For B.Sc. Part I (Hons.) Students (Paper- 2 group B (Pteridophyta)

STELAR ORGANIZATION IN PTERIDOPHYTES

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Lecture No.19

❖ The central vascular cylinder of the primary axis of pteridophytes is usually referred to as **stele**.

➢The term stele has been derived from a **Greek word** meaning **pillar**.

➢ Besides xylem and phloem it includes pith (if present) and is delimited from the cortex by pericycle.

➢The concept that stele is the fundamental unit of vascular system was put forward by **Van Tieghem and Douliot** (1886).

➢Van Tieghem and Douliot proposed the **stelar theory**, according to which root and stem has same basic structure consisting of two fundamental units –the cortex and central cylinder.

➢Van Tieghem and Douliot considered endodermis (the inner most layer of cortex) to be the anatomical boundary between these two fundamental unit.

➢Although a distinct endodermis is present between the cortex and stele in vascular cryptogams, higher plants usually lac the distinct endodermis and pericycle.

Types of stele in Pteridophytes

❖ Schmidt (1982) recognized the two principal types of stele in pteridophytes

1. Protostele
2. Siphonostele

1. Protostele

➢ It is non medullated stele consisting of a central core of xylum surrounded by a band of phloem which is delimited externally by a continuous sheath of endodermis.

➢ This is the most primitive both ontogenetically and phylogenetically .

➢ It is simplest type of stele.

➢ Pith is absent.

➢ Fossil Psilophytales (e.g. *Rhynia*, *Horneophyton*) as well as many primitive living vascular plants (e.g. *Psilotum*, *Tmesipteris*.).

➢ The protostele gives of leaf traces without any break in the continuity of the enveloping endodermis.

- With the departure of leaf trace there is no marked change in the solid xylum core.
- Each leaf trace is surrounded by its own endodermis.
- Following **four types** of protostele is recognized in pteridophytes

(A) Haplostele:

- This is the most primitive and simplest type of protostele.
- Named by Brebner in 1902
- Here the central solid smooth core of xylem remains surrounded by ring of phloem.
- Haplostele is found in fossil (e.g. *Rhynia*, *Horneophyton*, *Cooksonia*) as well as many living pteridophytes (*Psilotum*, *Selaginella*, *Lycopodium*).

(B) Actinostele:

- This is the modification of the haplostele and somewhat more advanced in having the central xylem core with radiating ribs.
- A protostele in which xylem appears as stellate or star shaped with many radiating arms in transverse section and phloem is present in small patches in between the radiating arms of the xylem is known as actinostele. **e.g. Living form (*Psilotium, Lycopodium serratum*)** and **fossil forms (e.g. *Asteroxylon, Sphenophyllum*).**

(C) Plectostele:

- Here the central core of xylem is divided into number of plates arranged parallel to each other.
- The xylem plate is surrounded by phloem.
- **Zimmermann** (1930) called such stele as plectostele

  e.g., aerial shoot and cone axis of *Lycopodium clavatum* .

(D) Mixed protostele:

- Sometimes solid xylem core of the protostele is broken into small groups of tracheids which remain embedded in phloem. Such stele is known as mixed protostele and is found in the stems of *Lycopodium cernuum* .
- A mixed protostele is different from a protostele with mixed pith.
- Here the xylem elements (i.e., tracheids) are mixed with the parenchymatous cells of the pith.
- Latter possess group of tracheids intermixed with parenchyma cells. e.g. *Osmunda regalis.*

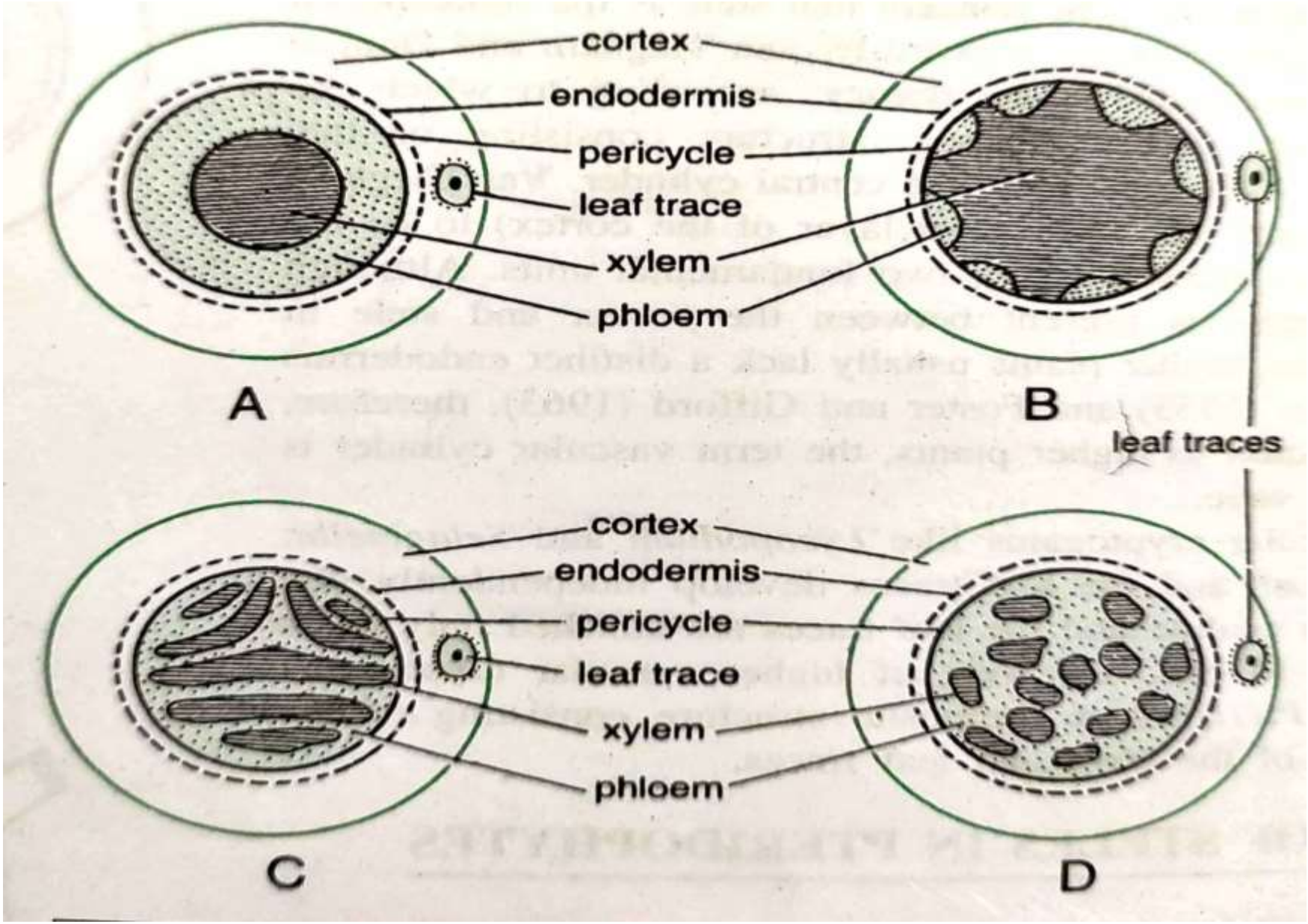


Figure: Protostele (A) Haplostele (B) Actinostele (C) Plectostele (D) Mixed protostele

2. Siphnostele

➢ A simple protostele is sufficient to meet the requirements of a small stem or a few larger ones under certain circumstances.

➢ However the requirement of increasing diameter of the stem is met with by certain internal modifications in the stele.

➢ The first step in this direction is the appearance of definite parenchymatous pith or medulla in the centre of the protostele.

➢ Such a modified protostele with a central pith is known as **siphnostele** or **medullated stele**.

❖ **Jeffrey** (1910) on the basis of their association with leaf and branch traces recognized two types of siphnostele.

✓ In one type, however, the leaf gaps are not found and they are known as **cladosiphonic siphonosteles.**

✓ In the other type both leaf and branch gaps are present and they are known as **phyllosiphonic siphonosteles**

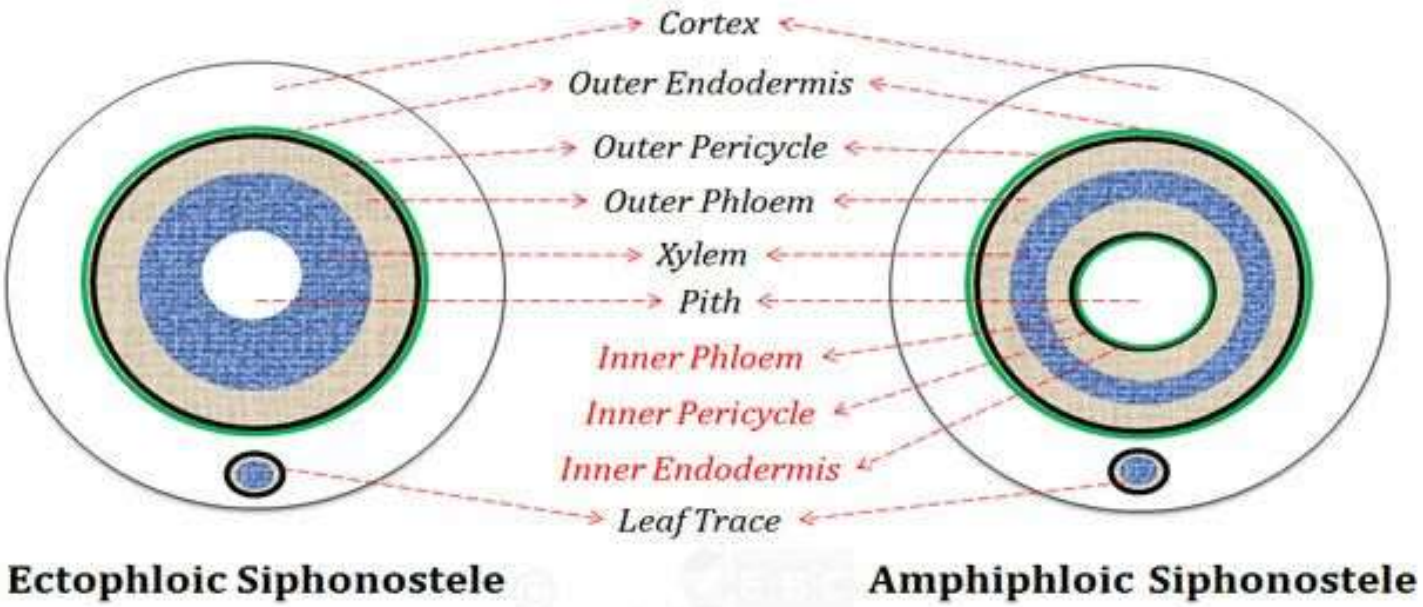
❖ A siphonostele may be of the following types

▪ **Ectophloic:** A single phloem ring external to the xylum, such a siphnostele is called ectophloic siphnostele. e.g. *Equisetum*, *Osmunda*, *Schizaea*.

▪ **Amphiphloic:** Contrary to this , the siphnosteles of *Adiantum*, *Dryopteris*, and *Marsilea* have a ring of phloem each external and internal to the xylum. This type of stele is called amphiphloic siphnostele. Such steles have two endodermal layers,

Outer endodermis – that lies outside the outer phloem

Inner endodermis -that lies inner to the inner phloem, outside the pith.



Origin of Siphnostele

❖ There are two main theories regarding the evolution of siphonostele from protostele:

(a) Intrastelar origin or Intraxylary

(b) Extrastelar Origin

(a) Intraxylary or Intrastelar origin:

➢ According to this theory the siphonostele is evolved by the conversion of the central mass of the xylem into parenchymatous pith.

➢This theory is also known as expansion theory and it is supported by Boodle (1901), Bower (1911), Gwynne-Vaughan (1903, 1914). Petry (1914), Thompson and Gewirtz and Fahn (1960) etc.

(b) Extrastelar Origin:

➢This theory is supported by Jaffery (1897, 1899, 1902, 1917). According to him the pith is originated as a result of invasion of the parenchymatous cells of the cortex into the stele.

➢ It takes place through the leaf gaps and branch gaps. This theory is also known as invasion theory.

Modifications of Siphnostele

❖ Depending on the presence of nonoverlapping or overlapping gaps, the following three types of siphnosteles are recognized.

(I) Solenostele: A solenostele with non overlapping leaf gap is known as solenostele.

The soleno stele may be ectophloic or amphiphloic.

(i) Ectophlopic solenostele: Phloem is present only on outer side

(ii) Amphiphloic solenostele: Phloem is present on both the sides of the xylem

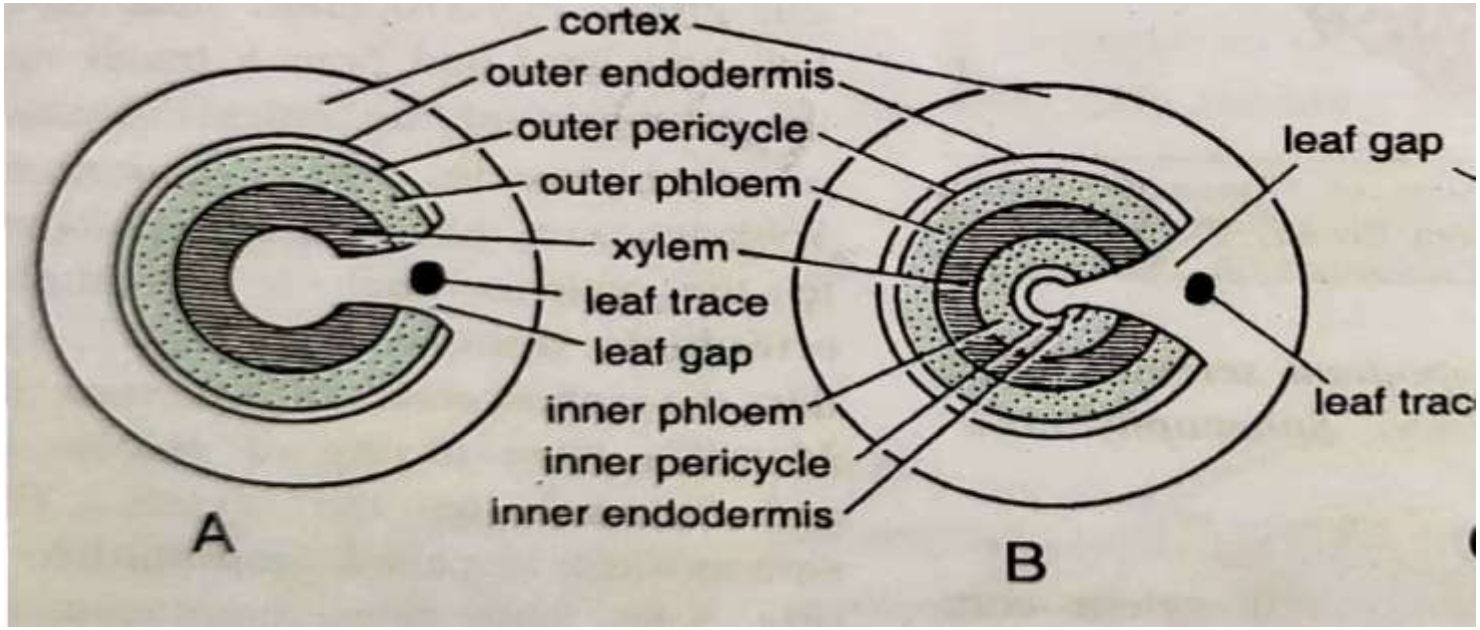
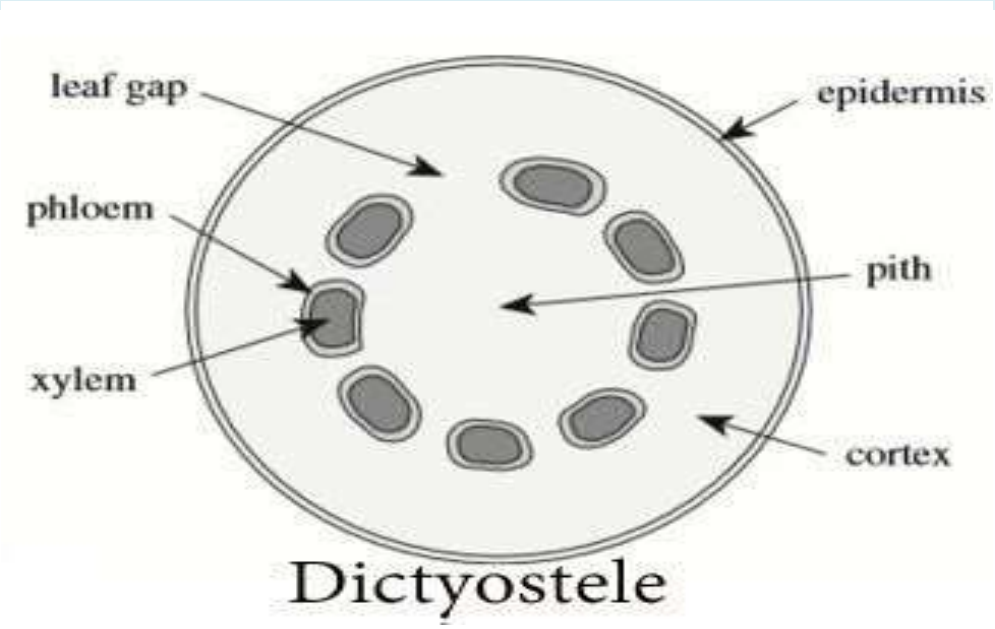


Figure: (A) Ectophloic solenostele (B) Amphiphloic solenostele

(II) Dictyostele: Many fern like *Dryopteris*, *Pteris*, *Ophioglossum*, etc. have a very small rhizome with crowded leaves . Consequently, the leaf gaps overlap with each other.

A siphnostele with overlapping leaf gap is known as dictyostele.



Dictyostele

(III) Polycyclic stele: Stelar structure of certain pteridophytes is still more complex . They possess two or more concentric rings of vascular tissue and are called polycyclic.

➢ If in a polycyclic stele the outer cylinder is solenostelic, it is called polycyclic solenostele and the outer cylinder is dictyostelic it is known as polycyclic dictyostele.

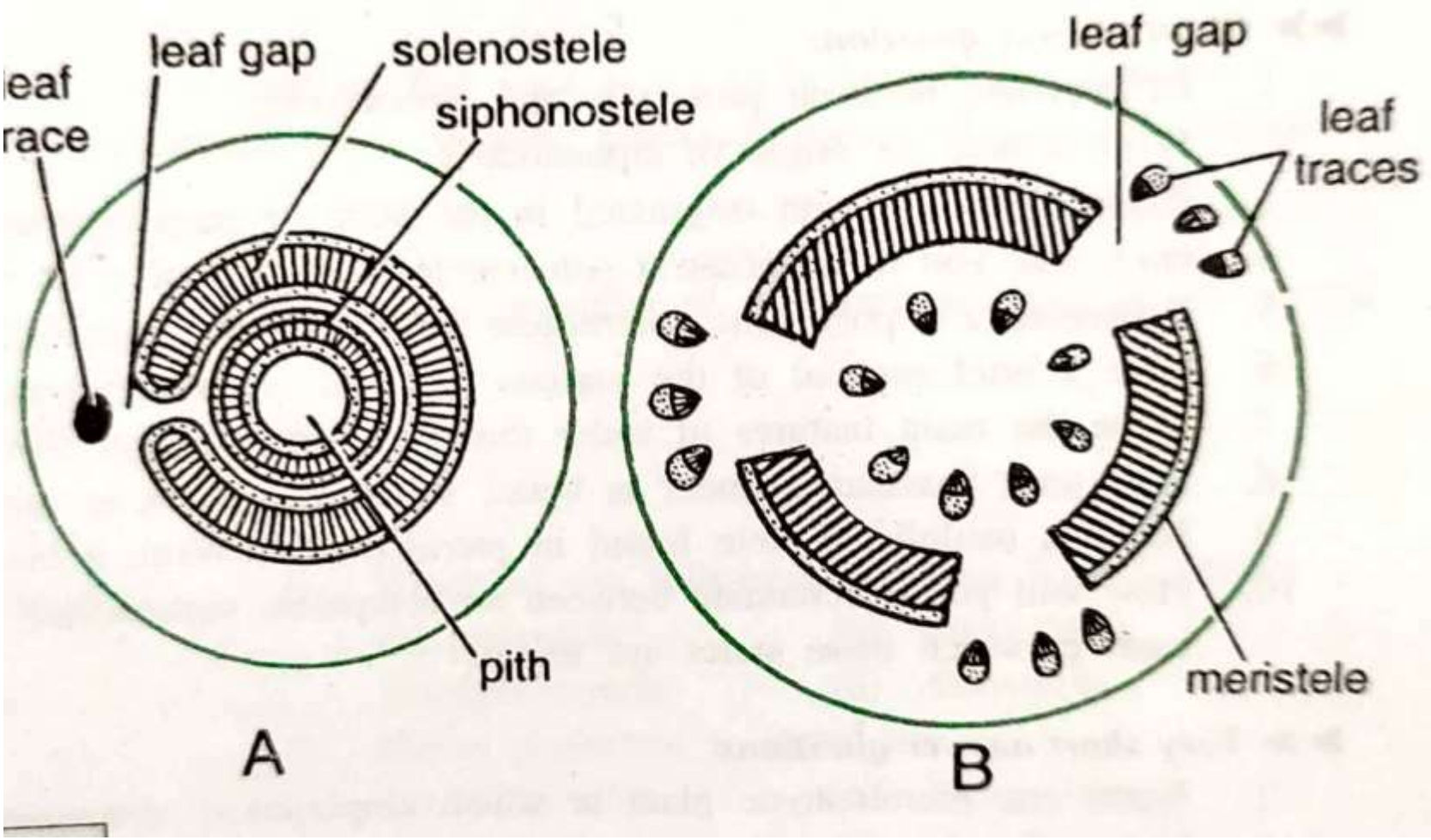


Figure : Polycyclic stele (A) Polycyclic solenostele (B) Polycyclic dictyostele

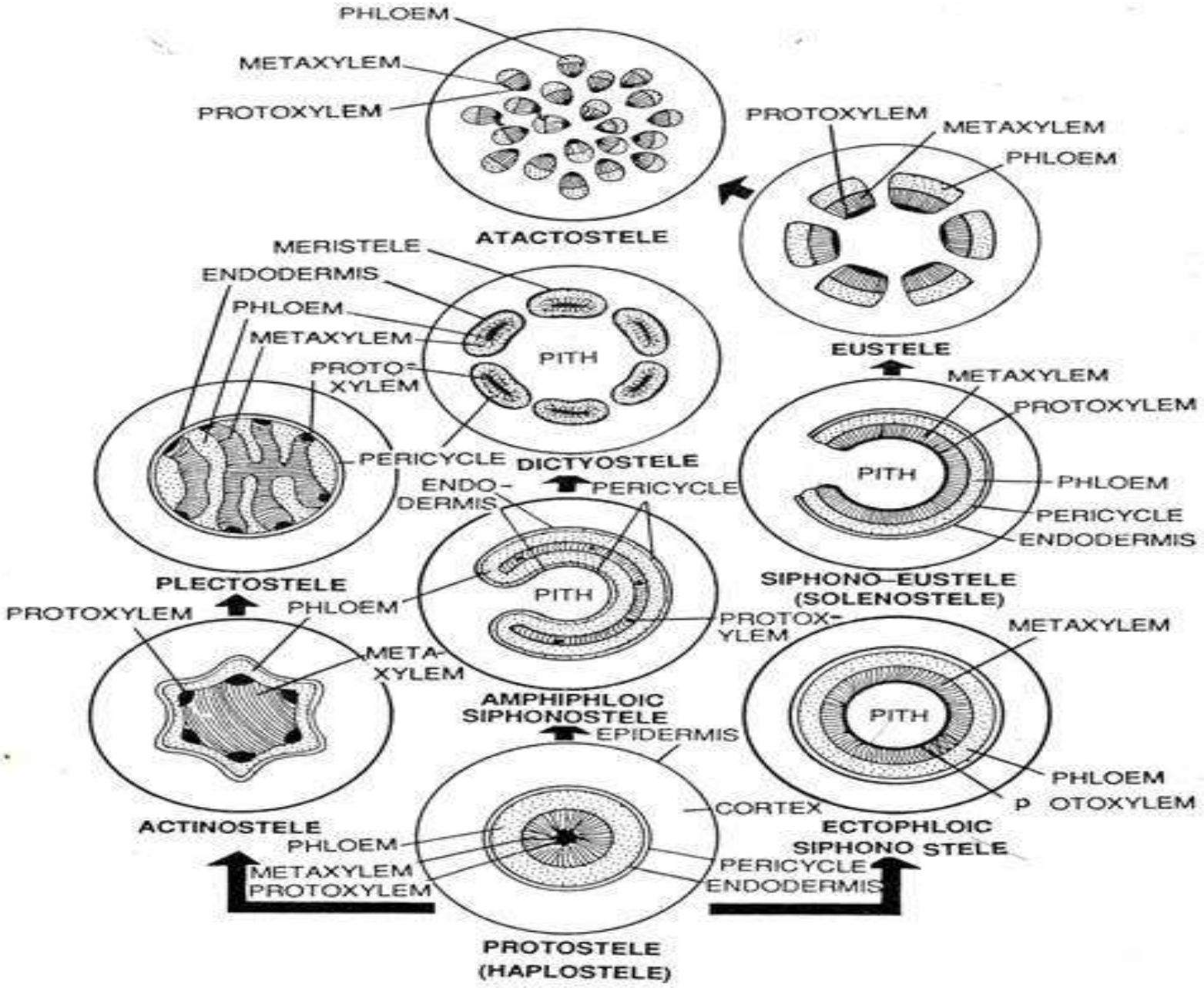


Figure: Different types of steles arranged in evolutionary sequence

Note: Figures are taken from the A text book of Botany by Singh, Pandey, Jain (Fifth edition) and internet source.

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Thank You!!!