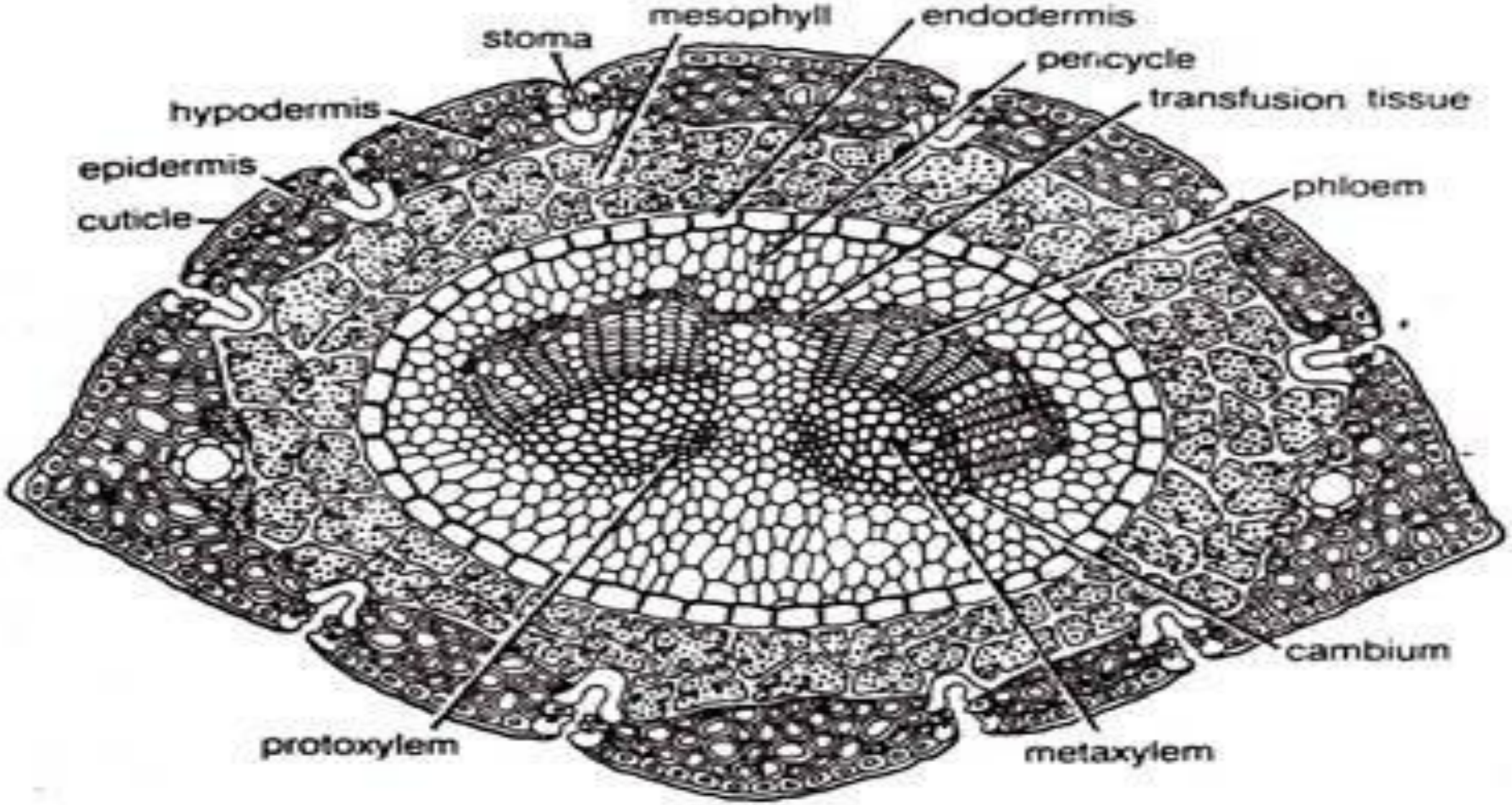


Fig. 38. Pinus. T.S. needle.

Reproduction in Pinus

Sporophytic plant body is monoecious, but the male and the female cones are produced on separate branches of the same plant.

Male cone

• Borne on the lower branches in the axils of scale leaves.

• Appear in the month of January (in plains) and March (in hills) reaching maturity within 2-3 months. • Can be seen in clusters just behind the shoot – apex.

Female cone

• Borne on the upper branches of the tree, in axils of scale leaves either singly or in groups of 2-4.

• Female cones are seen in February and get pollinated within 3-4 months.

• Complete maturation and seed dispersal takes place in the 3rd year of development.

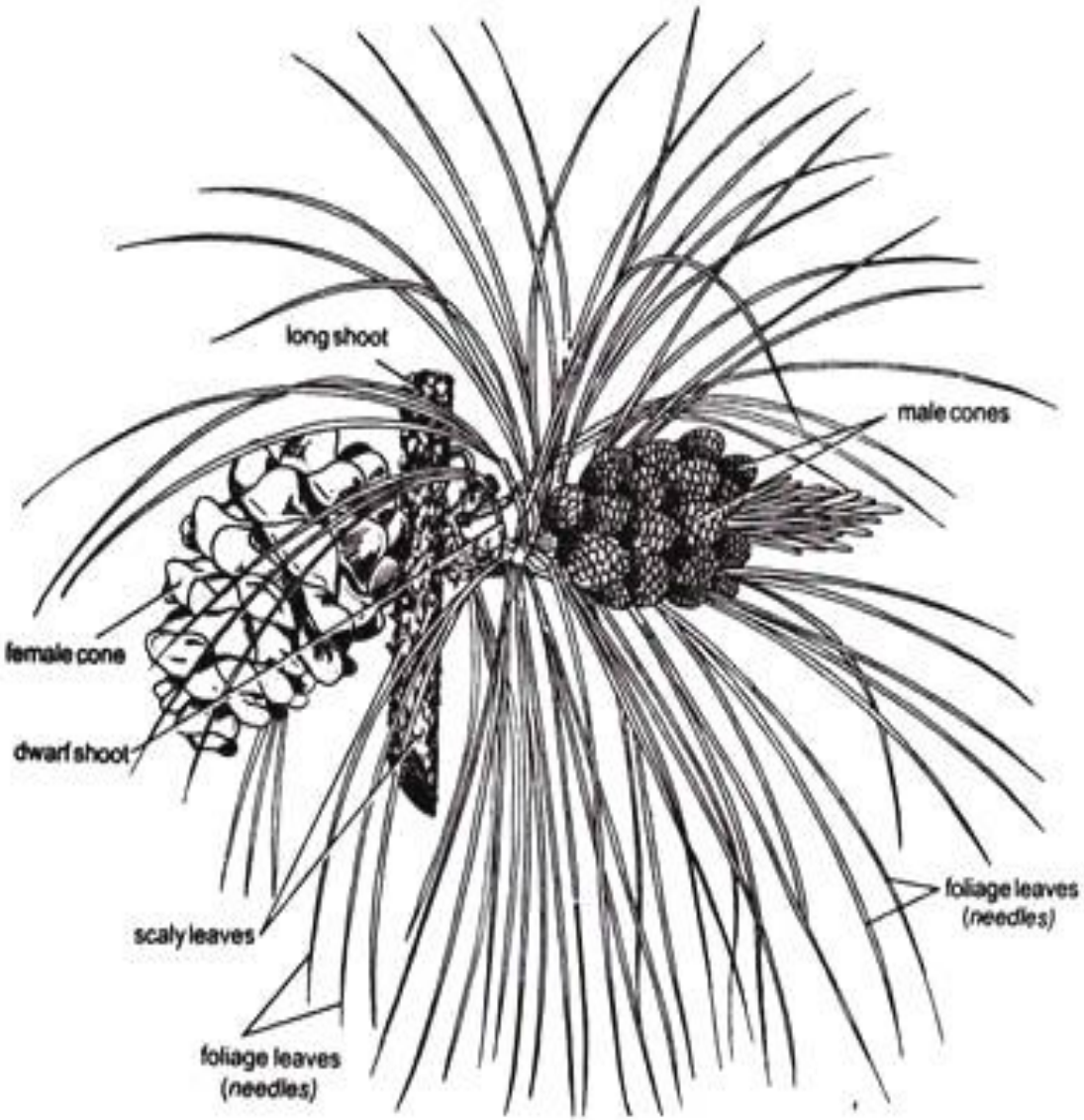


Fig. 39. Pinus. A long shoot bearing cluster of male cones and a mature female cone.

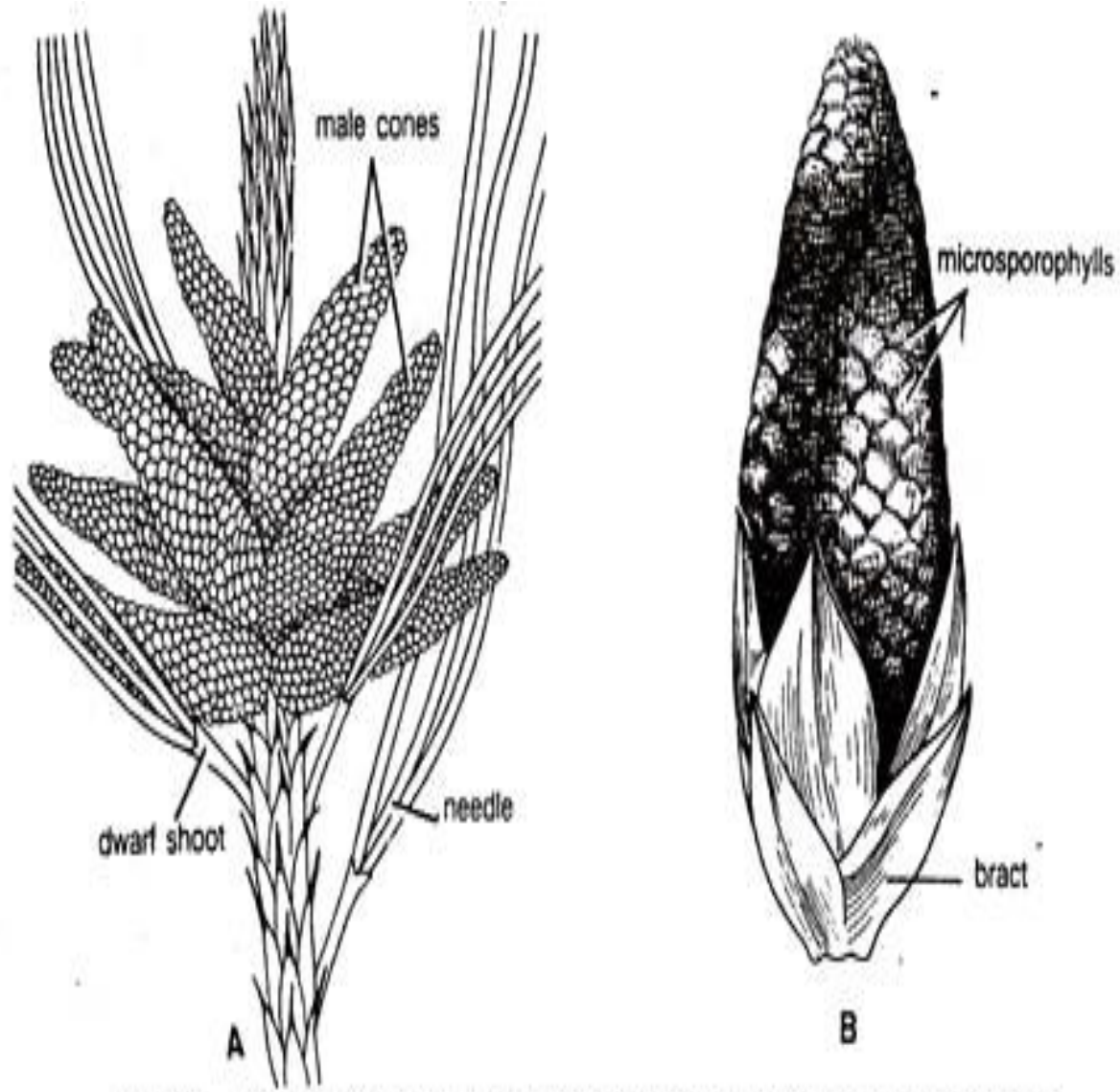


Fig. 40. Pinus wallichiana. A, A cluster of male cones; B, A single male cone.

L.S of Male cone

- Male cone consists of a large number of microsporophylls arranged spirally on the cone axis.
- Each microsporophyll is small, membranous, brown-coloured structure.
- A microsporophyll is comparable with the stamen of the flower of angiosperms because it consists of a stalk (filament) with a terminal leafy expansion (anther), the tip of which is projected upwards and called apophysis.
- Two pouch-like microsporangia (pollen sacs) are present on the abaxial or undersurface of each microsporophyll.
- In each microsporangium are present many microspores (pollen grains).

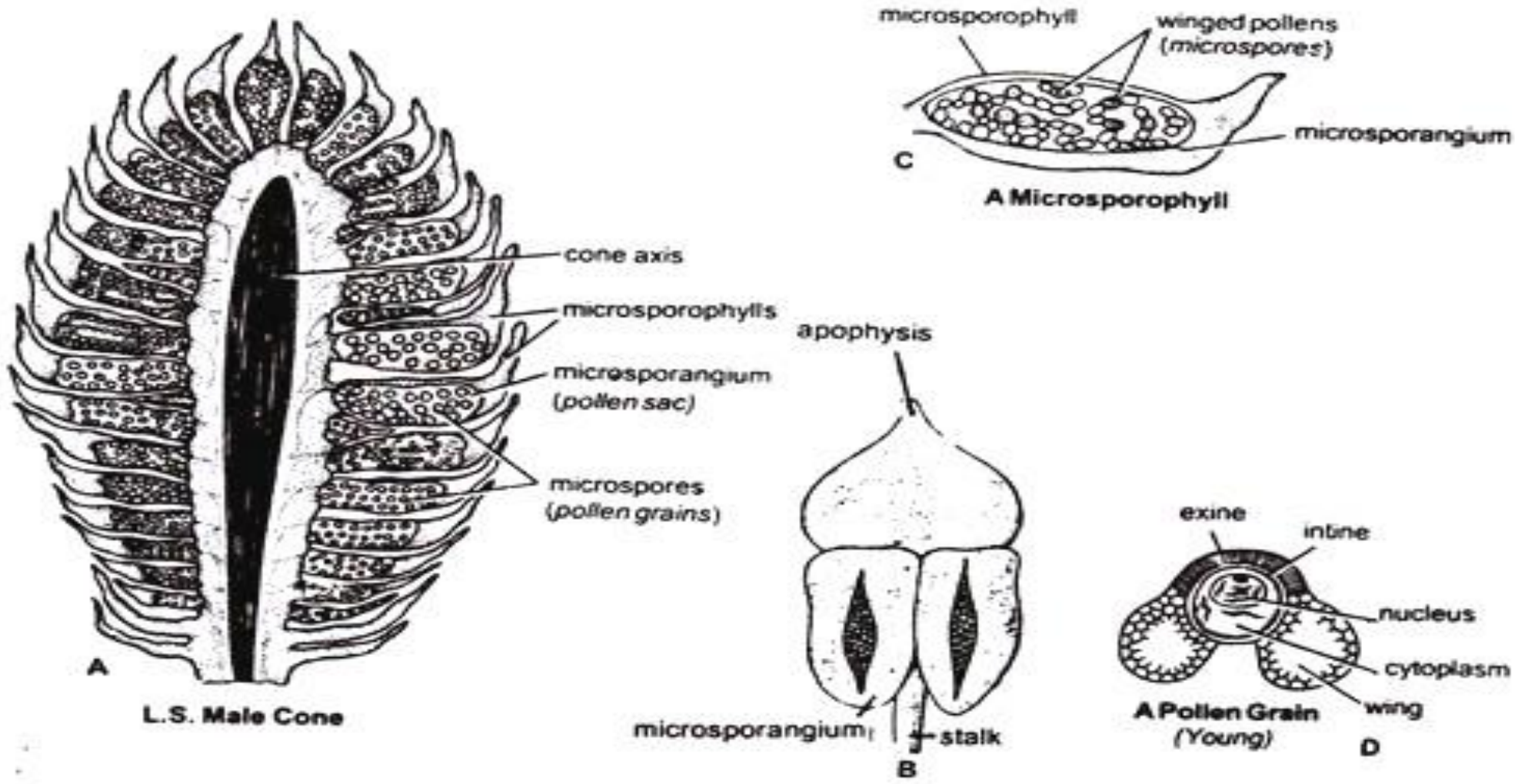


Fig. 41. Pinus. A, L.S. male cone; B, A single microsporophyll with microsporangia in surface view; C, A microsporophyll; D, A young pollen grain.

- Each microspore or pollen grain is a rounded and yellow-coloured, light, uninucleate structure with two outer coverings, i.e., thick outer exine and thin inner intine.
- The exine protrudes out on two sides in the form of two balloon-shaped wings.
- Wings help in floating and dispersal of pollen grains.
- A few microsporophylls of lower side of cone are sterile.
- Sporangia are also not present on the adaxial surface of each microsporophyll of the male cone

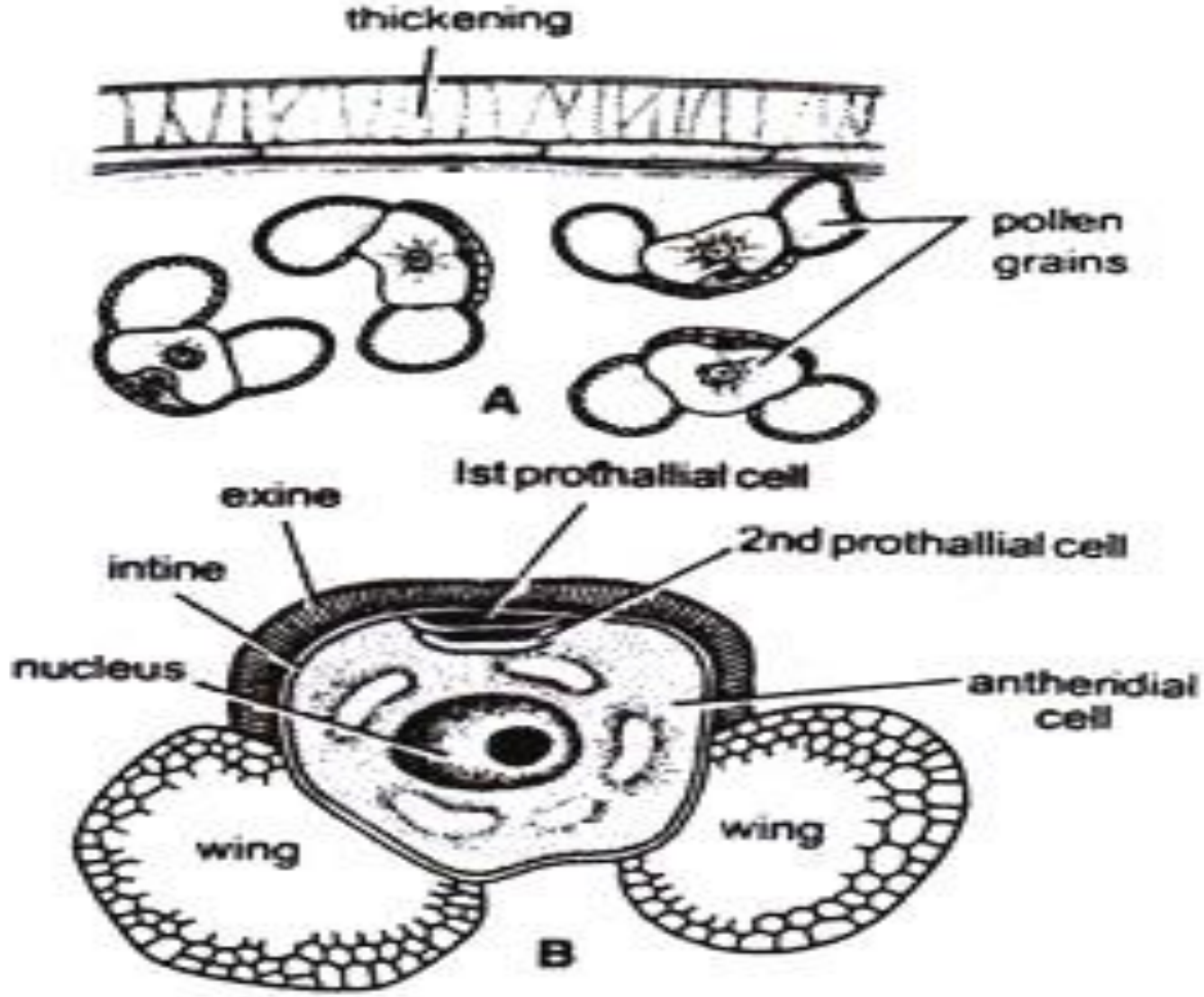


Fig. 42. Pinus. A few pollen grains and a mature winged pollen grain.

Female cone::-

- Female cone develops either solitary or in groups of 2 to 4.
- They also develop in the axil of scaly leaves on long shoots like male cones.
- Each female cone is an ovoid, structure when young but becomes elongated or cylindrical at maturity.

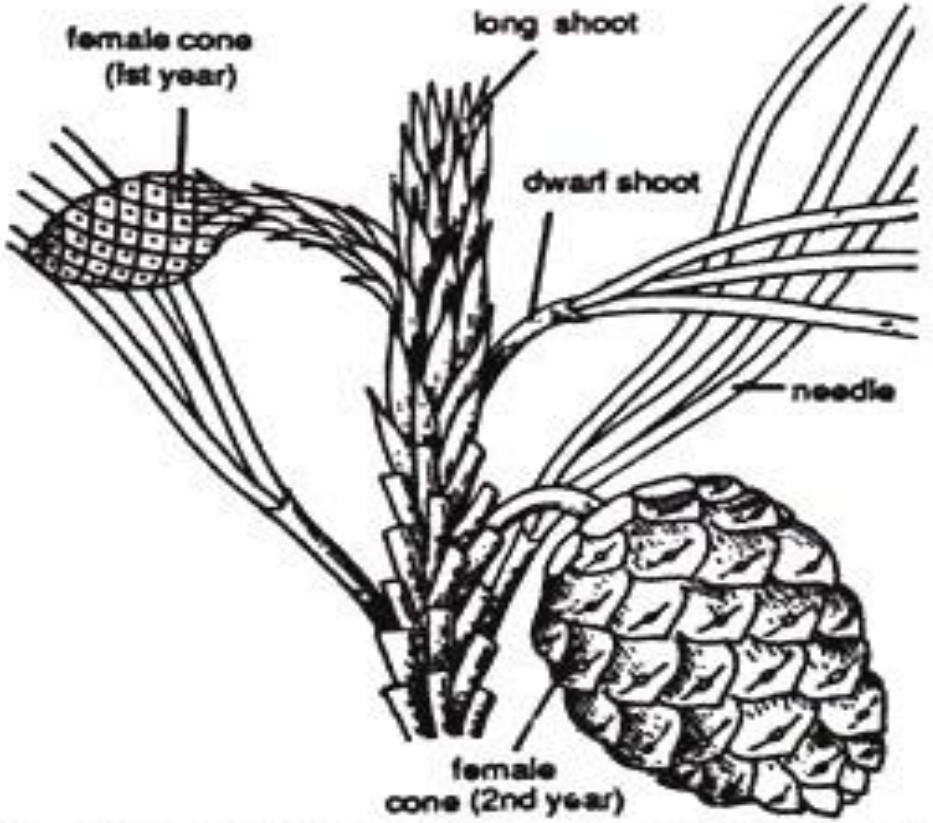
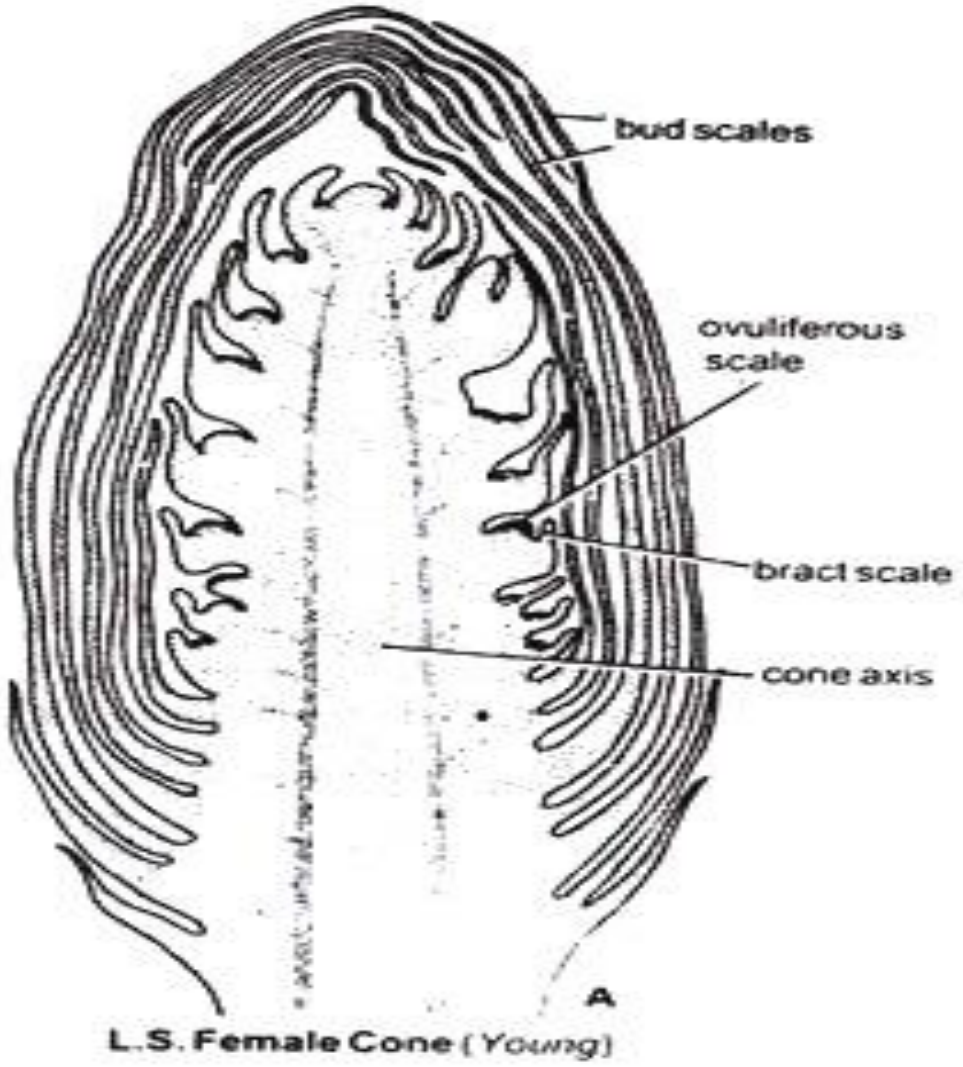


Fig. 43. Pinus. A fertile long shoot bearing 1st and 2nd year female cones.

L.S. Female Cone:-

- In the centre is present a cone axis.Many megasporophylls are arranged spirally on the cone axis.A few megasporophylls, present at the base and at the apex of strobilus, are sterile.
- Megasporophylls present in the middle of the strobilus are very large and they decrease in size towards the base and apex.Each megasporophyll consists of two types of scales, known as bract scales and ovuliferous scales.
- Bract scales are thin, dry, membranous, brown- coloured structures having fringed upper part. These are also called carpellary scales.
- An ovuliferous scale is present on the upper surface of each bract scale.Each oruliferous scale is woody, bigger and stouter than bract scale and it is triangular in shape.
- A broad sterile structure, with pointed tip, is present at the apex of these scales. This is called apophysis.
- At the base of upper surface of each ovuliferous scale are present two sessile and naked ovules.
- Micropyle of each ovule faces towards the cone axis.



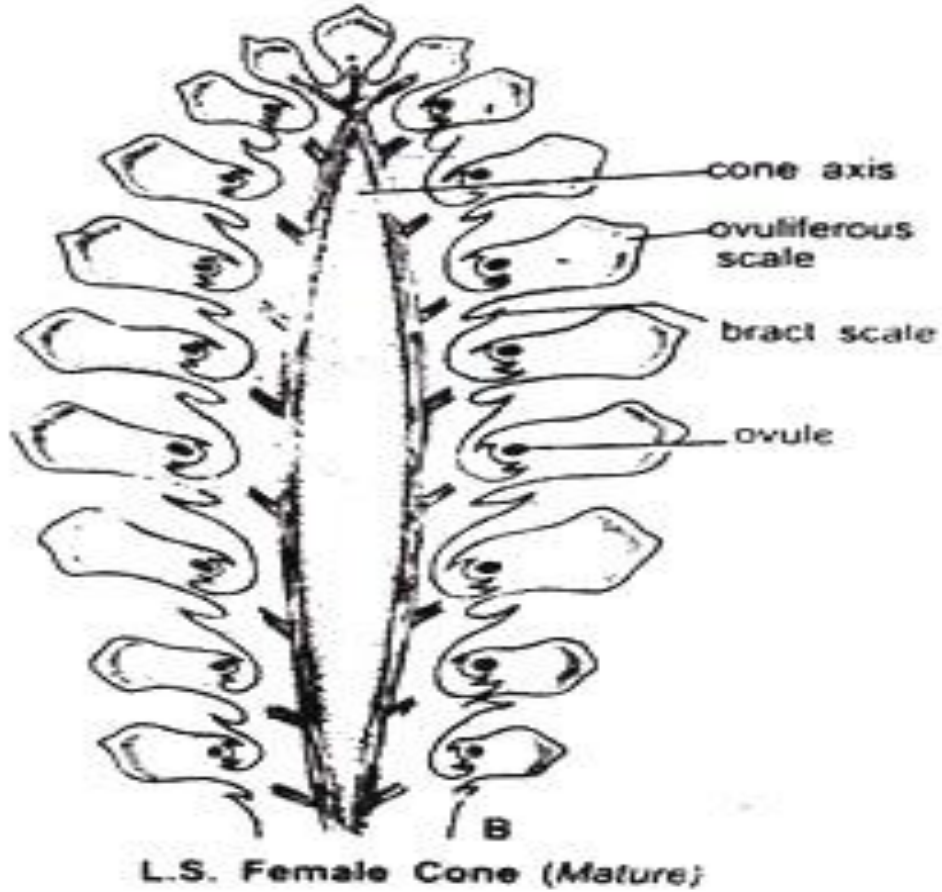


Fig. 44. *Pinus. A, L.S. female cone (young); B, L.S. female cone (old).*

Female Cone of 1st Year:-

- It is oval in shape.
- It ranges from 1 to 4 cm. In length.
- It is green to reddish-green in colour.
- It is attached with the help of a short stalk on the long shoot.
- Megasporophylls are arranged very close to each other, and so the cone is a compact structure.

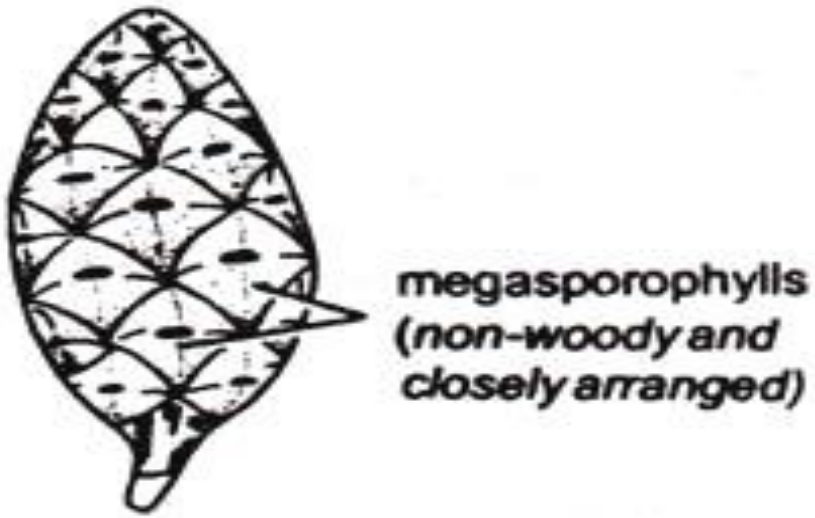


Fig. 45. Pinus. A 1st year female cone.

- **Female Cone of 2nd Year:-**
- It is elongated and larger than the first year cone.
- It ranges from 5 to 15 cm. Or more in length.
- It is red-coloured structure.
- It is woody in nature.
- Megasporophylls are compactly arranged but not so compact as in 1st year cone.
- Seeds are present inside in the later stages.

Fig. 46. Pinus. A 2nd year female cone.

Female Cone of 3rd Year:-

- It is elongated or roughly rounded in shape.
- It is also woody in nature like the 2nd year cone.
- Megasporophylls are loosely arranged.
- Seeds are dispersed from 3rd year cone.

Fig. 47. Pinus. A 3rd year female cone.

L.S of Ovule:-

- Each ovule is orthotropous, and it remains surrounded by a single integument, consisting of an outer fleshy, a middle stony and an inner fleshy layer.
- It opens with a mouth opening called micropyle.
- Integument surrounds the megasporangium or nucellus.
- Just opposite the micropyle is present a pollen chamber.
- In the endosperm or female gametophyte are present 2 to 5 archegonia.

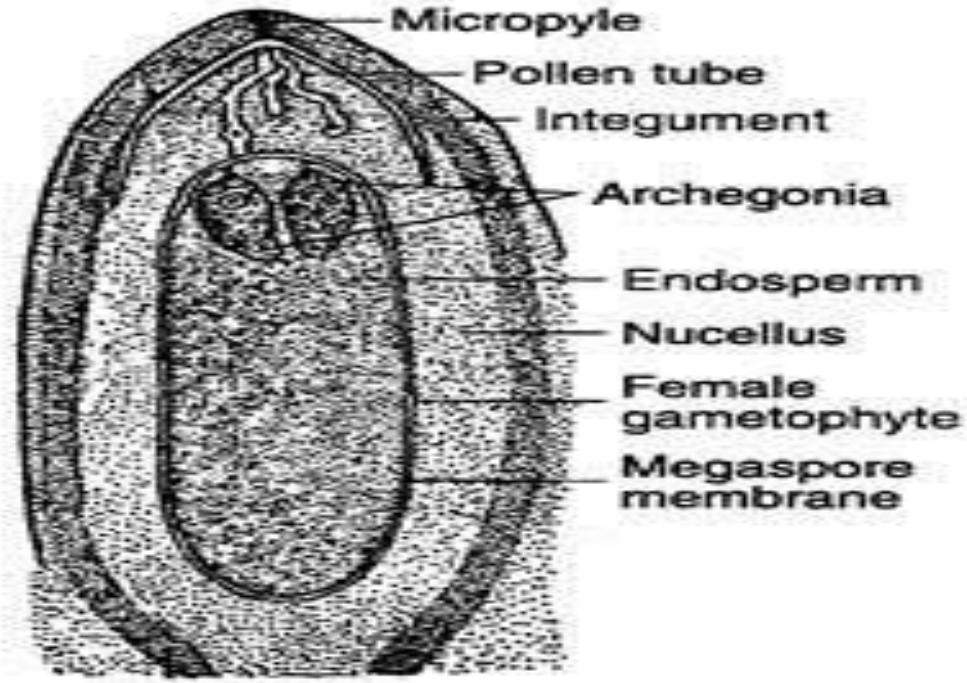


Fig. 1.64 : *Pinus* : Median L.S. of a mature ovule

Pollination:-

- Pinus is anemophilous i.e., wind-pollinated. The pollen grains are dispersed and remain suspended in the air for some time.
- At the same time, the nucellar beak in the ovule disorganises forming a viscous sugary liquid containing glucose, fructose and sucrose.
- This fluid comes out in a cyclic phenomenon (24 hr. Cycle) through the micropyle in the form of a pollination drop either at night or in the early hours of morning.
- The pollen grains are caught in the pollination drop and are collected in the pollen chamber as a result of drying off the fluid.
- The mouth of the micropyle is then sealed from the outer environment.

Fertilization:-

- The fertilisation takes place after one year of pollination.
- The pollen tube enters the tip of the archegonium by forcing itself between the cells of the nucellus.
- The pollen tube wall is disintegrated by the enzymes secreted from the egg and eventually two male nuclei are released.
- One of the male nuclei fuses with the egg cell and thus a zygote is formed.

Seed:

- Both the ovules of each ovuliferous scale develop into seeds .
- Each seed contains a large membranous wing formed from the ovuliferous scale.

Anatomy of seed shows following details:-

- It is enveloped by a seed coat developed from the middle stony layer of the ovule.
- Inner fleshy layer may survive in the form a thin membrane. Outer fleshy layer disappears.
- A thin, membranous and papery structure, called perisperm, develops inner to the seed coat.
- Well-developed endosperm is present.
- In the centre is present the embryo consisting of a hypocotyle, radicle, plumule and 2 to 14 or more cotyledons.

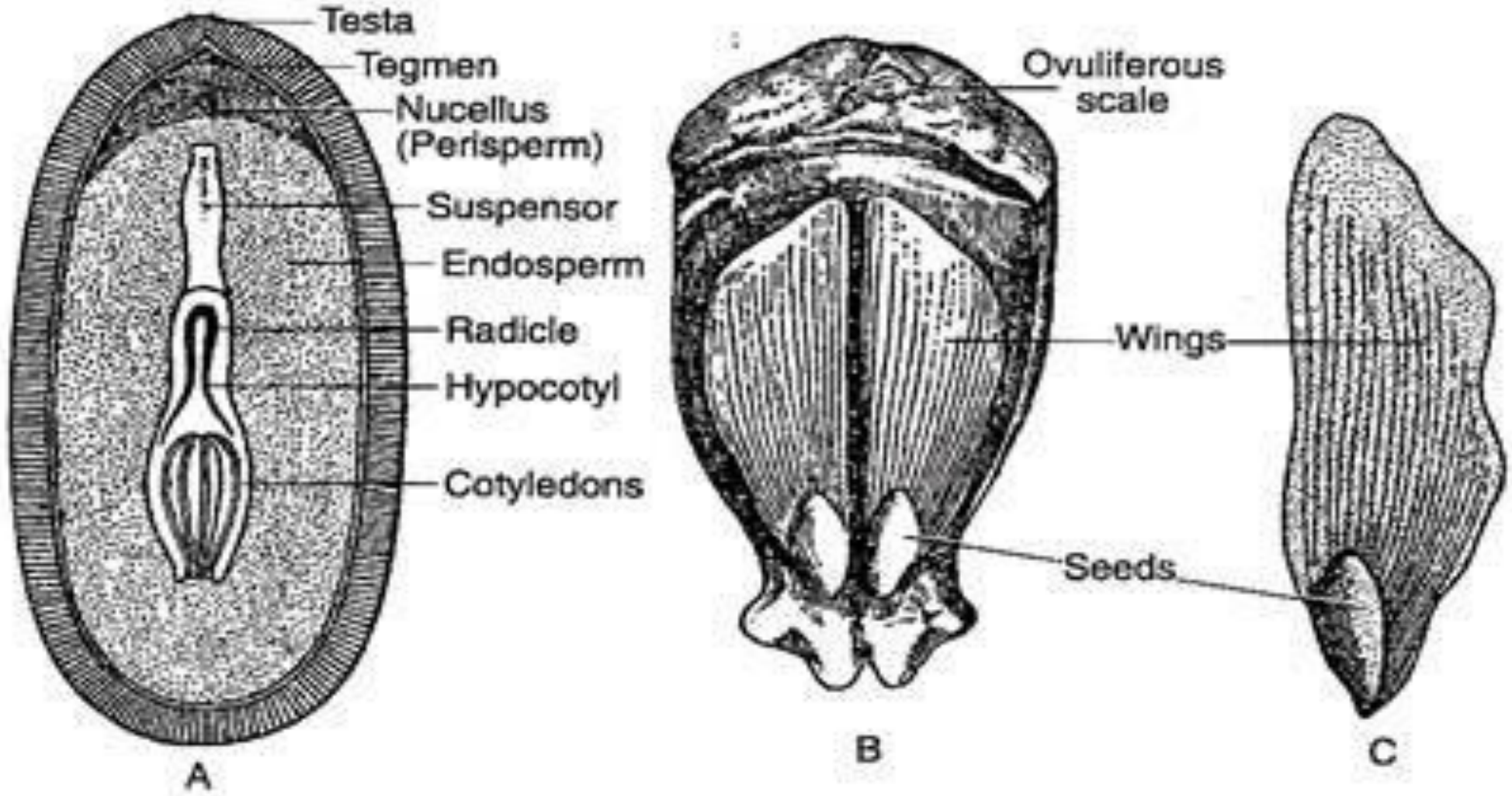


Fig. 1.68 : *Pinus* : A. L.S. of seed, B. An ovuliferous scale bearing seeds, C. A seed with wing

- The seeds are usually dispersed by wind.
- The embryo remains embedded within the endosperm.
- The seeds of *Pinus* remain viable for a long time.
- The germination of seed is epigeal.

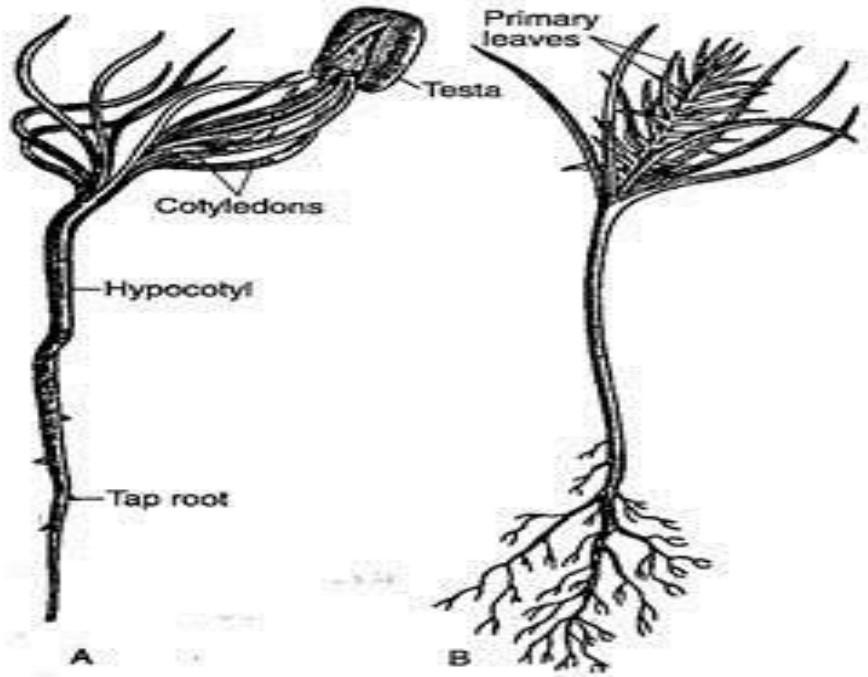
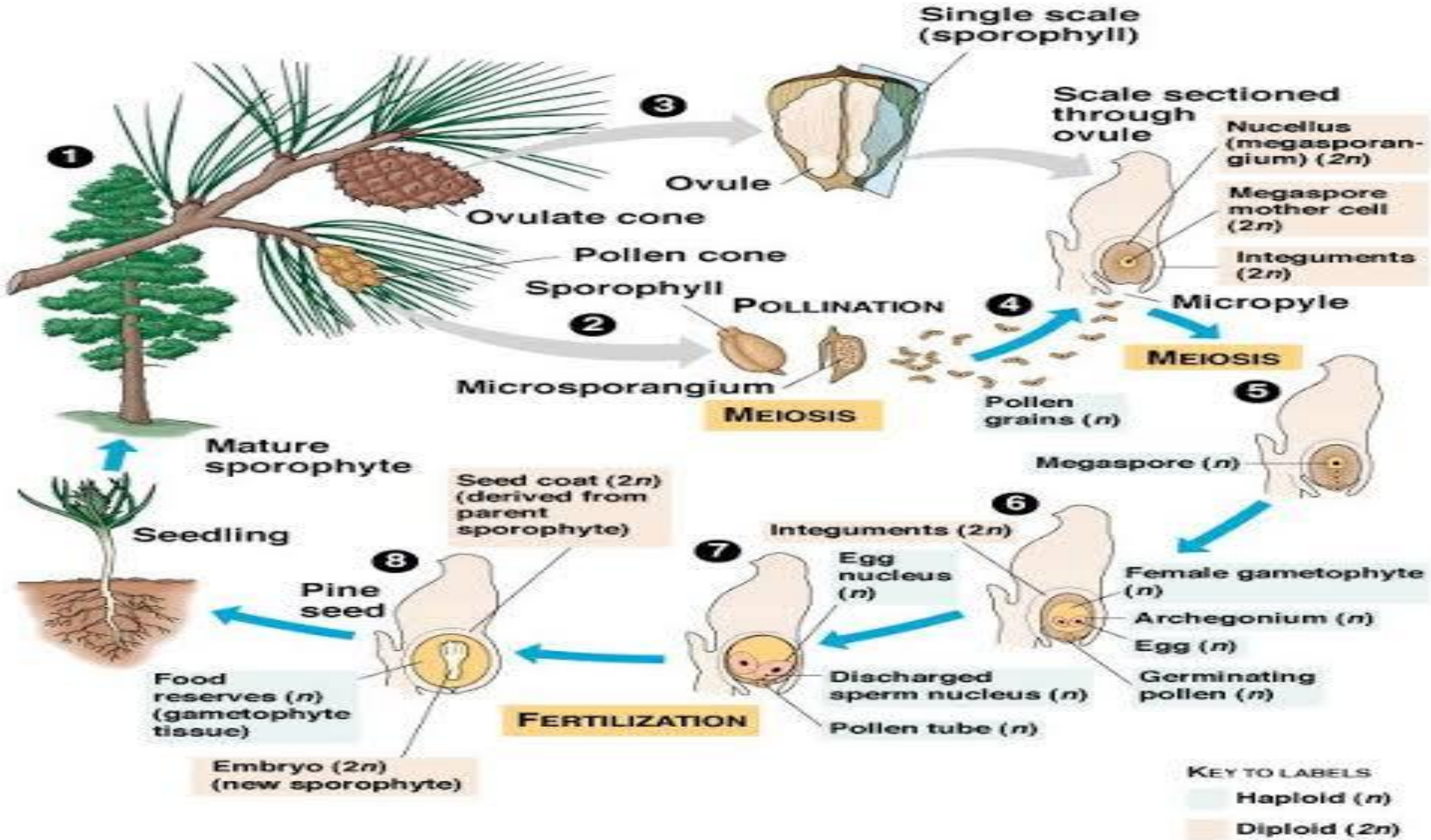


Fig. 1.69 : A–B. The stages in germination of seed



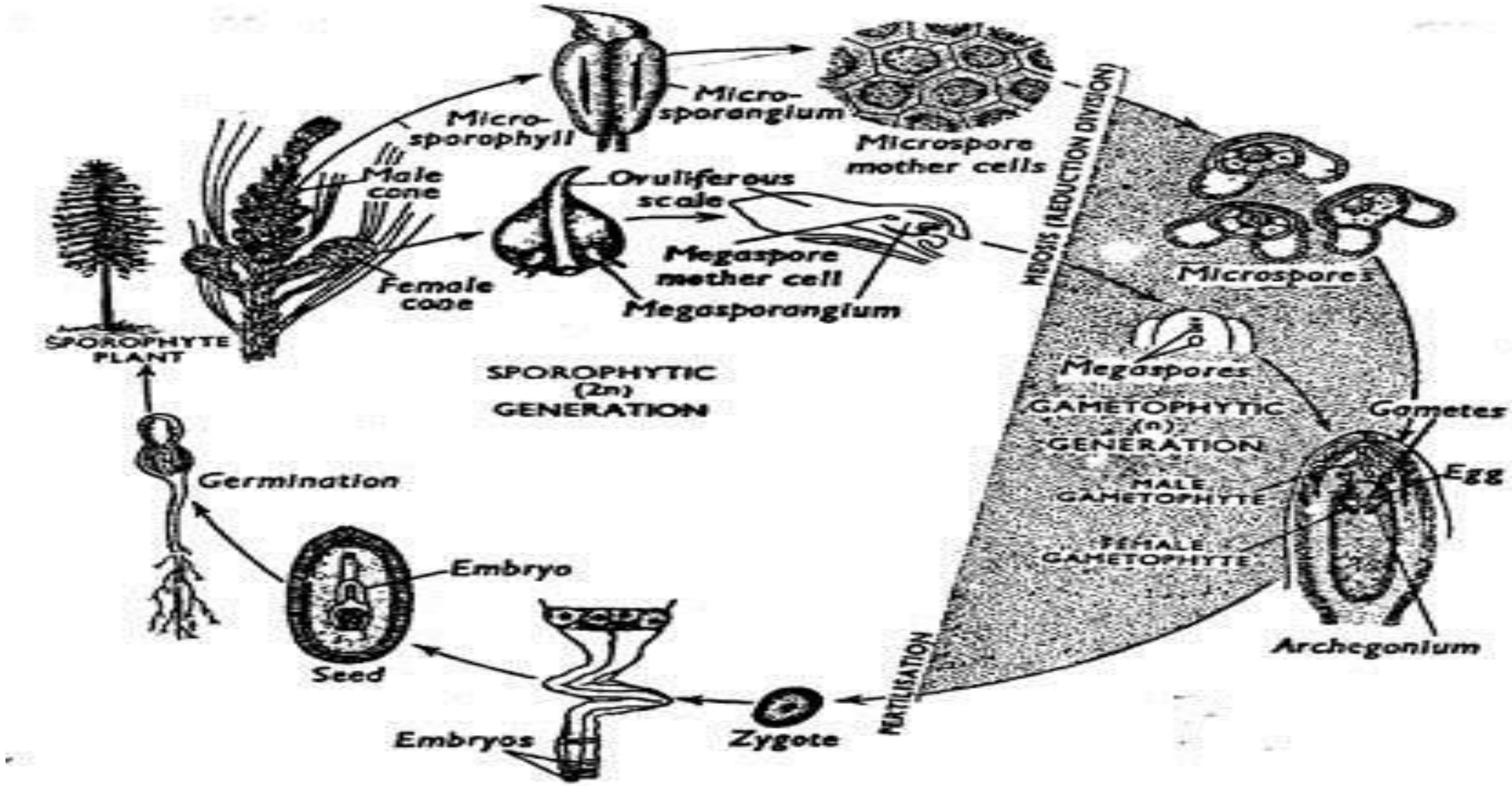


Fig. 1.70 : Life cycle of *Pinus*

THE END