Structure, systematic position and life cycle of *Cycas*

Miss Snehal Unde

F.Y.B.Sc. – Sem 2

Systematic Position

Division	Spermatophyta (seed producing plants)
Sub Division	Gymnosperms (naked ovules)
Class	Cycadopsida/ Cycadophyta (large pinnately compound leaves)
Order	Cycadales (male sporophylls in cones, spermatozoids are motile)
Family	Cycadaceae (palm like habit, ovule with pollen chamber)
Genus	*Cycas* (no female cones)

Cycas

- Slow growing, long lived plant
- Evergreen in habit
- Commercially cultivated as a garden plant and for ‘sago’; hence known as sago palm
- It is a xerophyte; common in tropical and sub-tropical forests.
- Several species of *Cycas* are found, out of which *C. revoluta* and *C. circinalis* are very common.
- Gymnosperms are intermediate between pteridophytes and angiosperms. Like pteridophytes, they produce archegonia while like angiosperms they produce seeds.

Cycas revoluta

Cycas revoluta

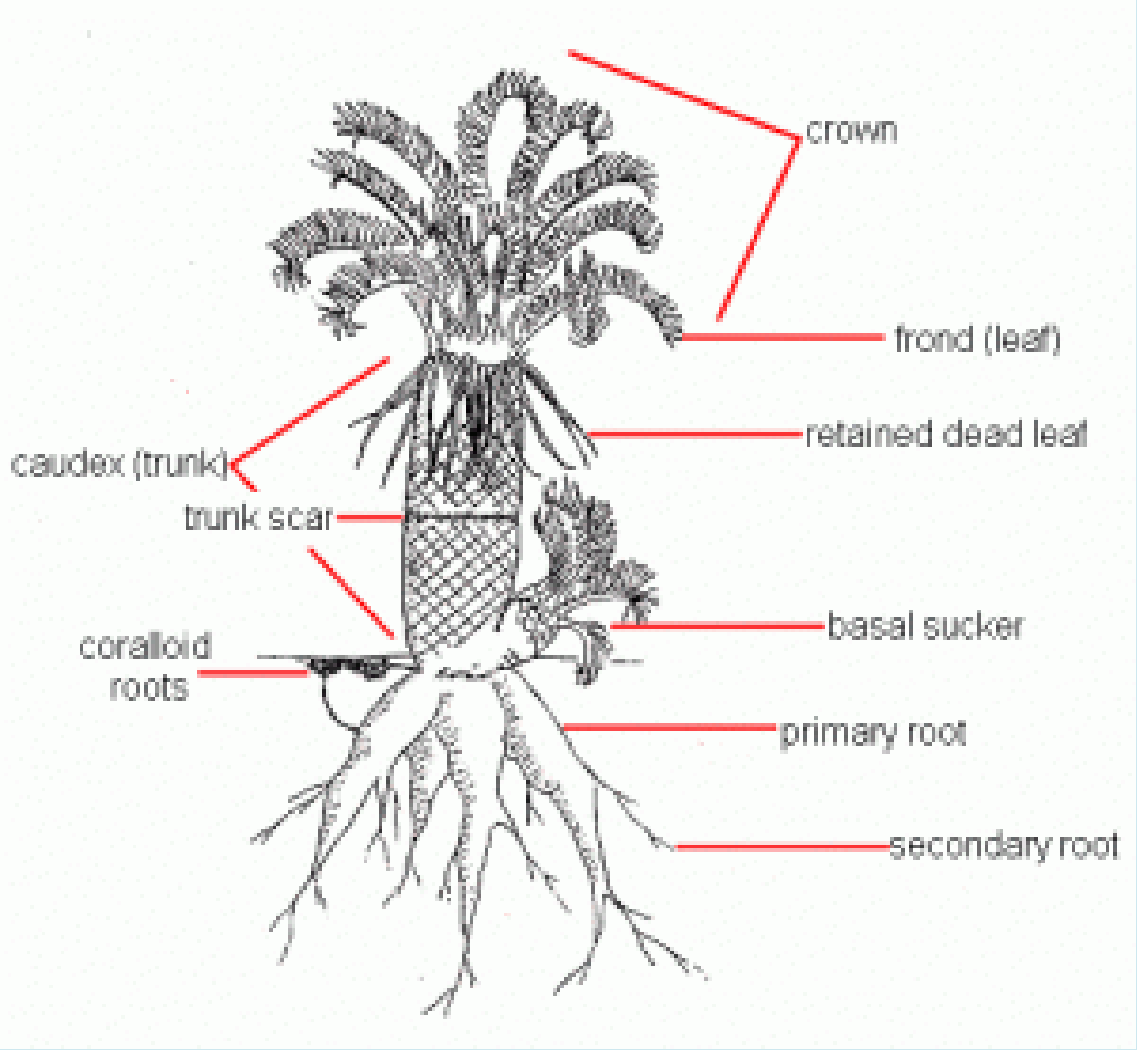
Male cone

Female plant showing megasporophylls

External morphology

- *Cycas* shows a palm like habit.
- It is about 3-5 m in height.
- It has stout, unbranched, short stem.
- The leaves are large and pinnately compound, forming a crown of leaves at the apex.
- The plant shows true roots, stem and leaves.

Cycas- external morphology



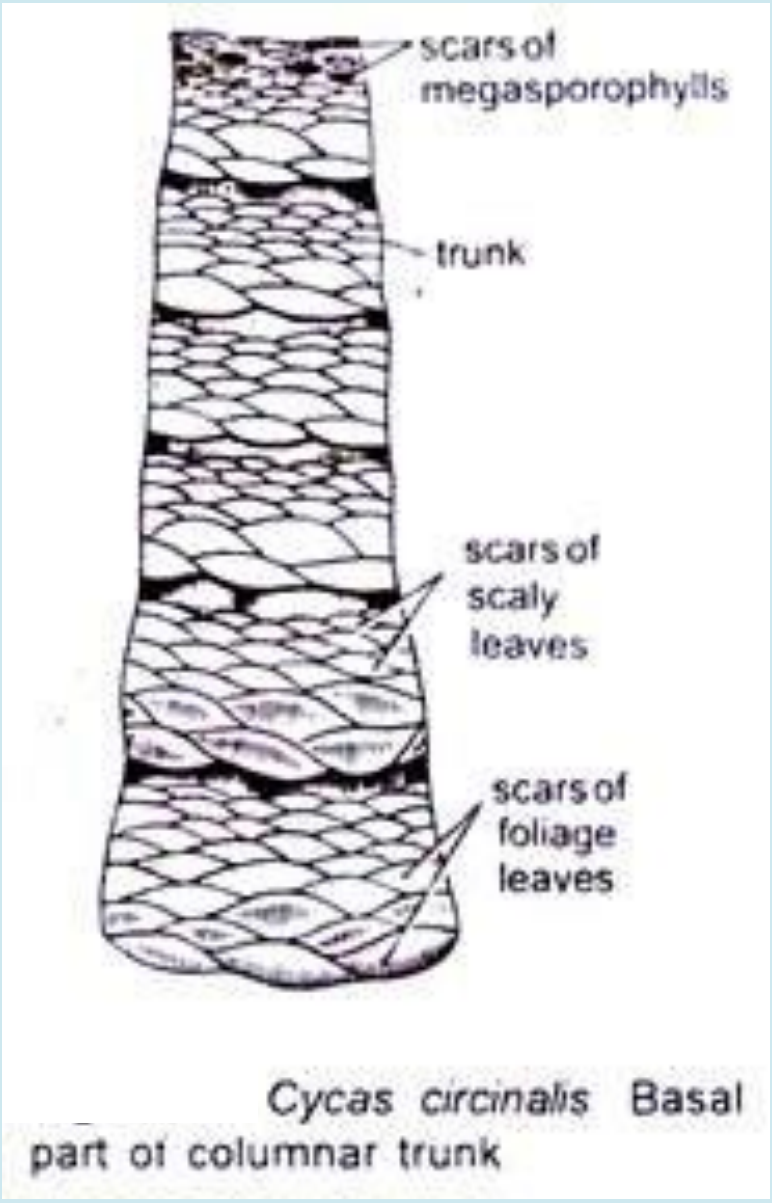
Roots

- *Cycas* shows extensive **tap root** system which goes deep into the soil.
- In addition, it also shows special roots called **coralloid roots**.
- Coralloid roots are **apogeotropic** (growing against gravity).
- They appear like **corals-** rough in appearance due to presence of small pores called **lenticels**. They show **dichotomous** branching.
- Often, these roots are infected with cyanobacteria (BGA) like ***Nostoc*** and ***Anabaena*** which perform Nitrogen fixation. In return, ***Cycas*** plant gives them shelter. This is a **symbiotic** association.

Cycas. A bunch of coralloid roots

Stem

- Stem is **cylindrical** and **woody**.
- Generally it is **unbranched**.
- Surface of the stem is **rough** due to its dry, brown scale leaves and persistent leaf bases of fallen foliage leaves.
- During favourable conditions, the stems produce enlarged buds or **bulbils** at the base, which help in vegetative reproduction.



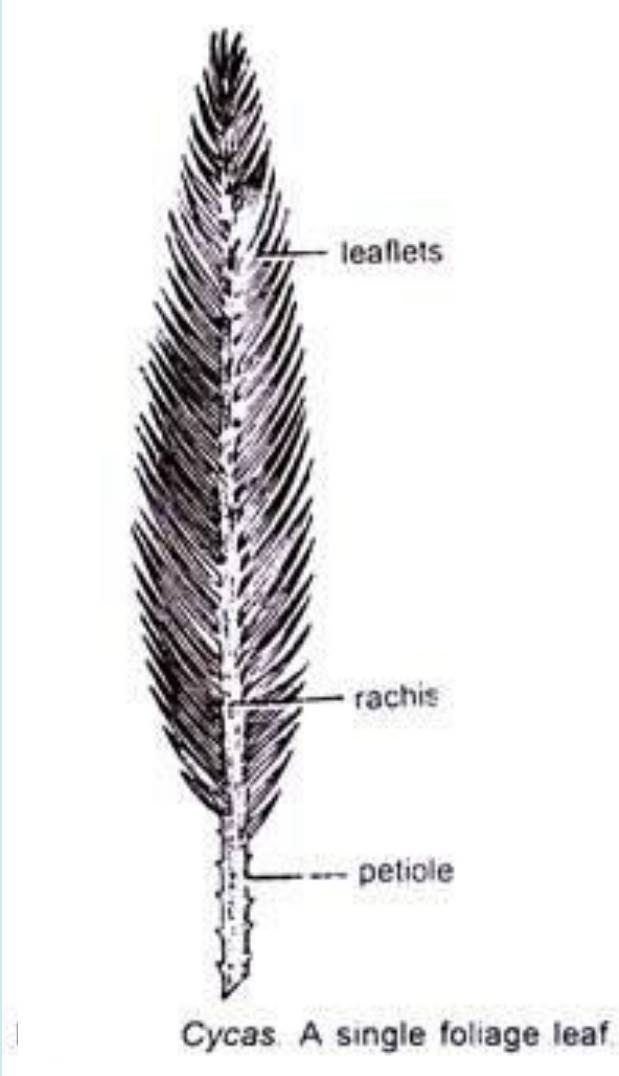
Cycas circinalis Basal part of columnar trunk

Leaves

- Leaves are of 2 types (**dimorphic**) - scale leaves and foliage leaves.
- **Scale leaves-** Dry, brown, triangular in outline, generally covered by small wooly hairs. They protect the foliage leaves and **sporophylls** during young condition.
- **Foliage leaves-** they form a **crown** at the apex. Each leaf is large and pinnately compound.
- Basal part of foliage leaf is the petiole/ stipe. It is covered by spines.

- The upper part of the foliage leaf shows central axis called the **rachis**.
- Leaflets/ pinnae are alternately arranged on the rachis.
- Pinna- each pinna is sessile, linear, lanceolate with leathery texture, entire margin and spiny apex. Midrib is seen but lateral veins are absent.
- In *Cycas revoluta*- margin is recurved. In *C. circinalis*- margin is straight.
- **Circinate ptyxis** is seen- the young leaves are rolled from the apex to the margin when they emerge.

A scaly leaf of *Cycas*



Cycas. A single foliage leaf.

Anatomy- T.S. of coralloid root

The T.S. of coralloid root is circular in outline. It shows the following layers:

1. **Periderm-** it is the outermost region consisting of cork cells and cork cambium. It shows small pores called lenticels and intervals.
2. **Cortex**: It is distinguished into 3 zones

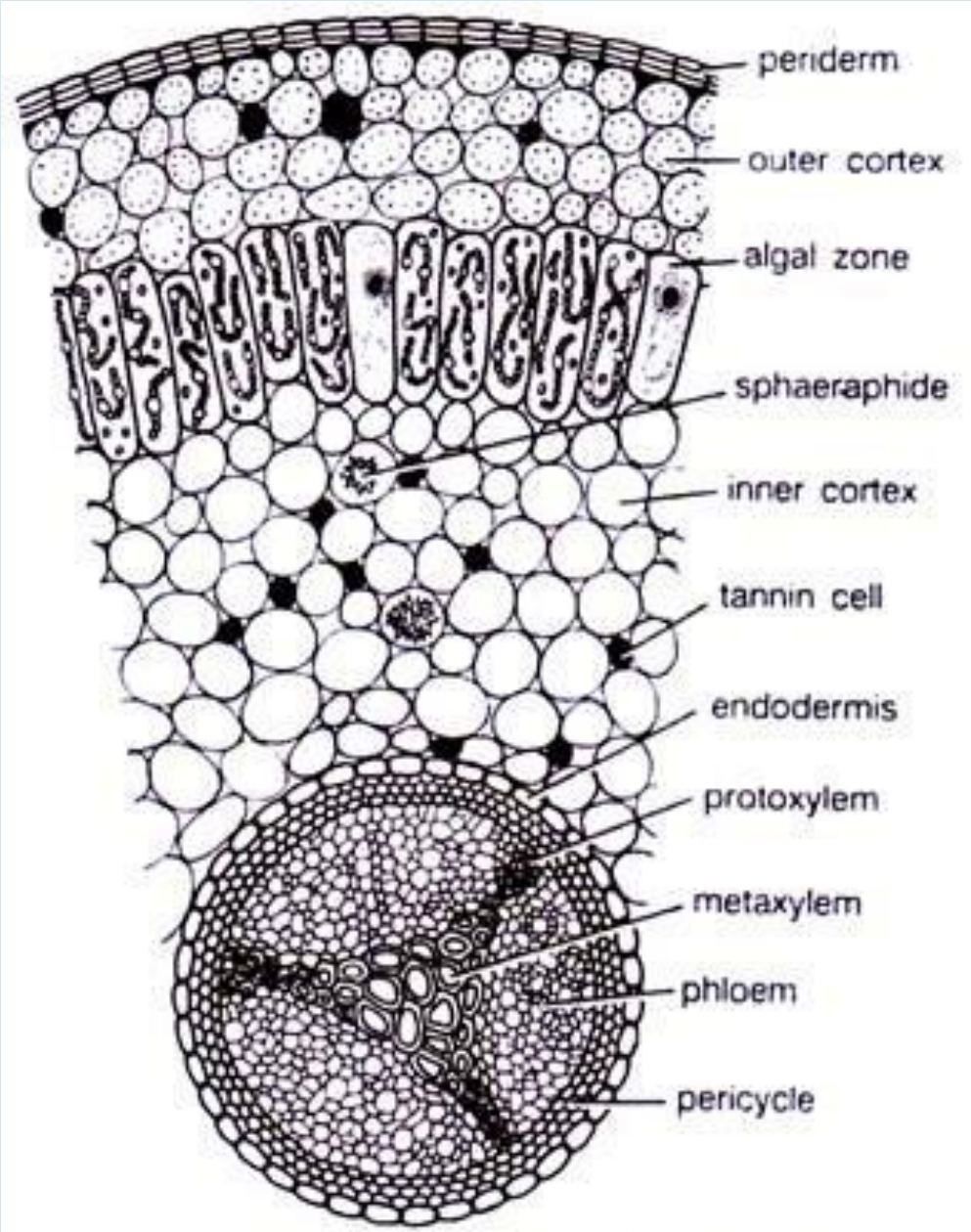
a) **Outer cortex-** made up of compressed parenchymatous cells.

b) **Middle cortex-** called algal zone which is distinct. It contains loosely arranged cells containing BGA and Nitrogen fixing bacteria.

c) **Inner cortex-** made of simple parenchymatous cells.

- The **cortical** region shows some tannin cells containing brownish yellow pigments (tannins) and sphaeraphides.

3. **Endodermis**: cells are barrel shaped with thick lateral walls.
4. **Stele**: it is triarch or tetrarch. It is surrounded by single layered parenchymatous pericycle. Vascular bundles are radial. The protoxylem is towards the periphery, so origin of xylem is exarch. The pith is usually reduced.



Cycas revoluta T S. coralloid root

T.S. of Rachis

The outline of the T.. Of rachis is circular.

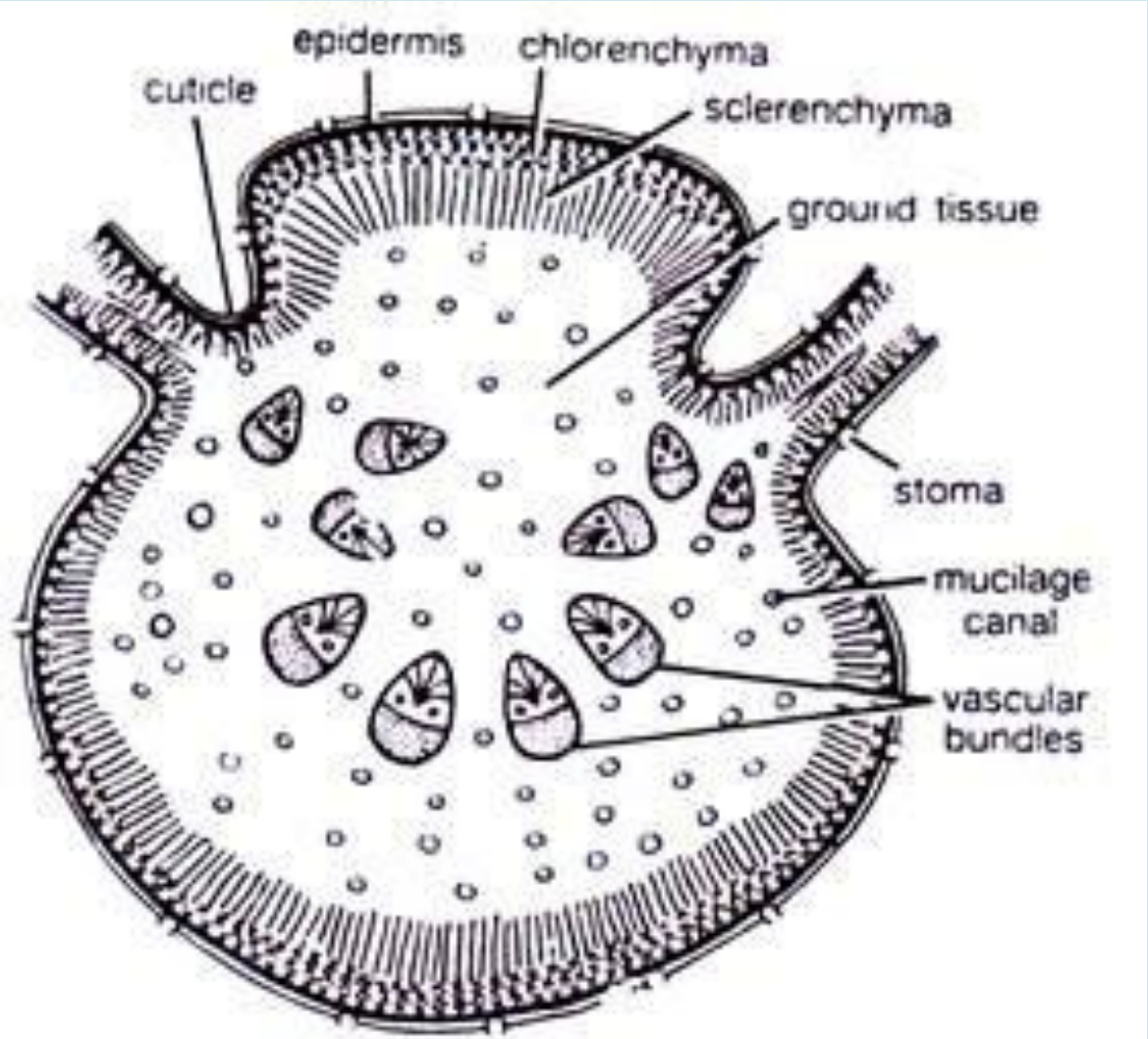
The rachis shows a pair of notches of leaflets dorso-ventrally.

1. **Epidermis**: it is a single layer of closely packed cells. The outer walls of these cells are highly **cutinised** forming a thick **cuticle** (a xerophytic adaptation). At regular intervals, it shows **sunken stomata**.

2. Ground tissue: it shows distinct **hypodermis-** made of 2-3 layers of **chlorenchyma** and inner zone made of a few layers of **sclerenchyma**. The rest of the ground tissue is parenchymatous, showing **mucilage ducts** scattered in it.

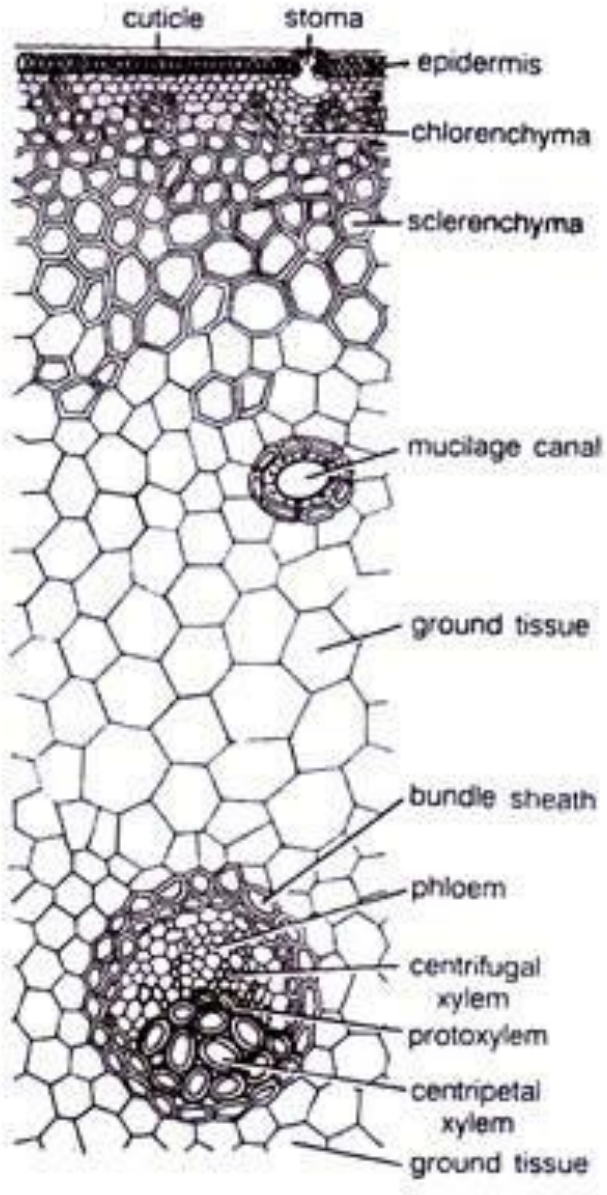
3. Vascular bundles: they are arranged in the form of the letter **omega** (Ω). Each vascular bundle is **conjoint**, **collateral**, **open** and surrounded by a sclerenchymatous **bundle sheath**. **Xylem** is towards the **centre** and is triangular in shape. Metaxylem is at the base while protoxylem is at the apex facing the periphery. The **phloem** is situated outside the xylem and it too faces the periphery. Cambium is non-active and is called **cambiform tissue**.

T.S. of rachis- outline



Cycas. T.S. rachis (diagrammatic).

T.S. of rachis- part magnified



Cycas revoluta. A part of T.S. of rachis.

T.S. of young stem

The T.S. of stem is circular in outline and shows the following layers:

Epidermis: it is single layered, with thin walled cells having cuticle.

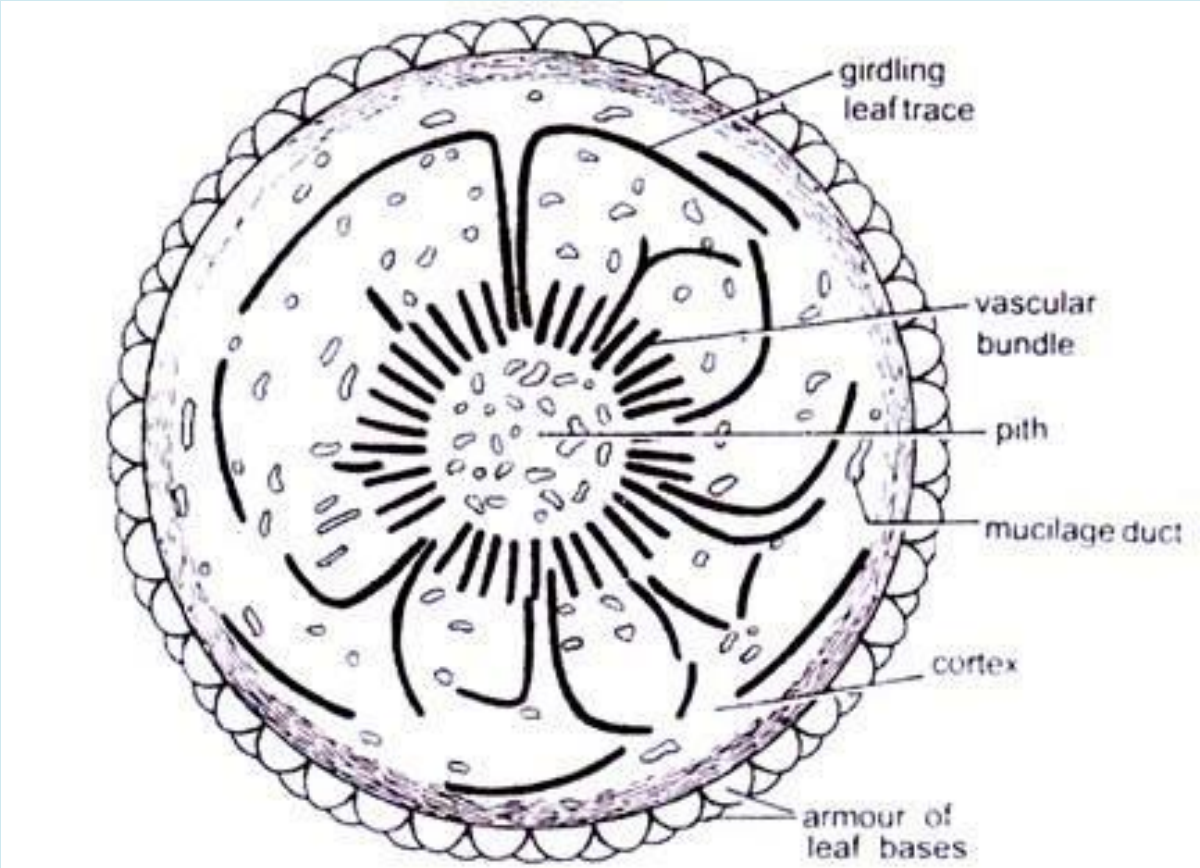
Cortex: It is several layers thick, it contains thin walled parenchymatous cells which store food material (starch grains). Mucilage ducts are present in the cortex. Cortex also shows leaf traces.

Endodermis: it is the innermost layer of cortex; it is indistinct.

Stele: The pericycle is not very distinct. Vascular bundles are many in number, arranged in a ring. Each vascular bundle is collateral, conjoint, open, endarch. Xylem is on the inner side while phloem is on the outer side. Protoxylem is towards the pith, hence endarch condition.

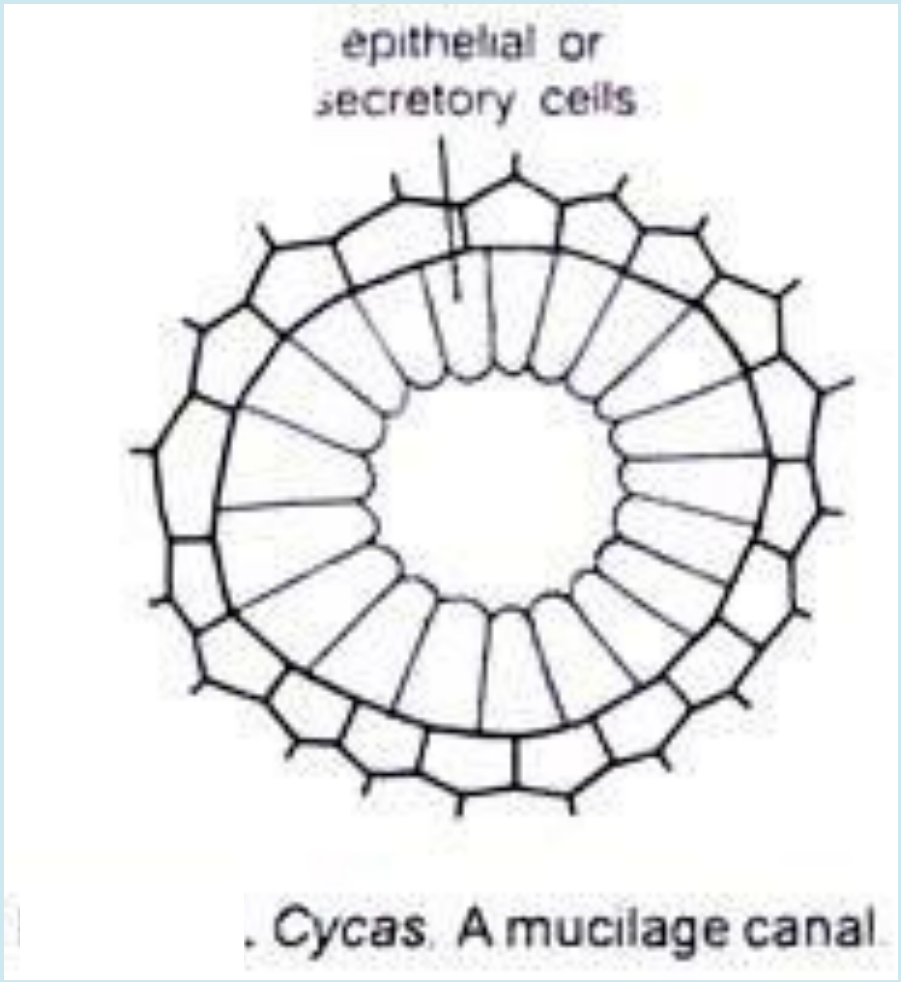
Pith: it is large and parenchymatous. Cells show presence of starch grains.

T.S. of young stem



Cycas. Diagrammatic representation of T S. young stem

Mucilage canal; vascular bundle seen in stem



. Cycas. A mucilage canal

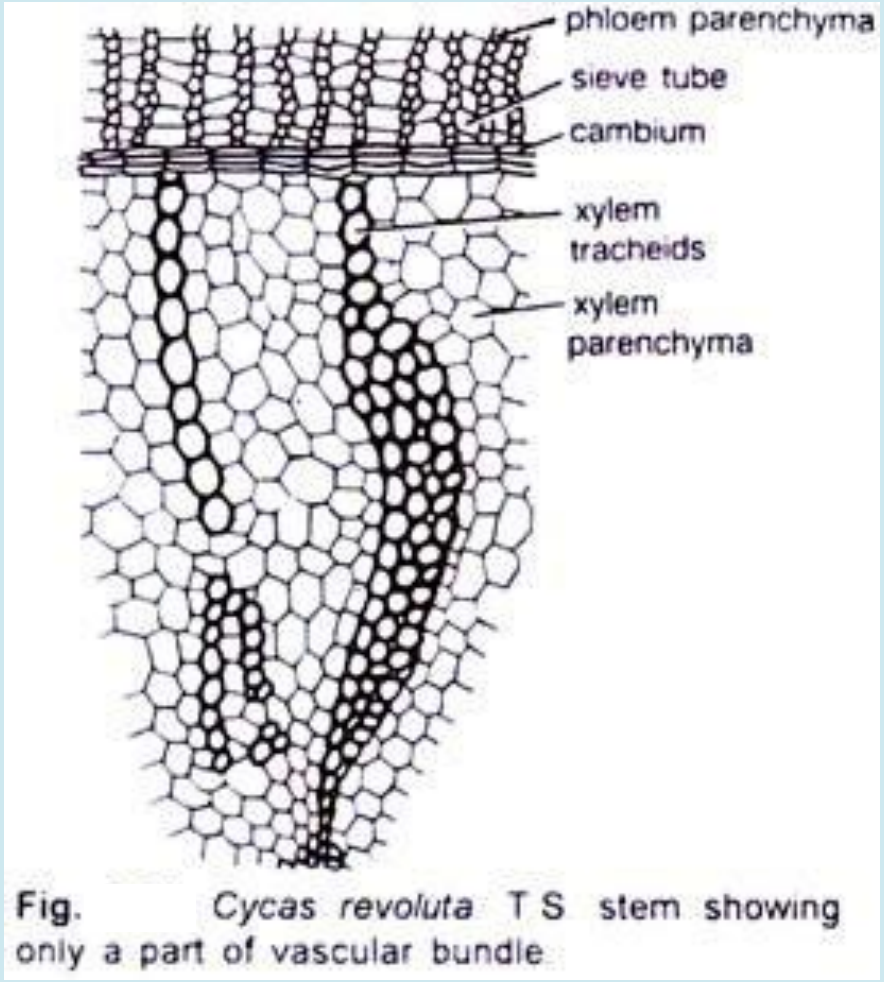
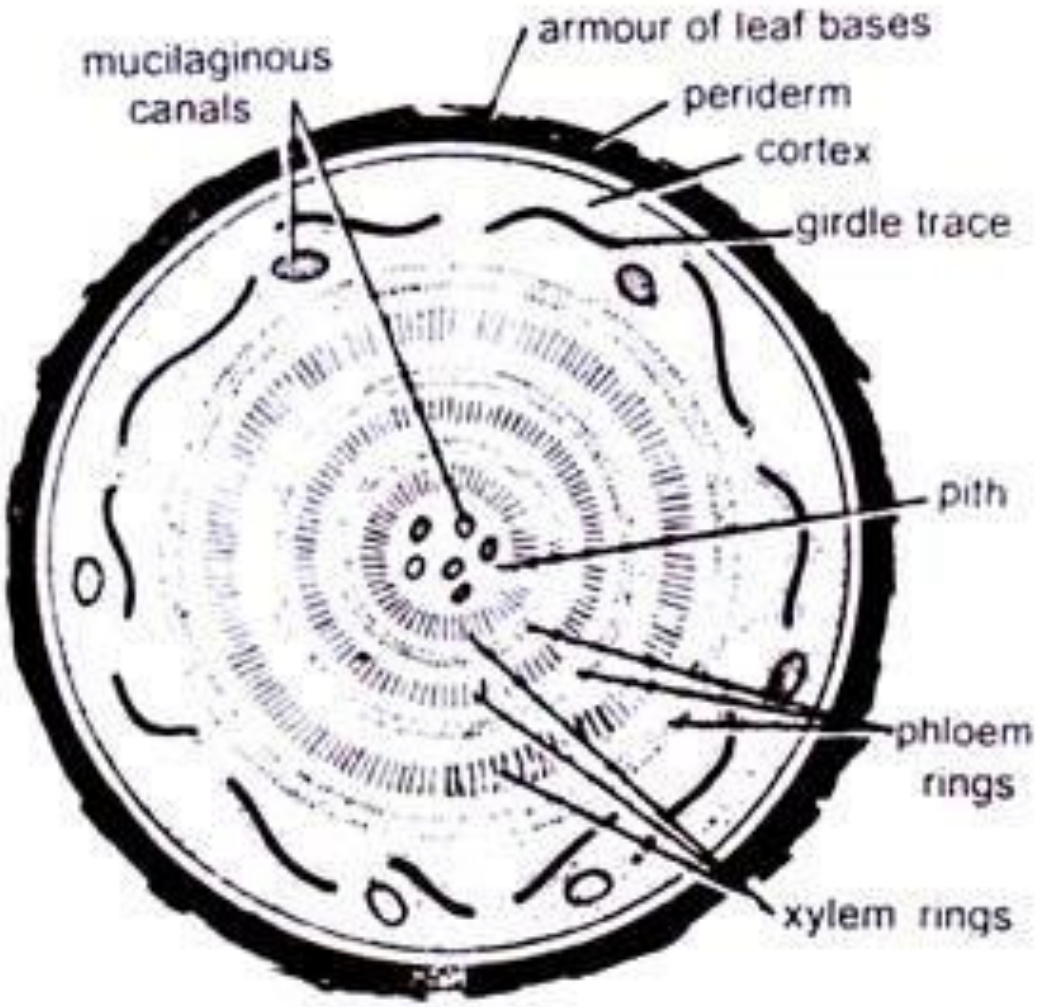


Fig. *Cycas revoluta* T S stem showing only a part of vascular bundle

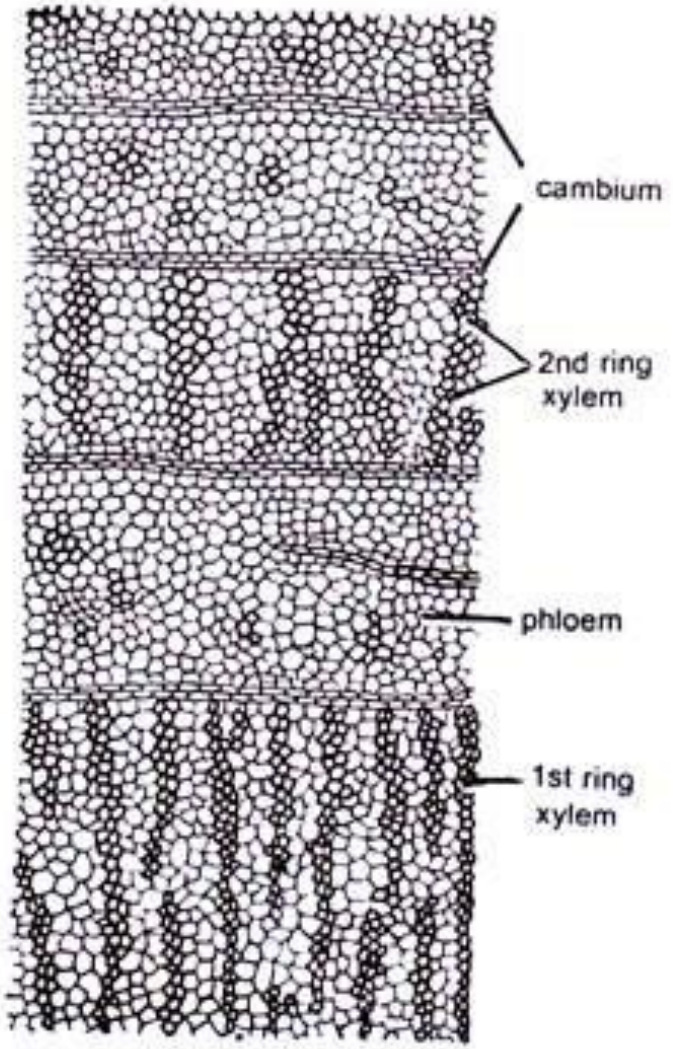
T.S. of old stem

- Secondary growth is seen.
- A thick outer periderm followed by large parenchymatous cortex, having many leaf traces and mucilaginous ducts are present in the old stem.
- Vascular strands are present in the form of rings. Medullary rays are also common.
- The number of vascular rings is variable from 2 to 14 in different species, thus showing polyxylic condition.
- Other details are similar to that of young stem.

T.S. of old stem



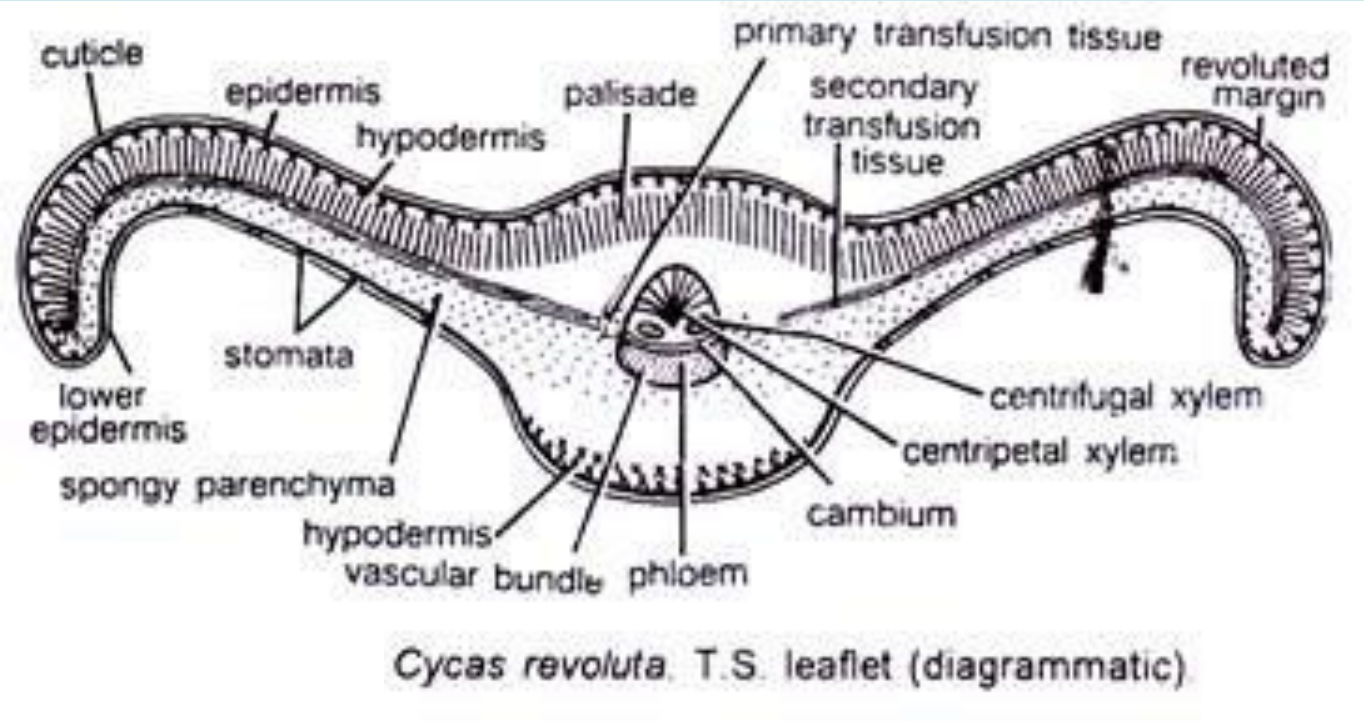
Cycas T.S old stem (diagrammatic)



Cycas. A part of T.S. stem showing secondary vascular tissues.

T.S. of leaflet

The midrib is seen in the centre and the lamina appears wing like on the sides with curved margins.



Cycas revoluta. T.S. leaflet (diagrammatic)

T.S. of leaflet

Upper epidermis: it consists of single layer of closely placed cells with highly cutinised outer walls (thick cuticle present). There are neither trichomes nor stomata in the upper epidermis.

Hypodermis: It is made up of 1-2 layers of sclerenchymatous cells below the upper epidermis. It gives leathery texture to the pinna and reduces transpiration (xerophytic adaptation).

Mesophyll: It is differentiated into palisade and spongy tissue. The pinna is **dorsiventral**.

Palisade tissue: It consists of a single layer of closely packed elongated chlorenchymatous cells which are photosynthetic in function.

Spongy tissue: It is 2-3 layered and made up of thin walled loosely packed cells, with less chloroplasts. It helps in transpiration, aeration and photosynthesis.

Transfusion tissue: It includes elongated, pitted parenchymatous cells placed between the palisade and spongy tissue. It runs horizontally from the midrib to the margins. It serves as the conducting tissue compensating for the absence of lateral veins.

Lower epidermis: Single layered with stomata.

Midrib: It shows single vascular bundle in the centre which is conjoint, collateral and open. It is surrounded by the sclerenchymatous bundle sheath. Xylem is ituated towards the upper epidermis & phloem towards the lower epidermis.

T.S. of leaflet

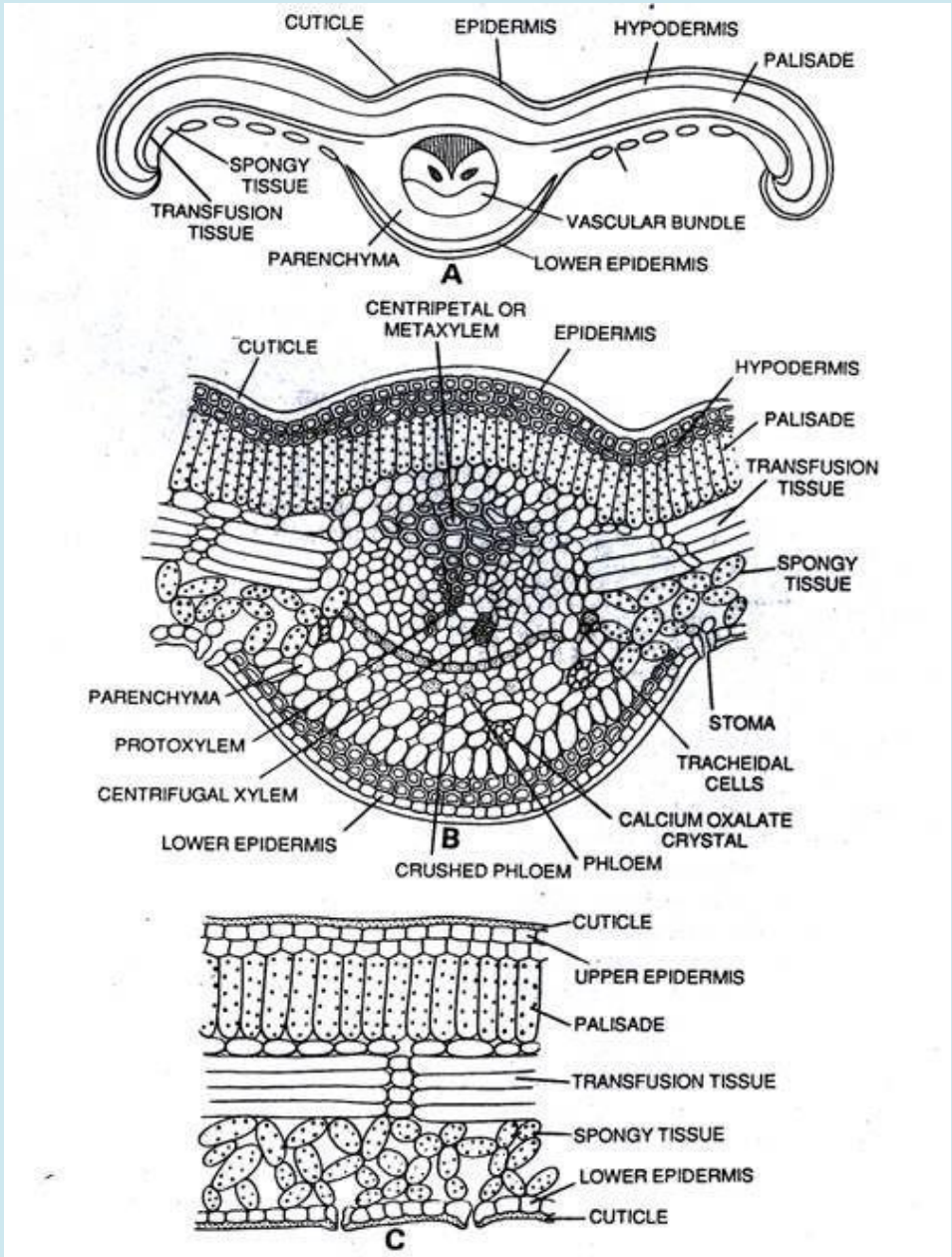


Fig. 3.22. *Cycas* sp. Anatomy of leaflet. A, T.S. of leaflet (diagrammatic structure); B, the detailed structure of mid-rib portion of the leaflet; C, T.S. of a portion of the wing of leaflet.

T.S. of leaflet

Economic importance of *Cycas*

- *Cycas* is commonly used as an ornamental plant. *Cycas revoluta*- plants are grown as ornamentals in various parts of the world.
- The leaves are used for decoration.
- Leaves are also used for making hats and mats.
- *Cycas* is used as source of food in many countries. Starch extracted from *Cycas* stem is called sago. *Cycas* is also known as sago palm.
- In Japan, seeds and stems of *Cycas revoluta* are used for making wine.
- The juice obtained from *Cycas circinalis* is used in skin diseases, vomiting of blood and stomach disorders.

Reproduction

Cycas is dioecious i.e. the male and female reproductive organs are borne on different plants.

Male reproductive organ: The male cone is produced at the **apex** of the stem. The **apical bud** is involved in this. Thus the further growth of the stem takes place by the development of **lateral buds**, which grow and join the main axis to assume a vertical position forming a false axis called **sympodium**.

Male cone

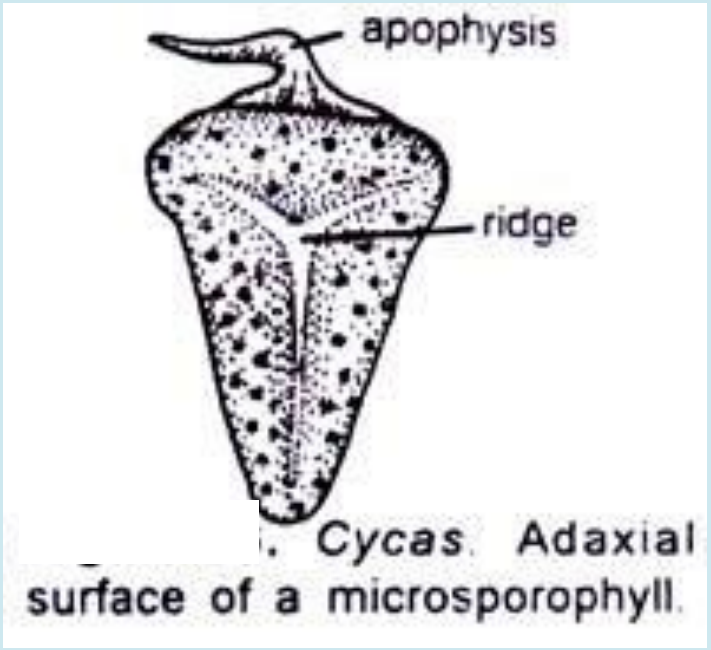
- Male cone is fusiform.
- It is woody in texture.
- It is about 30-50 cm long.
- It consists of a central elongated axis on which the microsporophylls are arranged in tight spirals.

Cycas. A single male cone.

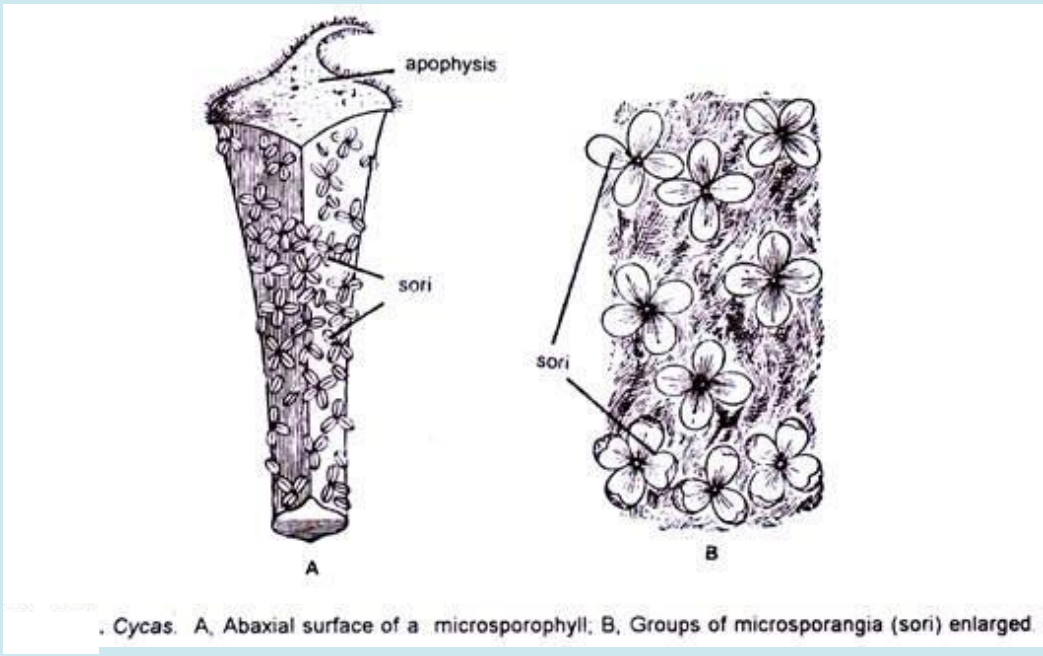
Microsporophyll

- Each microsporophyll is about 4-5 cm long, dry, brown, flat, scale like structure.
- It is somewhat **triangular** in shape.
- It is attached to the central axis of the cone by a narrow base.
- Its terminal broad **sterile** portion is free which abruptly ends upwards into a curved pointed structure called **apophysis**.
- At maturity, along the lower surface (**abaxial**) the microsporophylls produce **groups** of microsporangia, called **sori**. Each group consists of 3-5 microsporangia.

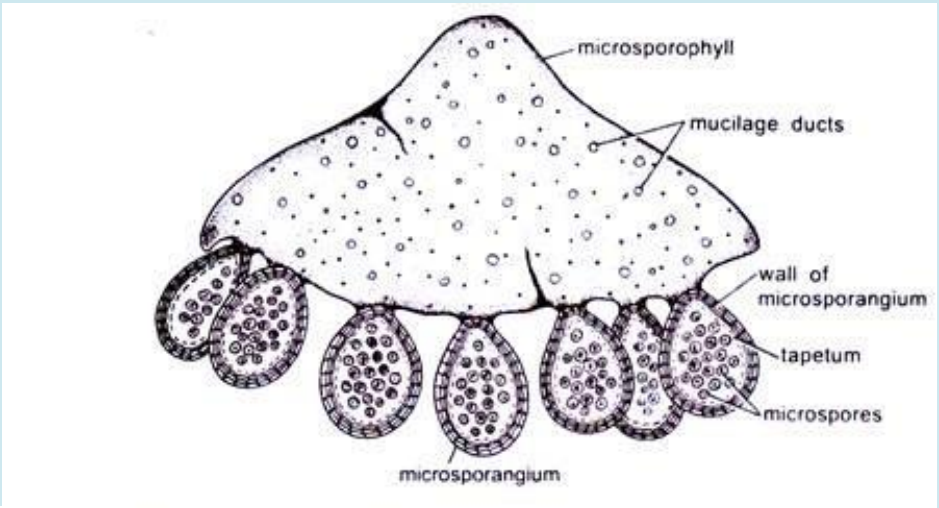
Microsporophyll, sori, T.S. of microsporophyll



. *Cycas*. Adaxial surface of a microsporophyll.



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



. T.S. microsporophyll of *Cycas*.

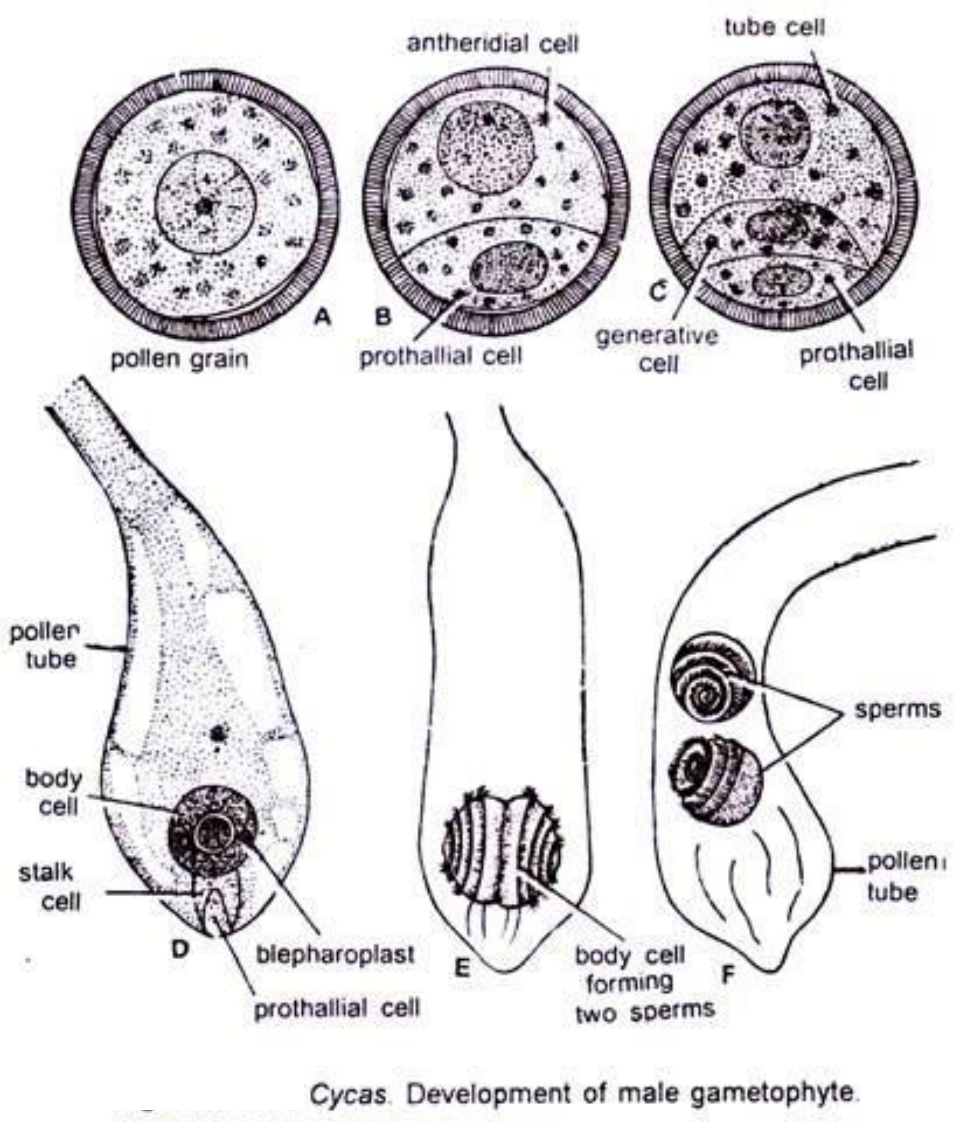
Microsporangium and microspore

- Each microsporangium (pollen sac) is sessile, oval and unilocular structure.
- It contains microspore mother cells which undergo meiosis at maturity and form haploid microspores.
- Each microspore (pollen grain) is unicellular and uninucleate body.
- It has outer smooth, thich walled exine and inner thin walled intine.

- Before leaving the microsporangium, each microspore divides into 3 cells- a small prothallial cell towards the lower side, the middle generative cell and the upper large tube cell.

- At this 3- celled stage of microspore, the microsporangium splits open by a longitudinal slit and the microspores are liberated.

Microspore



Cycas. Development of male gametophyte.

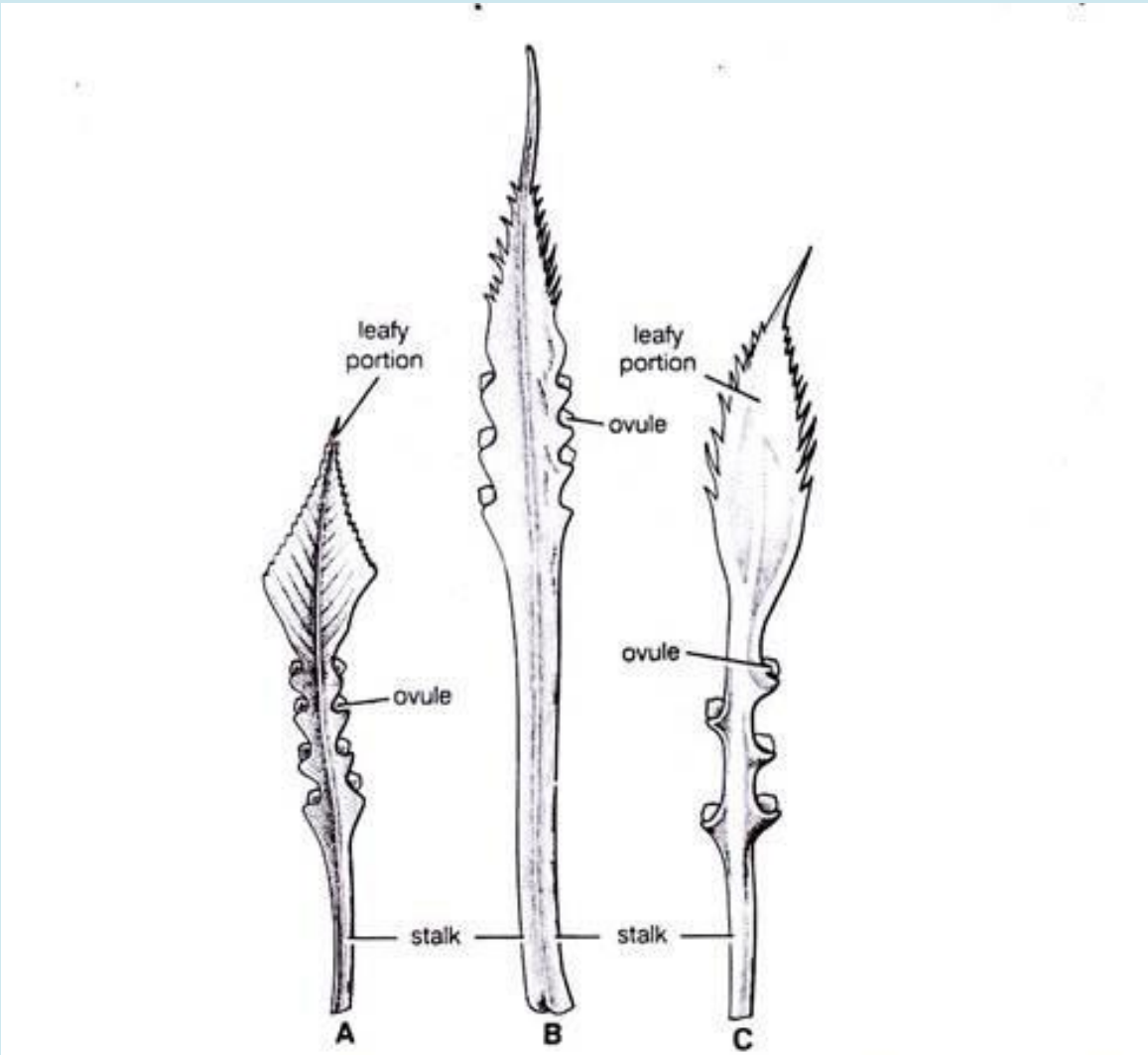
Female reproductive organ

- In *Cycas*, female cone is **not formed**. The female reproductive organs are called **megasporophylls**.
- They are spirally arranged around the apex of the stem alternating with foliage leaves.
- The apical bud is not utilized in developing the megasporophylls, hence it continues to grow.
- Thus the stem of the female plant is a true axis or **monopodium**.

Megasporophyll

- Each megasporophyll or carpel consists of the basal thick & fleshy cylindrical region and the distal expanded region covered by brown wooly hair.
- The basal region laterally bears 3-5 pairs of naked ovules.
- The distal region is either serrate eg. *C. circinalis* or finely pinnate eg. *C. revoluta*.

Megasporophyll

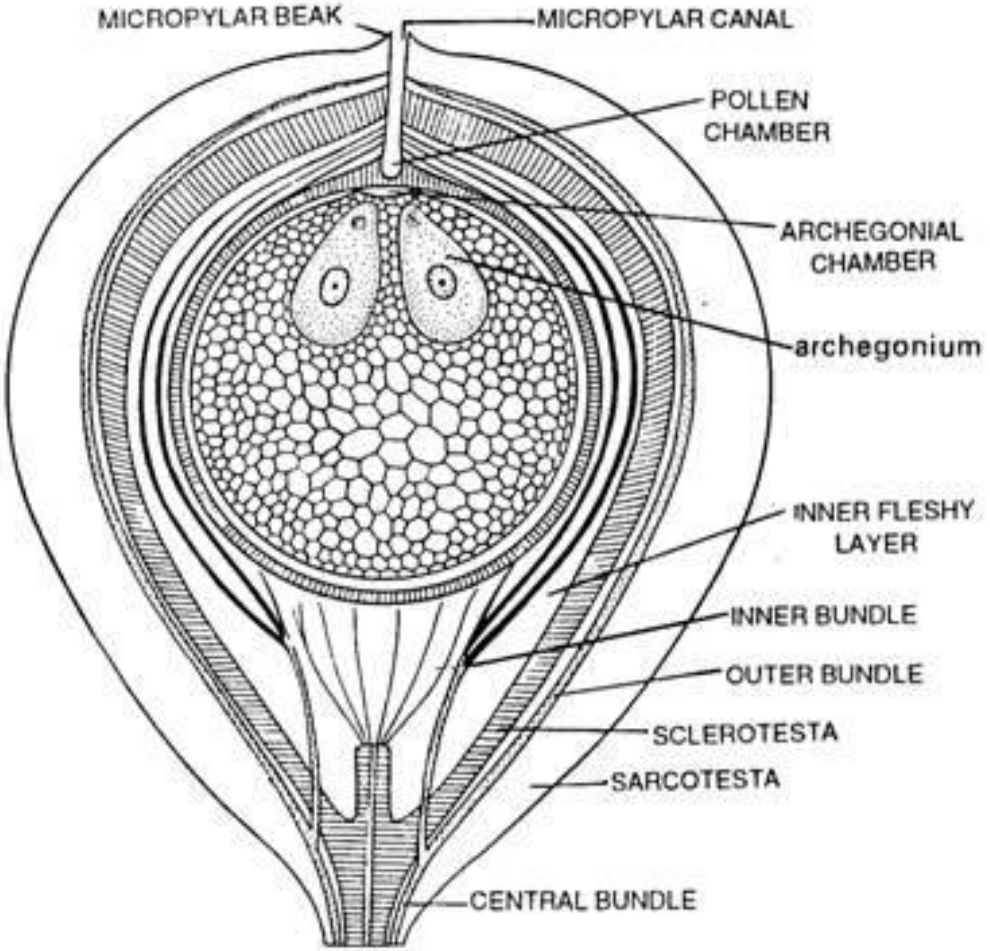


Megasporophylls of *Cycas*. A, *C. circinalis;* B, *C. rumphii;* C, *C. beddomei*.

L.S. of Ovule

- It is **sessile**, **orthotropous** or straight and is **exposed** (not covered by ovary).
- It is a large & oval structure, about 5 cm long and 4 cm broad.
- It consists of a fleshy mass of diploid tissue called **nucellus**.
- At the apex, the nucellus shows a **beak** like projection which encloses a cavity called the **pollen chamber**.
- The base of the nucellus is occupied by **chalaza**.
- The single integument later differentiates into **3 layers**. It totally surrounds the nucellus except at the apex where a minute aperture called **micropyle** is observed which leads to the pollen chamber.
- The **outer** and **inner** layer of integument is **fleshy** while the **middle** one is hard and **stony**.

L.S. of Ovule

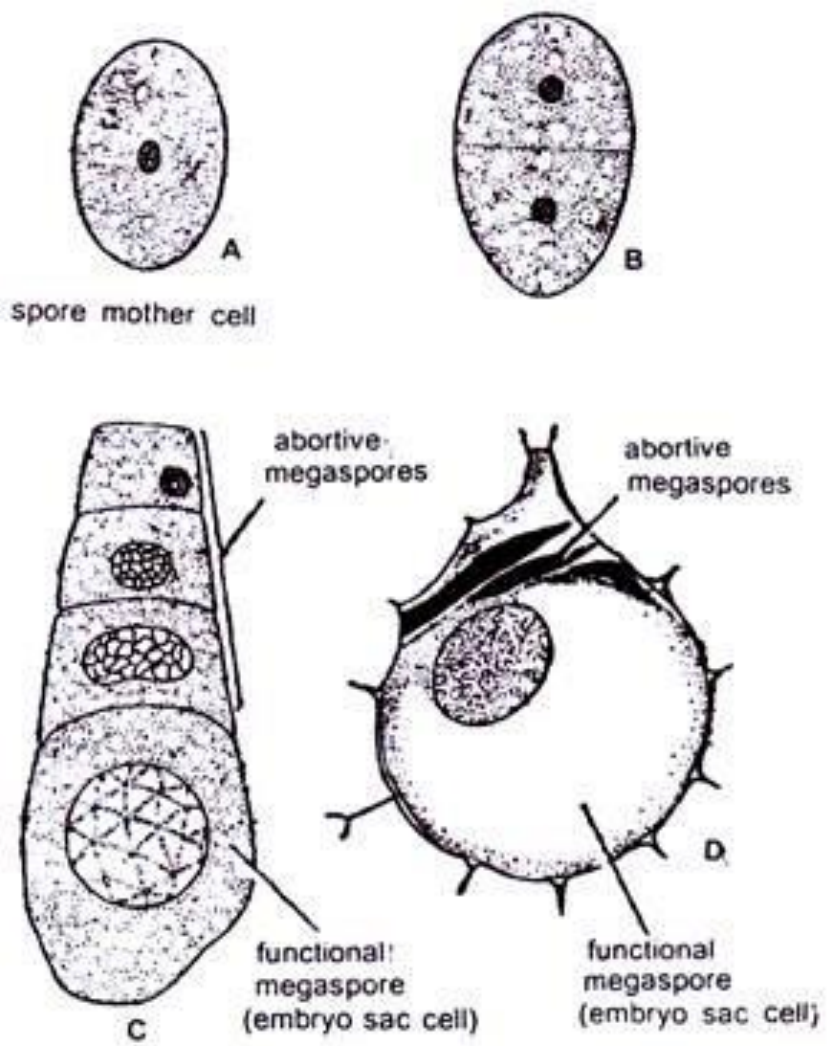


Cycas revoluta. V.S. of ovule showing internal structure before fertilization and its vascular supply.

Development of megaspore

- One of the diploid cells at the centre of the nucellus gets differentiated into **megaspore mother cell**.
- It undergoes meiosis to form **4 haploid megaspores** which are arranged in a vertical row.
- The upper 3 of the 4 degenerate and the **one** at the bottom remains & is called the **functional megaspore**.
- This functional megaspore is permanently retained within the nucellus.
- It enlarges and it **nucleus multiplies** many times (**mitotically**).
- This forms a tissue which represents the female **prothallus** or female **gametophyte**.
- At the tip of female gametophyte, 2-3 **archegonia** develop. They open into the **archegonial chamber**.
- As the female prothallus grows, the nucellus gradually reduces.

Development of megaspore

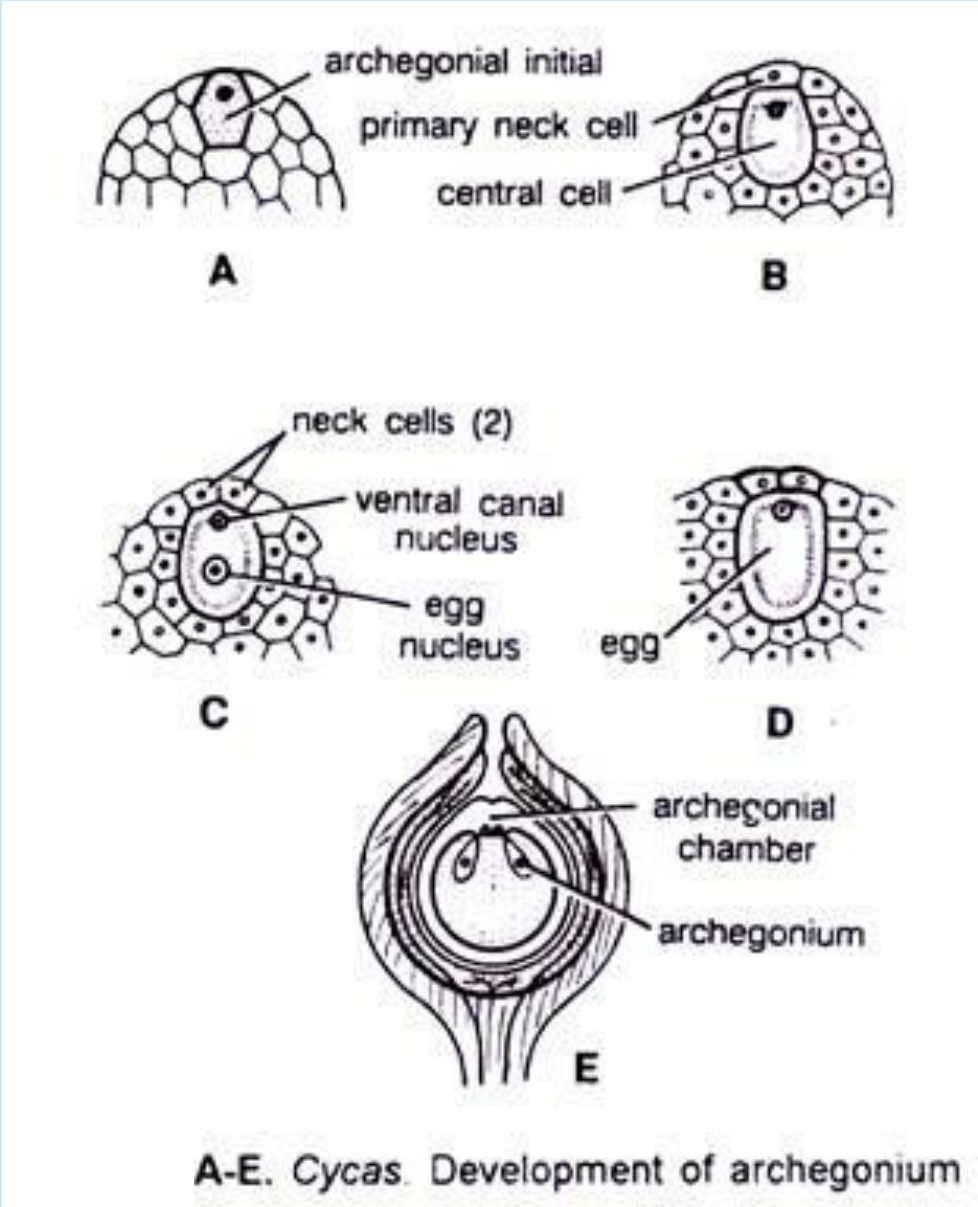


Cycas. Development of megaspores.

Archegonium

- It consists of a reduced **neck** and a large **venter**.
- The neck consists of only neck cells. Neck canal cells are absent.
- The venter encloses a large ventral cell surrounded by a single layer of cells called **archegonial jacket**.
- The nucleus of the central cell soon divides into an egg nucleus and a ventral canal nucleus.
- The latter degenerates and only the **egg nucleus** survives- which is the **largest** in the plant kingdom.

Development of archegonium



A-E. *Cycas*. Development of archegonium

Pollination

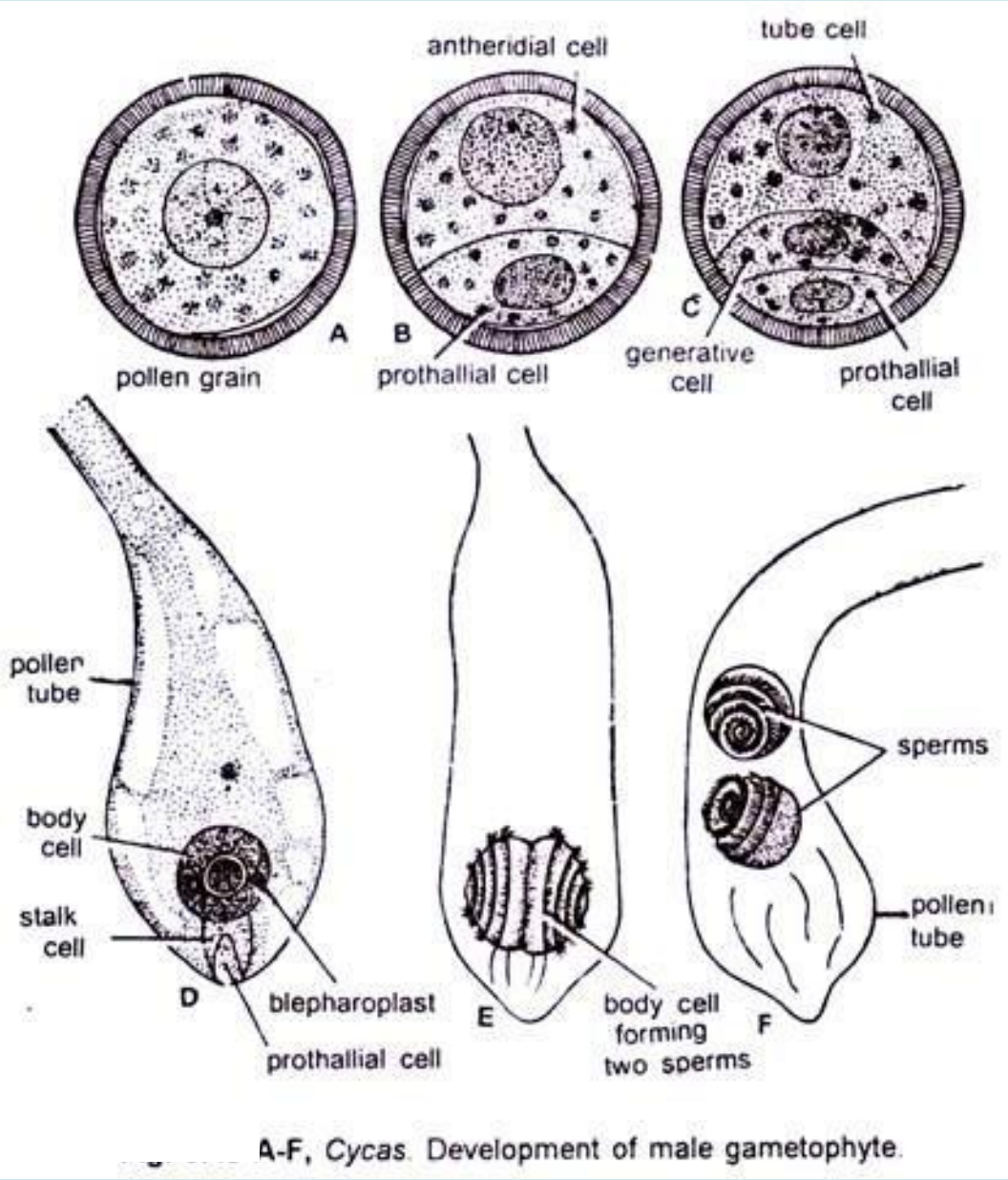
- *Cycas* is a wind pollinated plant- **anemophily** is seen.
- The pollen grains are liberated in the **3 celled stage**. They are blown around by the wind.
- Some of them get caught and entangled in the mucilaginous secretion called '**pollination drop**' which oozes out from the micropyle.
- When the mucilage dries, it shrinks and the pollen grains are drawn into the pollen chamber.
- The micropyle closes and becomes hard so that the pollen grains become locked into the **pollen chamber**. Here, they undergo a long period of rest.

Fertilization

- After a long period of rest, the pollen grain germinates within the pollen chamber.
- The exine ruptures near the tube cell and the intine grows out to form a **pollen tube**.
- This pollen tube carries along with it the **generative** cell & the **prothallial** cell.
- The generative cell divides to form a large **fertile** body cell (**spermatogenous** cell) and a small **sterile** cell.
- The fertile cells further divides into 2 cells which metamorphose into 2 **spermatozoids**.

- Each spermatozoid is a top shaped, **uninucleate**, **motile** body with 4-5 spherical bands of **cilia**.
- The pollen tube carrying the spermatozoids pierces through the nucellar tissue and enters the archegoinal chamber.
- There it bursts open to release the spermatozoids which swim to the neck of the archegonia.
- The male nucleus comes out of its cytoplasmic sheath and moves towards the egg nucleus & fuses with it to form **diploid zygote**.
- Even if many eggs are fertilized, only 1 develops into the embryo at maturity.

Formation of pollen tube

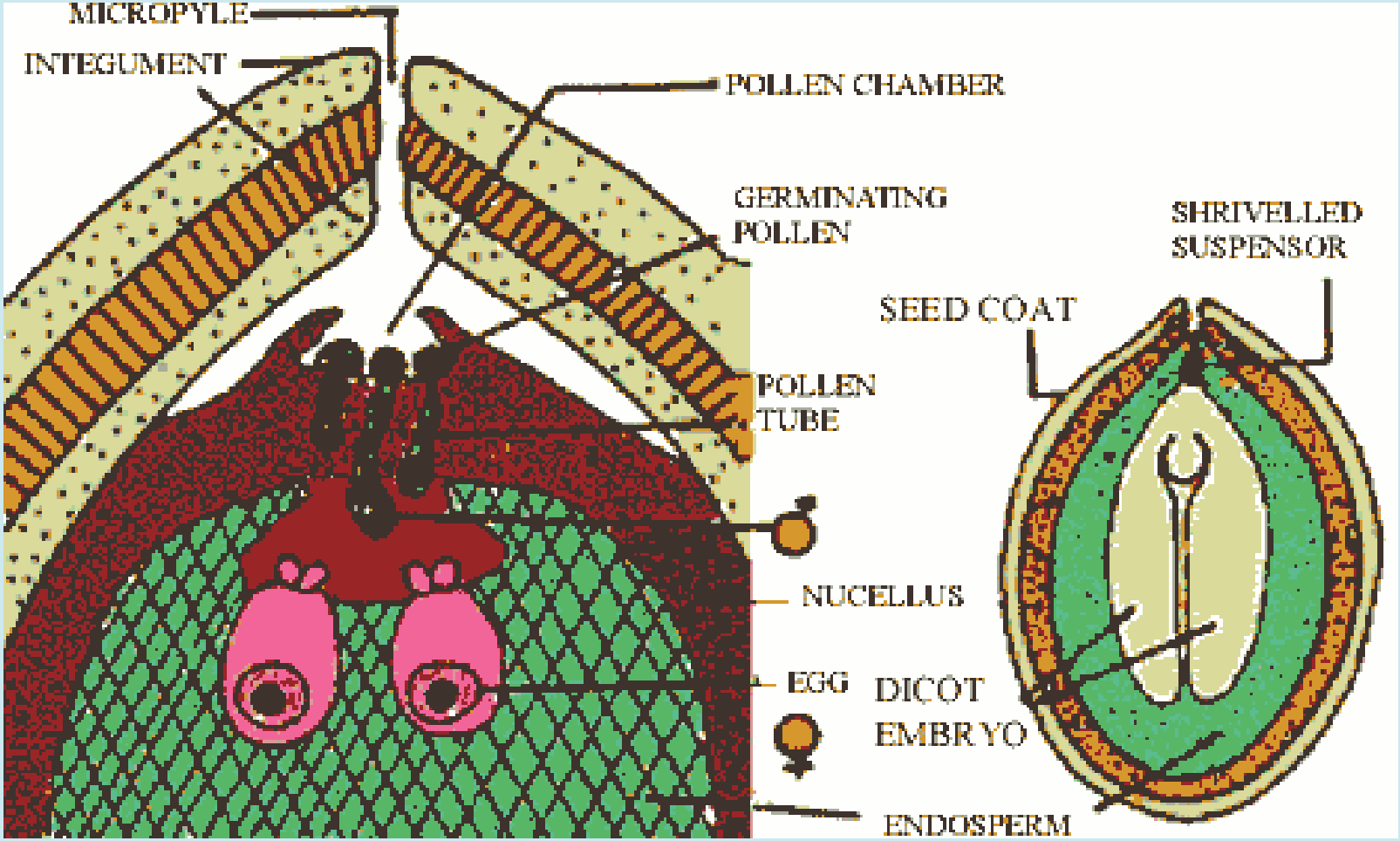


A-F, *Cycas*. Development of male gametophyte.

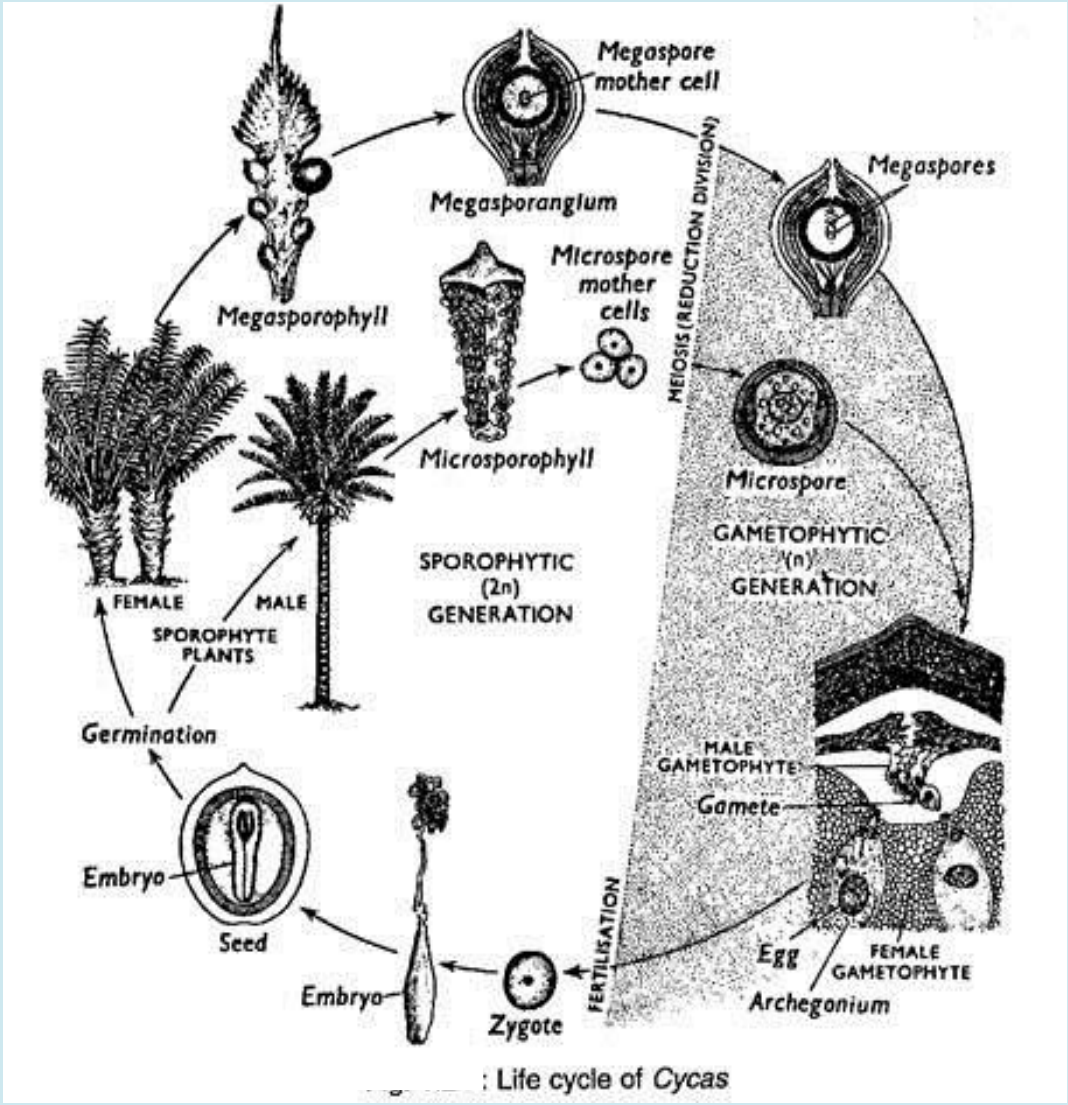
Formation of seed

- Fertilized egg undergoes a series of mitotic divisions to form **proembryo** and **suspensor**.
- The rest of the cells of female gametophyte get converted into **endosperm**.
- The proembryo and suspensor degenerate.
- The nucellus and inner integument become thin & papery and are called **perisperm**.
- The outer 2 layers of integuments form the **testa** (**seed coat**).
- The seed is hard, oval, brown, **dicotyledonous** and endospermic.

L.S. of ovule and L.S. of seed



Alternation of generations (life cycle)



: Life cycle of *Cycas*

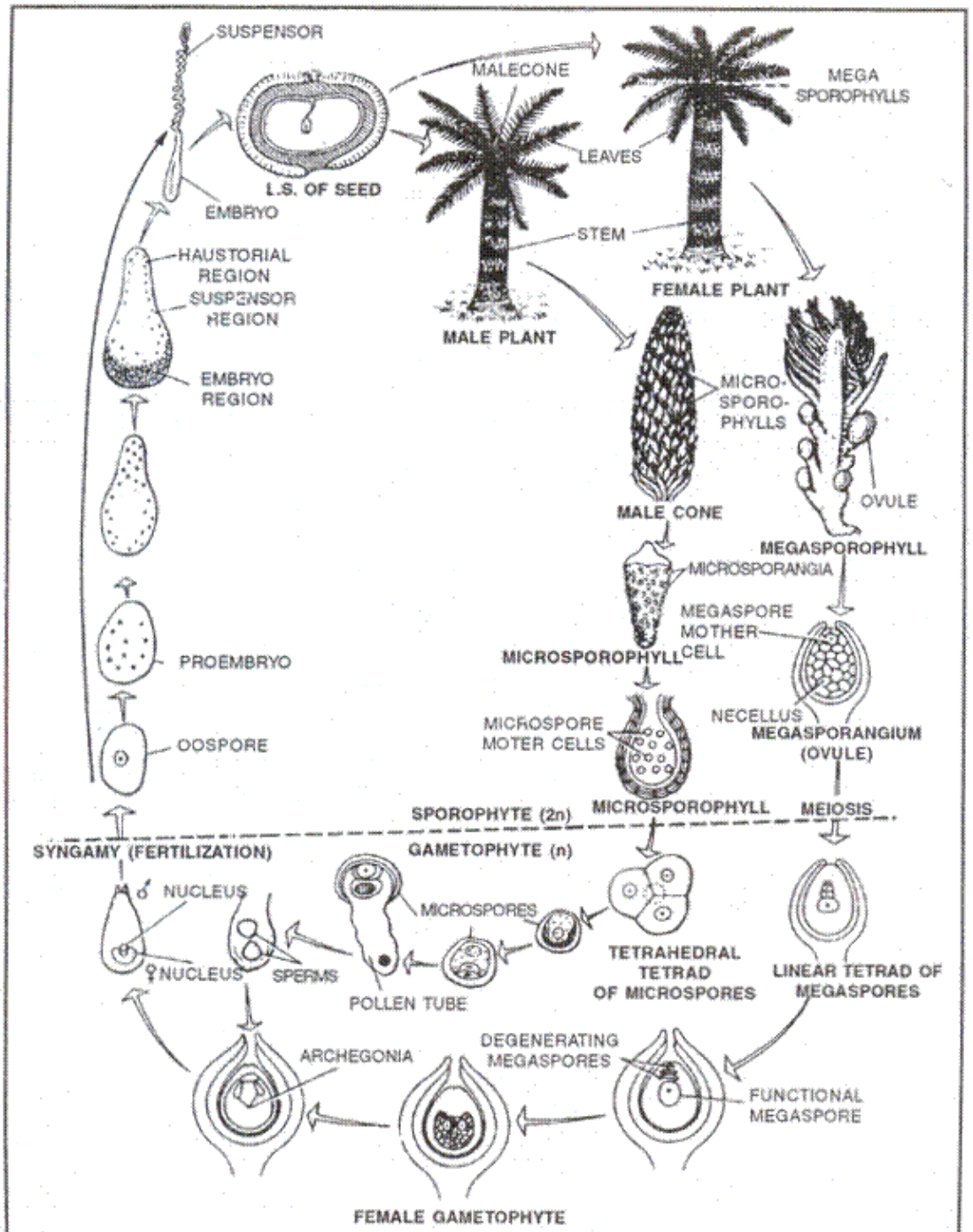


Figure 9.17 Diplontic life cycle of *Cycas*.