VIVEKANANDA COLLEGE

THAKURPUKUR

KOLKATA-700063

NAAC ACCREDITED 'A' GRADE

Topic:	GYMNOSPERMS
Course Title:	PLANT DIVERSITY II
Paper:	BOT-G-CC-2-2-TH
Unit:	2.3
Semester:	II
Name of the Teacher:	Mrs. Rinku Halder Sahu
Name of the Department:	Botany (Morning)

Life cycle of *Cycas*

- **Distribution of *Cycas*:**

It is the only genus of the family Cycadaceae, which is represented in India. It has about 15 species (Sporne, 1965), 20 species (Willis, 1966) which are widely distributed in Eastern as well as Western hemisphere from Madagascar, Eastern coast of Africa to Japan and Australia touching China and India.

In our country a few of the species are found growing abundantly in the South Andaman and Nicobar islands, Madras, Mysore, Malabar and in North East in Bengal, Assam, Nepal and Sikkim. A few of the species are also found in Burma and Ceylon.

The following species are found in India:

C. circinalis, C. pectinata,C. beddomei,C. rumphii,C. revoluta,C. siamensis.

- **Morphological Features:**

Cycas is a perennial, slow growing evergreen plant and is referred to as a living fossil because it occurs as a fossil e.g., *C. fusiana*. It looks like a palm tree. Its main plant body is s**porophytic, diploid, dominant**

and can be differentiated into three parts – roots, stem and leaves. Tallest species of Cycas is *C. media* with 20 feet height.

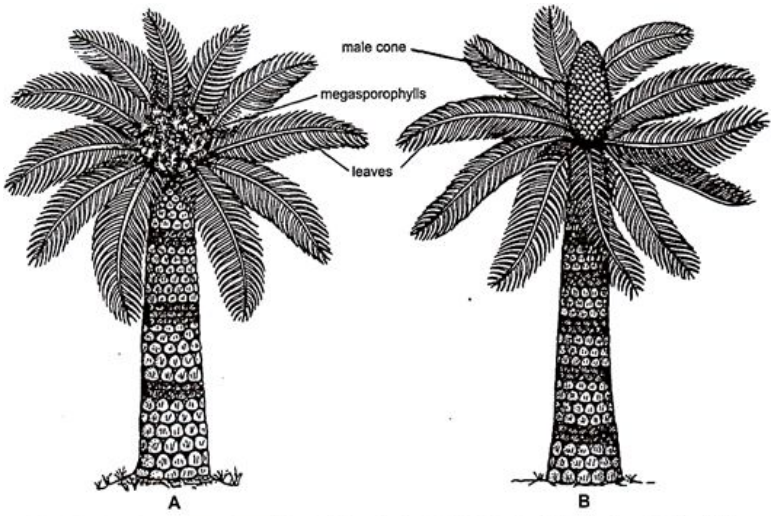

Fig. 1 (A, B), *Cycas.* External morphology (A) female plant of *C. Circinalis, (B) Male plant of C. Circinalis.*

1. Roots:

They are of two types – **normal and coralloid roots.**

- **Normal roots:** It grows deep into the soil and forms a 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.
- **Coralloid root**: 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 **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 (Fig. 2).

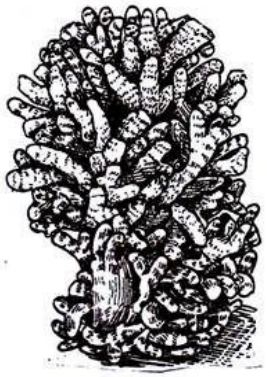

Fig. 2. *Cycas*. Coralloid roots.

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** (Fig. 4). 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 (Fig. 4).

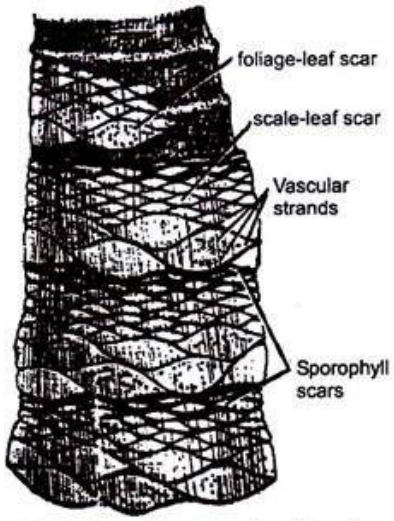

Fig. 4. *Cycas*, Stem showing alternate bands of larger foliage leaf bases and smaller scaly leaves and megasphorophyll bases.

- At the top is present a crown of leaves (Fig. 1).

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).

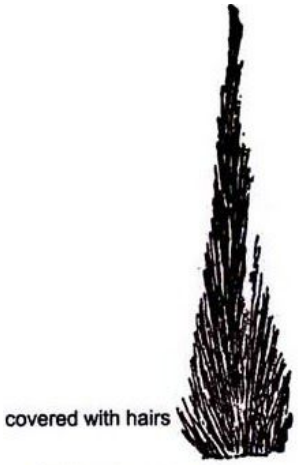

Fig. 3. *Cycas.* A scale leaf

- **(b) Foliage leaves:**
    1. These leaves are also produced in a crown at the apex of the stem.
    2. A single foliage leaf is pinnately compound. It
    3. is unipinnate and paripinnate.
    4. Each leaf has 80-100 pairs of leaflets which are arranged on both the sides of the adaxial groove of the rachis in opposite or alternate manner.
    5. The rachis is spiny below with the sheathing leaf base (Fig. 6A).
    6. These spines are modified leaflets. Each leaflet is leathery in texture, sessile elongated, ovate or lanceolate in shape

and has an entire margin with acute apex. Each pinna or leaflet contains a midrib without lateral veins.

7. In *C. micholitzii* the leaflet is repeatedly and deeply dichotomised (Fig. 5).

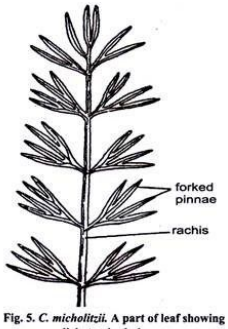

Fig. 5. *C. micholitzii.* A part of leaf showing dichotomised pinnae.

8.Margins of the pinnae are flat (Fig. 6B) but sometimes they are curved downwards and inwards (revolute) (Fig. 6C) which gives the plant a specific name *C. revoluta*.

9.Young leaves have circinately coiled leaflets which are also covered by hairs or ramenta like those of ferns (Fig. 6 D, E).

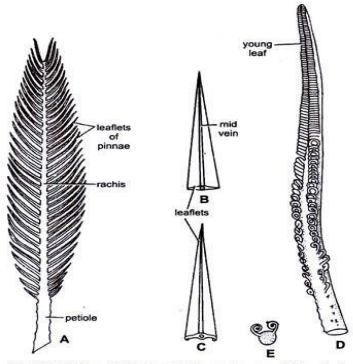

Fig. 6. (A–E) *Cycas*. (A) External features of a normal foliage leaf; (B) Flat leaflet of *C. rumphii*, (C) Revolute leaflet of *C. revoluta*, (D, E) Young foliage leaf showing circinate vernation of leaflets.

Internal Structure :

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 a 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 a 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. 7A, B).

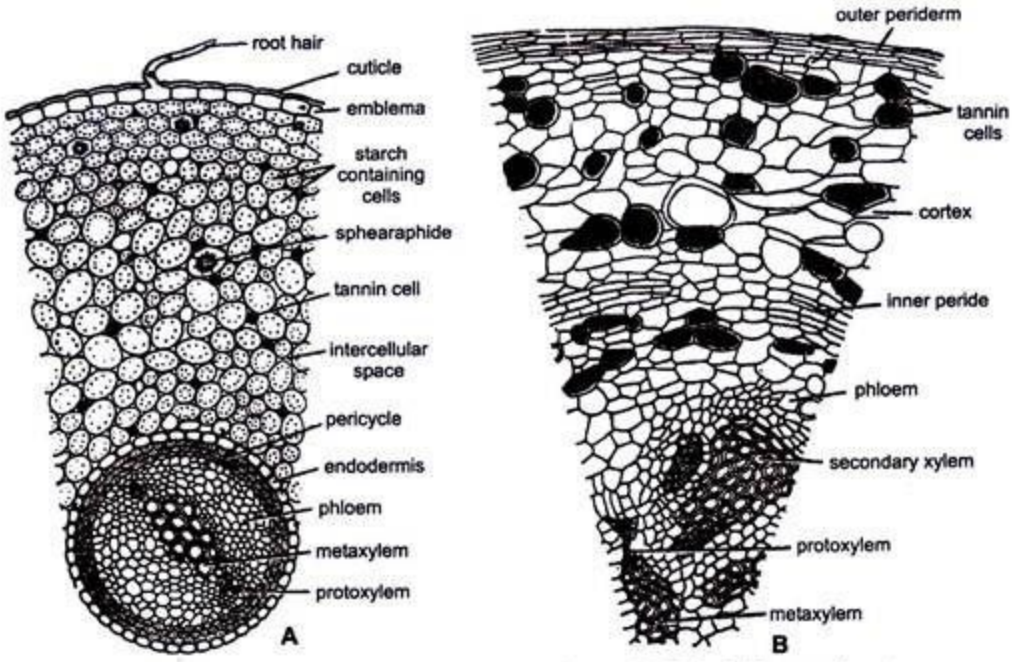

Fig. 7. (A, B). *Cycas*. (A) T.S. of young normal root, (B) T.S. of old normal root.

Secondary Growth:

The mature normal root shows secondary growth on both the lateral sides of primary xylem. Along with the inner side of primary phloem develops the cambium.

(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 roots 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 (Fig. 9A, B).
- The algal zone consists of loosely connected, radially elongated thin walled cells occupied by blue green algae (Anabaena

cycadae, Nostoc punctiforme, Oscillatoria), bacteria (Azotobacter, 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 a normal root.

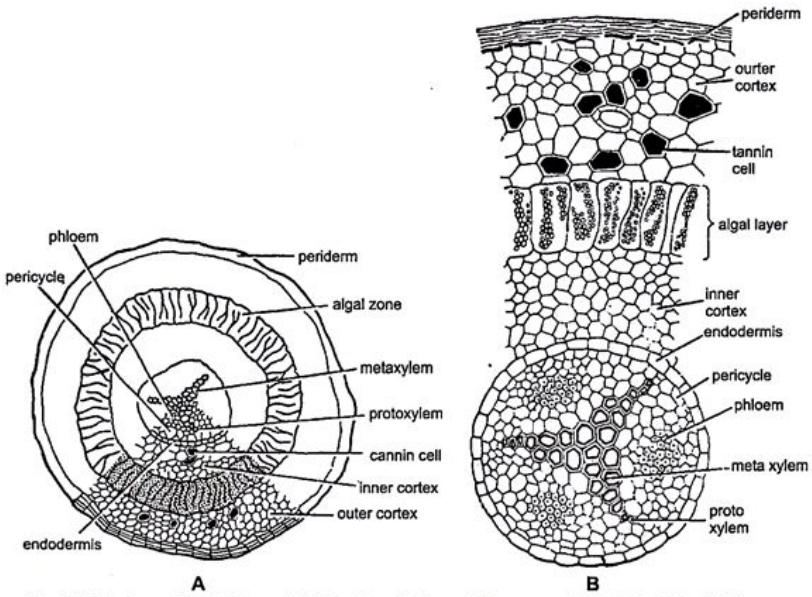

Fig. 9 (A, B). *Cycas.* **Coralloid root (A) T.S. of Coralloid root (diagrammatic), (B) T.S. of Coralloid root (a portion cellular)**

c. Vascular tissue:

- Endodermis is followed by a multilayered parenchymatous pericycle. Vascular bundles are radial.
- 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.

2. Stem:

A transverse section of the young stem is similar to a 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 (Fig. 11A).

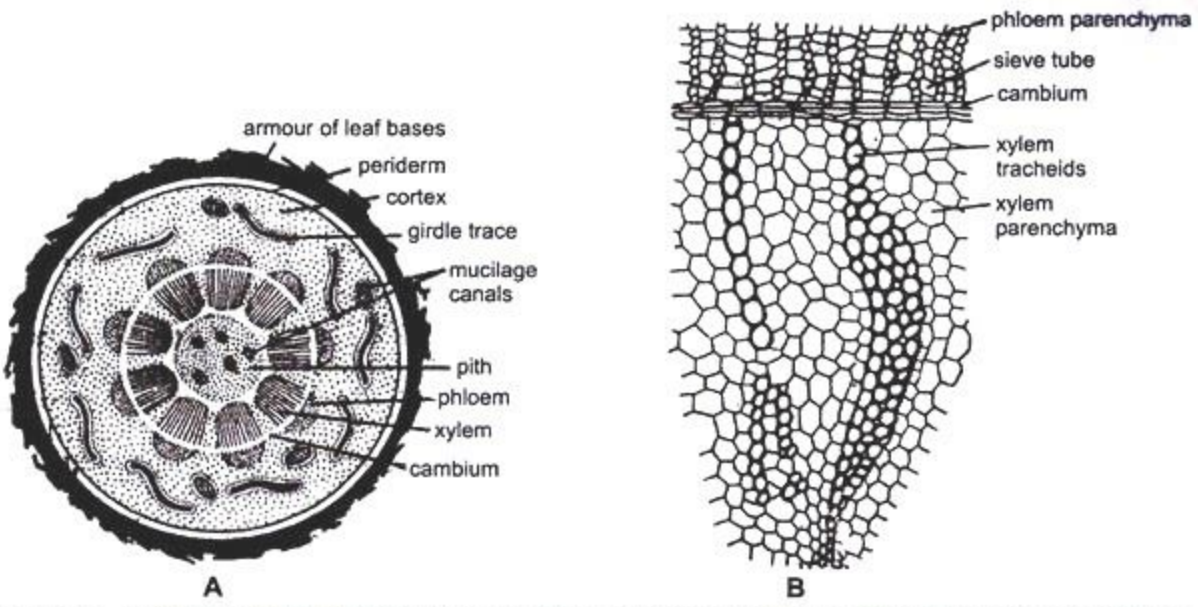

Fig. 11 (A, B) *Cycas*. (A) Diagrammatic representation of T.S. of young stem; (B) A part of vascular bundle.

b. Cortex:

- Epidermis encloses the cortex.
- It forms the major portion of the stem. It is composed of parenchymatous cells which are filled with a 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 (Fig. 10), which secrete mucilage.
- These canals are connected with those of the pith with the help of the medullary rays.
- The innermost layer of the cortex is endodermis. It is not distinct.

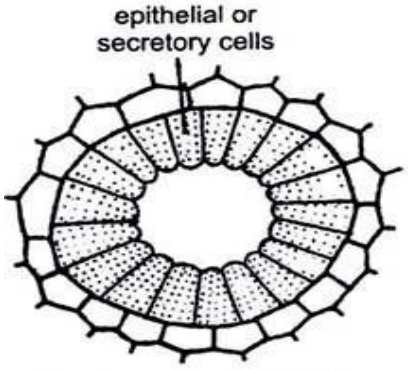

Fig. 10. *Cycas*. A mucilage canal

c. Vascular Cylinder:

- The vascular cylinder is surrounded by a not very conspicuous pericycle. Like dicot stem 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 (Fig. 11B).
- Vessels are absent.
- Outside the xylem is the phloem which consists of sieve tubes and phloem parenchyma.
- 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.

3. 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.

4. 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.
- Each leaf receives four traces, two of which are direct traces and the other two are given out from the opposite side of the direct traces.
- These two traces take a round around the main vascular cylinder in the opposite direction through the cortex and then enter the leaf base of opposite side from the point of their origin from the stele.
- These leaf traces are known as **girdle traces** or indirect trances and are peculiar structures in the stem of *Cycas*.

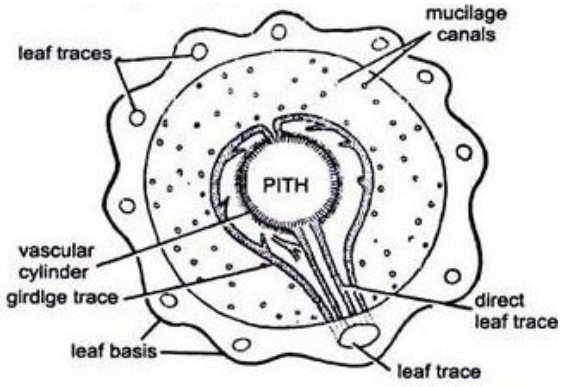

Fig. 12. Cycas. T.S. of stem showing leaf traces and girdle traces

Secondary growth:

- It is a slow process. At first a complete ring of cambium is formed by the development of interfascicular cambium 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 a 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 (a large amount of parenchyma is cut off in the xylem.** (Fig. 13).

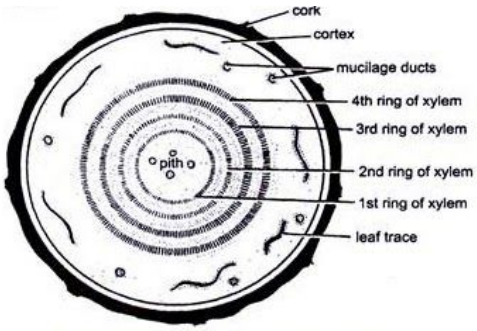

Fig. 13. *Cycas.* T. S of old stem (diagrammatic)

5. Rachis:

A transverse section of the rachis is somewhat rhomboidal in outline, but a little higher up it is shield shaped. Its internal structure can be differentiated into epidermis, cortex and Vascular bundles.

a. Epidermis:

It is the outermost covering. It is made up of compactly arranged thick walled cells. It is single layered, covered with thick cuticle and has stomata.

Hypodermis:

Epidermis is followed by hypodermis. It is differentiated into outer 2-3- layers of chlorenchyma (Chlorophyll containing thin walled cells) and inner 4-6 layers of sclerenchyma (thick walled, lignified cells; Fig. 14A, B).

Ground tissue:

Below the sclerenchyma is present a large tissue made up of thin walled parenchymatous cells. It is called ground tissue. In this region many mucilaginous canals and vascular bundles are present.

b. Vascular bundles:

- Vascular bundles are arranged in the shape of inverted Greek letter 'omega' [Ω; Fig. 14 A].
- Each vascular bundle is conjoint, collateral, endarch, open and diploxylic i. e., consists of centripetal and centrifugal Xylem and is surrounded by bundle sheath.
- Xylem is present towards the inner side and consists of tracheids and xylem parenchyma.
- Vessels are absent.
- Phloem is present towards the outer side of the vascular bundle.
- It consists of sieve tubes and phloem parenchyma.
- Companion cells are absent, Cambium is present in between the xylem and phloem.

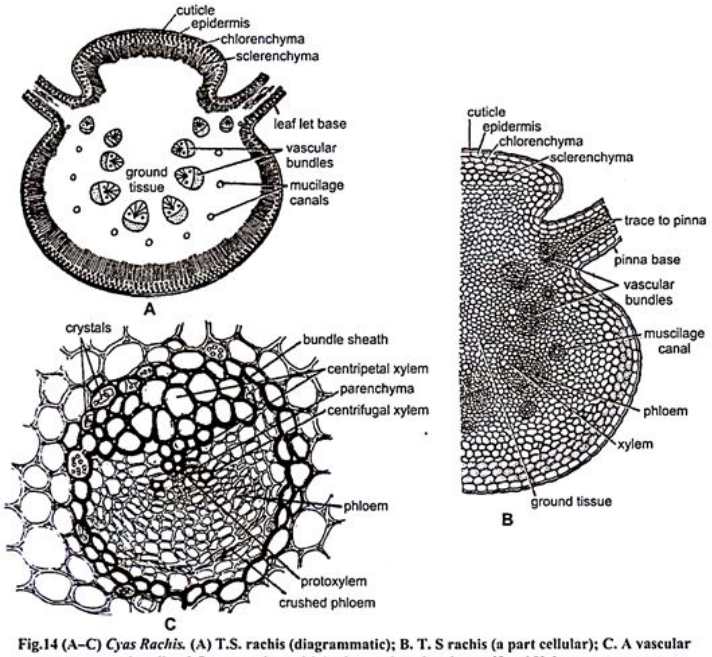

Fig.14 (A–C) *Cyas Rachis.* (A) T.S. rachis (diagrammatic); B. T. S rachis (a part cellular); C. A vascular bundle of *Cycas revoluta* with both centripetal and centrifugal Xylem.

- In rachis the vascular bundles are endarch at the base (centrifugal xylem is well developed, protoxylem faces towards the centre showing endarch condition, centripetal xylem is not developed), mesarch in the middle (centripetal and centrifugal xylem are present showing diploxylic condition) and exarch at the apex (centripetal xylem is well developed, triangular and exarch, centrifugal xylem is much reduced and in the form of two patches lying one on each side of the protoxylem elements of centripetal xylem) due to twisting of the rachis (Fig. 15 A-C).

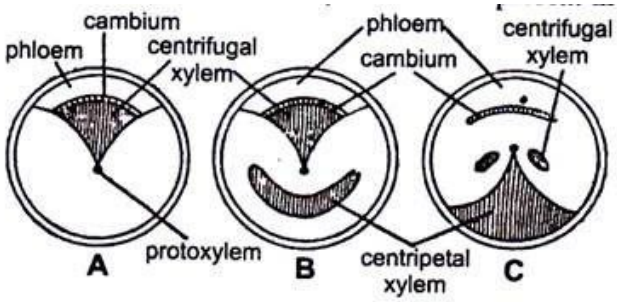

Fig. 15. (A–C) *Cyas*. Diagrammatic representation of vascular bundles at different levels. (A) At the base; (B) In the middle; (C) At the apex.

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 (Fig. 16A, B).

Its internal structure is as follows:

a. Epidermis:

- It is the outermost 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 cuticle**.

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 a 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 reticulated 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 parallel to the leaf surface from the midrib to the margin. This zone is called accessory transfusion tissue or secondary transfusion tissue or hydrostream or radial parenchyma.
- On either side of the leaflet it is connected with the primary transfusion tissue present around the 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.

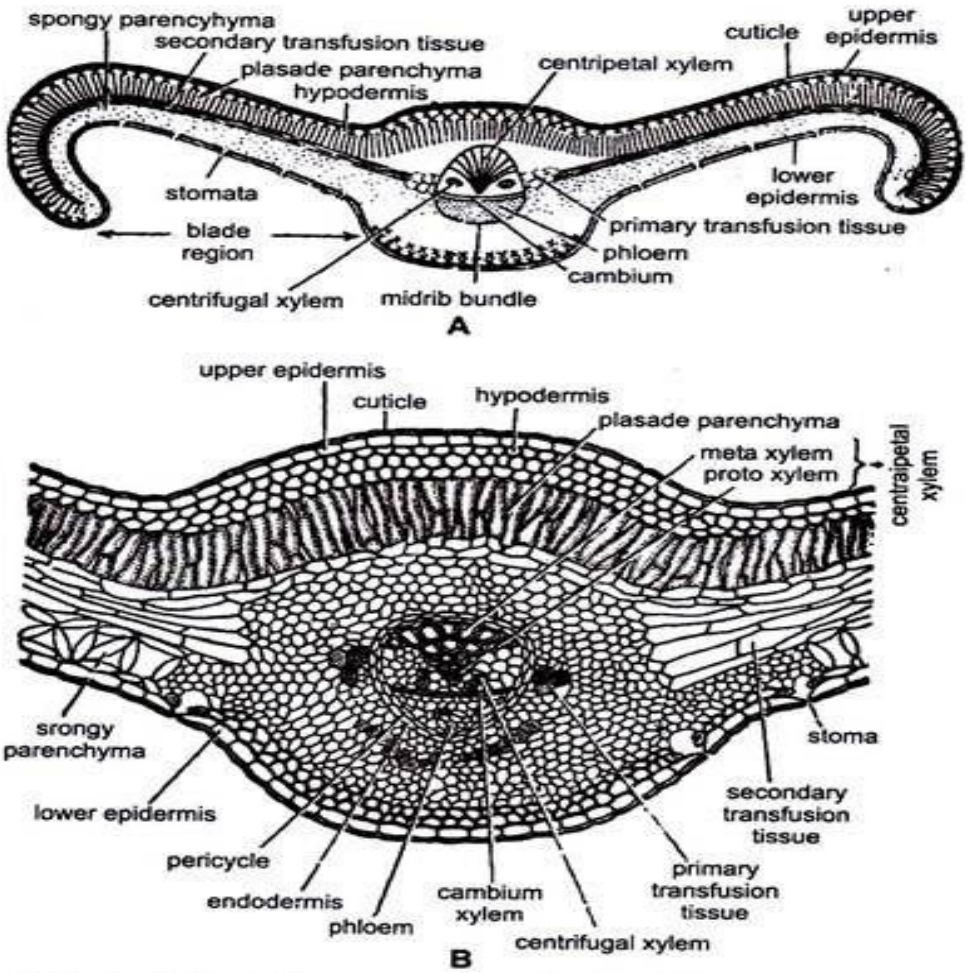

Fig. 16 (A–C). *Cycas.* **Transverse section of leaflet (A) diagrammatic; (B) A protion from the mid rib is magnified**