

Stele, types & their evolution

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According to the older botanists, the vascular bundle is the fundamental unit in the vascular system of pteridophytes and higher plants. **Van Tieghem** and **Douliot** (1886) interpreted the plant body of vascular plant in the different way. According to them, the fundamental parts of a shoot are the cortex and a central cylinder, is known as **stele**. Thus the **stele is defined as a central vascular cylinder, with or without pith delimited the cortex by endodermis**.

COMPONENTS OF STELE

Xylem

Phloem

Pericycle

Medullay rays

Pith

TYPES OF STELES

1. Protostele:

- ☐ Jeffrey (1898), for the first time pointed out the stelar theory from the point of view of the phylogeny. According to him, the primitive type of stele is **protostele**.
- ☐ In protostele, the vascular tissue is a solid mass and the central core of the xylem is completely surrounded by the strand of phloem.
- ☐ This is the **most primitive** and simplest type of stellar organization.
- ☐ **Pith is absent**.

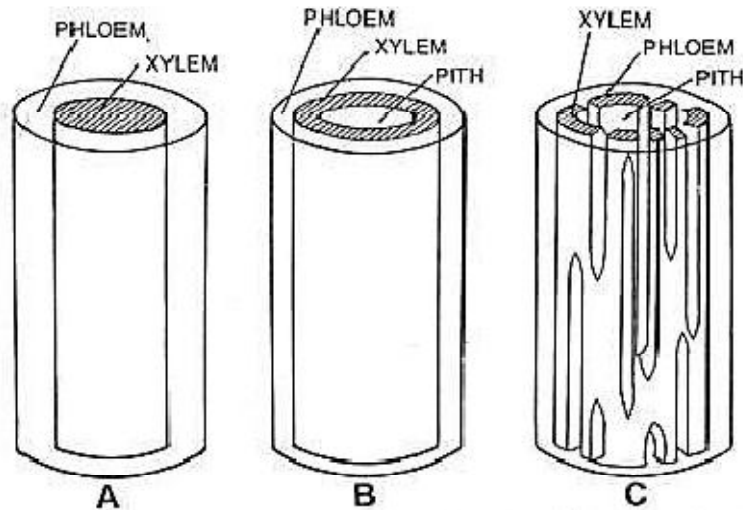


Fig. Types of arrangements of vascular tissues in steles. A, protostele; B, siphonostele; C, dictyostele.

FORMS OF PROTOSTELE

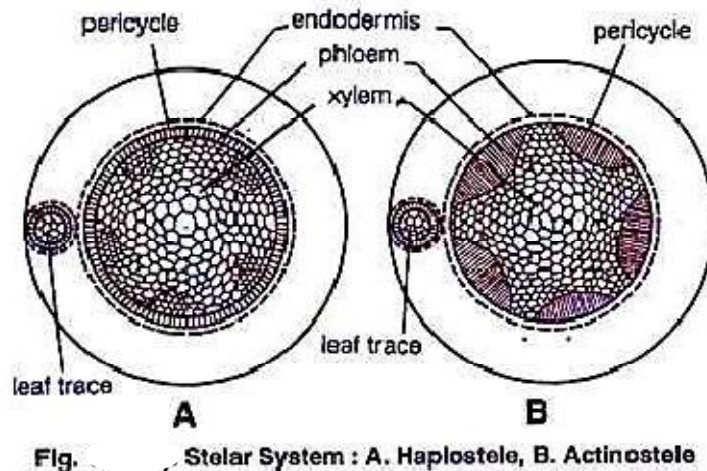
There are several forms of protostele:

(a) Haplostele:

- This is the most **primitive type of protostele**.
- Named by Brebner in 1902
- Here the central solid smooth core of xylem remains surrounded by phloem (e.g., in *Selaginella* spp., *Rhynias* sp).

(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., in *Psilotum* spp.)



(c) Plectostele:

- This is the most **advanced type of protostele**.
- Here the central core of xylem is divided into number of **plates** arranged parallel to each other. The **phloem alternates the xylem**.
- Zimmermann (1930) called such stele as plectostele . e.g., *Lycopodium*

(d) Mixed-protostele:

- Here the **xylem elements** (i.e., tracheids) are **mixed with the parenchymatous cells** of the pith.
- This type is found in primitive fossils and living ferns.
- They are treated to be the transitional types in between **true protosteles on the one hand and siphonosteles** on the other (e.g., in *Gleichenia* spp. and *Osmunda* spp.).

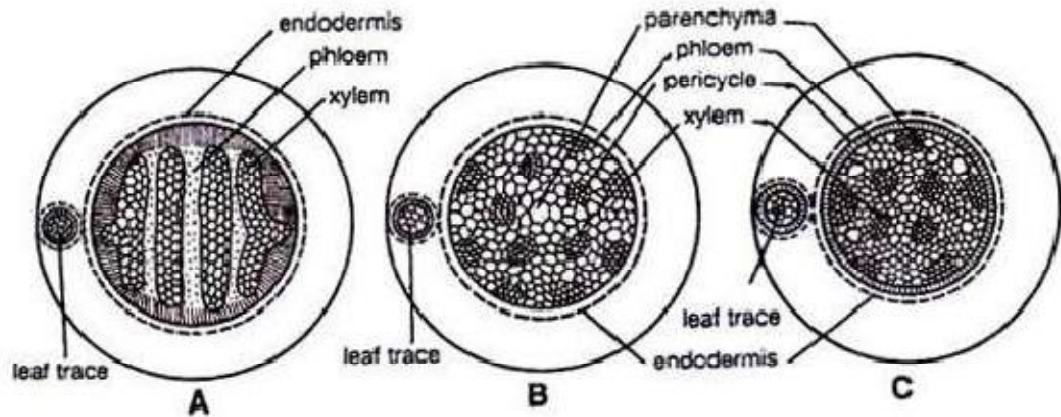
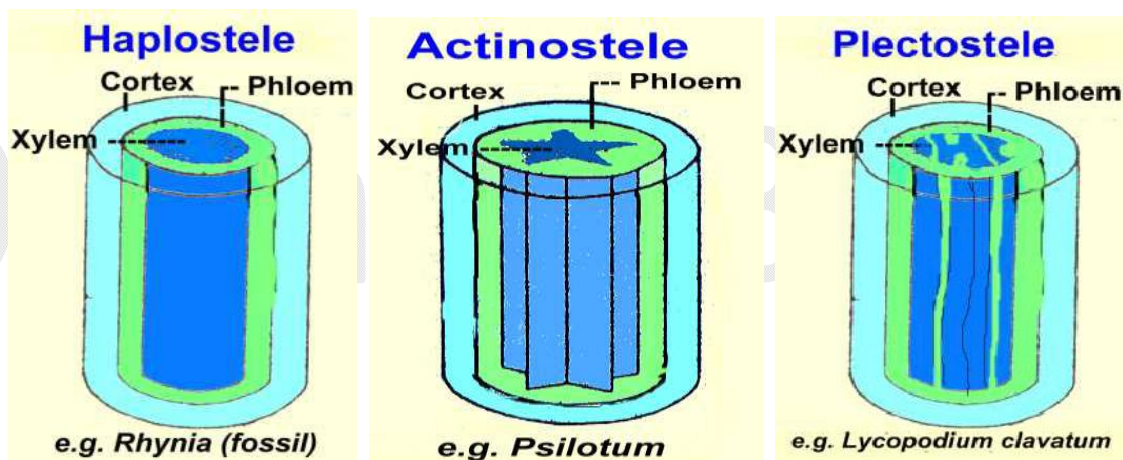


Fig. . Stellar System : A. Plectostele, B. Mixed protostele, C. Mixed protostele with pith.



2. Siphonostele:

- This is the modification of protostele.
- A stele **with central pith** surrounded by vascular tissue is called siphonostele or a medullated protostele is called **siphonostele**.
- Such stele contains a tubular vascular region and a **parenchymatous central region**.

- Jeffrey (1898) interpreted that the vascular portion of siphonostele possesses a parenchymatous area known as a immediately above the branch traces only or immediately leaf and branch traces.

TYPES OF SIPHONOSTELE

- A siphonostele may be of the following types:

Ectophloic

Amphiphloic

(a) Ectophloic siphonostele:

- In this type of siphonostele, the pith is surrounded by **concentric xylem cylinder** and next to xylem the concentric **phloem cylinder**.
- **Phloem is present only external to the xylem** (Fig. 3A) e.g., *Osmunda* sp, *Schizaea* sp).

(b) Amphiphloic siphonostele:

- In this type of siphonostele the pith is surrounded by the vascular tissue. The concentric **inner phloem cylinder surrounds the central pith**.
- Next to the inner phloem is the **concentric xylem cylinder** which is immediately surrounded by **outer phloem cylinder** (e.g., in *Marsilea* sp).

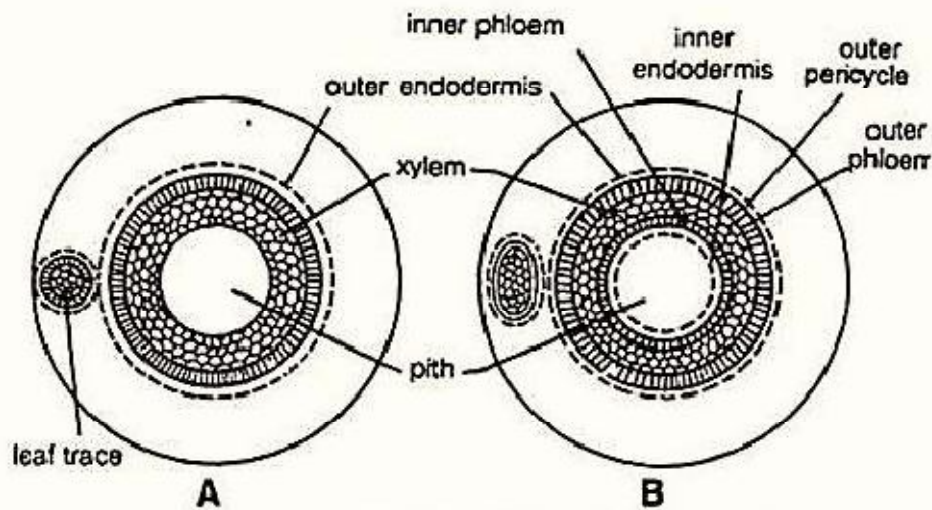
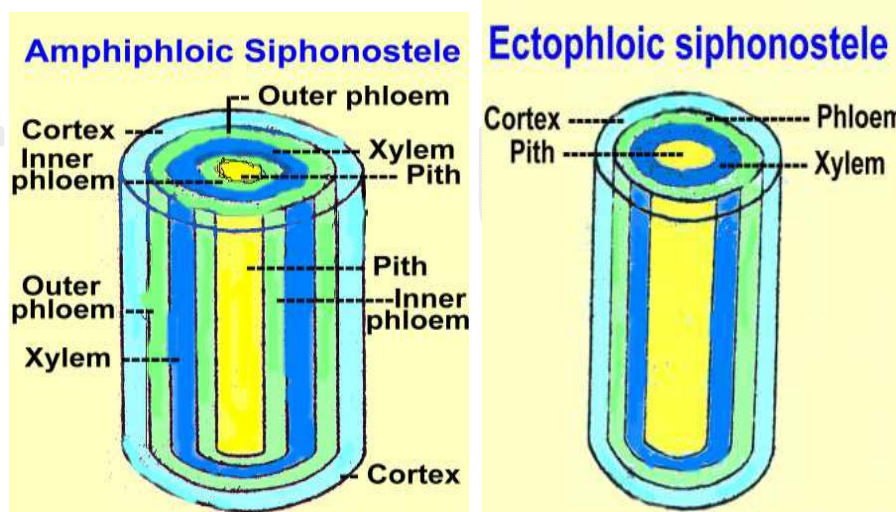


Fig. Stellar System : A. Ectophloic siphonostele, B. Amphiphloic siphonostele



EVOLUTION OF SIPHONOSTELE FROM PROTOSTELE:

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

(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.**

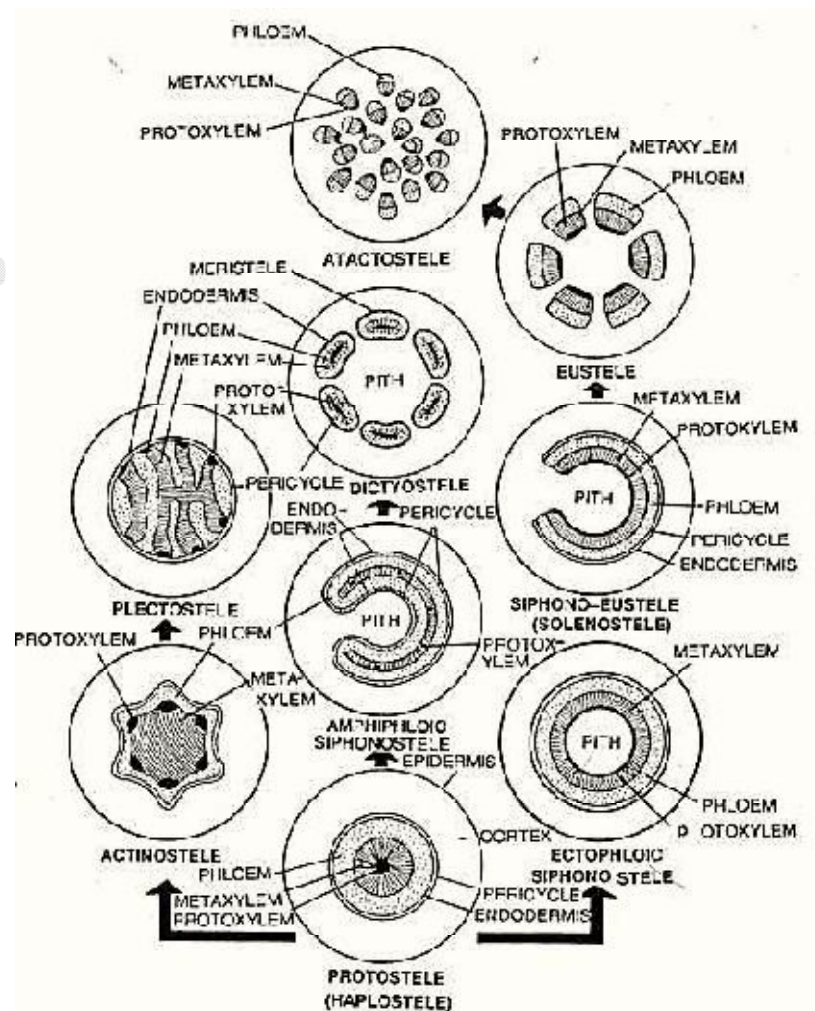


Fig. The stelar system. Different types of steles arranged in evolutionary sequence.

TYPES OF STELES DEPENDING UPON LEAF GAP

(a) Solenostele:

- The siphonostele which is **perforated by scattered leaf traces** is known as **solenostele** (Gwynne-Vaughan, 1907; Schoulte, 1938).
- In simple words, siphonostele with leaf gap is called solenostele
- It is actually a sub categorie of siphonostele.

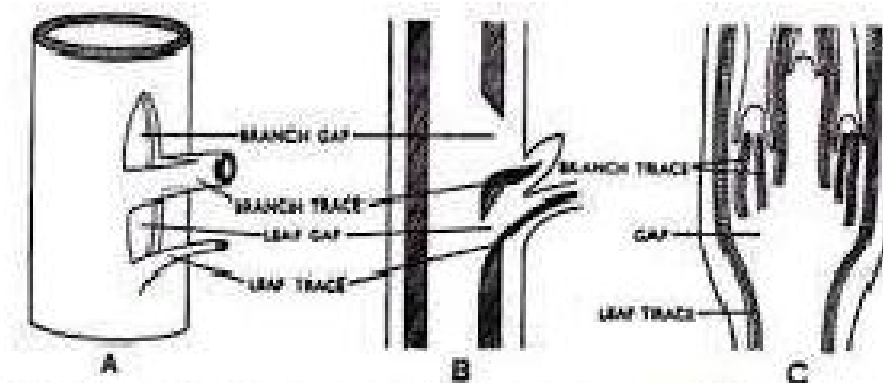
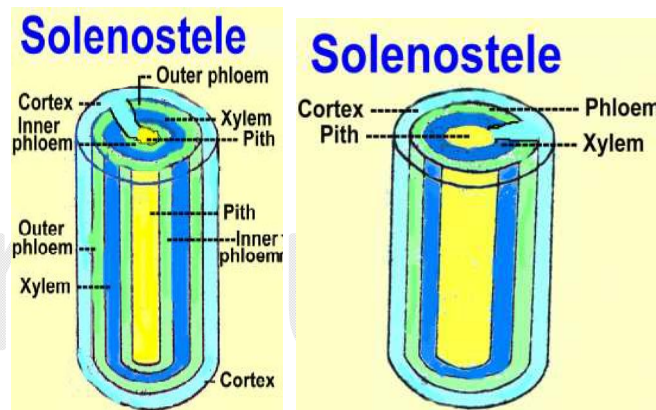


Fig. . . . Branch trace and gap (diagrammatic): A. A vascular cylinder showing departure of leaf and branch traces with associated gaps. B. Longitudinal section through a node showing the same. C. L.s. through a node with opposite leaf arrangement with branch and leaf traces and gaps.

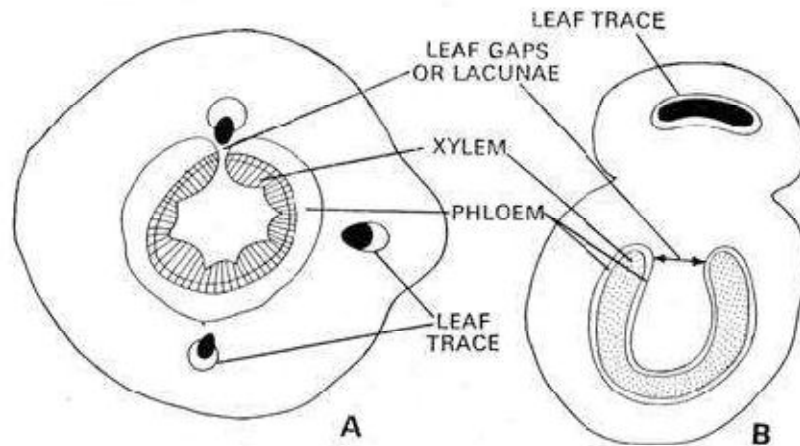
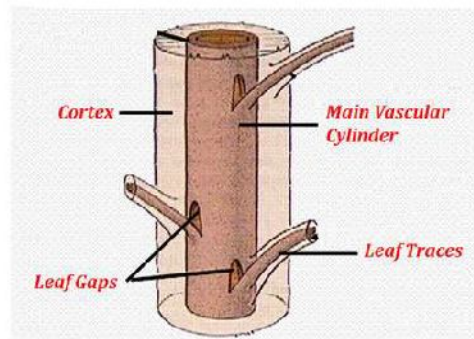


Fig. Nodal anatomy. A, nodal anatomy of *Picea* (a conifer) in transection; B, nodal anatomy of *Adiantum* (a fern) in transection. Both possess alternate leaf arrangement, single traces to leaves, and single leaf gaps at the nodes. A, has some secondary growth; B, has phloem on both sides of xylem.



Leaf Gaps and Leaf Traces

TYPES OF SOLENOSTELE

(i) Ectophlopic solenostele:

- Phloem is present only on **outer side**.
- e.g. *Nicotiana & Salix*.

(ii) Amphiphloic solenostele:

- Phloem is present on **both the sides** of the xylem.
- e.g *Adiantum, Marsilea*

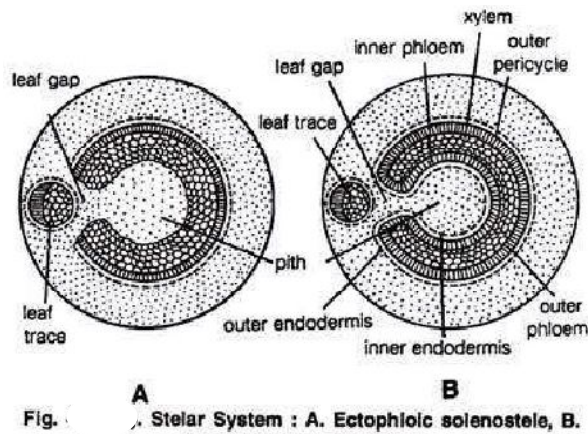


Fig. 1. Stellar System : A. Ectophloic solenostele, B.

(b) Dictyostele:

- A solenostele with more overlapping leaf gaps so as to show more than interruption in one transverse section is known as **dissected siphonostele** or **dissected solenostele** or **dictyostele**.
- It is broken into **network of separate vascular bundles**.
- Brebner (1902) called the siphonosteles with overlapping gaps as **dictyosteles**.
- The vascular parts of dictyostele between the neighbouring gaps are known as **meristeles** which are of protostelic type. The dictyostele with many meristeles looks like a cylindrical meshwork.
- These vascular bundles are concentric (central xylem surrounded by phloem, pericycle and endodermis), called **meristeles** (e.g. *Dryopteris*).

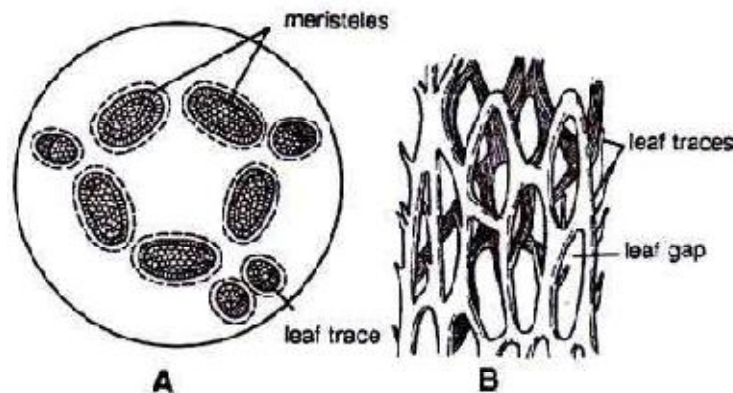
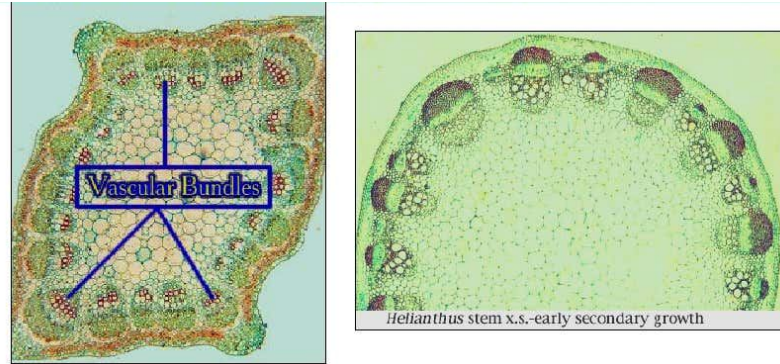


Fig. 2. Stellar System : A. Dictyostele, B. Vascular skeleton of a dictyostele

(c) Eustele:

- It is characteristic of **Gymnosperms and dicots stem**.
- In this type of stele **collateral or bicollateral vascular bundles are present in a ring** (Brebner, 1902)



(d) Atactostele:

- It is **characteristic of monocots**. In this type of stele vascular lies scattered in the (Brebner, 1902). It is the highly evolved stellar organisation. ground tissue.
- This is a special case of Eustele in which the stele is **more dissected with leaf gaps**, so that, in transverse section, the **vascular bundles are scattered** though the fundamental tissue (e.g. Monocot stems, Corn & Grasses).

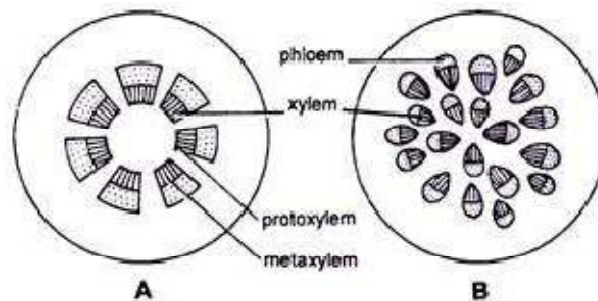


Fig. Stellar System : A. Eustele, B. Atactostele

Stelar organisation in vascular plants

