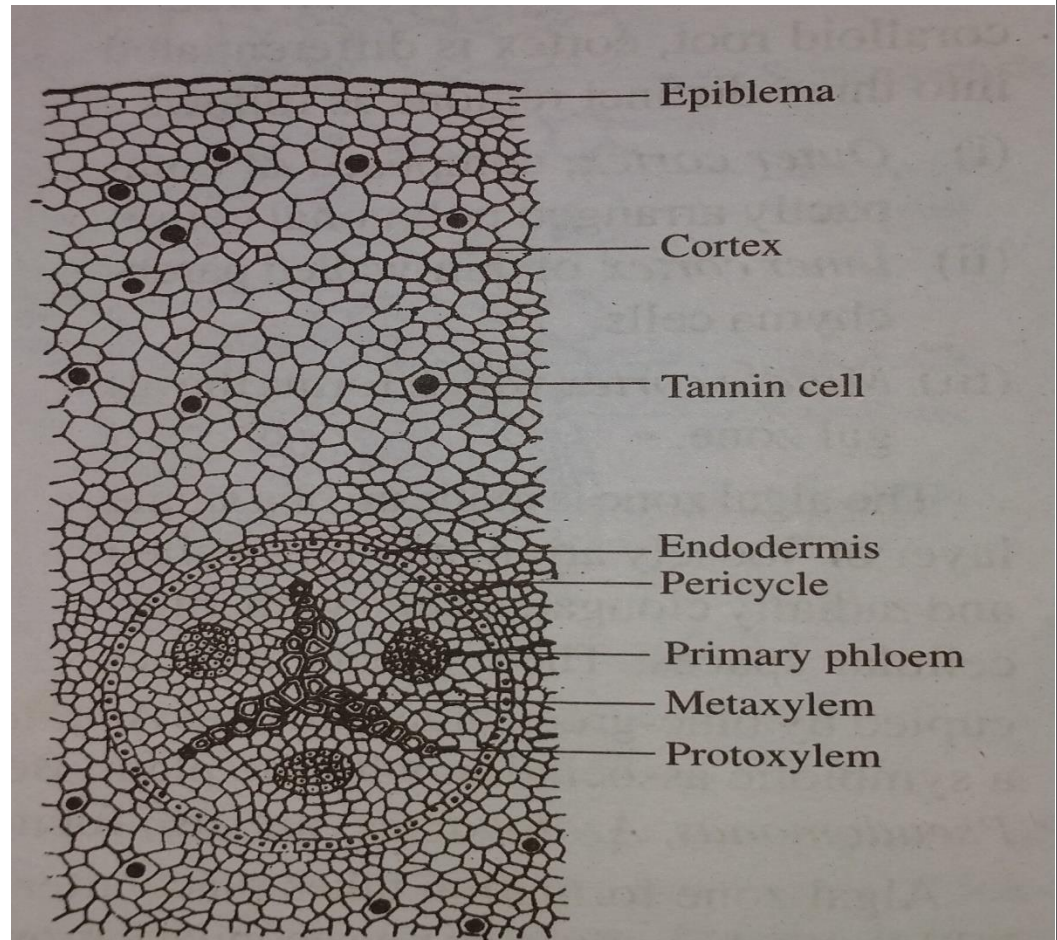


CYCAS – INTERNAL STRUCTURE

NORMAL ROOT

- Similar to Dicot root.
- 3 parts – Epiblema, cortex & stele or central vascular cylinder.



Cycas : T.S. of young normal root
[a portion enlarged]

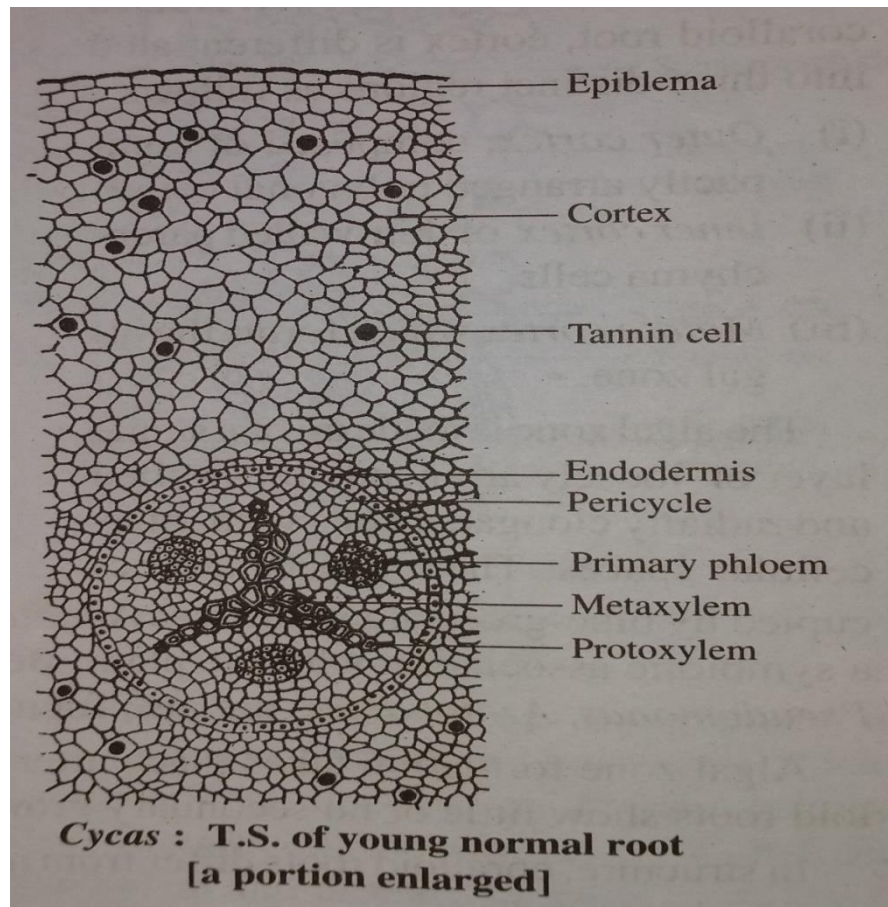
NORMAL ROOT

- Epiblema consists of **single layer of thin-walled cells.**
- Some cells give rise to **root hairs.**
- Cortex is **multi-layered & composed of thin-walled parenchyma cells filled with starch.**
- Some cells contain **tannin & mucilage.**
- They are **secretory** & they remain bordering **mucilage canals.**
- Inner most layer of the cortex forms **endodermis.**
- **Casparian bands** are present in the endodermal cells.

NORMAL ROOT

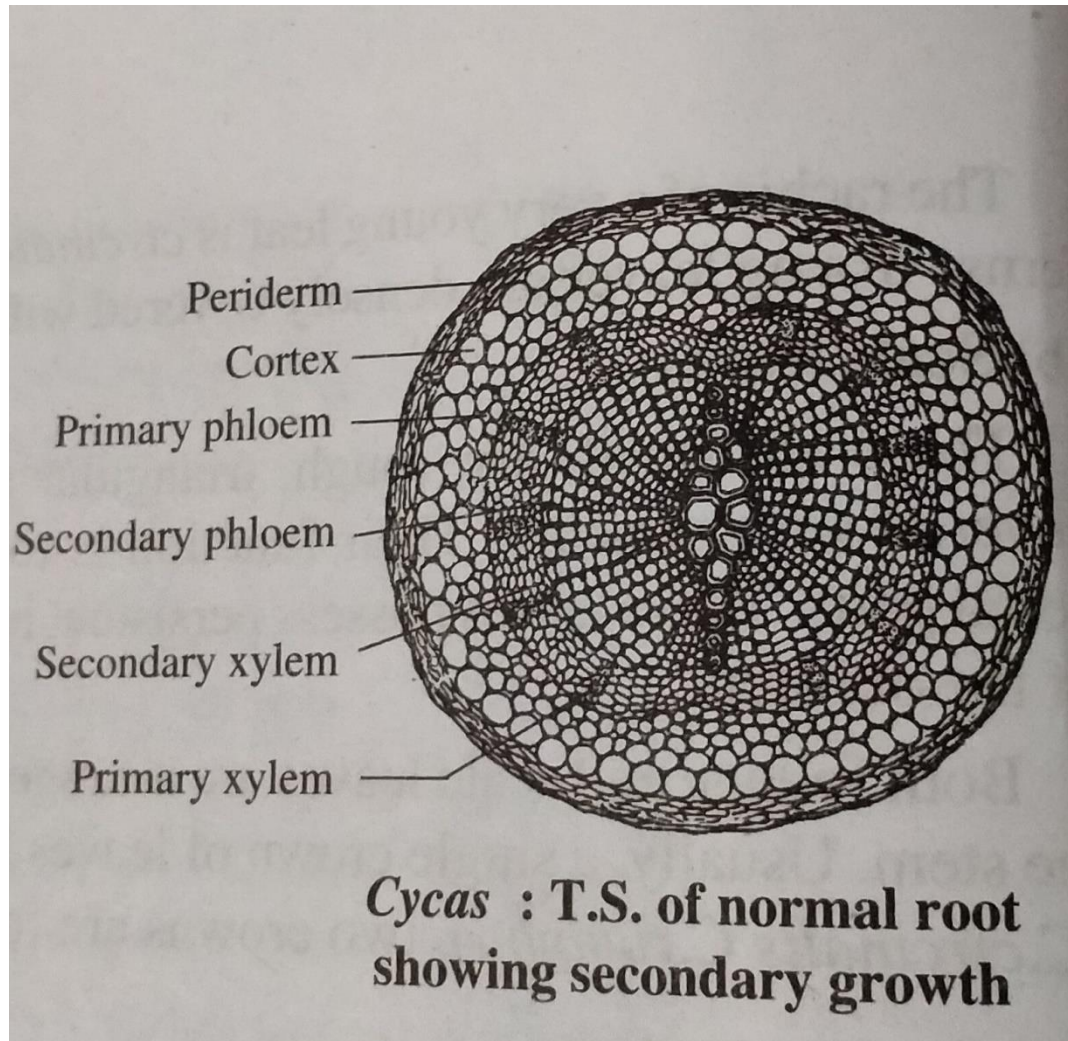
- **Stelar region is bounded by a multi-layered & parenchymatous pericycle.**
- **Cells are thin-walled & starch filled cells.**
- **Vascular tissues form central diarch to tetrarch stele.**
- **The diarch steel refers to the presence of two patches of protoxylem points.**
- **The xylem consists of xylem tracheids. A tracheid is one celled, non-living, elongated xylem element with thick lignified and pitted cell walls.**
- **The xylem is exarch i.e., the protoxylem is pointing towards the periphery while the metaxylem is located near the centre .**

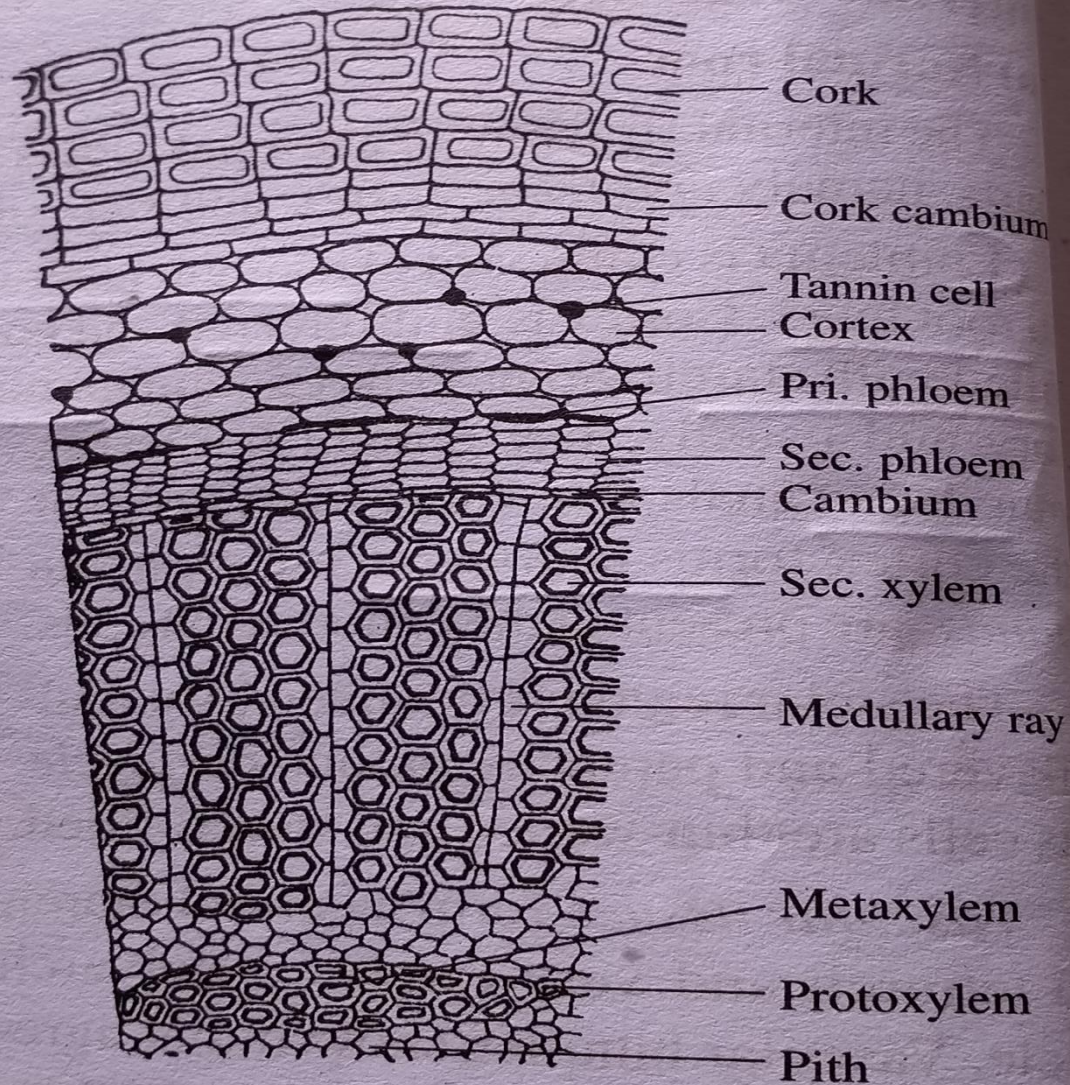
- Centre of root is occupied by metaxylem or metaxylem & parenchyma.
- Pith is reduced or absent.



- Root shows **secondary growth** which starts by the formation of cambium strips inner to the primary phloem strands.
- These strips cut off secondary phloem towards the outer side & secondary xylem towards the inner side.
- Primary phloem gets crushed , primary xylem still occupies the centre of the stele.
- **Cork cambium or phellogen** arises from the outer layers of the cortex.
- It forms cork on its outer side & **phellogen or secondary cortex** towards the inner side.
- Periderm formation is same as in dicots.

- Periderm is composed of the **phellogen, phellem, and phelloderm.**
- During secondary growth, the outer epidermal layer and the cortical layer are broken because of the cambium.
- To replace them, the cells of the cortex turn meristematic, giving rise to cork cambium or phellogen. It is composed of thin-walled, narrow and rectangular cells.
- Phellogen cuts off cells on its either side.
- The cells cut off toward the outside give rise to the phellem or cork. The suberin deposits in its cell wall make it impervious to water. The inner cells give rise to the secondary cortex or phelloderm. The secondary cortex is parenchymatous.





***Cycas* : T.S. of old normal
root [a portion enlarged]**

CORALLOID ROOT

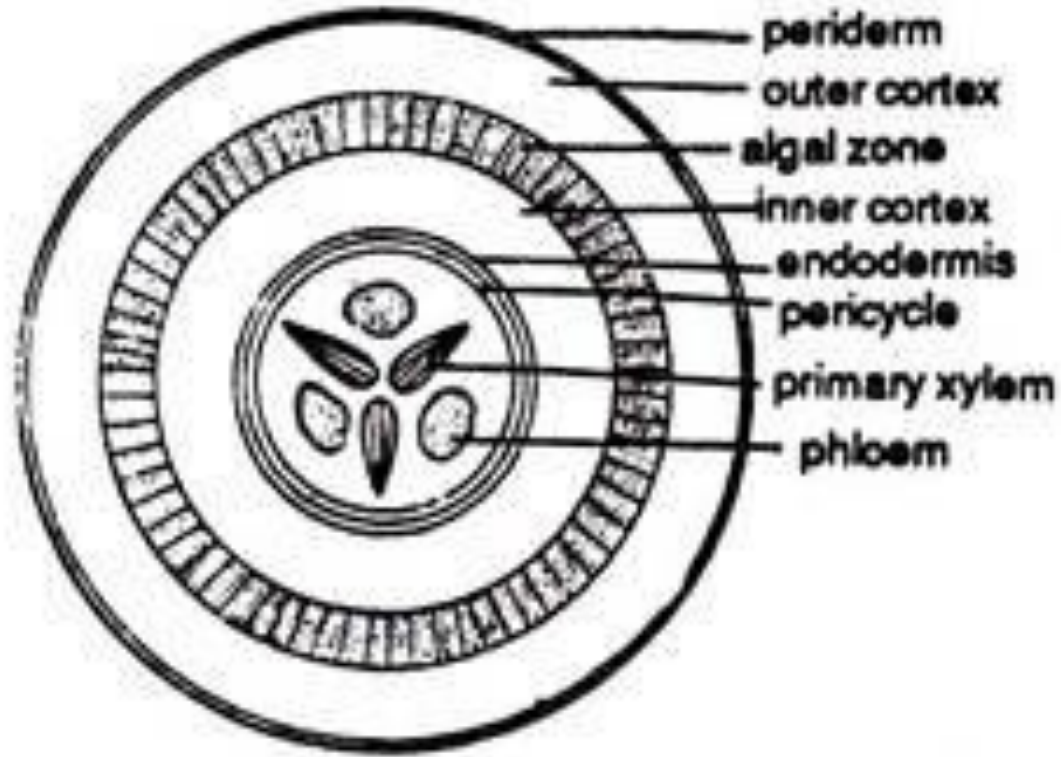


Fig. 9. *Cycas*. T.S. coralloid root (diagrammatic).

- Outer cortex
- Inner cortex
- Middle cortex (algal zone)
- *Anabaena cycadae*, *Nostoc punctiforme*.
- Algal formation takes place after the entrance of endophytic algae.

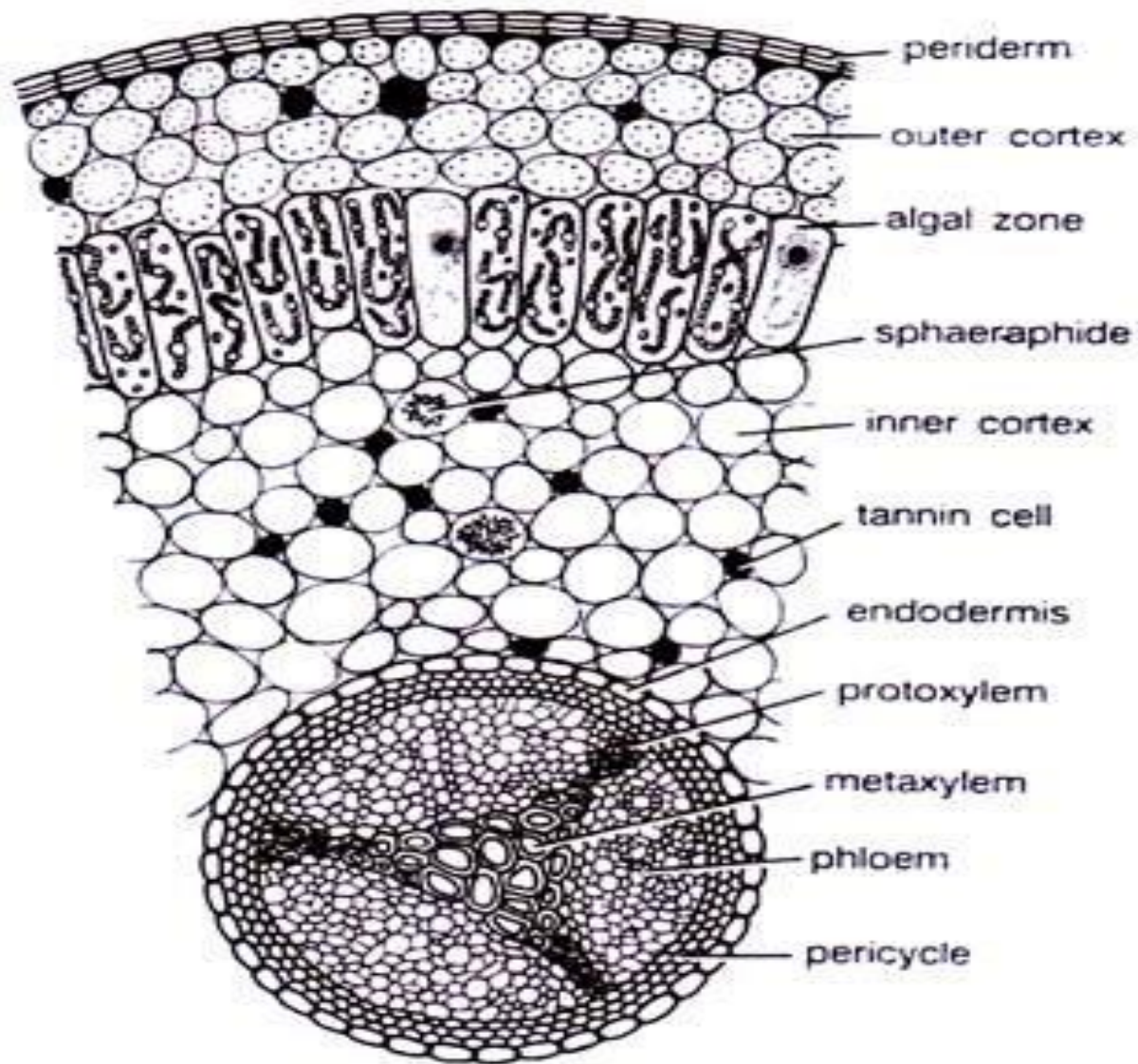


Fig. 8.18. *Cycas revoluta* T.S. coralloid root.

DIFFERENCE BETWEEN CORALLOID ROOTS & NORMAL ROOTS

- 1. Cortex is differentiated in to three regions ;
two in normal roots.**
- 2. Secondary tissues are poorly developed or
absent in them.**

STEM

- Young stem is **irregular** in outline.
- Internal structure similar to that of a dicot stem.
- Differentiated in to **epidermis**, **cortex** & **vascular cylinder**.
- **EPIDERMIS**
 - **Outer most layer**
 - **Covered with thick cuticle**
 - **Discontinuous due to the presence of persistent leaf bases.**

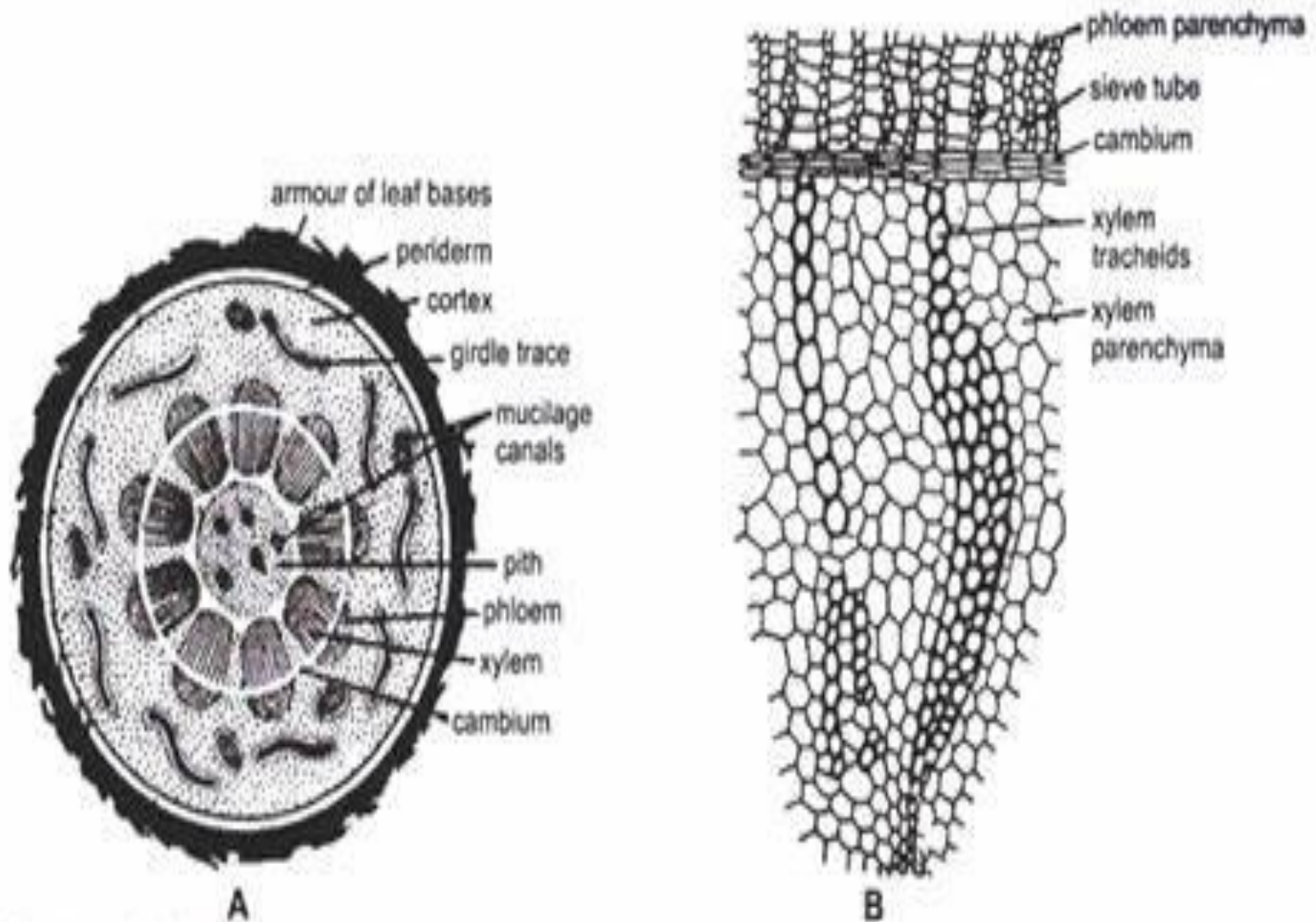
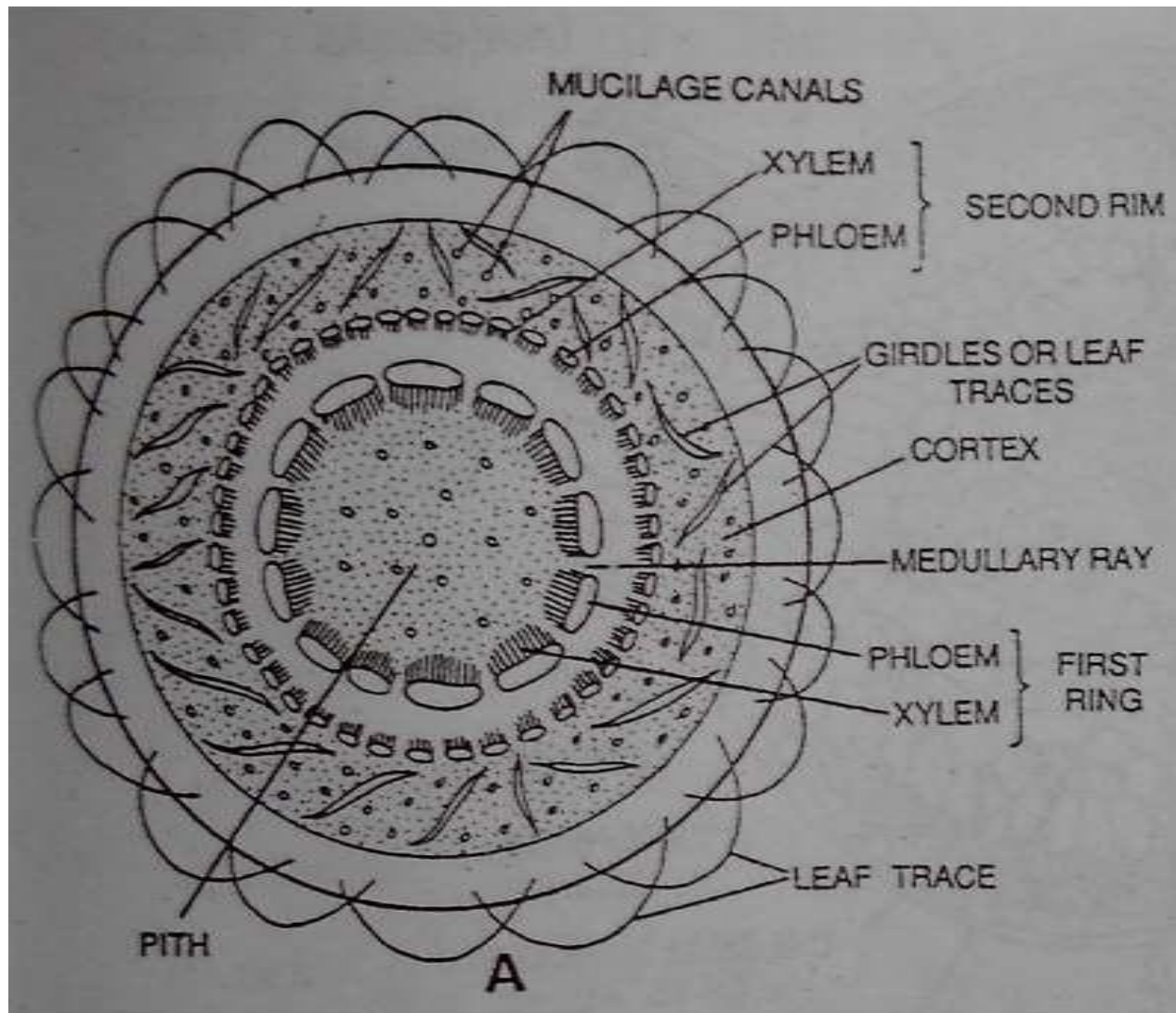


Fig. 11 (A, B) *Cycas*. (A) Diagrammatic representation of T.S. of young stem; (B) A part of vascular bundle.



○ CORTEX

- Major part
- composed of parenchymatous cells
- Rich in starch grains
- Transversed by **mucilaginous canals & leaf traces**
- Innermost layer of cortex is endodermis
- It followed by pericycle.
- Not distinct in young stem.

○ VASCULAR CYLINDER

- Very small
- Several VB arranged in a ring
- Forms an **ectophloic siphonostele**
- VB are conjoint, collateral & open
- Xylem is endarch.
- Bundles separated by medullary rays.
- Xylem consists of tracheids & xylem parenchyma.
- **vessels are absent.**
- Phloem is composed of sieve tubes & parenchyma
- **Companion cells are absent**

- Monostele type of siphonostele in which a ring of xylem occurs around the pith, and a ring of **phloem outside the xylem**.
- **EG : Equisetum**

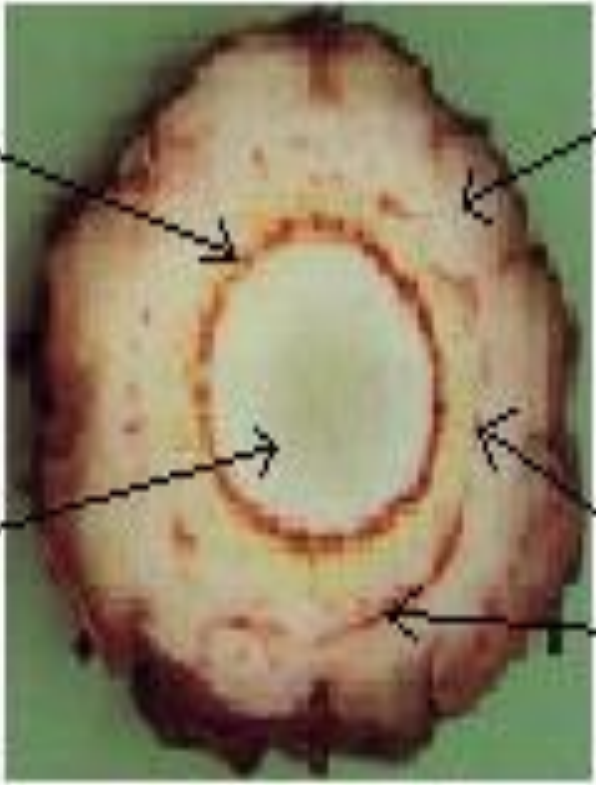
- A well developed **parenchymatous pith** is present in the centre.
- Cells are **rich in starch**.
- Some contain **tannins & mucilage canals**.

LEAF TRACES IN CYCAS

- In T.S of stem numerous leaf traces can be seen in the **cortical region**.
- They are vascular strands which **supply to leaves**.
- Each leaf receives **4 leaf traces**.
- Out of **2 arise on the same side as leaf**. They enter directly into leaf. They are called **direct leaf traces**.
- Other **2 arise opposite the leaf** & enter the leaf **turning around the vascular cylinder**. These traces form a girdle around the vascular cylinder, hence called **girdle traces**.

vascular bundles

cortex



stele

leaf traces

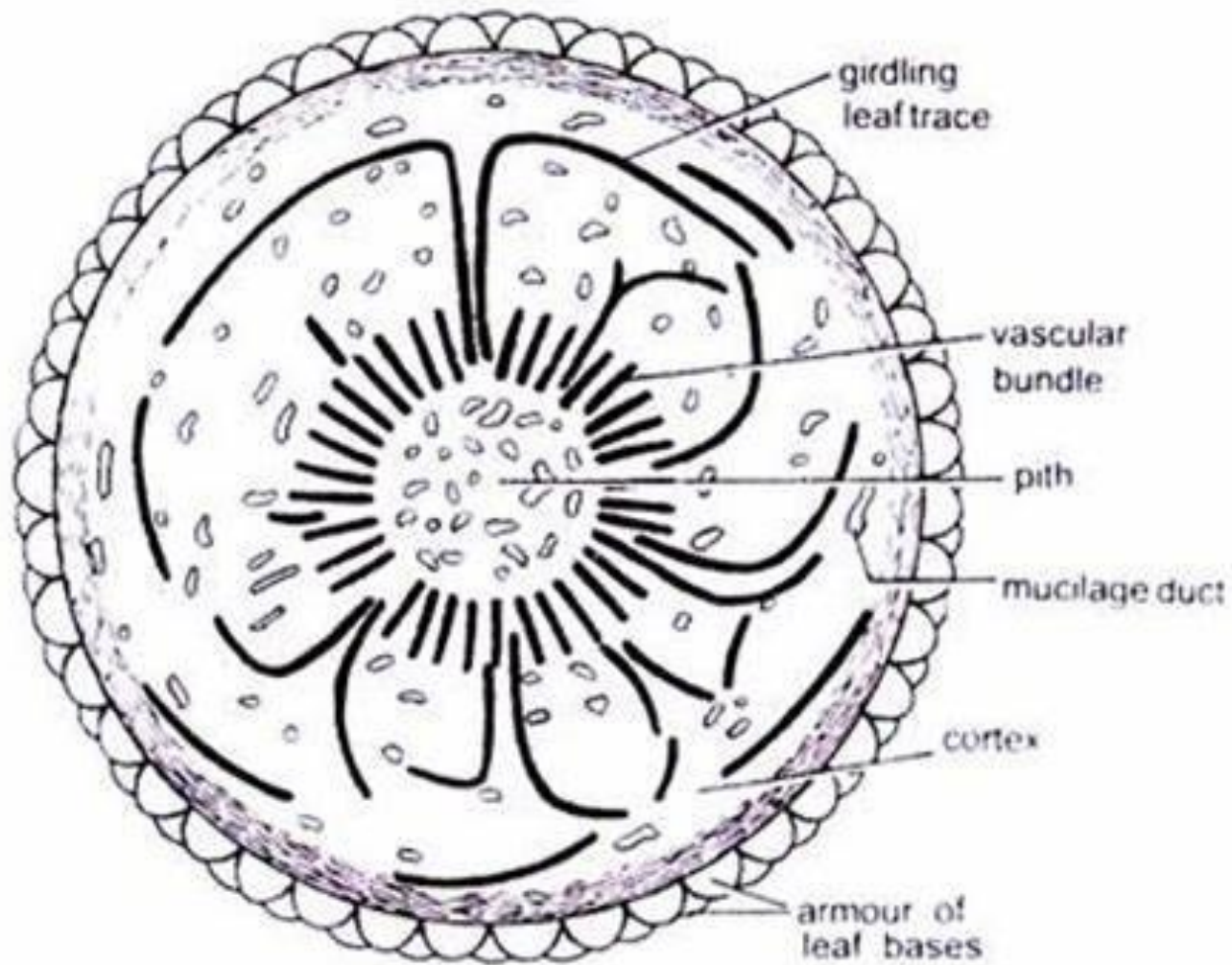
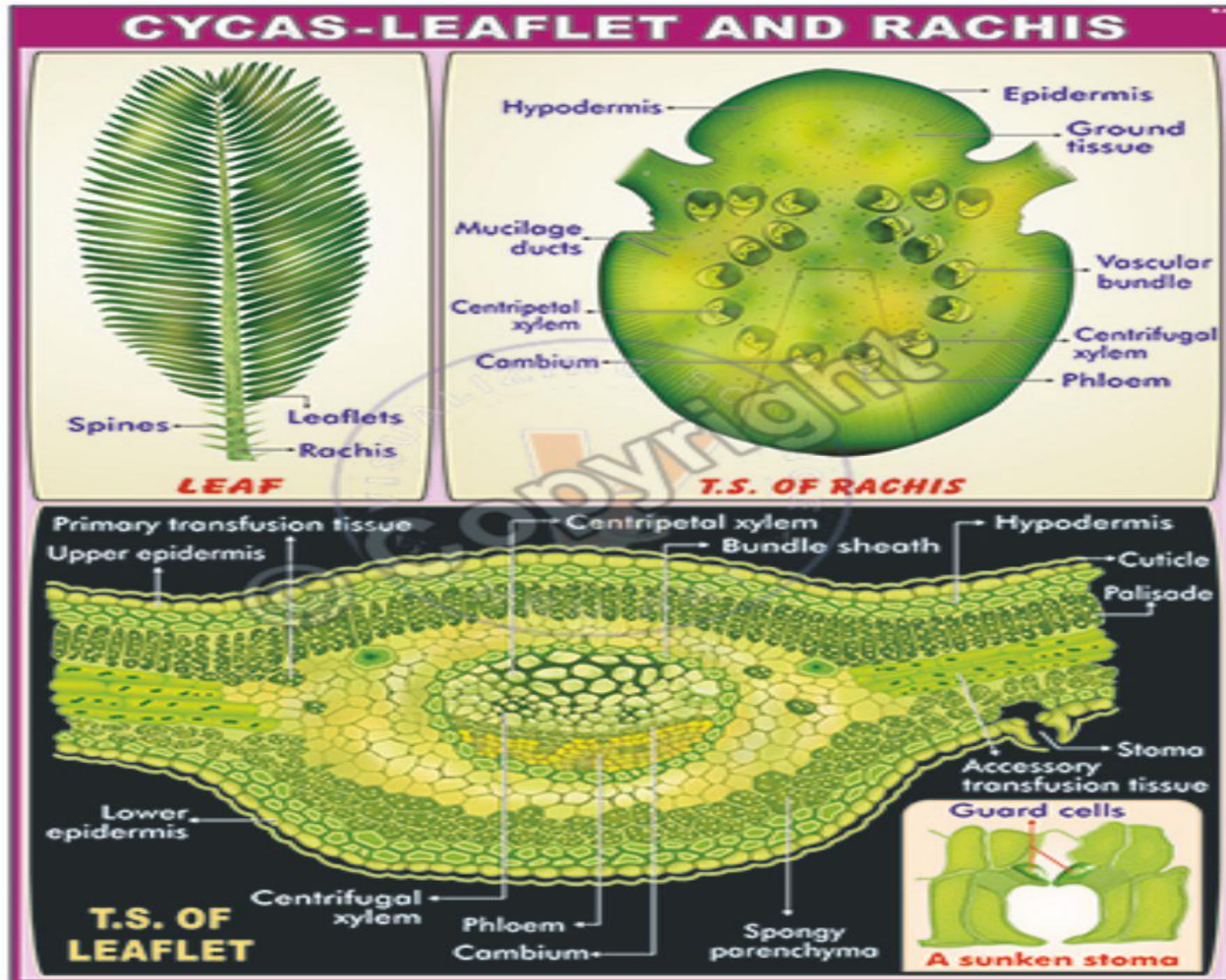


Fig. 8.20. *Cycas*. Diagrammatic representation of T.S. young stem.

SECONDARY GROWTH OF THE STEM

- Old stem of *Cycas* shows secondary growth.
- Same as in dicot stem
- By the activity of a **continuous cambial ring**.
- Cambium stops functioning after a short period & new cambium develops , it repeated several times & resulting in the formation of a few alternating concentric rings or xylem & phloem.
- *C. pectinata* – 20 rings of cambium – monoxylic to polyxylic.
- **Anomalous secondary growth** (polyxylic condition)
- Phellogen , phelloderm & phellem formation occur
- Lenticels present.

INTERNAL STRUCTURE OF RACHIS



RACHIS

- Rachis is circular, biconvex, or flat in outline.
- Woody & thick
- Differentiated into **epidermis**, **hypodermis**, **ground tissue** & **vascular tissue**.
- **EPIDERMIS**
 - ✓ Outermost layer
 - ✓ Uniseriate
 - ✓ Covered with thick cuticle
 - ✓ Stomata sunken & irregularly scattered
 - ✓ Stoma consists of two guard cells & two subsidiary cells

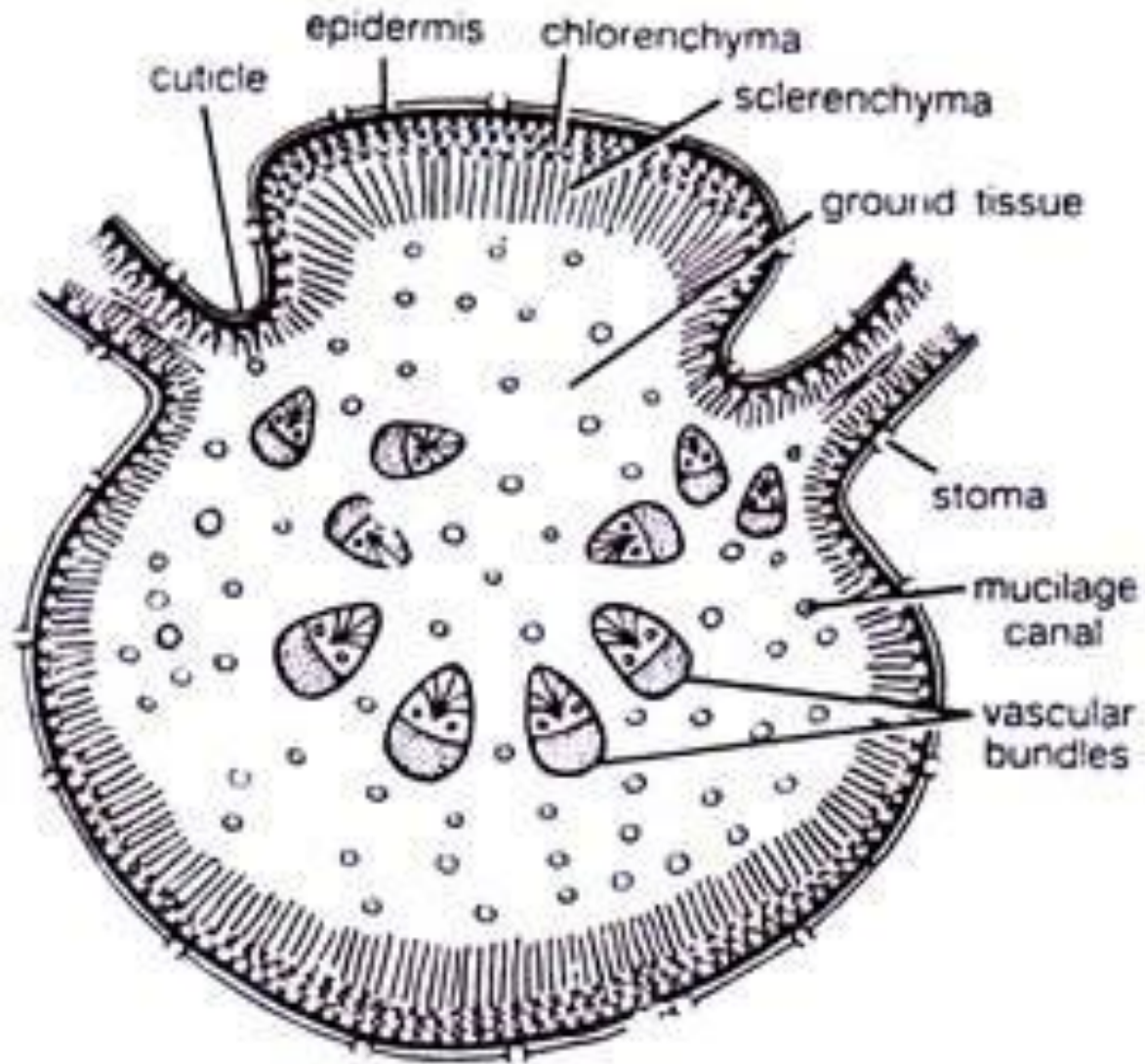
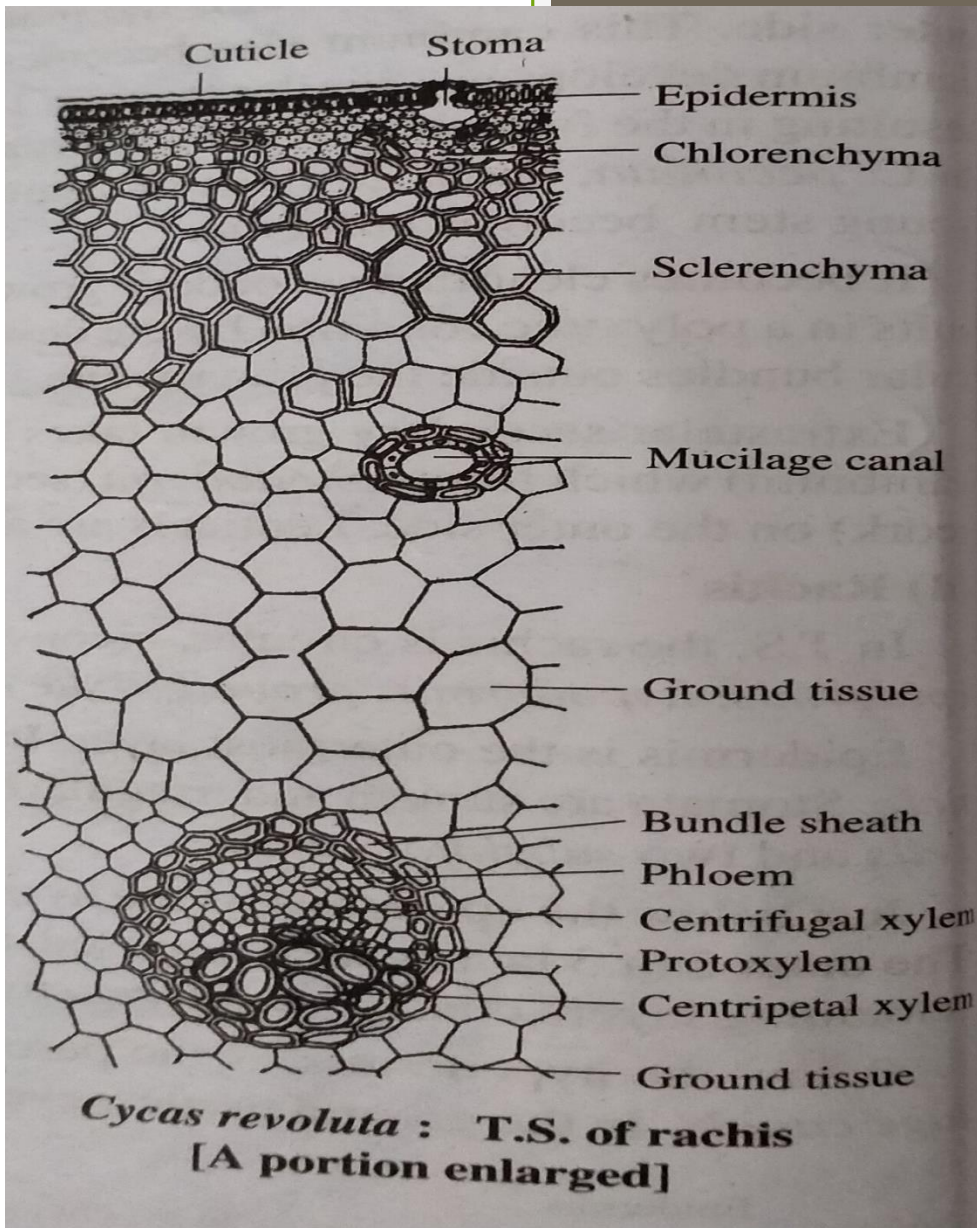


Fig. 8.25. *Cycas*. T.S. rachis (diagrammatic).



- Just below epidermis, is the hypodermis.
- Composed of two types of cells.
- Outer 2 or 3 layers are composed of thin-walled **chlorenchymatous cells** & remaining layers consist of **sclerenchymatous cells**.
- Below hypodermis, **parenchymatous ground tissue**, with **many mucilage canals**.
- VB are arranged in a typical **inverted omega-like structure** (Ω) or horse shoe shaped manner.

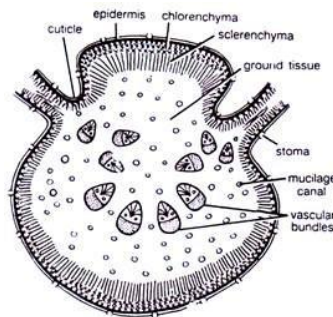


Fig. 8.25. Cycas. T.S. rachis (diagrammatic).

- VB are **diploxylic, conjoint, collateral, & open**.
- Surrounded by **uniseriate** or **multiseriate pericycle**.
- Bundle surrounded by a **single layered bundle sheath** composed of **thin-walled sclerenchymatous cells**.
- They are **diploxylic** (have both **centrifugal** [endarch] & **centripetal** [exarch] xylem.
- Xylem is located towards the centre .
- Phloem towards the periphery
- Between them **thin strip of cambium** is present.

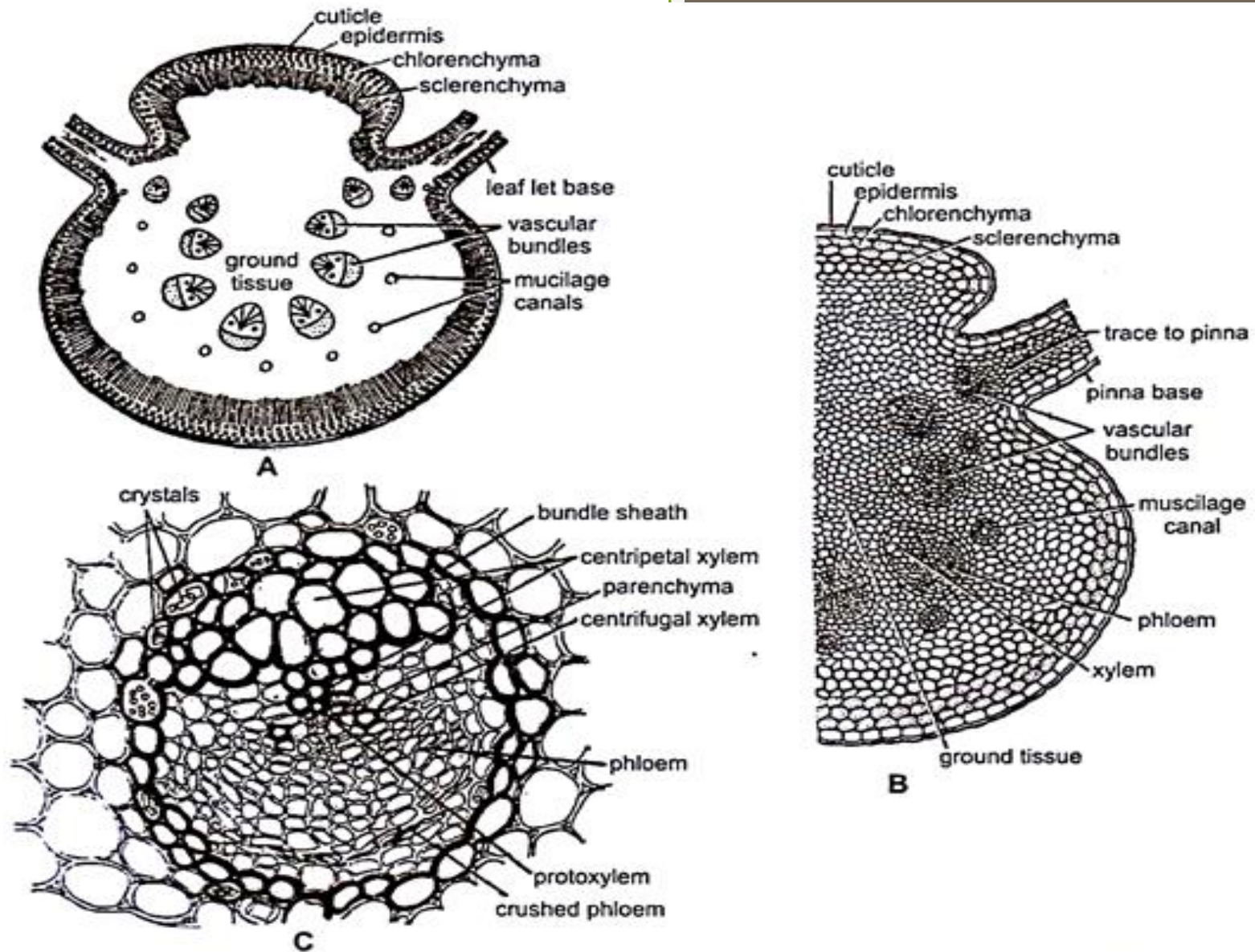


Fig.14 (A-C) *Cycas Rachis*. (A) T.S. rachis (diagrammatic); B. T. S rachis (a part cellular); C. A vascular bundle of *Cycas revoluta* with both centripetal and centrifugal Xylem.

- There is difference between the arrangement of xylem & phloem in VB in the **upper, middle & basal regions** of the rachis.
- **Basal region** – VB have only **centrifugal xylem**
- **Middle region** – Groups of thick-walled cells develop just behind the protoxylem elements & finally differentiate into **centripetal xylem**.
- **Upper region** – **More centripetal xylem than the centrifugal xylem.**
- Centrifugal xylem lies in small groups on both the sides of the centripetal xylem.
- At extreme tip, centrifugal xylem is completely absent.
- Base – **Endarch**
- Middle – **Pseudoendarch**
- Apex - **Exarch**
- **Gradual transition** occur

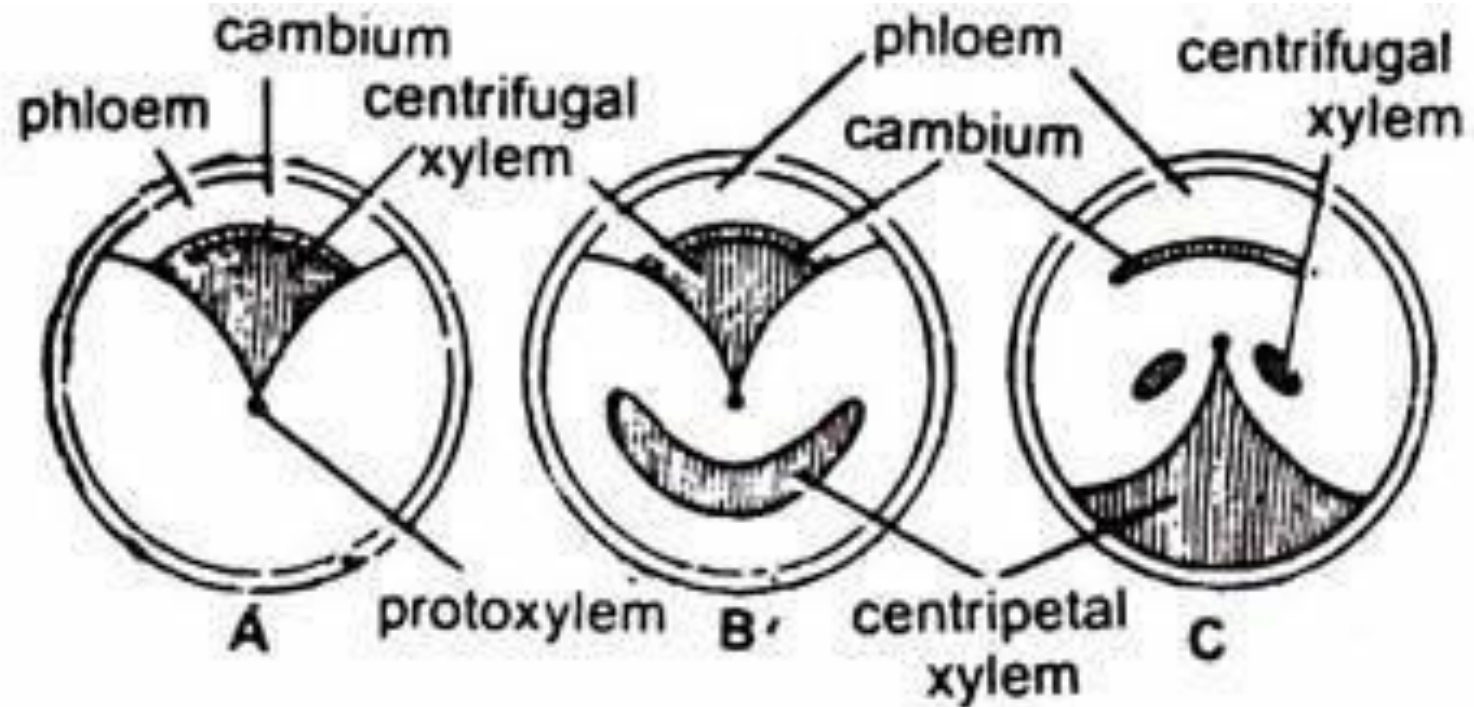
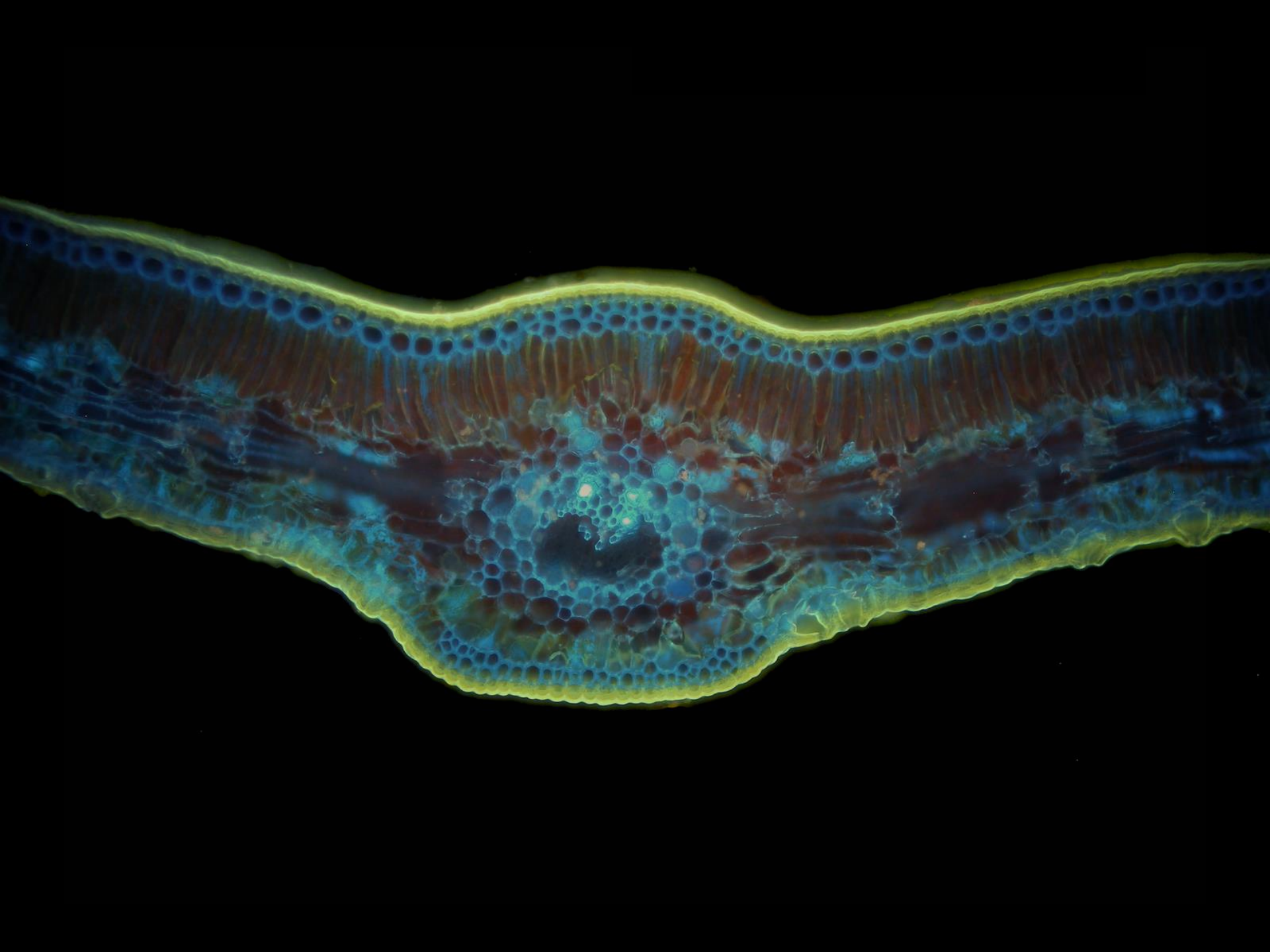


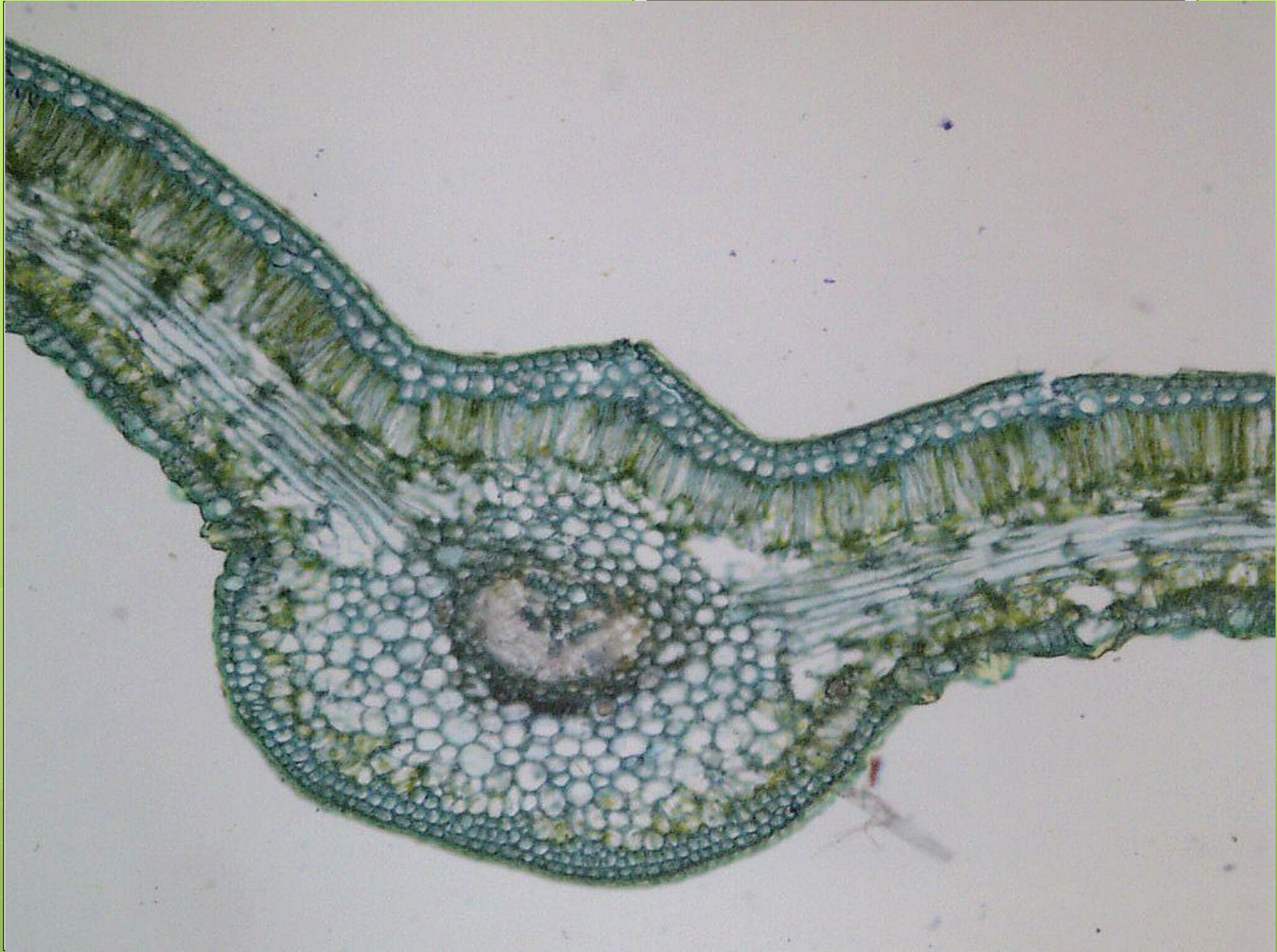
Fig. 15. *Cycas*. Diagrammatic representation of vascular bundles of rachis at different levels. A, At the base; B, In the middle; C, At the apex.

INTERNAL STRUCTURE OF LEAFLET

LEAFLET

- Dorsi – ventral
- **Xerophytic adaptations**
- Single, unbranched midrib without lateral veins.
- Leaflet is swollen in the midrib region.
- Margins are **curved** in some species Eg: **C.revolvata** & **C.beddomei**
- **Straight or flat** in others (Eg: **C.circinalis**, **C.pectinata** & **C.numphii**)





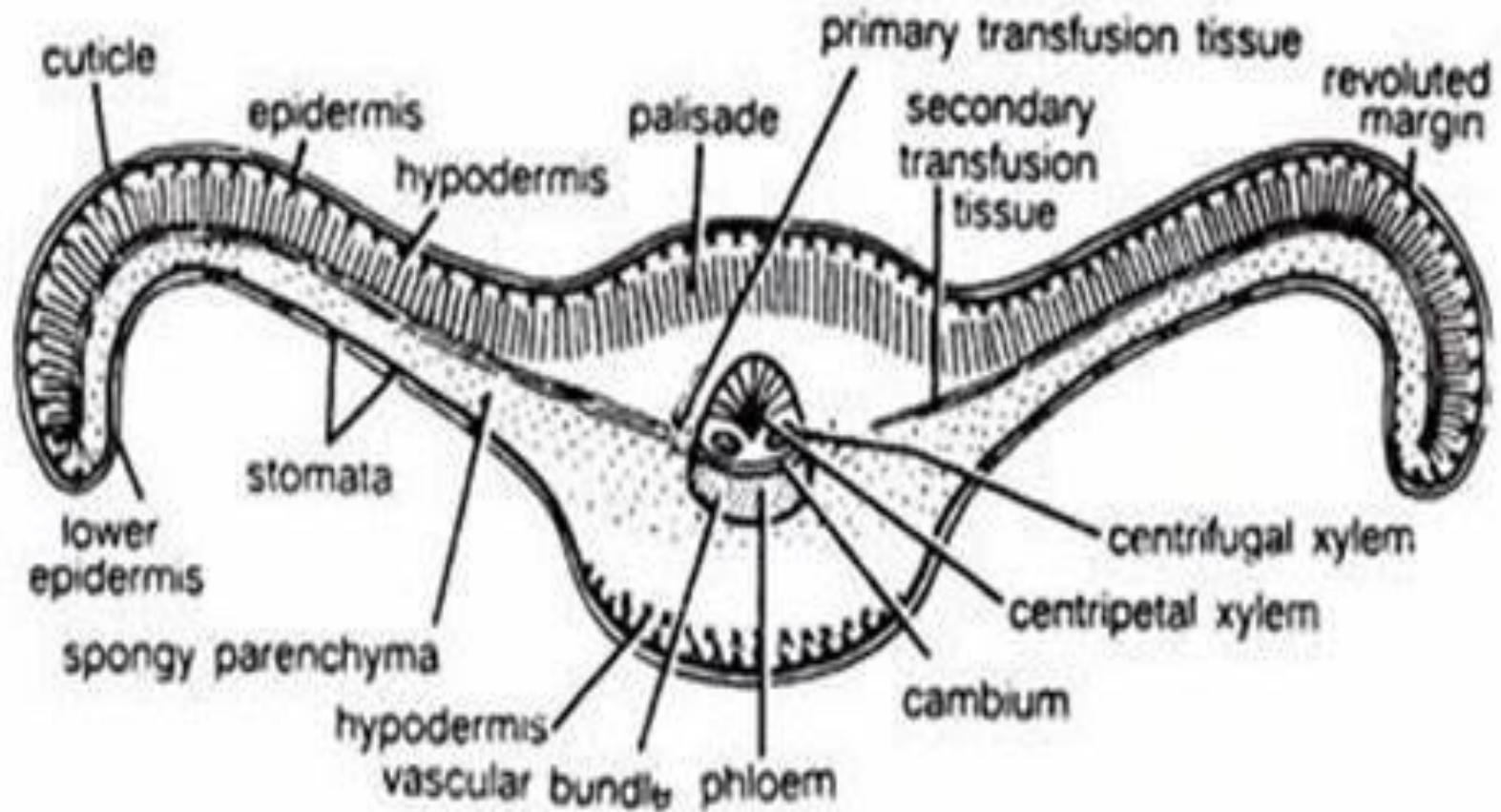
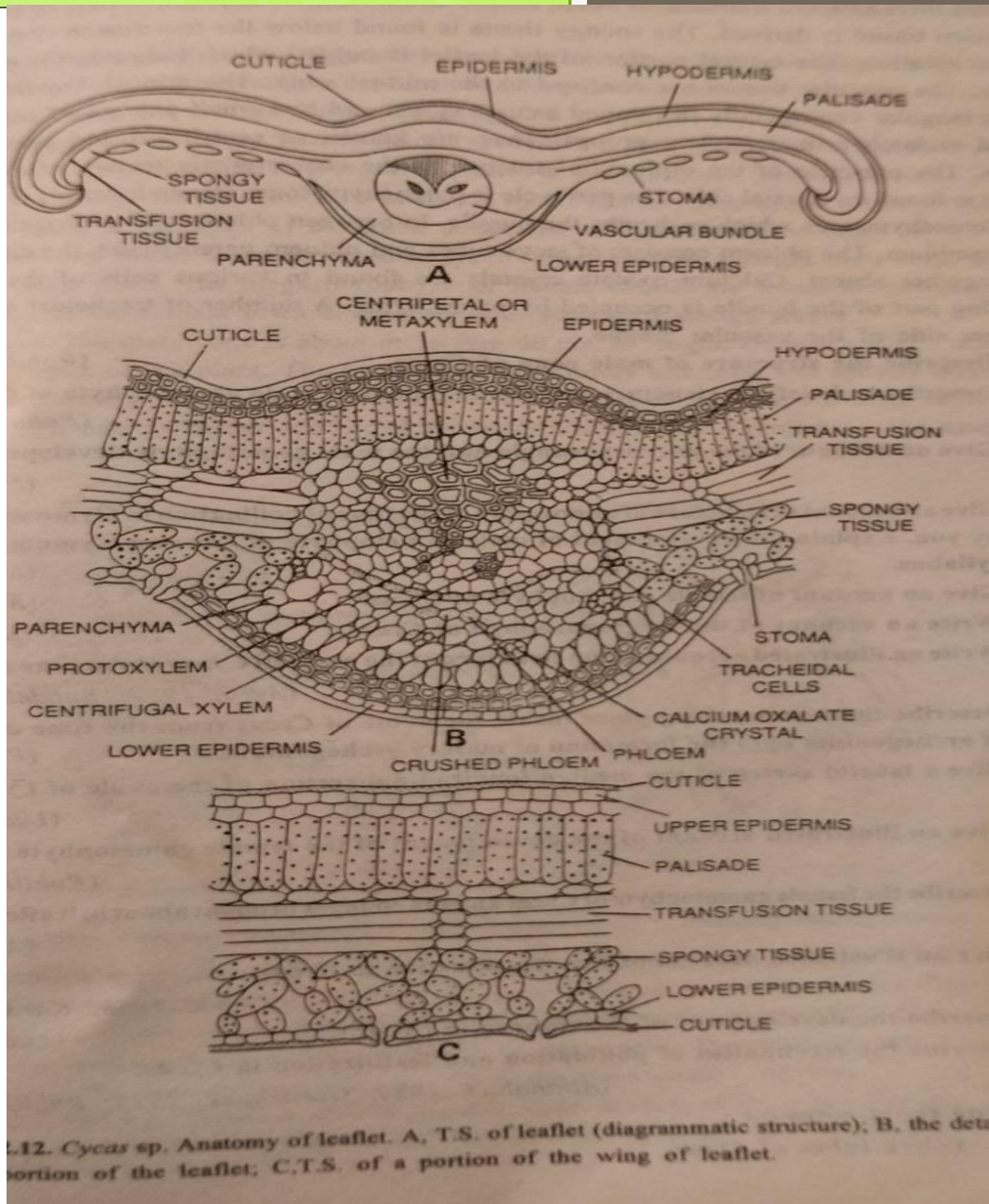


Fig. 16. *Cycas revoluta*. T.S. leaflet (diagrammatic).

- 3 main parts
- Epidermis , hypodermis & mesophyll
- EPIDERMIS
 - ✓ Outermost layer
 - ✓ Uniseriate
 - ✓ Cuticle present
 - ✓ Upper epidermis is continuous
 - ✓ Lower epidermis is interrupted by minute pits.
 - ✓ Sunken haplochelic stomata present

- **Sclerenchymatous** hypodermis.
- Multi-layered in the midrib region & single layered in other parts.
- Hypodermis is followed by the **mesophyll** which is differentiated into **palisade** & **spongy parenchyma**.
- Palisade parenchyma – Consists of single layer of vertically elongated & compactly arranged **columnar cells**. Act as **photosynthetic or assimilatory zone**.

- Spongy parenchyma – Consists of several layers of **loosely arranged cells** that are confined to the wings. Act as **aerating zone**.
- Both are **rich in chloroplasts**.
- There are tracheid like cells on the lateral sides of the vascular xylem in the midrib region.
- They are **transfusion tissue**.



412. *Cycas* sp. Anatomy of leaflet. A, T.S. of leaflet (diagrammatic structure); B, the detail portion of the leaflet; C, T.S. of a portion of the wing of leaflet.

- In the wing region, long , colourless & transversely elongated parenchyma cells present between palisade & spongy parenchyma which represent **secondary or accessory transfusion tissue.**
- Single VB in the midrib region.
- Surrounded by **parenchymatous bundle sheath.**
- VB is conjoint, collateral , open & **diploxylic.**

- **Centripetal xylem & two groups of centrifugal xylem**, one on either side of the centripetal protoxylem.
- Phloem present on the adaxial side of the xylem.
- Composed of sieve tubes & parenchyma.
- Thin layer of cambium present
- Spaeoraphides present

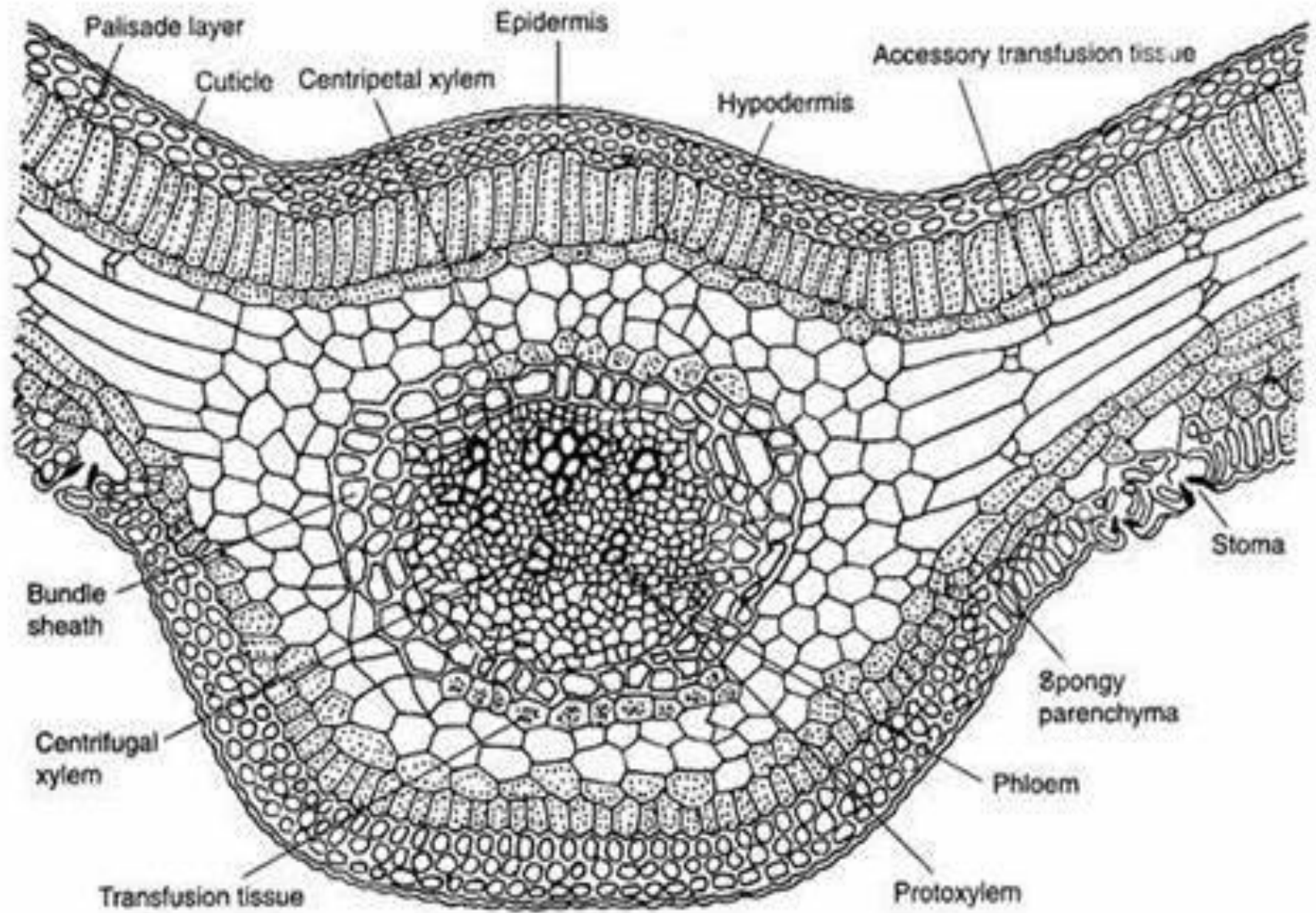


Fig. 1.16 : T.S. of leaflet of Cycas

XEROPHYTIC ADAPTATIONS OF LEAFLETS

- Presence of thick cuticle
- Epidermis with thick-walled parenchyma cells.
- Sclerenchymatous hypodermis
- Stomata are sunken & distributed only on the lower epidermis.
- Unbranched midrib.
- Presence of transfusion tissue.