11. Cycas

Division - *Cycadophyta*
Class - *Cycadopsida*
Order - *Cycadales*
Family - *Cycadaceae*
Genus - *Cycas*

Cycas is a *gymnosperm*. It belongs to the order *Cycadales*.

The plants are confined to the *tropical* and *sub-tropical* regions of the world. *Cycas* plants are found abundantly in *Australia*. *Cycas revoluta* the *'Sago palm'* of *China* and *Japan* is the most cultivated species all over the world. *Cycas* has *20 species*. In India the genus is represented by six species.

Cycas circinalis
Cycas pectinata
Cycas beddomei

Cycas media is the tallest species, which grows upto 20 feet in height.

Cycas is a *palm-like* plant. It is an *evergreen* plant. The plant is a diploid *sporophyte*. The plant body consist of *root* *stem* and *leaves*.

The *roots* are of two types, the normal *tap-roots* forming a tap-root system and *coralloid* roots. The tap roots are positively *geotropic* and they have *root hairs*. These roots *fix* the plant in the soil and *absorb* water and minerals. From the normal roots develop some lateral branches that bear vertical, *negatively geotropic* roots. These roots are repeatedly *dichotomously branched* and *coral-like*. So they are called *coralloid* roots. These roots get infected with *blue green algae* like *nostoc* and *anabaena*.

2m

diplocycus?

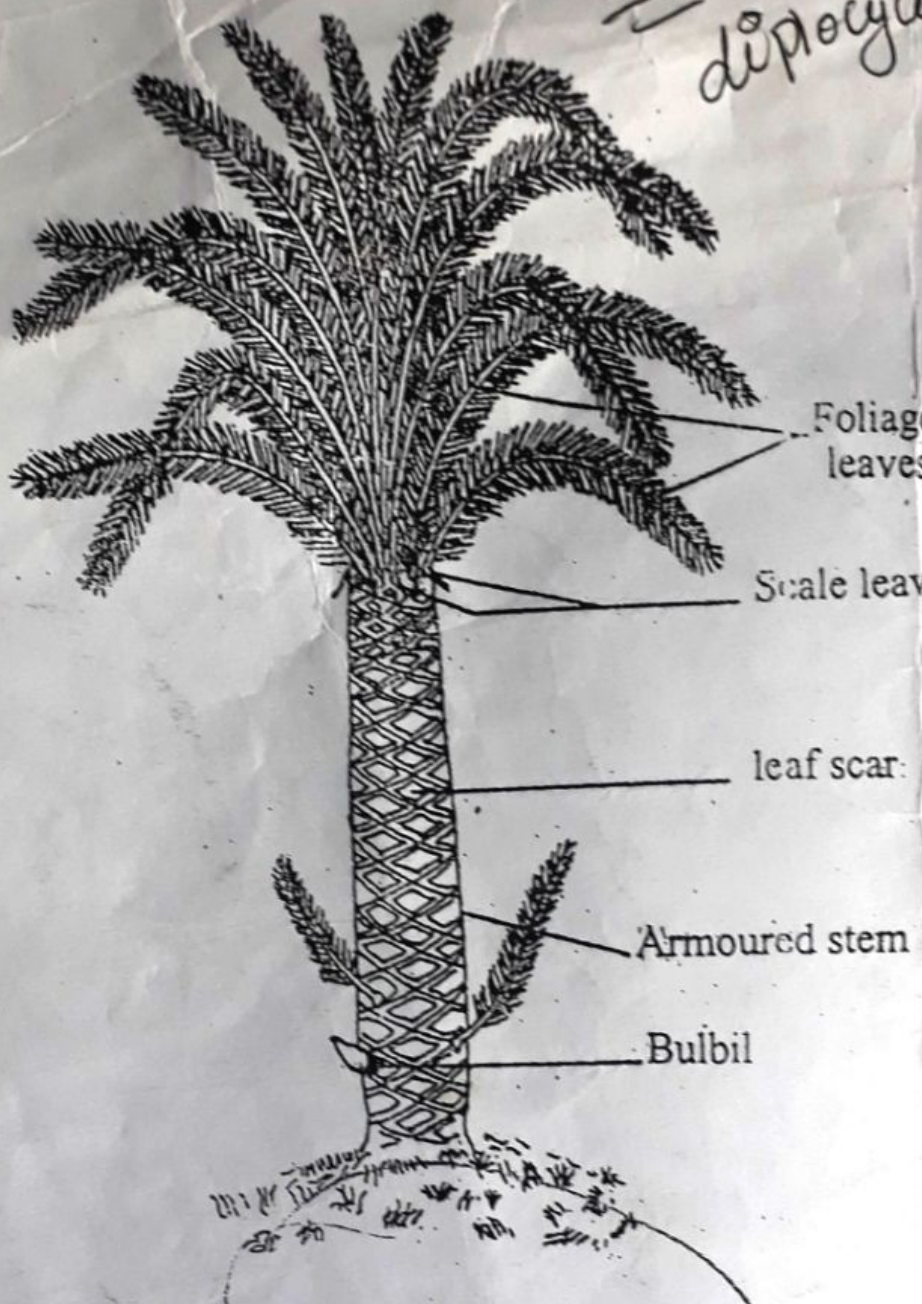


Fig. 11. 1. Cycas - Plant.

The *stem* is *thick, woody* and *unbranched.* The young stem is *tuberous* while mature stem is *columnar, erect* and *stout.* It is covered with persistent *leaf bases.* The stem bears a terminal group of *leaves.*

The *leaves* are *dimorphic.* i.e. the leaves are of two types namely *foliage leaves* and *scale leaves.*

The *foliage leaves* are *green* large *pinnately compound* with a spiny *petiole.* The leaves are *spirally arranged.* Each leaf consists a *rachis* and 80-100 pairs of *pinnae* or *leaflets.* The

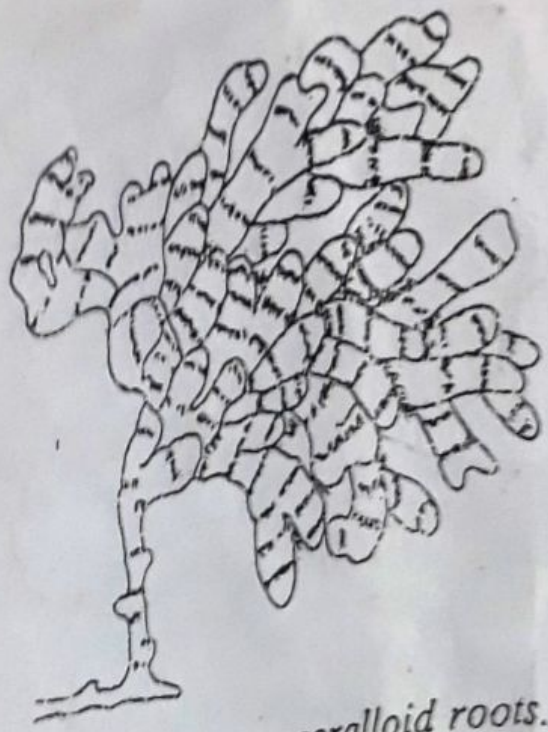


Fig. 11.-2 : Cycas: coralloid roots.

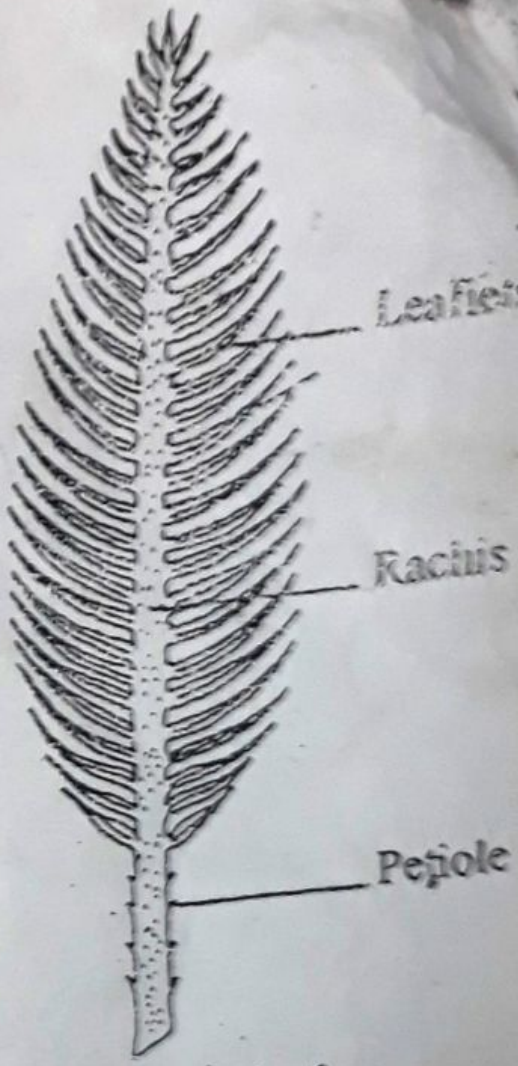
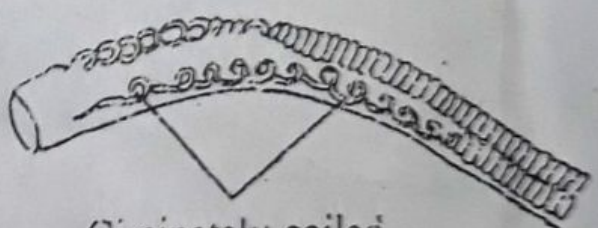


Fig. 11.3: Cycas - A single foliage leaf.

Each pinna is tough, leathery and entire with a definite midrib but no lateral veins. Leaves, when young have circinately coiled pinnae which are covered with *ramenta* (hairs).



Circinately coiled leaflets

Fig. 11.4: Cycas - A young leaf showing circinate vernation.

Fig. 11. 5. Cycas - A scale leaf

Scale leaves are also known as *cataphylls.* These are dry, small, *brown* coloured triangular leaves and are covered with *hairs.* These scale leaves are present at the apex of the stem and young developing foliage leaves. Scales are also persistent like leaf bases.

The *Cycas* plant grows very *slowly,* but live for ages. *Cycas circinnalis* can survive for a long period of *100 years.*

Cycas is *dioecious.* ie, there is separate male and female plants. The female plants are common but male plants are rare. The reproductive structures are produced as *cones.*

Internal Structure of Root

Normal Root:

The transverse section of young root is *circular* in outline and it resembles with *dicotyledons* in structure. It is differentiated into *epiblema, cortex, pericycle* and *vascular stele.*

Epiblema: The outermost layer is *epiblema* and it is *single layered.* It is composed of thin-walled cells. *Root hairs* are given out from some of these cells.

Cortex: The cortex is *multilayered* and *parenchymatous.* The cells are filled with *starch.* Some *tannin-filled* cells *mucilage cells* and *sphaeraphides* are also present in the cortex. The *innermost* layer of cortex is *endodermis.* It is *single layered* and it shows *casparian strips.*

Pericycle: The endodermis, is followed by a multilayered *pericycle.*

Vascular Stele: The vascular *stele* consists of radial vascular bundles. *Xylem* and *phloem* bundles alternate each other. The root is *diarch* with two protoxylem groups. The xylem is *exarch.* The protoxylem consists of *spiral tracheids* and the metaxylem consists of *scalariform* tracheids. *Xylem vessels* are *absent. Phloem* consists of *sieve tubes* and *phloem parenchyma. Companion* cells are absent.

Pith is *absent.*

The T.S. of *old root* shows *secondary* growth as in *dicots.* The *epiblema* gets ruptured. Some of the cells of the outermost

cortical region become *meristematic* and function as *cork cambium*. It produces *cork* towards outerside and *secondary cortex* towards innerside. *Cork* cells are dead and full of suberin. The *endodermis* is single layered and is followed by many layered *pericycle*. The *pericycle* cells become *meristematic* and form a complete *cambial ring*. It produces *secondary phloem* towards the outerside and *secondary xylem* towards the innerside. The primary phloem gets crushed. *Medullary rays* are formed. In the centre a small parenchymatous *pith* is present.

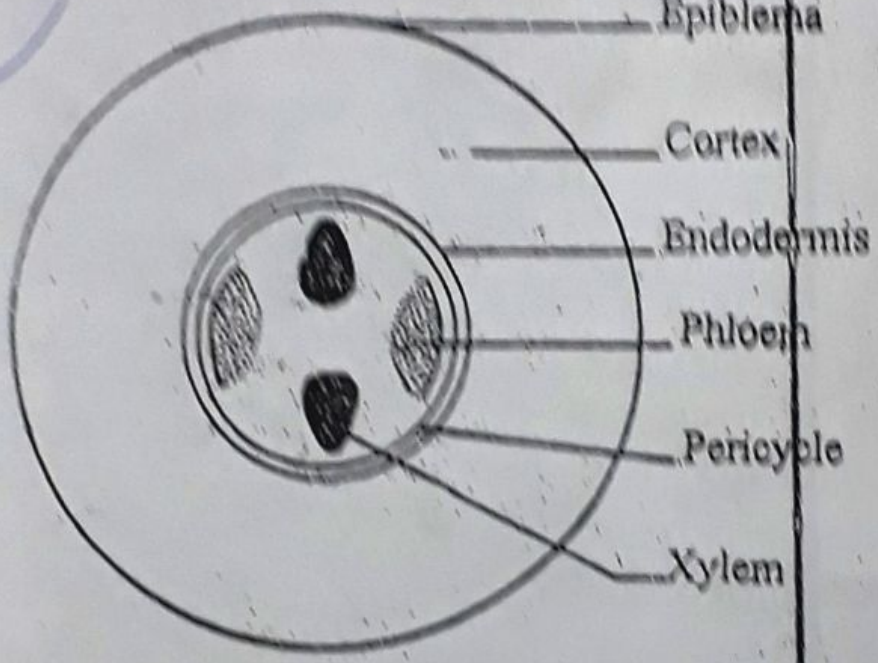


Fig. 11.6 Cycas - T.S. of normal young root outline (diagrammatic).

Coralloid Root:

The T.S. of *coralloid* root is almost similar to that of normal root. It is differentiated into *epiblema, cortex, pericycle, vascular stele* and *pith*.

The *epiblema* is the outermost layer. It is single layered.

Cortex is *multilayered* and *parenchymatous*. The cortex is divided into an outer cortex, a middle cortex with *algal zone*

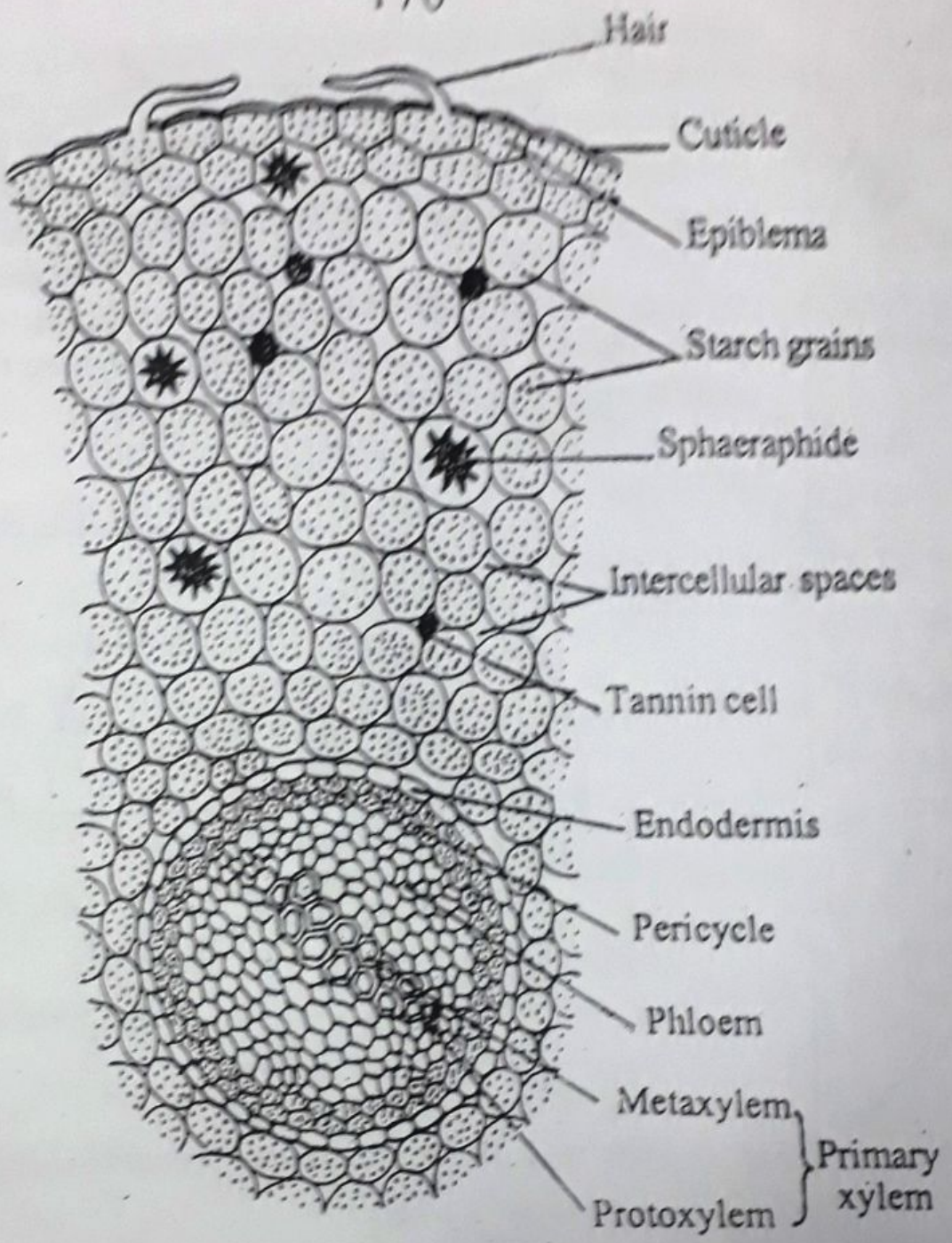


Fig. 11.7 Cycas revoluta - Transverse Section showing details of primary root. (diarch)

and inner cortex. Algal zone has ***radially*** elongated cells in the middle of the cortex in which blue green alga *Anabaena* is present.

Endodermis is the innermost layer of cortex and it is followed by many layered ***pericycle.***

Vascular stele consists of ***radial,*** vascular bundles. Xylem is ***triarch*** and ***exarch.*** Secondary growth is generally absent.

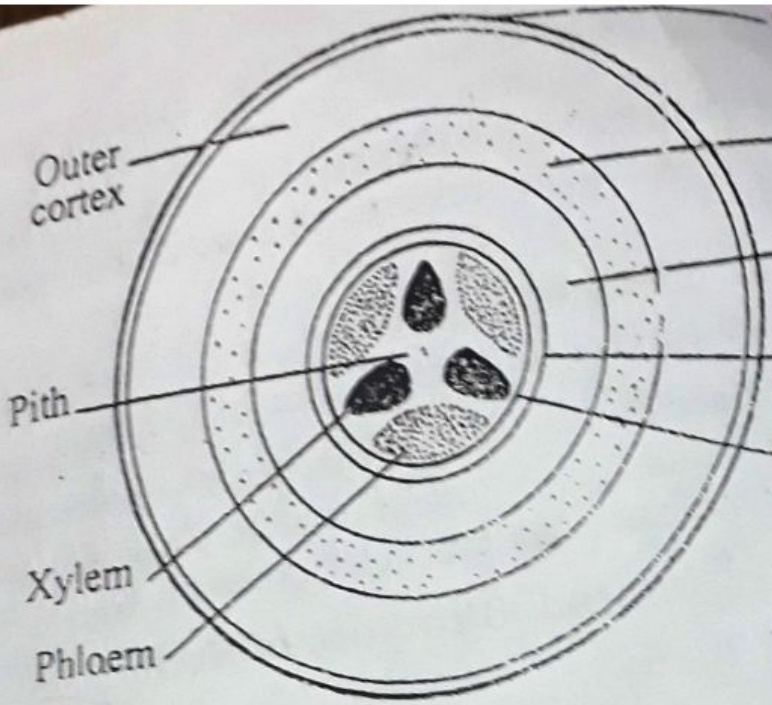
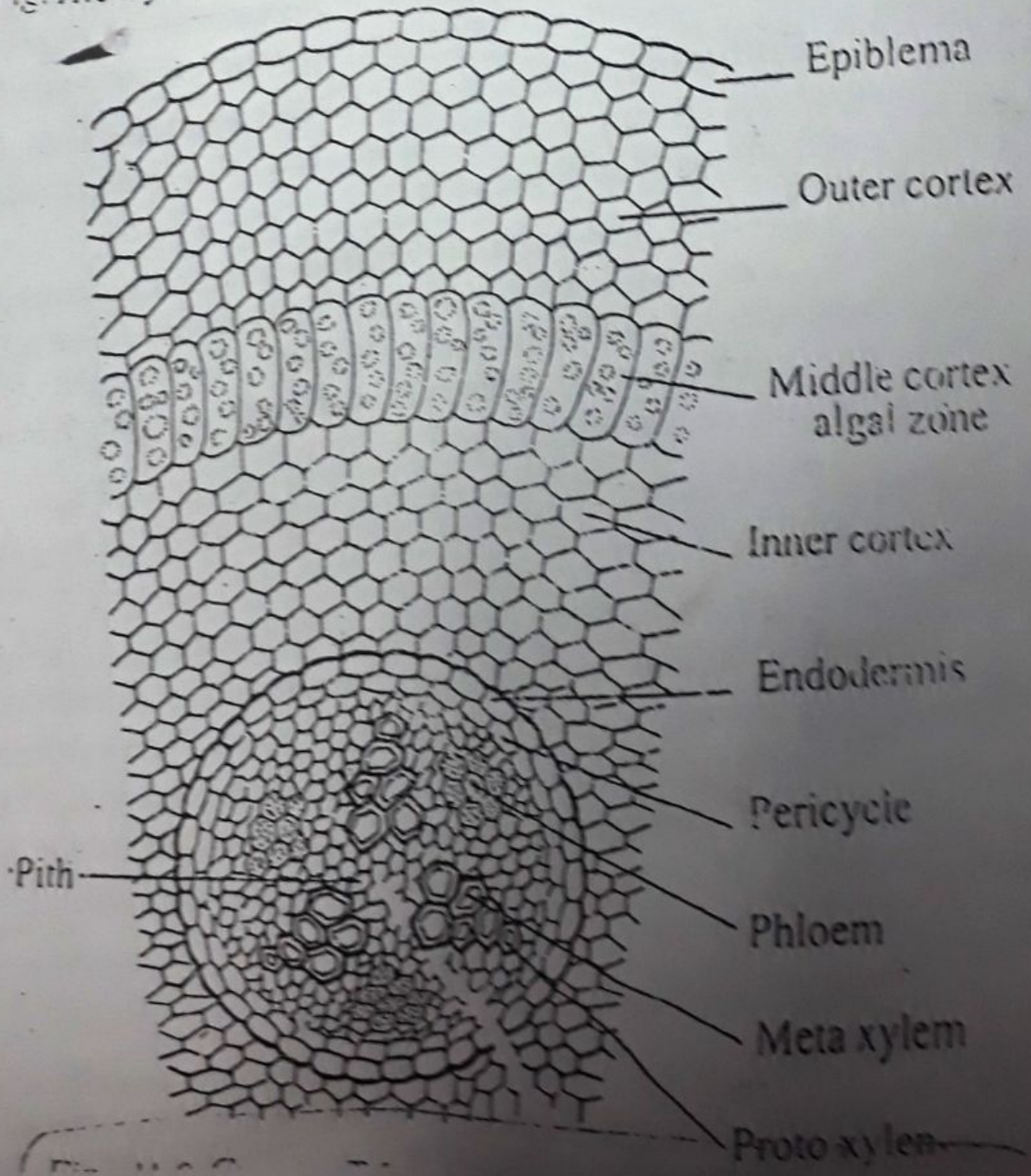


Fig. 11.8: Cycas - T.S. of coralloid root outline (diagrammatic).



Internal Structure of Stem

The *T.S. of stem* is irregular in outline, due to the presence of numerous persistent leaf bases. It consists of ***epidermis, cortex, pericycle, vascular tissue*** and ***pith.***

Epidermis is the outermost layer. It is single layered.

Cortex consists of thin-walled ***parenchymatous cells*** which are filled with ***starch grains.*** Many ***leaf traces*** are present in the cortex. The cortex contains ***mucilage ducts.*** Starch present in the parenchymatous cells of the cortex is the source of ***'sago'.***

Endodermis is single layered and the ***pericycle*** is few layered.

Vascular tissue is composed of many ***vascular bundles*** arranged in a ***ring.*** The bundles are ***conjoint, collateral, endarch*** and ***open.*** The stele is ***ectophloic siphonostele.*** Xylem consists of ***tracheids*** and xylem ***parenchyma. Xylem vessels*** are ***absent.*** Phloem consists of ***sieve tubes,*** phloem ***parenchyma*** and phloem ***fibres. Companion*** cells are ***absent.***

The primary ***cambium*** between the xylem and phloem remains ***active*** only for a ***short period.***

The young stem is ***monoxylic.*** ie. with one ring of vascular bundles only.

There is a ***large pith*** in the centre, made up of parenchymatous cells.

T.S. of ***old stem*** shows ***secondary growth.*** The young stem of *Cycas* is ~~*monoxylic.*~~ ie. ~~it contains a single ring of vascular bundles~~. But in the old stem new cambial rings are produced outside the primary ring. Thus the old stem is ***polycylic.*** ie. with more than one vascuar rings. These ***cambinal rings*** cut ***secondary phloem*** towards outerside and ***secondary xylem*** towards inside. The secondary wood is loose, soft and scanty. ie. ***monoxylic.*** ~~*Medullary*~~ ***rays*** are present.

The ***cork cambium*** develops on the outer region of cortex. The cambium produces ***cork tissue*** towards outerside and ***secondary cortex*** towards the innerside.

A large ***pith*** lies in the centre. The pith cells are parenchymatous and ***starch filled.*** There are many ***mucilage*** ducts in the pith.

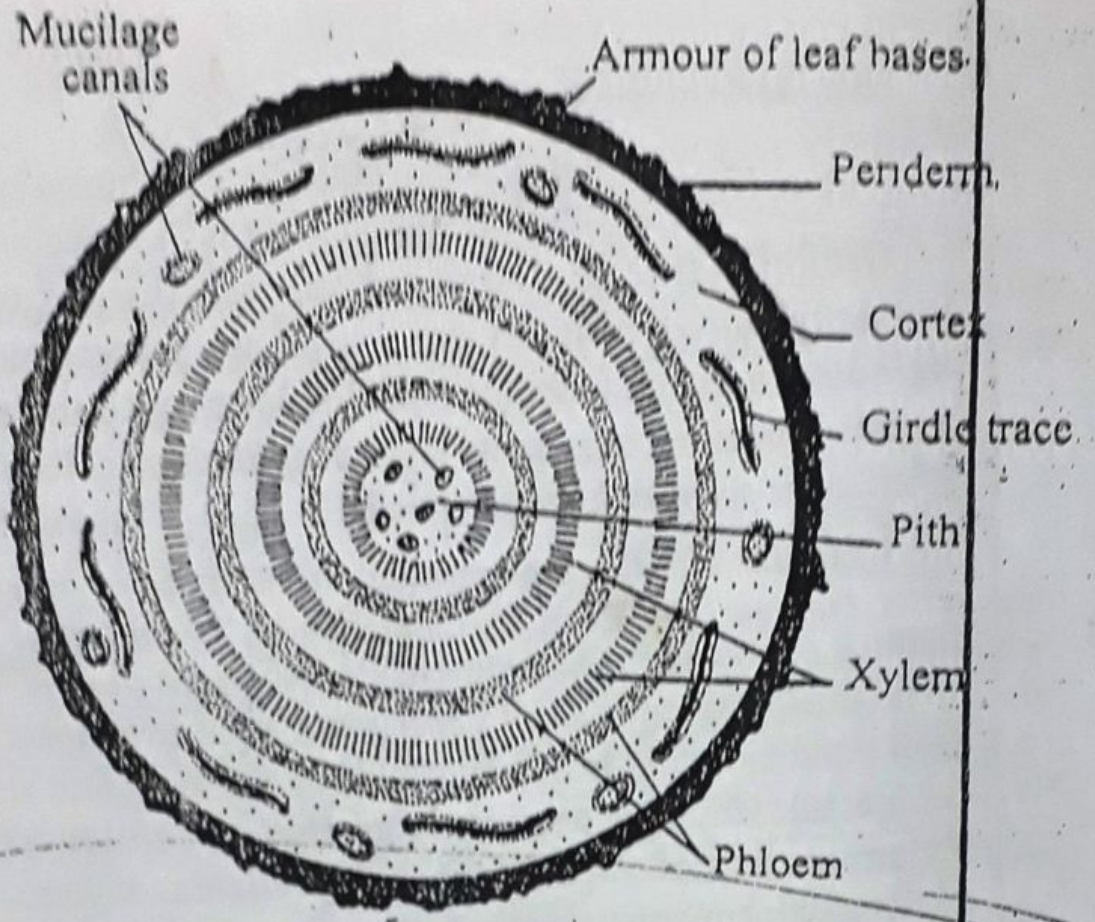


Fig. 11.10. Cycas - Diagrammatic representation of T.S. of old stem.

Internal Structure of Leaf

The *Cycas* leaf is pinnately compound. Each leaf has a *rachis* and *leaflets.*

The *T.S. of rachis* of *leaf* is cylindrical in outline showing insertion of *pinnae* or leaflets on the upper side.

It is differentiated into *epidermis, hypodermis, ground tissue* and a ring of *vascular bundles.*

Epidermis is single layered, thickly *cuticularized,* and is interrupted by *sunken stomata* throughout its surface. This condition is known as *amphistomatic.*

Hypodermis is present below the epidermis. It is composed of mainly thick walled *sclerenchymatous cells* with *chlorenchyma cells*. The sclerenchymatous hypodermis is 2-3 layered.

Ground tissue is a large region, consisting of thin-walled *parenchymatous cells*. In this region are present many *mucilaginous ducts* and *vascular bundles*. Mucilage ducts are double-layered, consisting of an inner layer of *epithelium* cells, surrounded by an outer *sclerenchymatous* cells.

Vascular bundles are arranged in the shape of inverted greek letter *Omega* (Ω). Each vascular bundle is *collateral* and *open* and it is surrounded by a single layered *bundle sheath*. The *xylem* is *diploxylic*, ie. consists of *centripetal* and *centrifugal* xylem. In each bundle, xylem is present towards the innerside and phloem is outerside. In between xylem and phloem *cambium* is present. Xylem consists of *tracheids* and *parenchyma*. *Xylem vessels* are *absent*. Phloem consists of *sieve tubes* and phloem parenchyma. *Companion cells* are *absent*.

The vascular bundles show different structures at different levels of rachis starting from base to the apex.

At the very *base*, only the *centrifugal xylem* is well developed. Xylem is *endarch*. *Centripetal* xylem is not developed.

In the middle, *centripetal* as well as *centrifugal* xylem are present showing *diploxylic* condition.

At the apex, *centripetal* xylem is well developed, triangular and *exarch*. *Centrifugal xylem* is much *reduced*.

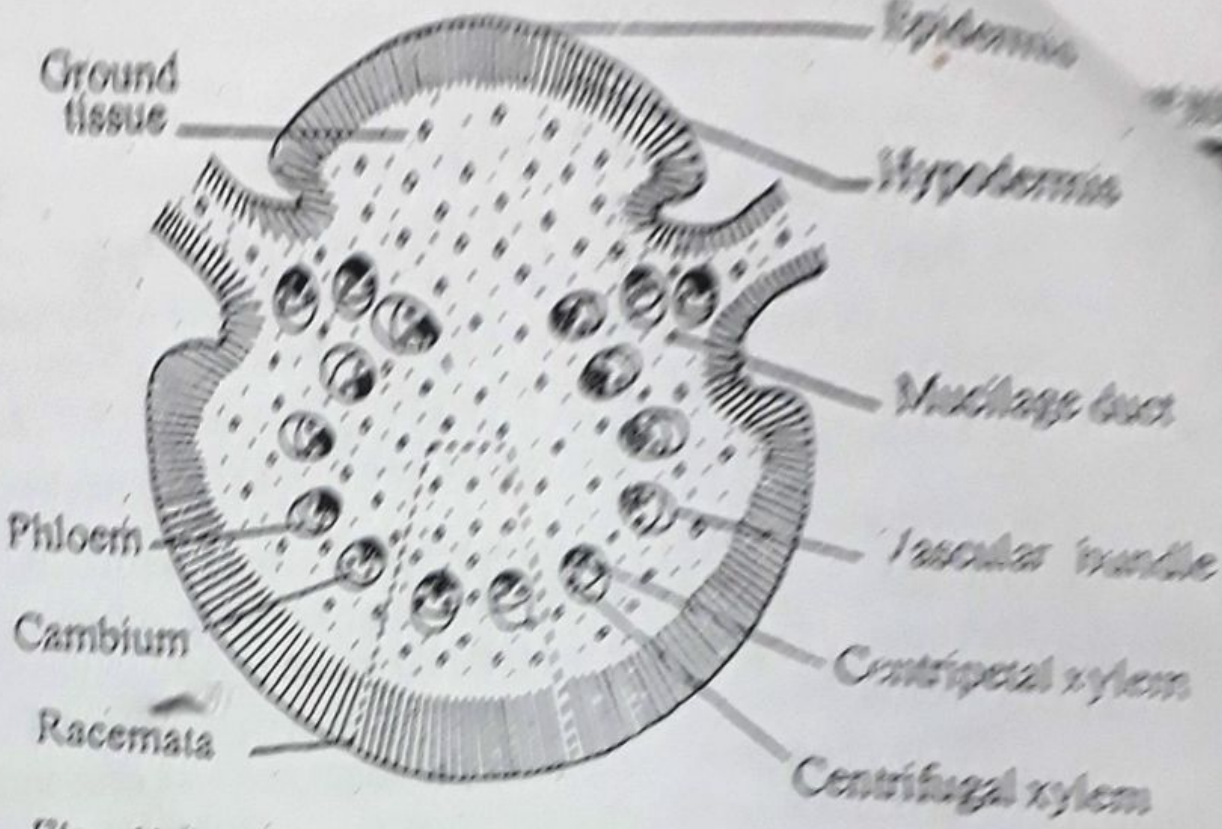
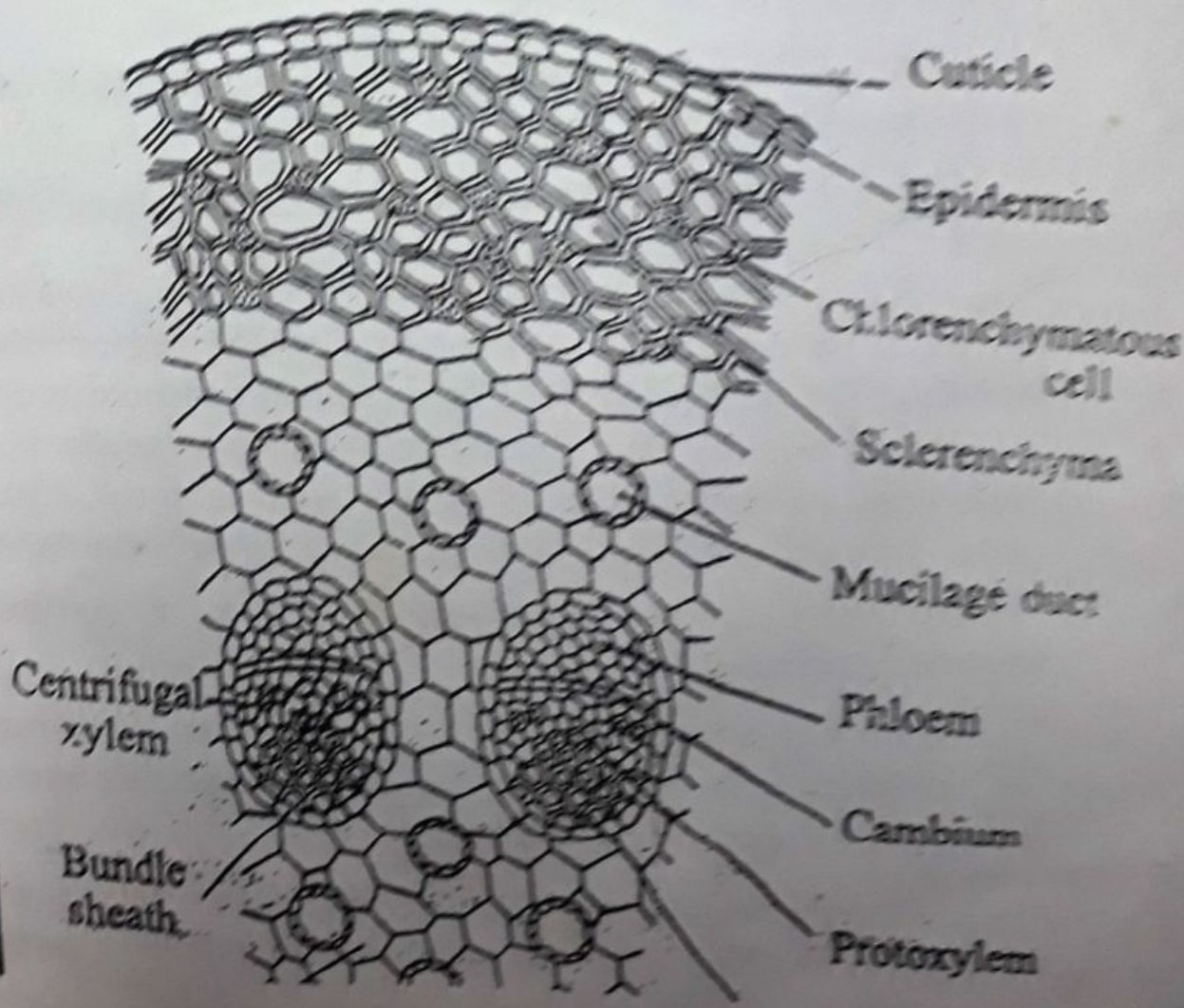


Fig. 11.11: Cycas. T.S. of rachis outline (diagrammatic).



Special features

1. Presence of sclerenchymatous *hypodermis* with chlorenchyma.
2. Presence of *sunken stomata* all over the surface.
3. Vascular bundles arranged in *inverted Omega* (Ω) shaped arc.
4. *Diploxylic* nature of vascular bundles.
5. Presence of *mucilage ducts.*

Internal structure of Leaf let

The Cycas *leaflets* are large, tough, thick and *leathery.* They are also known as *pinnae.*

In a vertical section, the leaflet is differentiated into a swollen *mid-rib* portion and two *lateral wings.* The wings are curved downward as in *C. revoluta* or flat as in *C. pectinata.*

It is differentiated into *epidermis, hypodermis, mesophyll tissue, transfusion tissue* and *vascular tissue.*

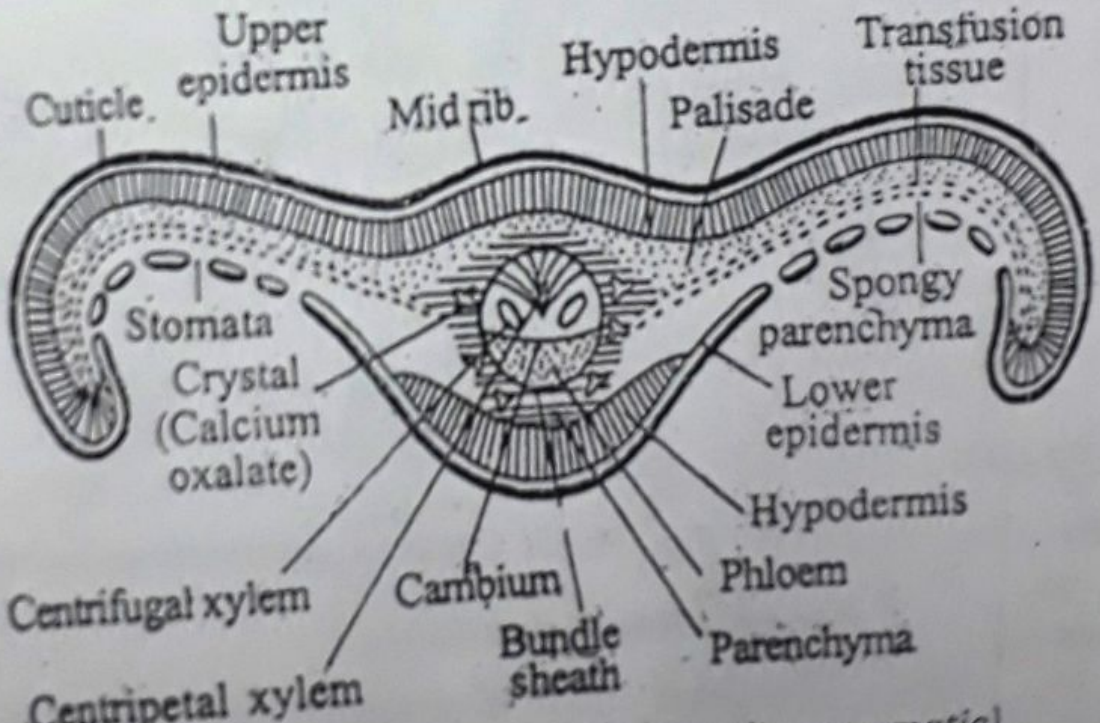


Fig. 11.13: Cycas - T. S. of leaflet (diagrammatic).

Upper *epidermis* is single layered and is thickly *cuticularized.*

Hypodermis is present below the epidermis. It is *sclerenchy-*

Hypodermis is absent below the lower epidermis except

Mesophyll lies below the hypodermis and is well developed. It is differentiated into upper ***palisade*** and lower ***spongy parenchyma.*** Palisade cells are radially elongated and filled with chloroplasts. ***Spongy*** parenchyma cells are loosely arranged with intercellular spaces. The cells are oval and filled with chloroplasts. ***Palisade*** is present both in the midrib and wings below the hypodermis. ***Spongy parenchyma*** is present only in the ***wings*** directly above the lower epidermis.

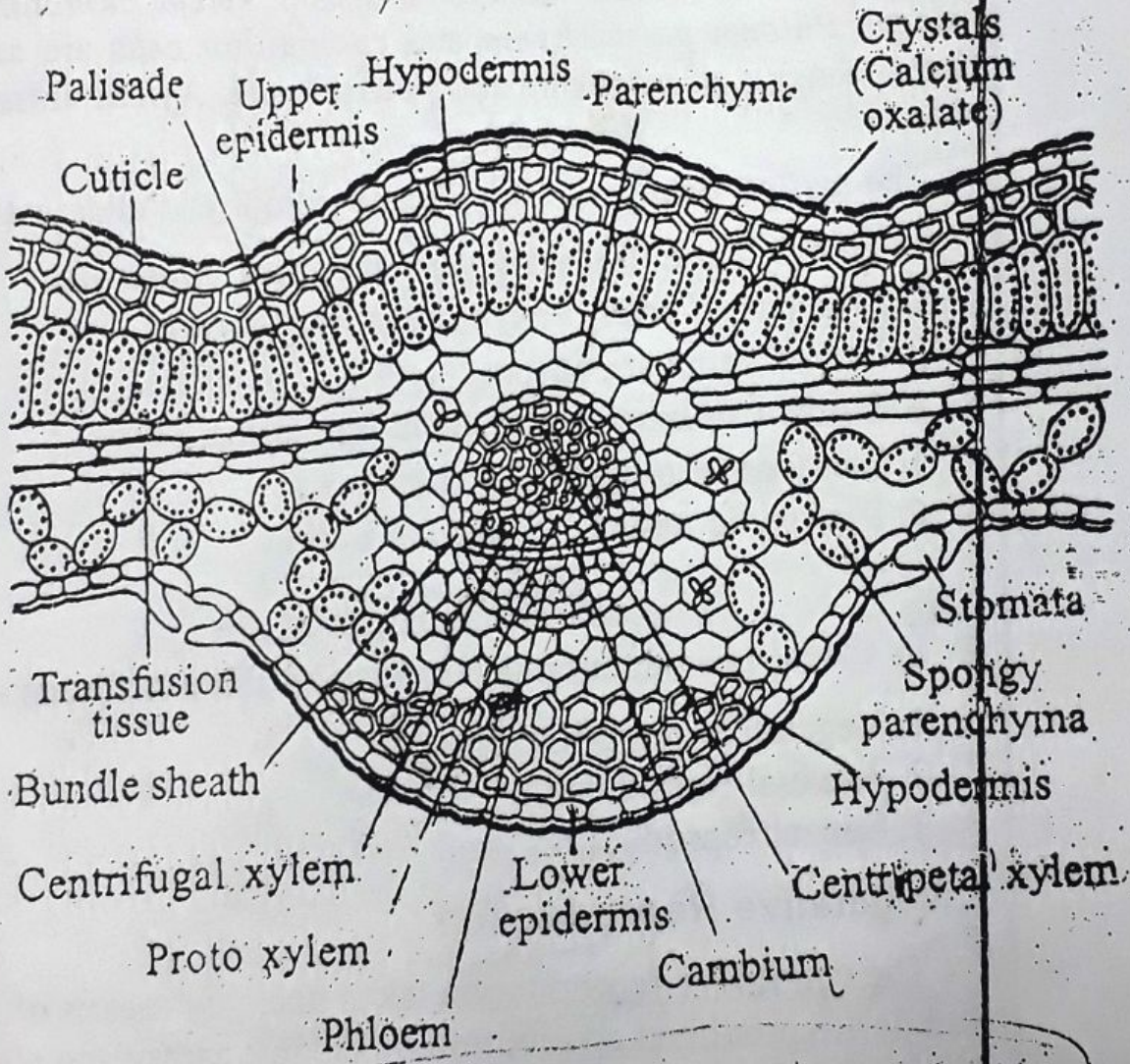


Fig. 11.14. Cycas - T.S. of leaflet (A part cellular)

2m

The ***transfusion tissue*** lies between palisade tissue and the lower spongy parenchyma. It is 3 to 5 celled thick. Cells are long and ***colourless.*** It runs transversely from the midrib to the margins in the wings. 2m

The *lower epidermis* is single layered. Stomata are sunken.

In the midrib region lies a *single vascular bundle.* It is surrounded by *parenchymatous tissue* with *calcium oxalate crystals.*

The vascular bundle is *conjoint, collateral, open* and *diploxylic.* It shows a large, triangular patch of centripetal *xylem* and two small groups of *centrifugal xylem,* one on each side of the centripetal protoxylem. The vascular bundle consists of *xylem, cambium* and *phloem. Phloem parenchyma* and *companion cells* are *absent.* Xylem consists of *tracheids* and *parenchyma. Xylem vessels* are absent.

The *leaflets* or *pinnae* show some xerophytic characters.

1. Thickly cuticularized *upper* and *lower epidermis.*
2. Presence of *sclerenchymatous hypodermis.*
3. Lateral veins are absent.
4. *Sunken stomata* in the lower epidermis.
5. Presence of *transfusion tissue.*
6. Diploxylic nature of vascular bundle.

Reproduction

In *Cycas*, reproduction takes place by three methods:-

1. Vegetative reproduction
2. Asexual reproduction
3. Sexual reproduction

1. Vegetative Reproduction

The vegetative reproduction takes place by means of *bulbils.* Bulbils are produced adventitiously on any part of the plant. The bulbils develop from the axil of the *scale leaves.* It is usually produced in the *crevices* between the persistant leaf bases. It germinates under favourable conditions and produces new plant after falling on the soil.

A bulbil from male plant will develop only into male plant while that from the female plant will develop only female plant.

In *Cycas circinalis, Swamy* (1948) has reported the production of new plants from *suckers.* The suckers are produced from

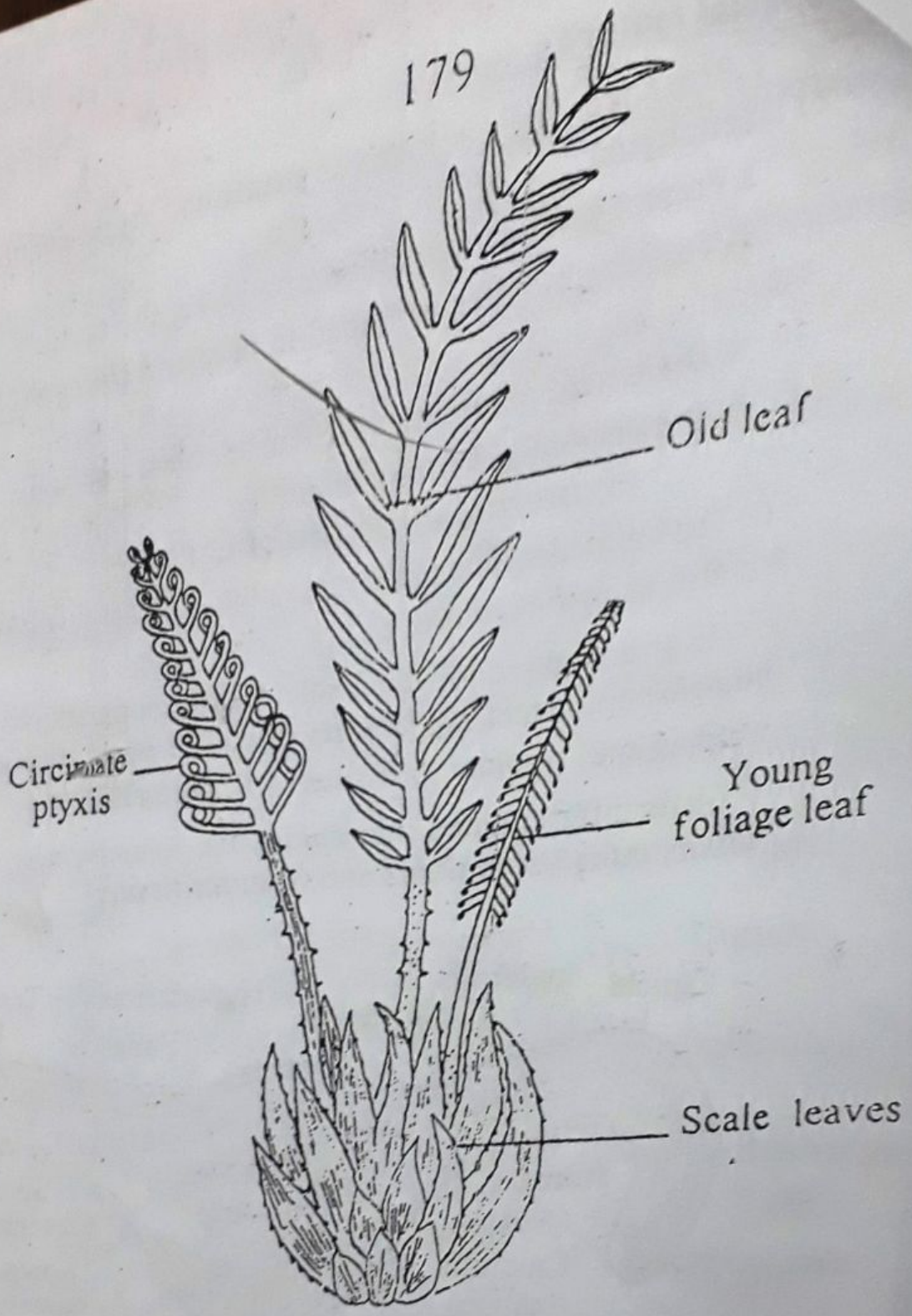


Fig. 11.15: Cycas. A germinating bulbil.

2. ~~Asexual~~ Sexual Reproduction

The *Cycas* plant is a diploid *sporophyte*. It reproduces ~~*asexually*~~ by *spores*. ~~Spores are produced in the cones.~~

Cycas is *dioecious*. ie. there are separate male and female plants. The female plants are very common but male plants are very rare.

The reproductive parts are in the form of *cones* or *strobili*. The cones are terminally produced upon the *main stem*.

Male cone: The male cone is the male reproductive organ. It is produced by the male plant. It is terminal, stalked, large and *conical* in shape. It consists of a central *cone axis* and numerous *microsporophylls*. The microsporophylls are spirally arranged around the cone axis. The microsporophylls are leaf like, woody, wedge-shaped brown coloured structures with narrow base and expanded upper portion. The upper portion is pointed and sterile and it is called *apophysis*. The narrow base is attached to the cone axis with a short stalk.

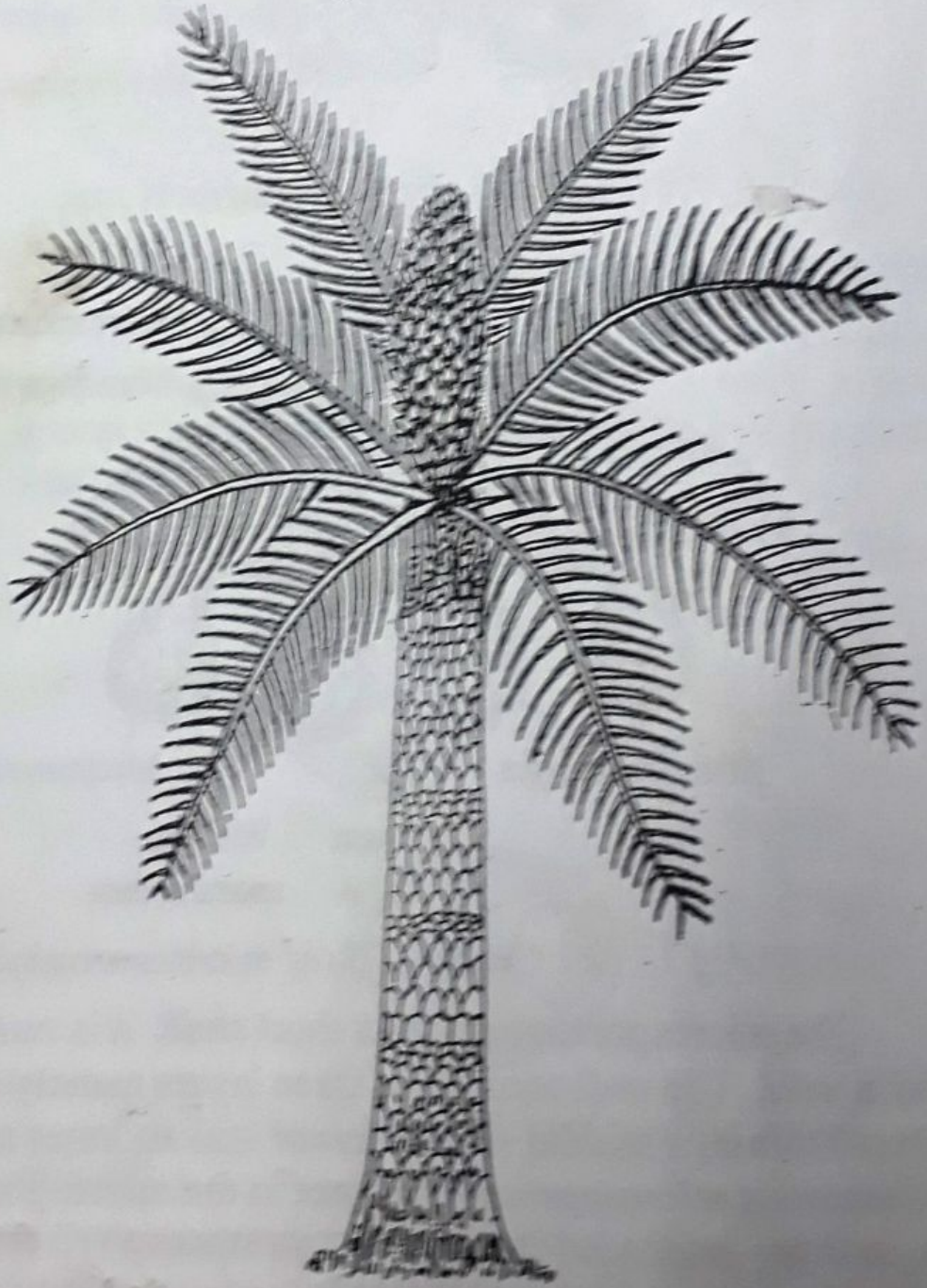


Fig. 11.16: Cycas revoluta. A male plant.

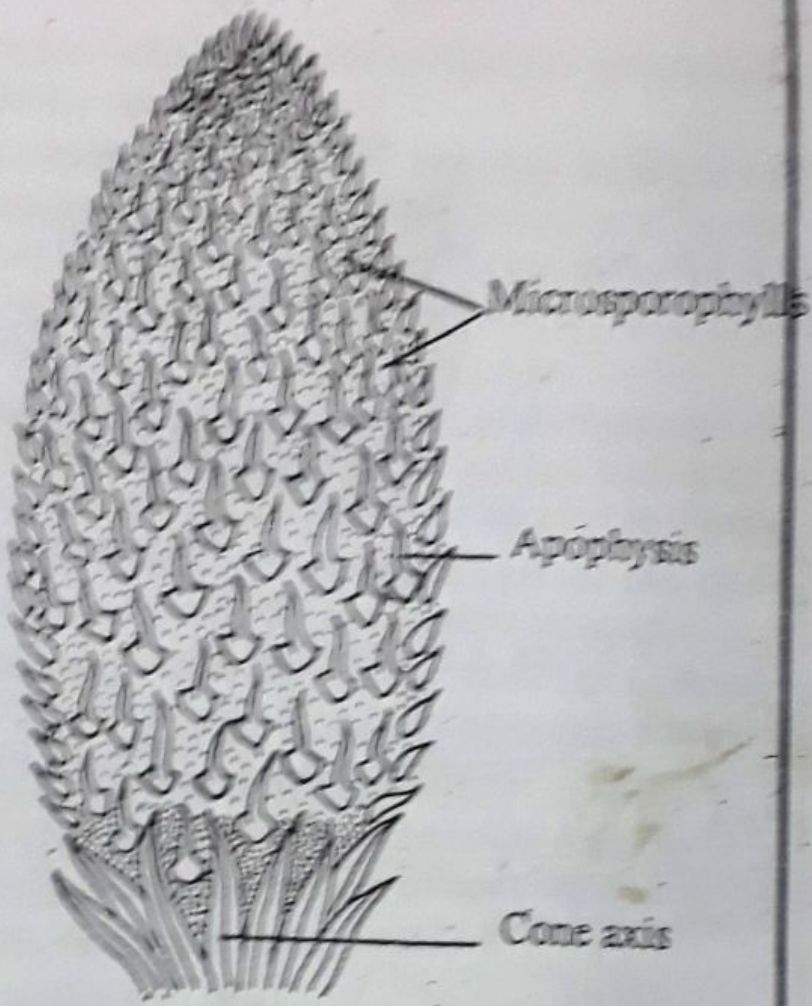


Fig. 11.17 : Cycas. Male cone.

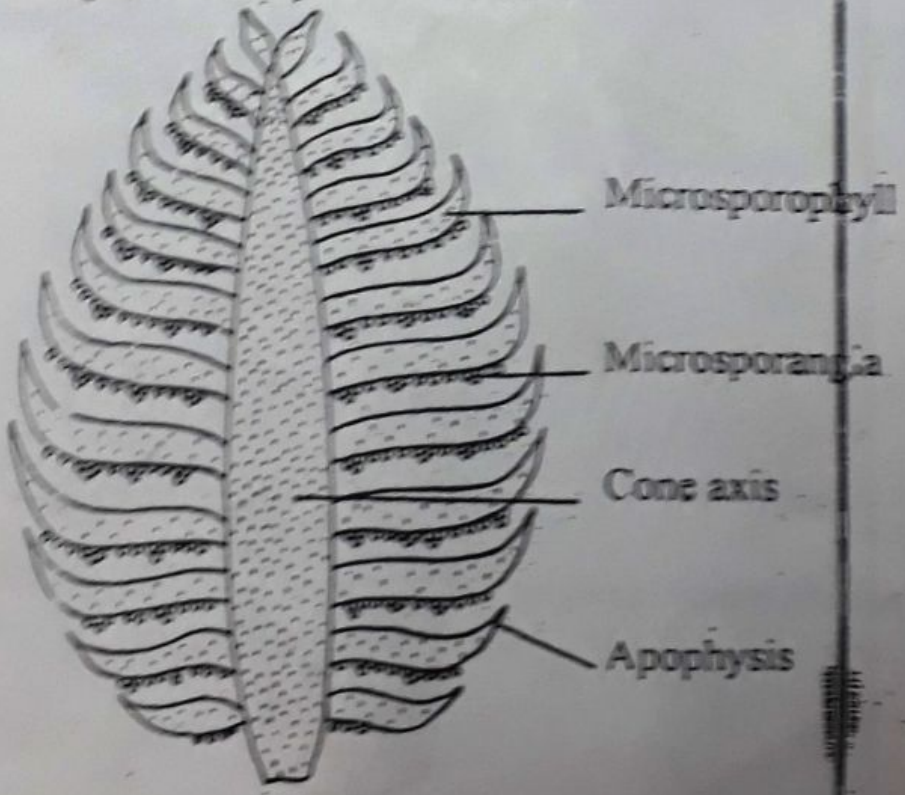


Fig. 11.18: Cycas - L. S. of Male cone.

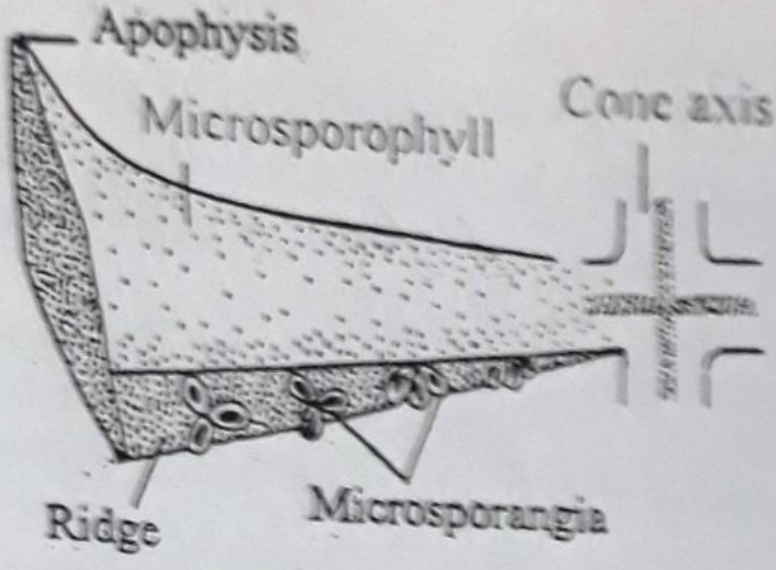


Fig. 11.19 Cycas. L.S. of a single microsporophyll with cone axis.

Each microsporophyll on the lower surface (abaxial) in the middle region bears thousands of *microsporangia* in 3-5 groups. Each group is called a *sorus*. Microsporangia are arranged in sori around a central *papilla*. Sporangia show radial lines of dehiscence. In between these sori are present many *hair-like* structures.

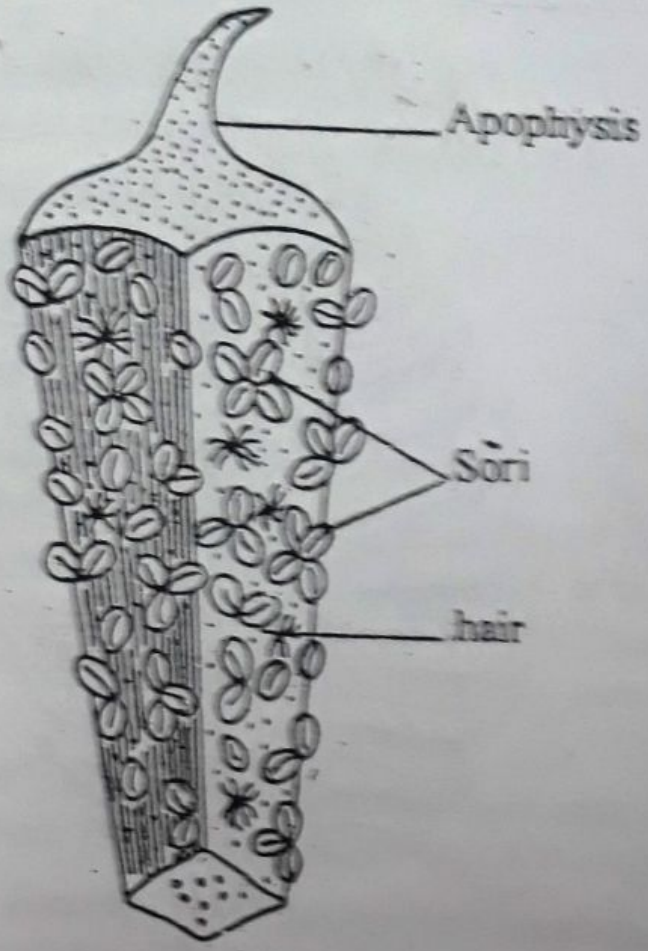


Fig. 11.20. Cycas

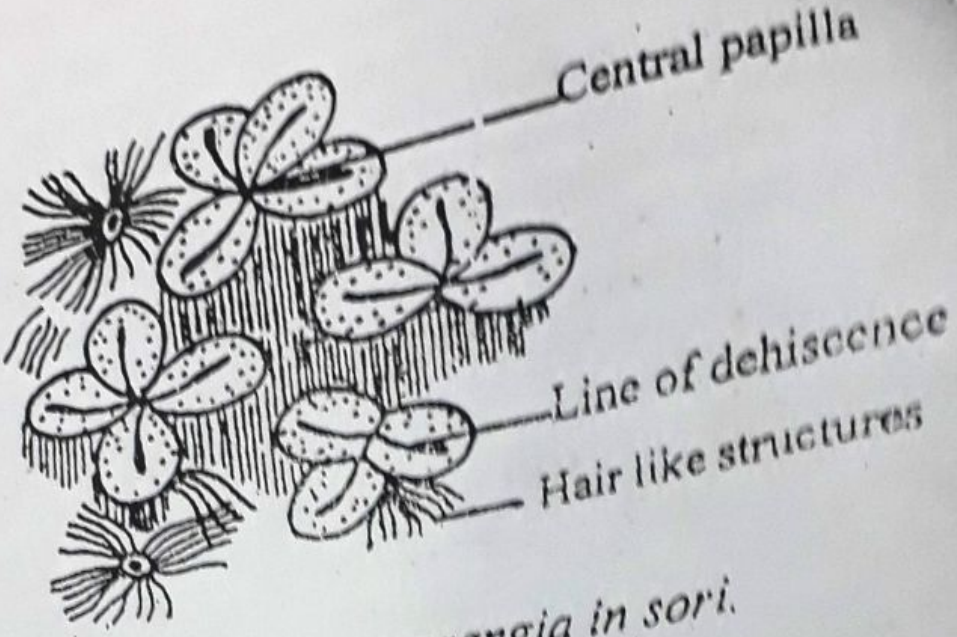


Fig. 11.21: Cycas - Microsporangia in sori.

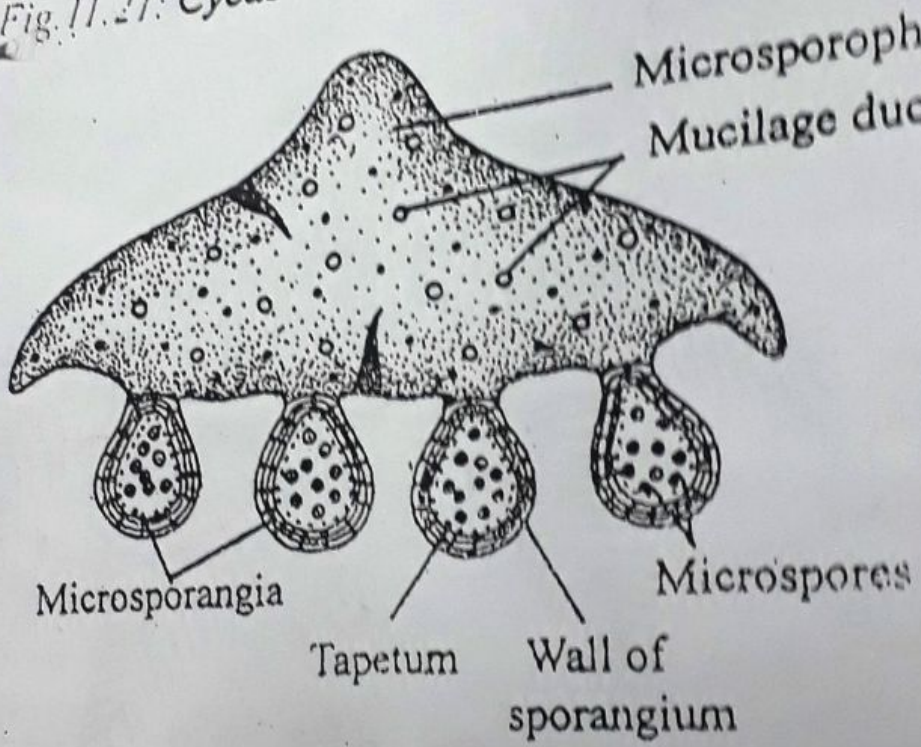


Fig. 11.22: Cycas - T.S. of microsporophyll.

The microsporangium has a short ***stalk***. It is surrounded by a ***wall***. The wall consists of three layers namely an outer ***exothecium***, a middle ***endothecium*** and an inner ***tapetum***. Numerous ***microspores*** are present in the microsporangium. In the expanded region of microsporophyll are present many ***mucilaginous canals*** and ***vascular bundles***.

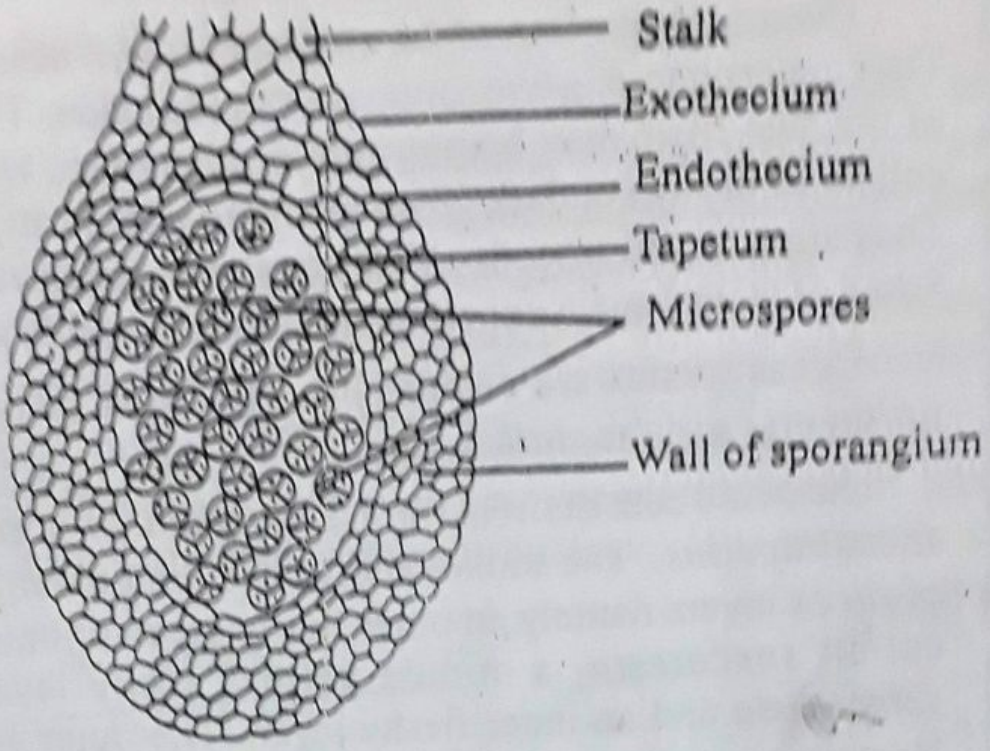


Fig. 11.23: Cycas-Single microsporangium enlarged.

The development of microsporangium is of ***eusporangiate type*** i.e., it develops from a group of ***sporangial initials***. The hypodermal cells of the sporophyll functions as ***sporangial initials***.

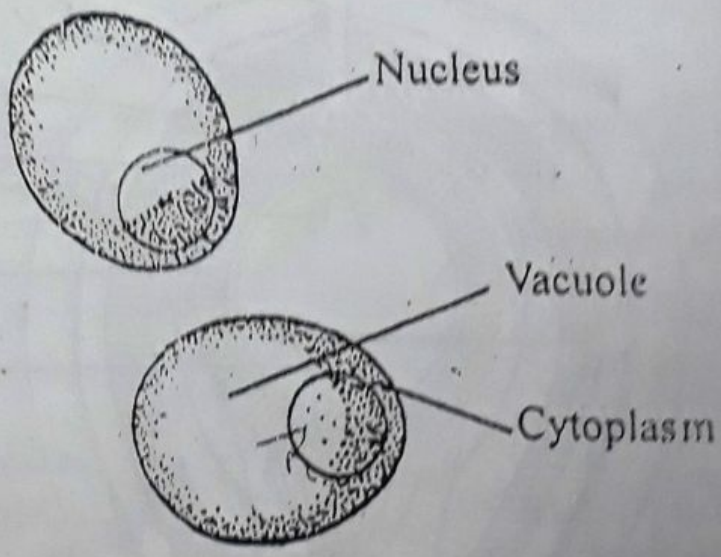


Fig. 11.24: Cycas-Mature pollen grains showing vacuoles.

The sporangial initial divides by a periclinal wall into an outer ***primary wall cell*** and an inner ***archesporial cell***. The

primary wall cell by repeated anticlinal and periclinal divisions produce the *sporangial wall*.

The *archesporial* cell by irregular divisions form the *microspore mother cells*. Each microspore mother cell produces four haploid *microspores* by a *reduction division*. The tapetum provides nourishment to the developing microspores.

At maturity, some of the cells of the sporangial wall at the anterior end become thick walled and large. The sporangium dehisces at this point to liberate the microspores.

The *microspores* or pollengrains are globular, *uninucleate*, *unicellular*, and *haploid* structures.

Each microspore has an outer *exine* and an inner *intine*, *cytoplasm* and a *nucleus*. A large *vacuole* is also present.

Female Reproductive Structures

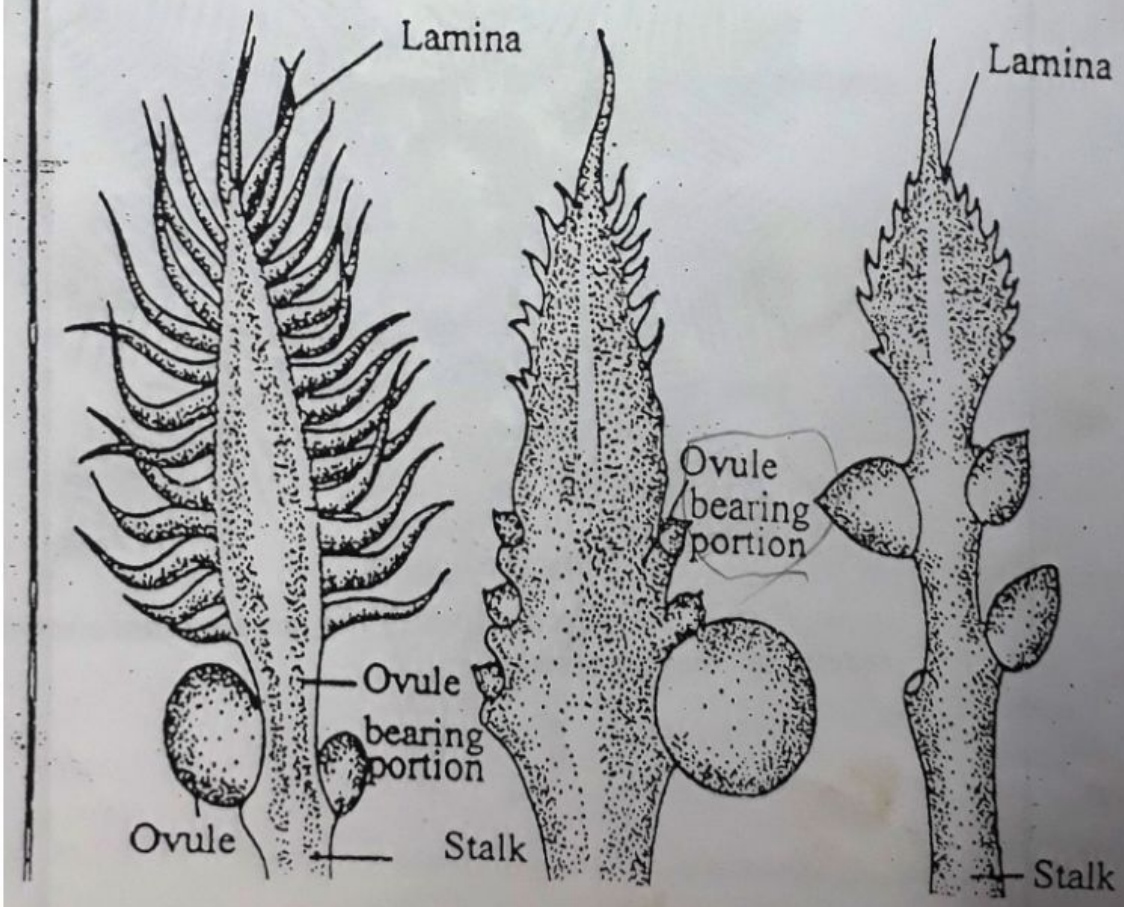
There is *no true female cone* or strobilus in Cycas. Female reproductive organs are called *megasporophylls* and

Fig. 11.25: Cycas-Apex of the female plant showing rosette of megasporophylls.

are not organised into cones. The megasporophylls are arranged spirally in ***acropetal succession*** around the stem apex of the female plant, like the foliage leaves. They are produced in larger numbers than the foliage leaves and thus appear like a ***rosette*** or a ***crown***.

Each ***megasporophyll*** is leaf-like and densely covered with brown hairs. The megasporophylls are considered to be ***modified leaves***. They are flat and dorsiventral structures, measuring 15-30cm in length. Each megasporophyll consists of a lower ***petiole*** or ***stalk*** a middle ***ovulebearing portion***and an upper ***leafy lamina***.

The upper part is sterile and it varies with species. In ***Cycas revoluta***, the upper part is very much dissected, forming many ***pinnae***. In ***Cycas rumphii*** the upper part bears only short spines, which represent ***reduced pinnae***. In ***Cycas circinalis*** the upper part shows only dentate or ***serrate*** margins.



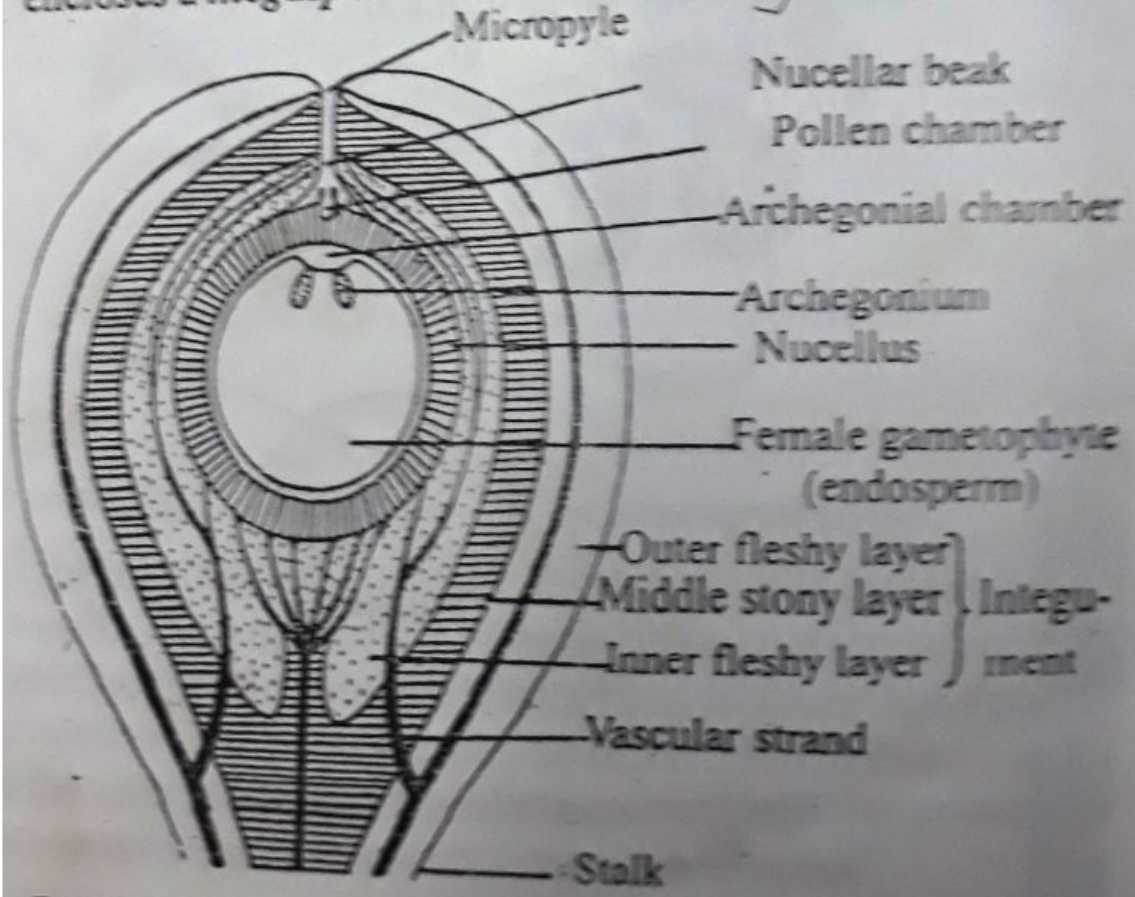
a spiny petiole ... 80-100 pairs of pinnae

The middle portion of the megasporophyll bears ovu
They are produced in two rows, one on either side. The ovu
of the two rows may be opposite or alternate. Ovules are
yellow or orange or dark green coloured and shortly stalked.
They are oval and smooth. All the ovules do not develop fully.
Some of them remain unpollinated and small and finally abort.

Cycas ovules are *orthotropous* (straight ovules). It is *unitegmic* and the *stalk* is short.

The ovule consists of a *stalk*, an *integument*, a *micropyle* and a *nucellus*. The stalk is short. The *integument* consists of *three* layers namely an outer fleshy green or orange layer called *sarcotesta*, a middle yellow, stony layer called *sclerotesta* and an inner fleshy layer. The outer and fleshy layers are supplied with *vascular strands*, but the middle stony layer receives no vascular supply.

The *nucellus* lies just below the integument and forms a *nucellar beak* in the region of the micropyle. The nucellus encloses a *megaspore* or the *embryo-sac*.



The megaspore nucleus undergoes repeated divisions to form the *endosperm* or *female gametophyte*.

Certain cells at the top of the nucellus dissolve and form a cavity called *pollen chamber*. Pollen grains are received in the pollen chamber after pollination. Just below the pollen chamber is present an *archegonial chamber*. Just below the archegonial chamber 3-6 *archegonia* are present towards the micropylar end. The archegonial chamber is filled with a fluid.

In the central region of the nucellus, one of the cells differentiates into a *megaspore mother cell*. It has dense cytoplasm and prominent nucleus. It is larger in size. It

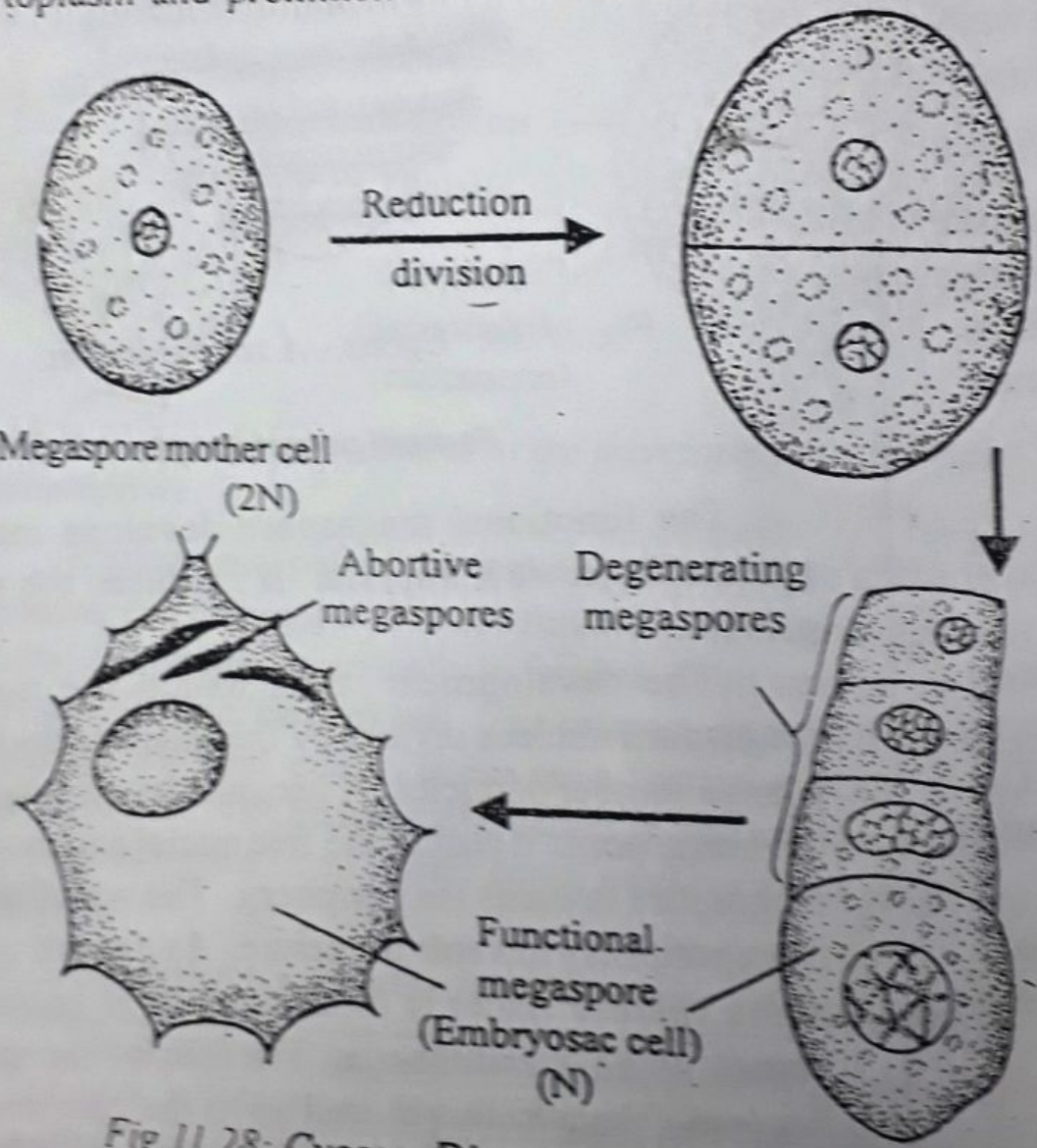
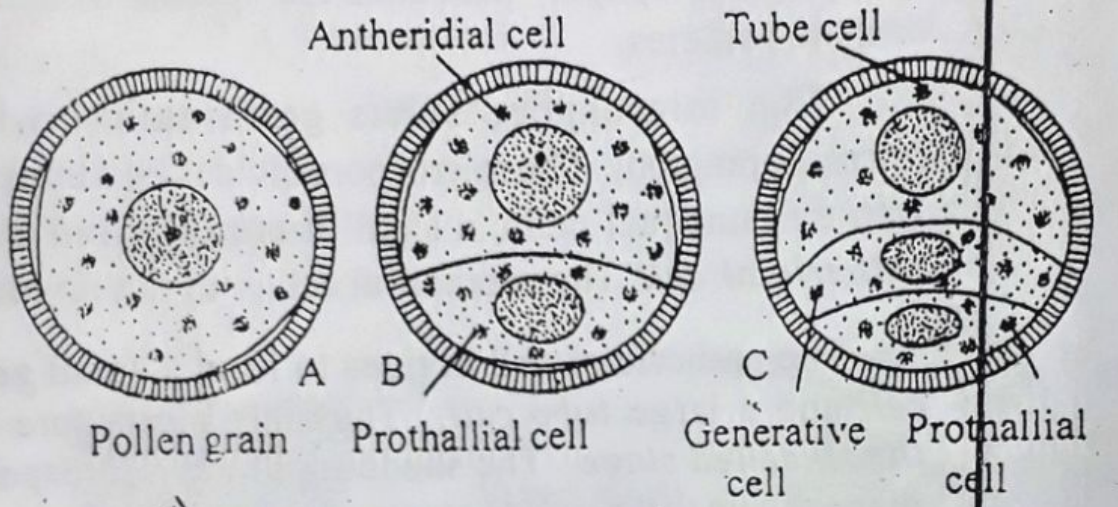


Fig. 11.28: *Cycas - Diagrams showing development of megaspores.*

undergoes a *reduction division* and forms a linear tetrad of four *megaspores*. The *megaspores* are *haploid*. The lowermost megaspore is functional and the upper three degenerate to provide nourishment to the functional megaspore.

Gametophyte

Cycas is *heterosporous*. It produces two types of spores called *microspores* and *megaspores*. The microspore



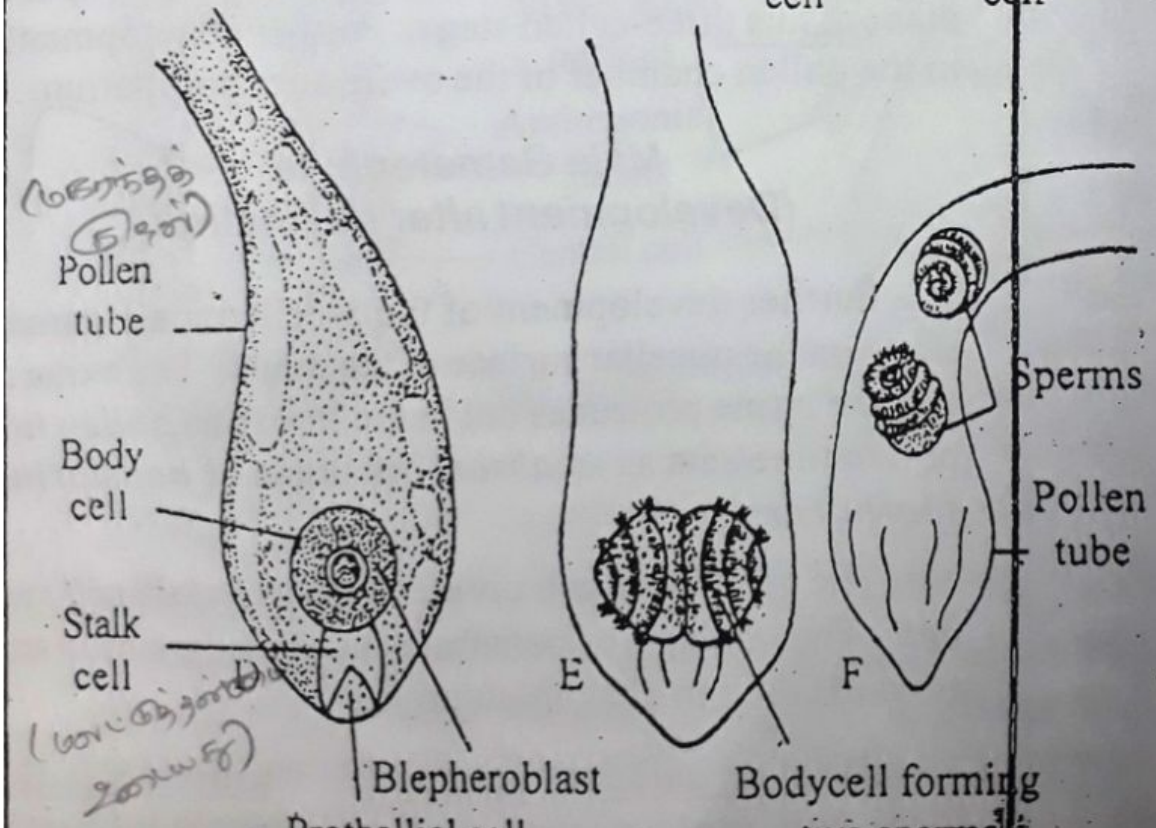


Fig.11.29 Cycas - Development of male gametophyte.

develops into *male gametophyte* and the megaspore develops into *female gametophyte*.

Male Gametophyte (Development before pollination)

The microspore is the first cell of male gametophyte. The male gametophyte develops from the microspore. The male gametophyte produces the sperms or antherozoids or male gametes.

The microspore starts germination within the microsporangium. The microspore divides by a transverse wall into two unequal cells, a small *prothallial cell* and a large *antheridial cell*. The prothallial cell does not divide further.

The antheridial cell divides to form a small *generative cell* and a large *tube cell*. Thus the microspore becomes *three- celled stage*. The shedding of the microspores takes place at this three-celled stage. Further development occurs in the pollen chamber of the ovule after pollination.

Male Gametophyte (Development after pollination)

Further development of the 3-celled male gametophyte starts on the nucellar surface of the ovule. The exine ruptures and the intine protrudes out in the form of a *pollen tube*. The pollen tube acts as an *absorbing* organ or *haustorium* and a *sperm carrier*.

The generative cell divides to form a *stalk cell* and a *body cell*. The pollen tube penetrates the nucellar tissue and grows towards the female gametophyte.

The stalk cell does not divide. The body cell divides to form *two male gametes* or *antherozoids*, just before fertilization. The antherozoids swim freely in the cytoplasm of the pollen tube. There is an interval of about four months

The *antherozoids* or *sperms* are naked, top-sha... structures, measuring 180-210µm. The blepharoblast of t... antherozoids elongates into a large spirally arranged structure with many cilia.

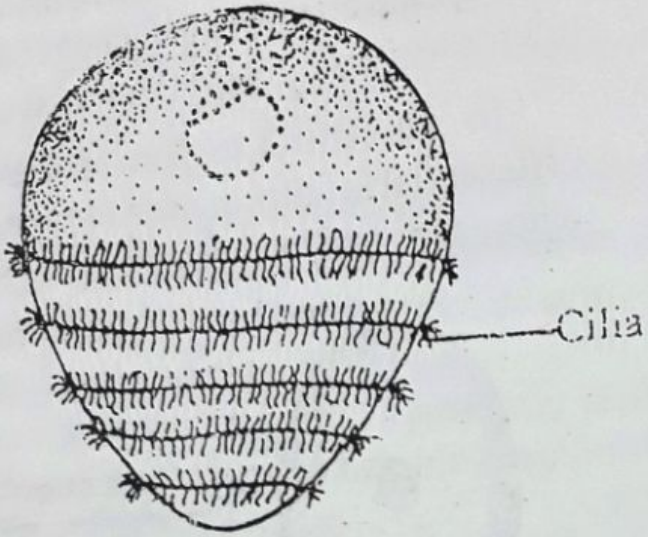


Fig. 11.30: Cycas - A single sperm.

Female gametophyte

The functional megaspore develops into the female gametophyte. It is ***haploid.*** It produces the egg or female gamete.

The development starts within the nucellus. The megaspore nucleus divides by free nuclear divisions to form a large number of nuclei. A vacuole develops in the centre of the megaspore. It pushes the free nuclei and cytoplasm of the megaspore towards the periphery. The wall formation starts from periphery towards the centre. As a result of wall formation a ***cellular tissue*** is formed which is known as ***female gametophyte*** or ***endosperm.*** The cells of the endosperm are ***haploid.*** The nucellus is used up as the gametophyte develops and it is represented by a very thin layer in the mature gametophyte.

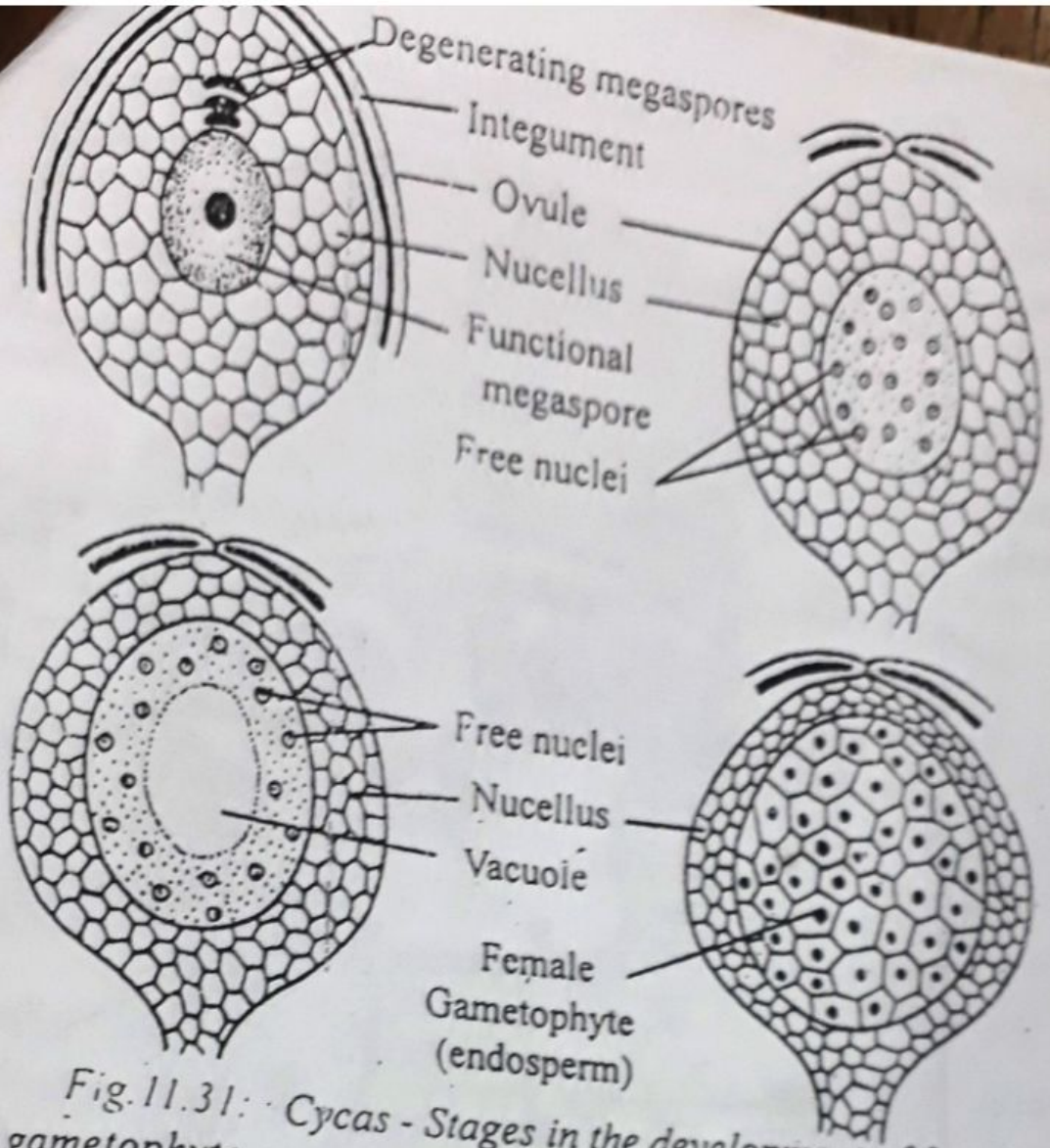


Fig. 11.31: Cycas - Stages in the development of female gametophyte.

A superficial cell of the female gametophyte at the micropylar end enlarges in size and functions as an ***archegonial initial***. It divides periclinally to form an outer ***primary neck cell*** and an inner ***central cell***. The primary neck cell divides to form ***two neck cells***. These cells form the neck of the archegonium. The central cell enlarges in size and the nucleus divides to form a small ***venter canal nucleus*** and a large ***egg nucleus***.

The *egg* of *Cycas* is the ***largest among all living plants***.

The ***mature archegonium*** consists of a ***venter*** and ***neck***. The neck is formed of ***two neck cells*** and the venter has a ***ventral canal nucleus*** and an ***egg***. The venter is surrounded by a nutritive jacket called ***archegonial jacket***.

The number of archegonia varies in different species of Cycas. In *Cycas rumphii*, 3 -6 archegonia, in *Cycas circinalis* 3 -8, and in *Cycas revoluta* 2 - 8 archegonia are formed. The nuclellar tissue above the archegonial initials disintegrates to form an *archegonial chamber.*

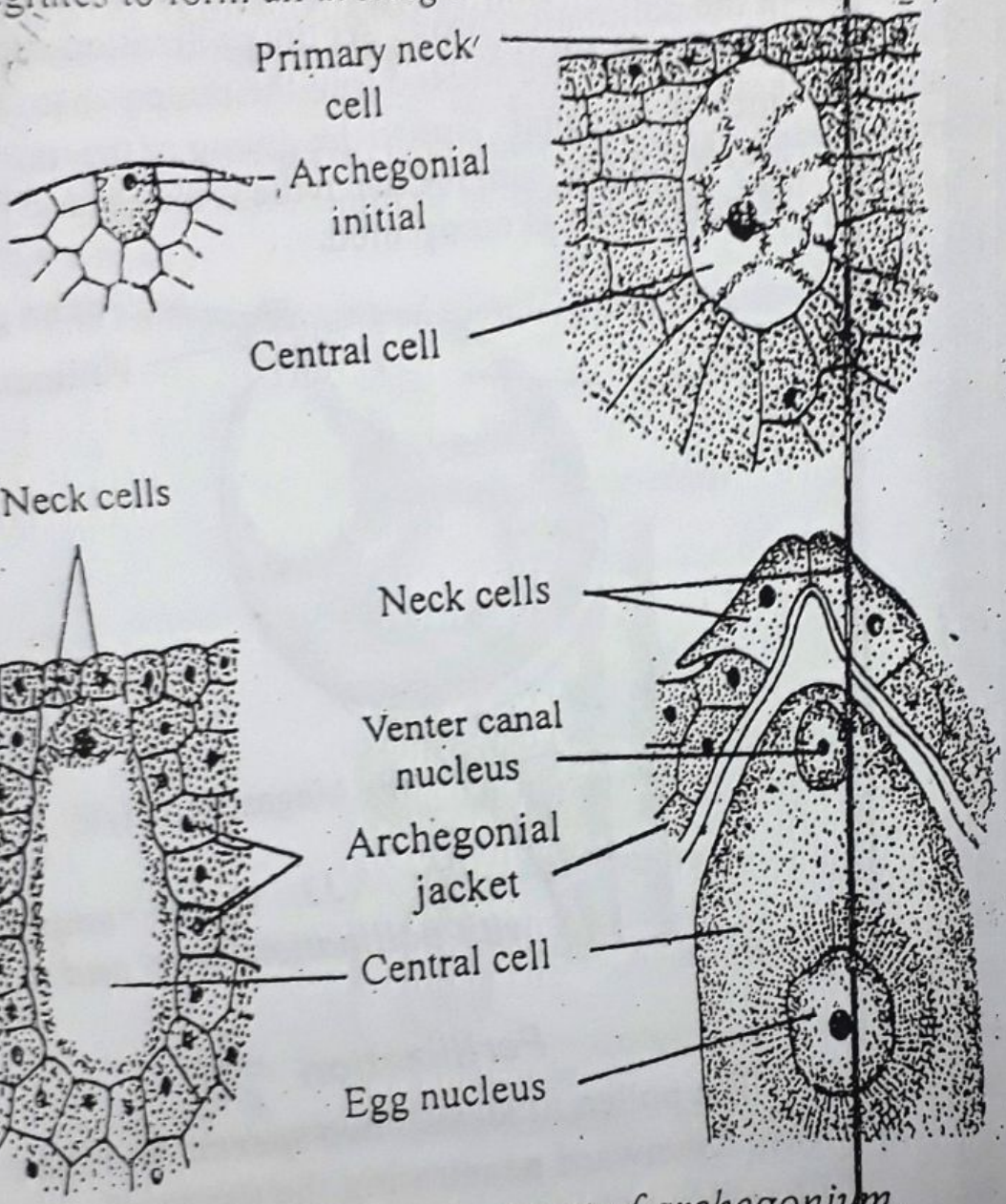


Fig. 1: 32: Cycas - Development of archegonium.

Pollination

The pollination in Cycas is ***anemophyllous*** and it takes place by *wind.* The microsporangium dehisces by a longitudinal slit and the microspores are blown away by wind for pollination.

At the time of pollination, some of the cells of the *nucellar* beak disorganise to form a drop of *mucilage.* This

mucilaginous drop oozes out from the micropyle in the form of a *pollination drop.*

Some of the microspores carried by the air are entangled in the pollination drop. As the pollination drop dries up, the microspores are sucked into the pollen chamber through the micropylar canal. Due to the drying of the mucilaginous fluid the micropylar canal of the ovule is plugged. Thus, the process of pollination is completed.

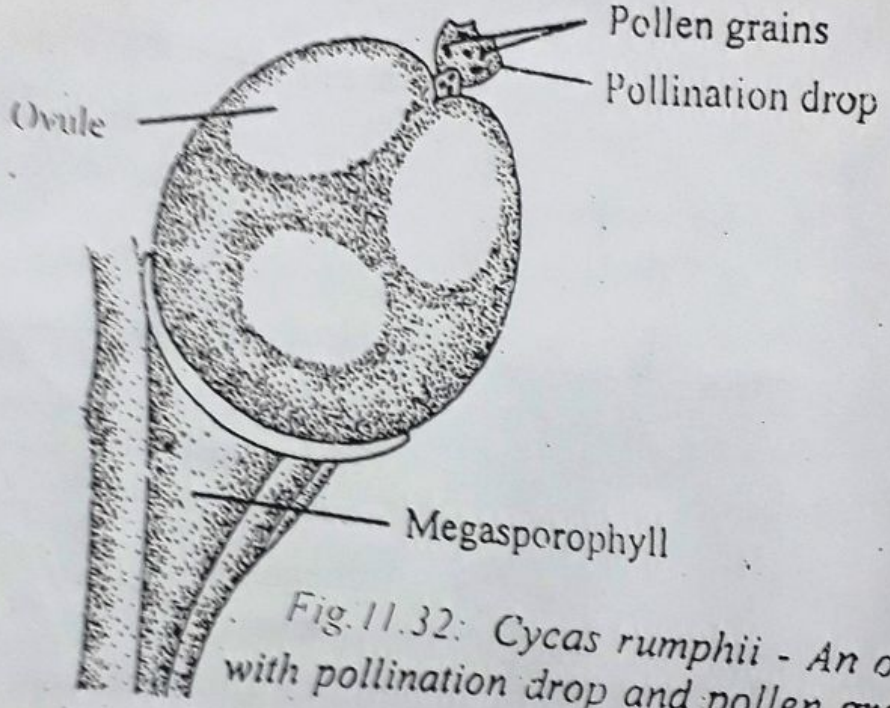


Fig. 11.32: Cycas rumphii - An ovule with pollination drop and pollen grains.

Fertilization

The pollen tube with ***two sperms*** and the tube nucleus grows downward penetrating the tissue of *pollen chamber.* The pollen tube bursts and discharges its contents into the ***archegonial chamber.*** One of the motile sperms enters the archegonium and fuses with the egg producing the diploid ***zygote.***

In Cycas, fertilization takes place with the help of ***motile, ciliated sperms.*** This phenomenon in known as ***zoidogamy.*** The pollen tube acts as a ***sperm carrier.*** It also acts as a ***haustorium*** by absorbing food for the developing male gametes.

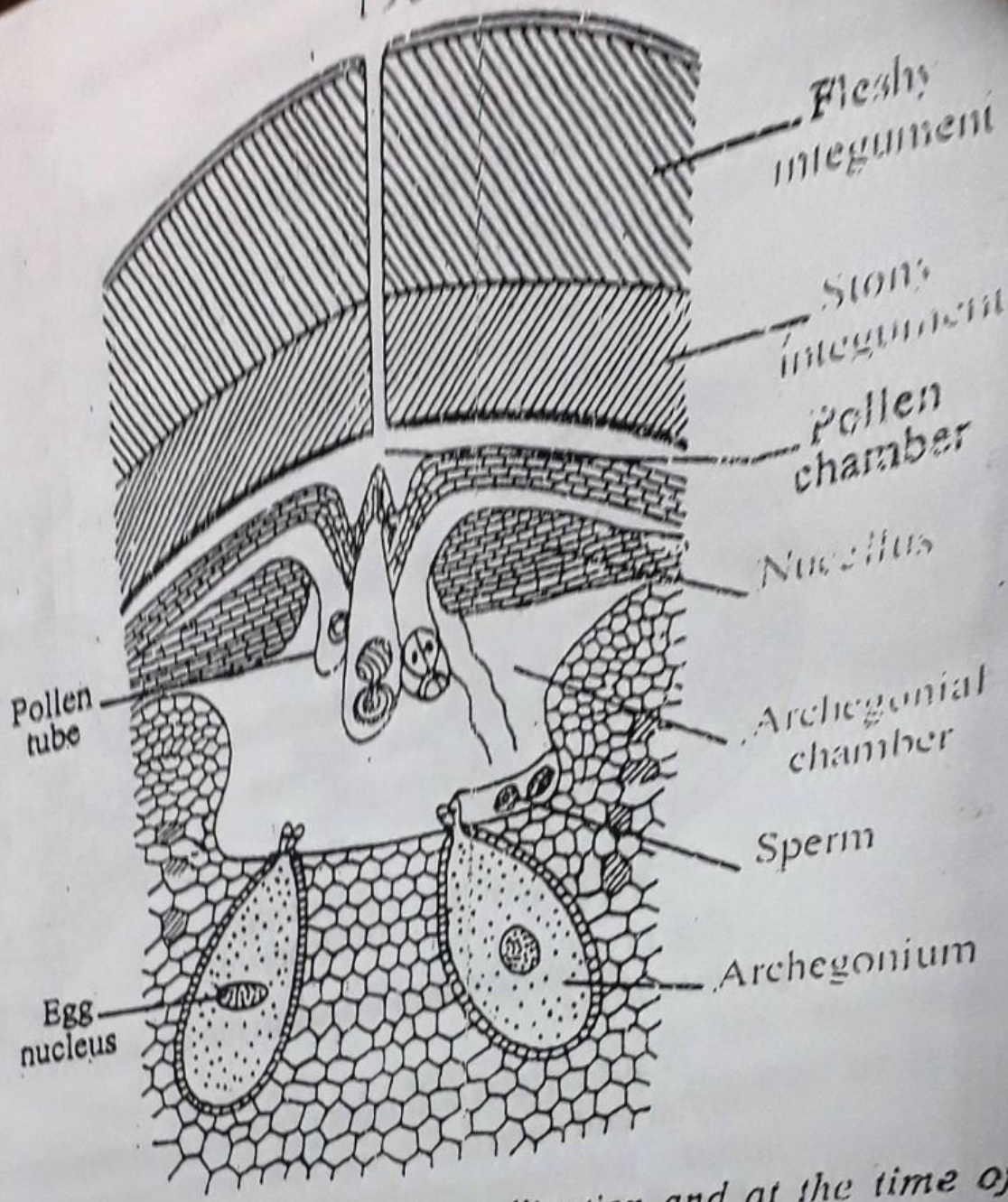
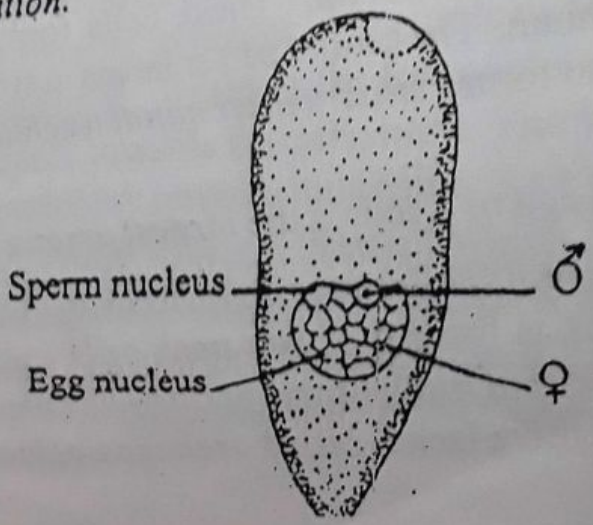


Fig. 11.33: Cycas. Ovule after pollination and at the time of fertilization.



The fertilized egg or *zygote* is the first cell of the *sporophyte*. The zygote contains dense cytoplasm and a large *nucleus*. The zygote is *diploid*. The nucleus undergoes repeated nuclear divisions to form hundreds of nuclei. A *vacuole* appears in the centre

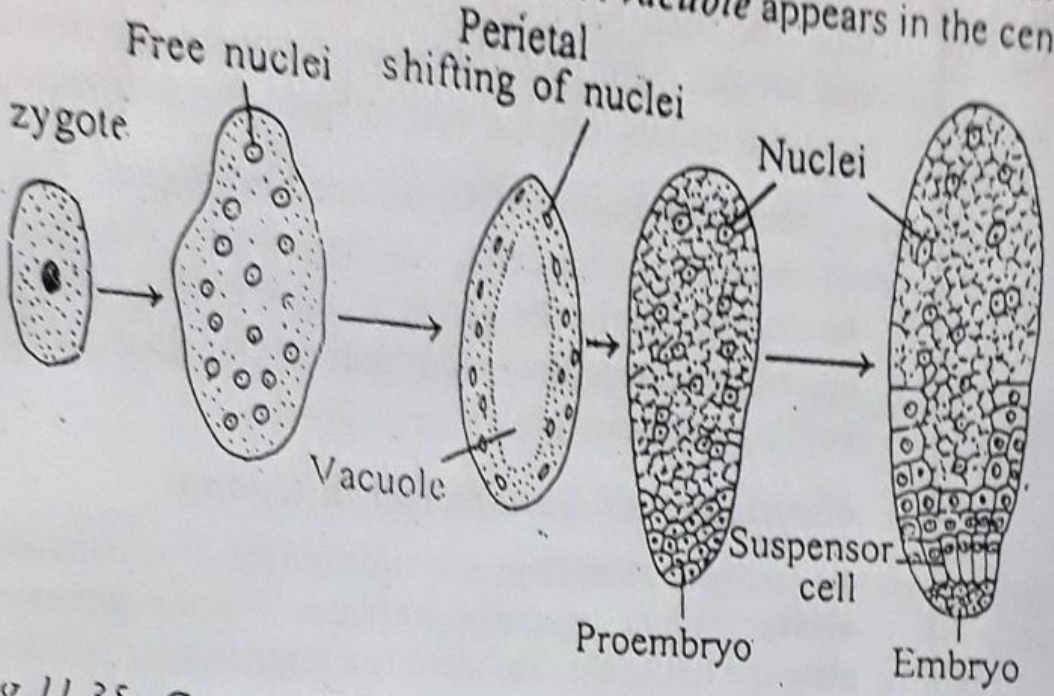


Fig. 11.35: Cycas - Development stages of the embryo.

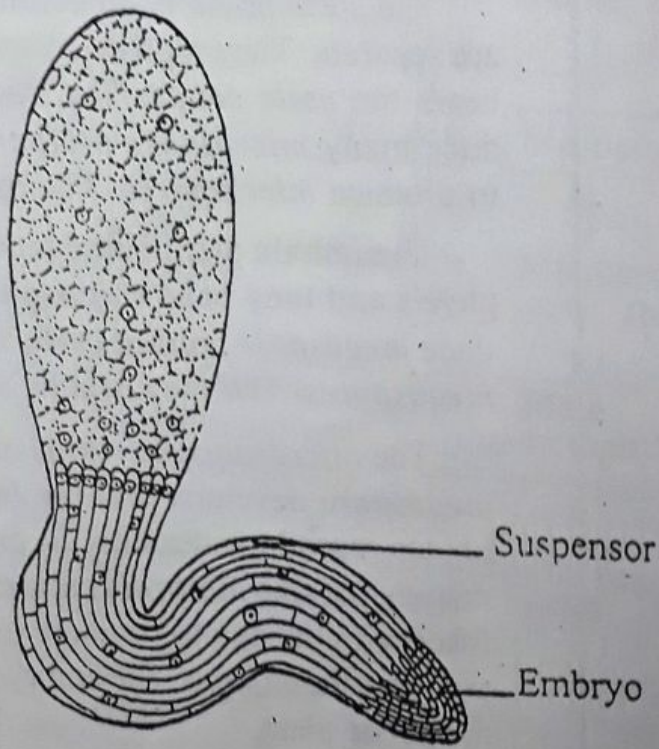


Fig. 11.36: Cycas - An older stage of the proembryo.

and it pushes all the nuclei to the periphery. Wall formation starts from the base towards the upperside to form a small mass of cells. This mass of ***embryonal cells*** is called the ***pro-embryo.*** It is differentiated into ***three regions.*** The upper region is called ***haustorial region.*** It absorbs food for the developing embryo. The middle region is called ***suspensor region.*** It forms the long, coiled ***suspensor*** and pushes the embryo into the food containing cells of the endosperm. The inner region is called ***embryonal region.*** It contains 9 groups of meristematic cells, which form the ***embryo.***

The ***embryo*** consists of ***radicle, plumule*** and ***cotyledons.***

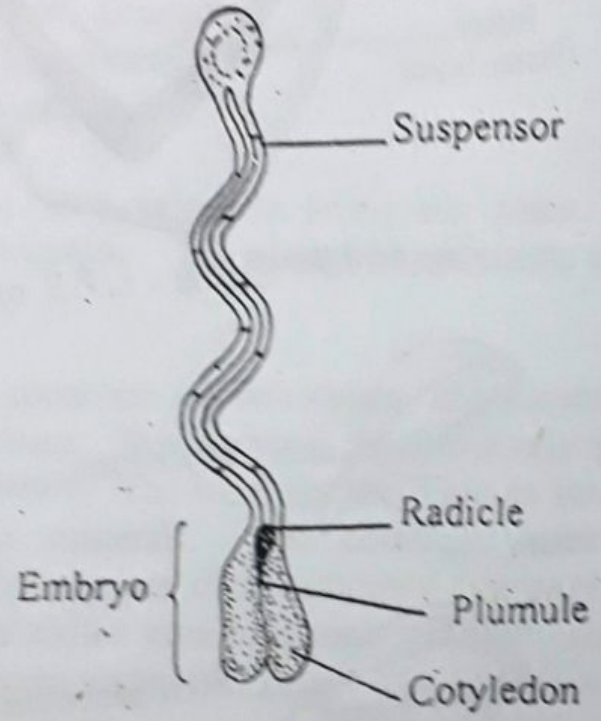


Fig. 11.37: Cycas showing formation of proembryo.

Seed

After fertilization, the *ovule* is converted into *seed.* The L.S. of mature seed shows an ***orange*** seed coat, which is formed from the three-layered ***integument*** of the ovule. The outer fleshy layer of the integument forms *sacrotesta* and middle stony layer forms the *sclerotesta* while inner layer remains thin and papery.

The nucellus is used up during the embryo development. Inside the seed, a well developed ***endosperm*** is present, which stores a large amount of food material. The ***embryo*** is embedded within

the endosperm. The embryo consists of *plumule, radicle* and *two* large *cotyledons*. The embryo remains suspended in the endosperm by a spirally *coiled suspensor*. The embryo is *straight*.

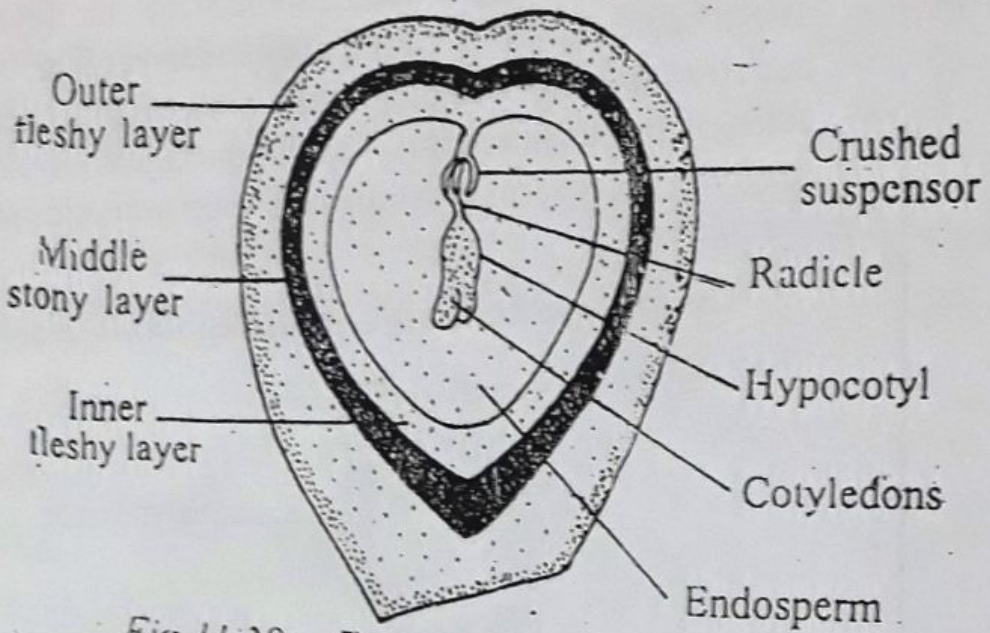
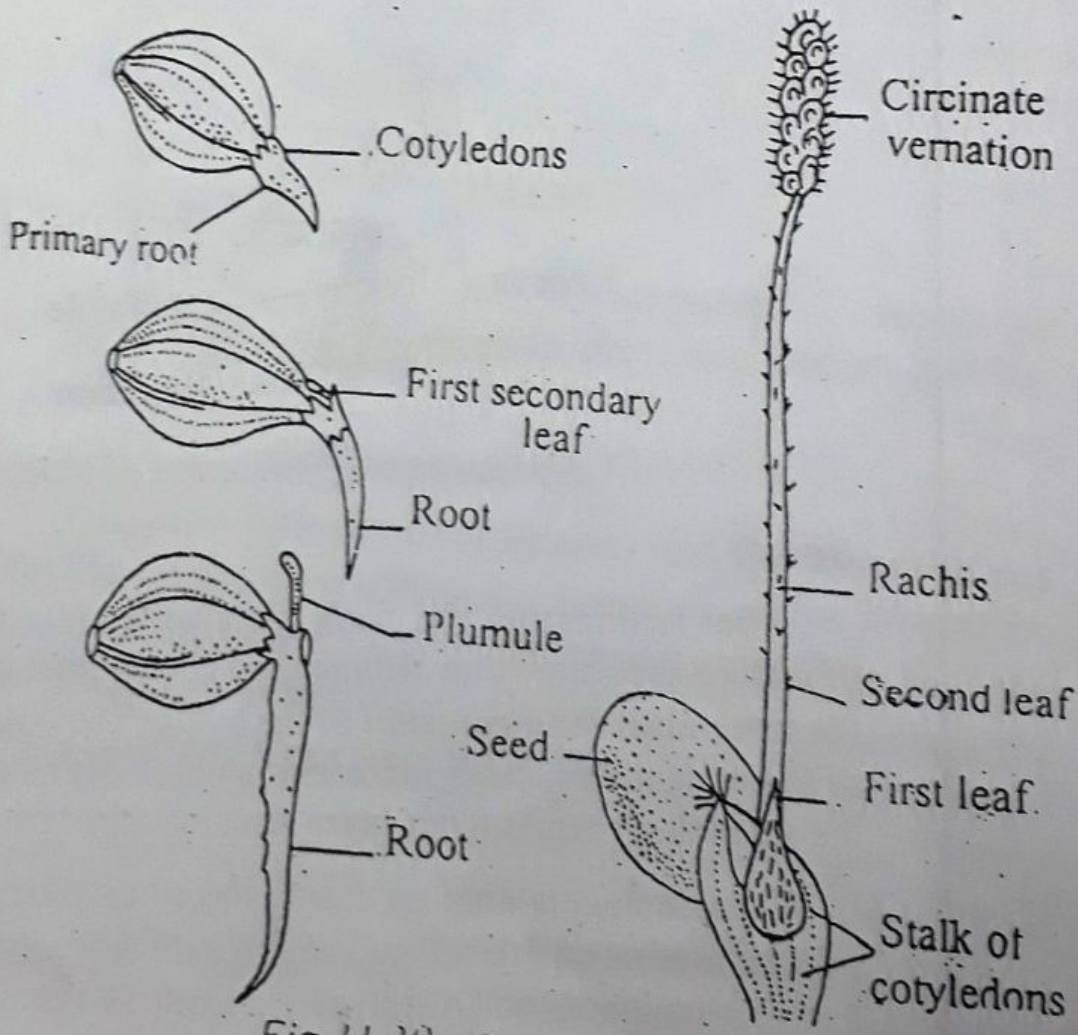


Fig. 11.38: Cycas - L.V.S. of seed.



The *Cycas* seed germinates without undergoing a period of rest. The seed develops into a new sporophyte plant. The seed coat breaks open and the *radicle* comes out through the micropyle and grows into the soil to form the *primary root*.

The germination of *Cycas* seed is *epigeal*. The cotyledons do not come out of the seed, but they absorb the food material from the endosperm for the germinating seedling. The plumule comes out and produces few *scale leaves* and then a *foliage leaf*. The seedling of *Cycas* grows very slowly.

Alternation of Generation in Cycas

In *Cycas*, the plant is a *sporophyte*. It is *asexual* and *diploid*. The sporophyte regularly alternates with the gametophyte to complete the life cycle. So, there is a regular alternation of generation in *Cycas*.

The sporophyte is *dioecious*. ie. the male and female plants are separate. They reproduce *asexually* by *spores*. The male plant bears the *male cones*. The microsporangia of male cones produce many *microspore mother cells* and they undergo *meiosis* to produce *microspores*. The microspores are *haploid*.

The female plant bears *female cones* containing megasporophylls and they bear *megasporangia*. The megasporangia produce *megaspore mother cells*, which undergo *meiosis* to produce *megaspores*. The megaspores are *haploid*.

The *microspore* develops into the *male gametophyte* and the *megaspore* develops into the *female gametophyte*. The gametophytes reproduce sexually to produce male and female gametes, namely the *spermatozoids* and *eggs*. They are *haploid*. The sperm fuses with the egg to produce the *zygote*. The zygote is *diploid*. It produces the embryo. The embryo grows into the diploid *sporophyte*, the *Cycas* plant.

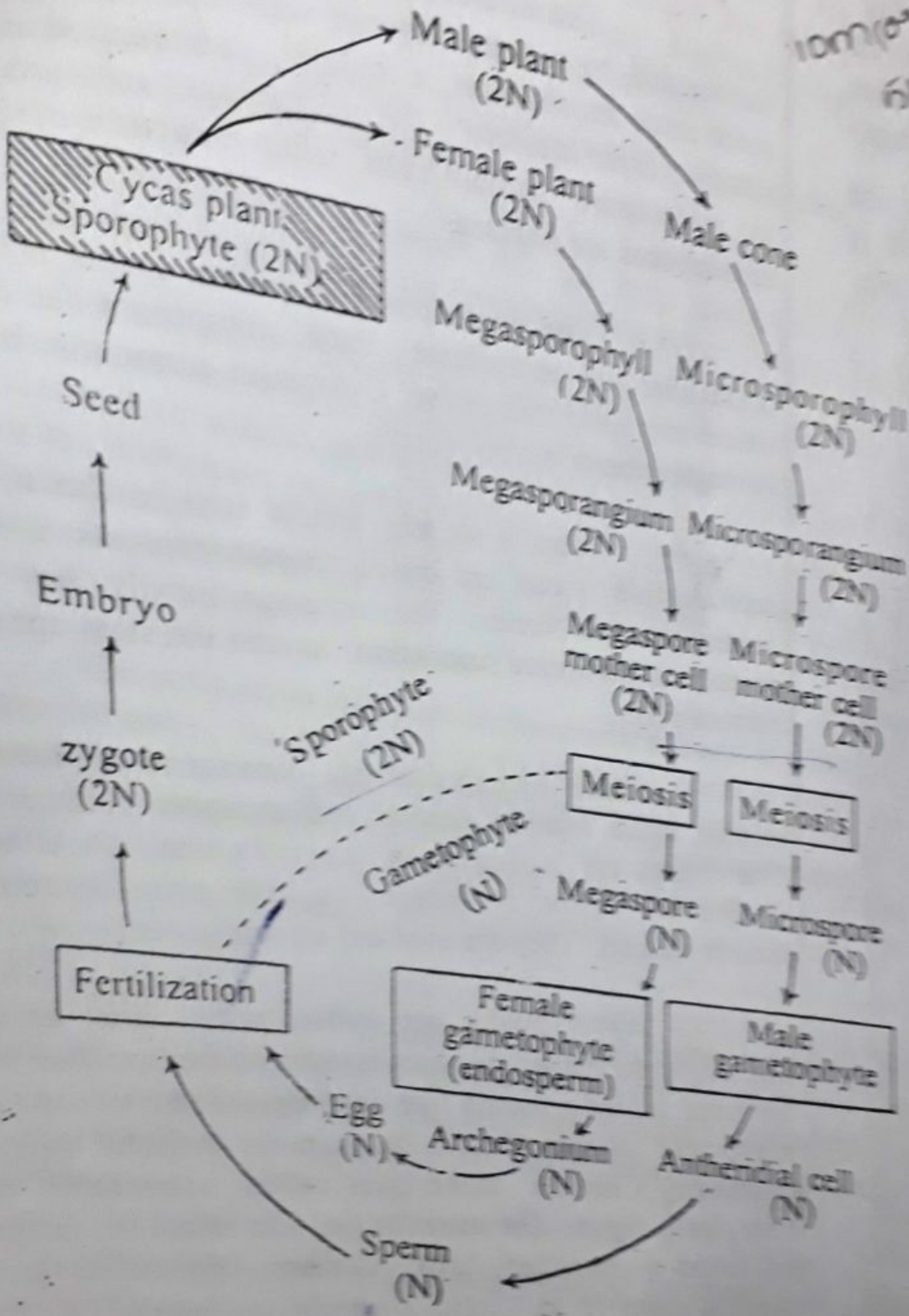


Fig. 11.40: Gruphic life cycle of Cycas.

Life Cycle of Cycas

Cycas is a ***Gymnosperm***. It belongs to the order *Cycadales*.

The plants are confined to the tropical and sub-tropical regions of the world. *Cycas* has 20 species. In India the genus is represented by six species.

1. *Cycas circinalis*
2. *Cycas pectinata*
3. *Cycas media*.

Cycas is a palm-like evergreen plant. The plant is a diploid *sporophyte*. The plant body consists of *root*, *stem* and *leaves*.

The roots are of two types, the normal *tap roots* and *coralloid roots*. The tap roots are positively geotropic. They have *root hairs*. The roots fix the plant in the soil and absorb water and minerals. The coralloid roots are negatively geotropic. They are dichotomously branched and coral-like. So they are called coralloid roots. These roots get infected with blue green algae like *Nostoc* and *Anabaena*.

The stem is thick, woody, and unbranched. It is covered with persistent leaf bases. The stem bears a terminal group of leaves.

The leaves are *dimorphic* i.e., the leaves are of two types, namely *foliage leaves* and *scale leaves*. The foliage leaves are green, large, pinnately compond with a spiny *petiole*. The leaves are spirally arranged. Each leaf consists of a rachis and 80 - 100 pairs of *pinnae* or leaflets. Each pinna is tough, leathery and entire with a definite midrib. Young leaves are circinately coiled and are covered with *ramenta*.

Scale leaves are also known as *cataphylls*. These are dry, small brown coloured, triangular leaves and are covered with hairs. The scale leaves are present at the apex of the stem.

Cycas is *dioecious* i.e., there are separate male and female plants. The reproductive structures are produced as *cones*. The female plants are common but male plants are rare.

In *Cycas*, reproduction takes place by three methods.
1. Vegetative reproduction
2. Asexual reproduction
3. Sexual reproduction.

1. Vegetative Reproduction

It takes place by means of *bulbils*. Bulbils are produced adventitiously on any part of the plant. Bulbils produce new plants after falling in the soil.

2. Asexual Reproduction

The *Cycas* plant is a diploid *sporophyte*. It reproduces asexually by ***spores***. *Cycas* is ***dioecious*** i.e., there are separate male and female plants

The reproductive parts are in the form of ***cones*** or ***strobili***. The cones are terminally produced upon the main stem.

The male cone is produced in the male plant. The male cone consists of a central *cone axis* and numerous ***microsporophylls***. The microsponophylls are spirally arranged around the cone axis. The microsporophylls are leaf like woody, wedge-shaped, brown coloured structures with narrow base and expanded upper portion. The upper portion is called *apophysis*. Each microsporophyll on the lower surface bear thousands of ***microsporangia***, in 3 – 5 groups. Each group is

The microsporangium has a short ***stalk*** and it is surrounded by a many layered wall. The wall consists of an outer thick ***exothecium***, a middle ***endothecium*** and an inner nutritive layer ***tapetum***. The ***microspores*** are produced from the ***microspore mother cells*** after ***reduction division***. The microspores are ***haploid***.

The microspores or pollen grains are globular, unicellular and uninucleate. Each microspore has outer thick ***exine*** and inner thin ***intine***, Cytoplasm surrounds the nucleus. A large ***vacuole*** is also present.

There is no true female cone in *Cycas*. Female reproductive organs are called ***megasporophylls*** and are not organised into cones. The megasporophylls are arranged spirally in ***acropetal*** succession around the stem apex of the female plant.

Each megasporophyll consists of a lower ***stalk***,a middle ***ovule bearing protion*** and an upper pinnate ***lamina***. The ovules are produced in two rows one on either side. Ovules are yellow or orange or dark green coloured, and shortly stalked. They are oval and smooth.

Cycas ovules are ***orthotropous***. It is ***unitegmic***. The single integument remains fused with the ***nucellus*** from all the sides except a mouth like opening called *micropyle*. The integument consists of three layers,an outer fleshy layer called ***sarcotesta***, a middle stony layer called ***sclerotesta*** and an inner ***fleshy layer***. The ***nucellus*** lies just below the integument and forms a ***nucellar beak***. Certain cells at the tip of the nucellus dissolve to form a *pollen chamber*. Within the nucellus is present an enlarged *megaspore* or ***embryo sac***. The megaspore develops from the *megaspore mother cell*. The megaspore mother cell undergoes *reduction division* to produce *four haploid megaspores*. The lower most

megaspore nucleus undergoes repeated divisions to form the *endosperm or female gametophyte*. Just below the pollen chamber is present an ***archegonial chamber***. Just below the archegonial chamber 3 – 6 ***archegonia*** are present:

Cycas is ***heterosporous***; It produces two types of spores namely ***microspores*** and ***megaspores***.

The microspore develops into the male gametophyte and megaspore develops into the female gametophyte.

The microspore divides into two unequal cells. a small *prothallial cell* and a large *antheridial cell*. The antheridialcell divides to form a small *generative cell* and a large *tube cell*. Thus the microspore becomes 3 celled. Only at this 3 – celled stage microspores are liberated from the microsporangium. Further development occurs in the pollen chamber of the ovule after pollination.

The pollination in *Cycas* is ***anemophilous*** and it takes place by wind. At the time of pollination the nucellar beak produces a drop of mucilage. The mucilage oozes out from the micropyle in the form of a *pollination* drop. The microspores are carried by the air and are entangled in the pollination drop. The 3 – celled microspore starts germination on the nucellar surface of the ovule.

The exine ruptures and the intine protrudes out inthe form of a ***pollen tube***. The generative cell divides to form a *stalk cell* and a ***body cell***. The body cell divides to form two *male* ***gametes*** or sperms or antherozoids just before fertilization.

The antherozoids are naked,top-shaped structures with many cilia.

The functional megaspore is the first cell of the female gametophyte. It undergoes free nuclear divisions to form a

large number of nuclei A vacuole develops in the centre of the megaspore. The wall formation starts from periphery towards the centre. As a result a cellular tissue is formed called *femalegametophyte* or *endosperm*.

In the female gametophyte at the micropylar end, archegonia are developed.

The mature ***archegonium*** consists of a ***venter*** and ***neck***. The neck is formed of two ***neck cells*** and the venter has a *ventral canal* ***nucleus*** and an ***egg***. The egg is ***haploid***.

The ***pollen tube*** with two sperms and the tube nucleus grows downward penetrating the tissue of pollen chamber. The pollen tube discharges its contents into the archegonial chamber. One of the sperms fuses with the egg, producing the diploid ***zygote***.

The fertilized egg or zygote is the first cell of the sporophyte. The zygote divides and produces a mass of embryonal cells, called the ***pro-embryo***.

The pro-embryo has three regions. The upper region is called *haustorial* ***region***. It absorbs food for the developing embryo. The middle region is called ***suspensor region*** and it forms the long, coiled ***suspensor***. It pushes the embryo into the endosperm. The inner ***embryonal region*** contains *meristematic* ***cells***, which form the ***embryo***.

The embryo consists of ***radicle***, *plumule* and *cotyledons*. After fertilization the ovule is converted into ***seed***. The integument of the ovule forms the ***seed coat***. The nucellus is used up during the embryo development. Inside the seed, ***endosperm*** is present. Embedded within the endosperm is present the ***embryo***.

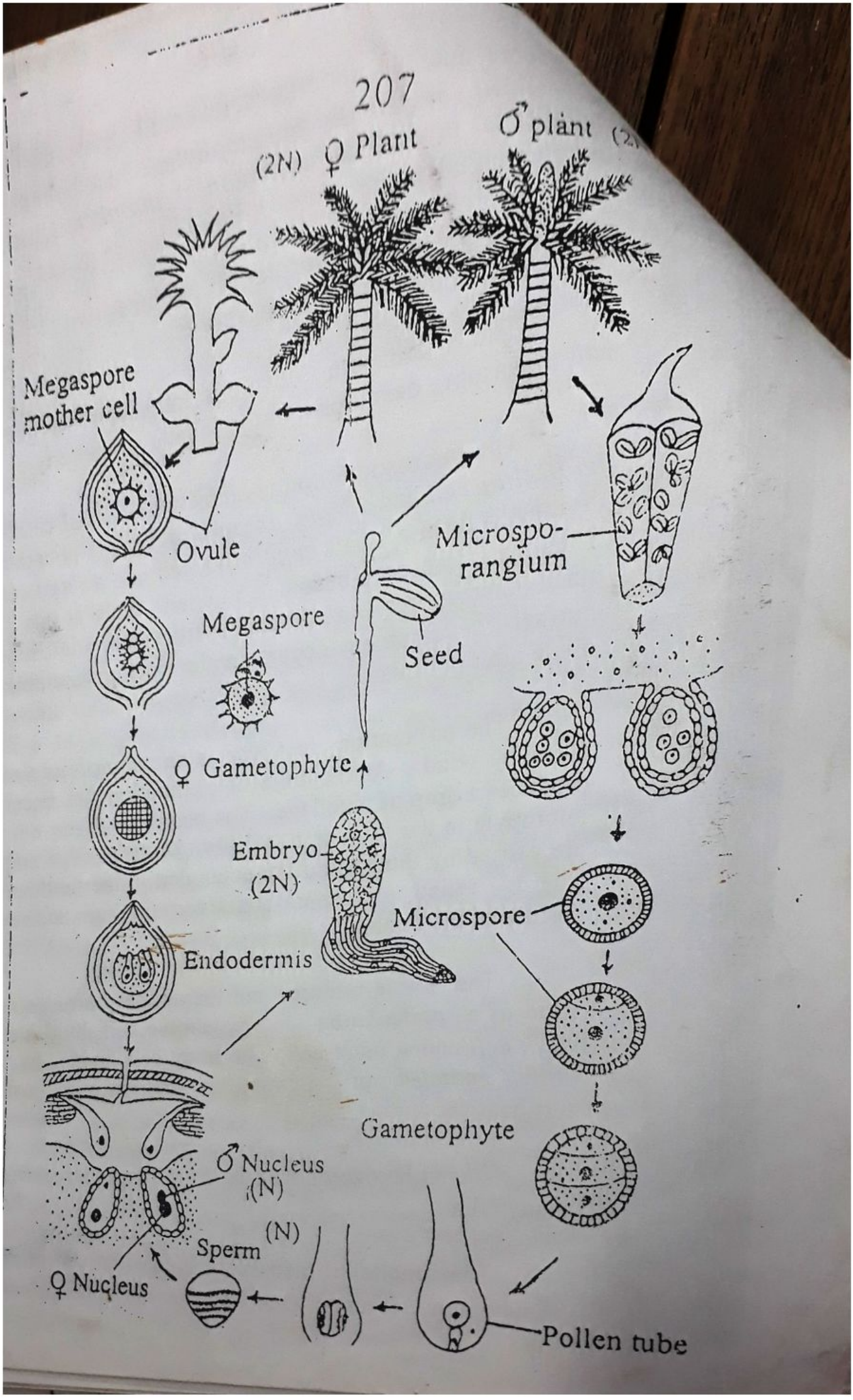
The seed develops into a young ***sporophyte*** plant.

In Cycas, the plant is a ***sporophyte***. It is ***diploid***. The sporophyte regularly alternates with the gametophyte to complete the life – cycle. So there is a regular alternation of generation in Cycas. The sporophyte is ***dioecious*** i.e., the male and female plants are separate. They reproduce asexually by spores.

The male plant bears the male cones. The ***microsporangia*** of male cones produce many ***microspore mother cells*** and they undergo meiosis to produce ***microspores***. The microspores are ***haploid***.

The female plant bears ***megasporophylls***. The megasporophylls have megasporangia. The megasporangia produce ***megaspore mother cells***, which undergo meiosis to produce megaspores, The ***megaspores*** are haploid.

The microspore develops into the ***male gametophyte*** and the megaspore develops into the ***female gametophyte*** The gametophytes reproduce sexually to produce male and female gametes, namely the spermatozoids and eggs. They are haploid. The ***sperm*** fuses with the ***egg*** to produce the zygote. The ***zygote*** is diploid. It produces the ***embryo***. The embryo grows into the diploid sporophyte, the Cycas plant.


(2N) ♀ Plant
♂ plant (2
Megaspore mother cell
Ovule
Microspo-rangium
Megaspore
Seed
♀ Gametophyte
Embryo (2N)
Microspore
Endodermis
Gametophyte
♂ Nucleus (N)
(N)
Sperm
♀ Nucleus
Pollen tube

Economic Importance of Cycas

1. *Cycas* is used as a source of *food* in many countries. Starch extracted from cycas stem is called *'Sago'*.

2. In Japan, seeds and stems of *Cycas revoluta* are used for preparing *wine*.

3. The *juice* obtained from young leaves of *Cycas circinnalis* is used in skin diseases, vomitting of blood and stomach disorders.

4. *Cycas revoluta* plants are grown as *ornamental* in various parts of the world.

Primitive features of Cycas

1. The *unbranched stem*, with a thick persistent leaf bases.
2. The *circinate* vernation of *leaf lets*.
3. Presence of *mesarch* bundles in the leaf.
4. Microsporangia aggregate to form *sori*.
5. Presence of motile and *ciliated sperms*.