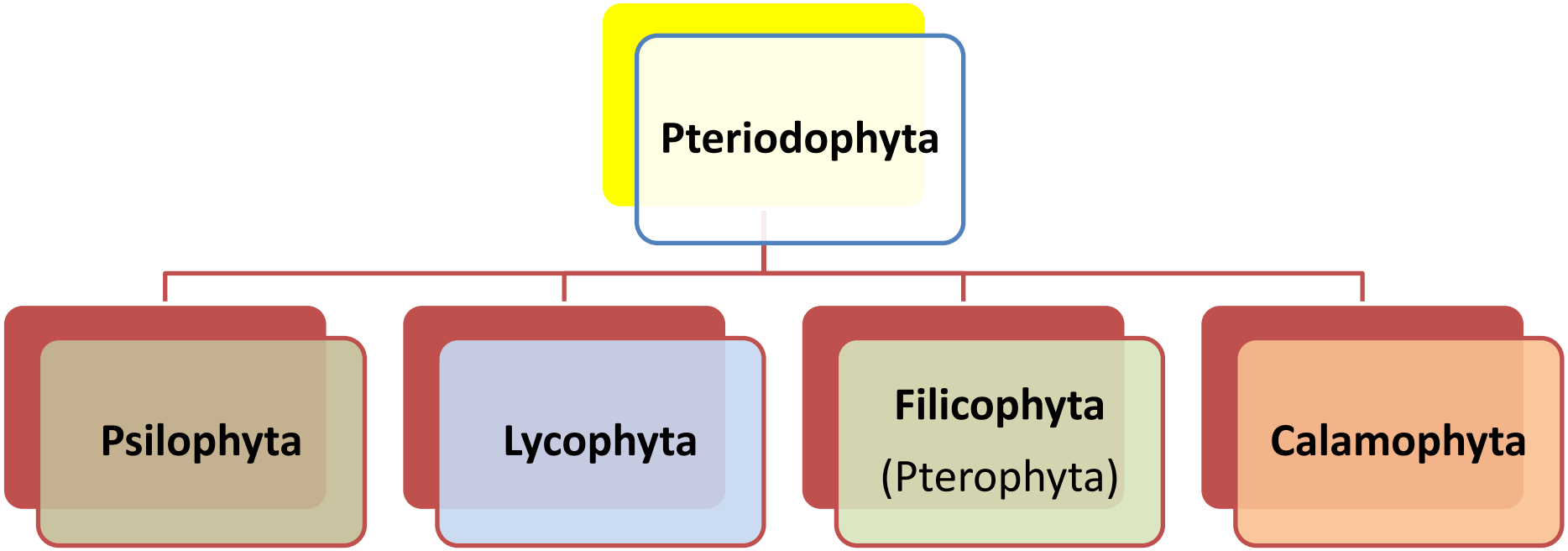
Pteriodophyta



Origin of Pteridophyta

(a question that has been unsolved)

1. They are directly evolved from algae:

from brown algae or green algae (particularly the filamentous Chaetophoraceous type) and the similarities between bryophytes and pteridophytes are due to **prallel evolution from algae** and **not** to a phylogentic connection between them.

2. They originate from Bryophytes:

particularly from *Anthoceros*. Campbell (1895) was the first to declare the anthocerotean origin of Pteridophytes, at first it was not accepted, but when the fossil Psilophytes were discovered this theory was brought into light again.

WHY ??

- In Psilophytes, the sporophyte was rootless, leafless and dichotomously branched.

If in *Anthoceros* sporophyte:

- the intercalary meristematic zone is shifted to occupy the apices of the branches and
- the bivalves resulting from the dehiscence of sporophyte are transformed into dichotomous branches,

the fine structure is much related to Psilophytes sporophyte.

- The sex organs in *Anthoceros* resemble those of Pteridophytes: archegonia in *Anthoceros* (no stalk, can not distinguish archegonial wall) resembling archegonia of Pteridophytes.

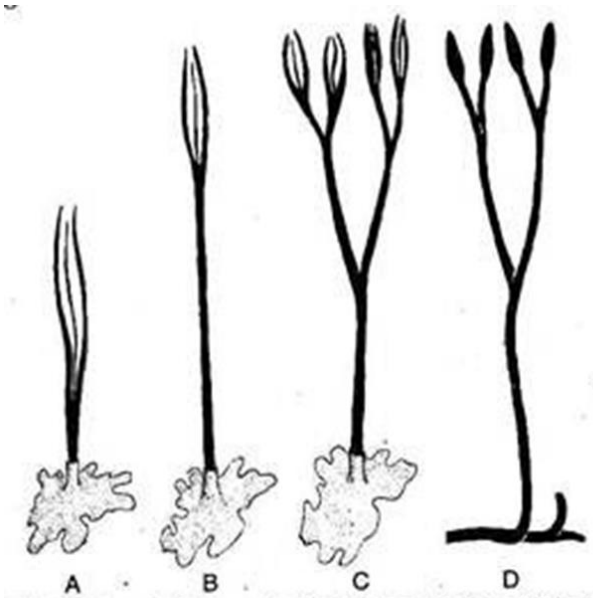


Fig. 7.131 : A–D. Hypothesis in the evolution of *Rhynia* type sporophyte from *Anthoceros* type ancestor (*after* smith, 1955). A. *Anthoceros*, B. *Sporogonites*, C. *Horneophyton*, D. *Rhynia*

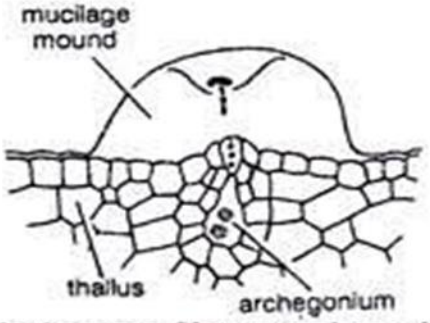


Fig. 5. *Anthoceros*. Mature archegonium with mucilage mound.

Modern Interpretation

- **Modern studies** of cell ultrastructure, biochemical nature and molecular studies (5S/16S- rRNA sequence, molecular sequence data from plastid, nuclear and mitochondrial encoded genes etc.) **suggest that bryophytes are not the ancestor of vascular plants.**
- It has been indicated that both the bryophytes and pteridophytes have evolved from green algal ancestors, probably from *Coleochaete*, closely related to charophytes, and mosses appear to be a sister group to the tracheophytes.
- *Coleochaete* is an excellent model for the algal ancestor of land plants.
- *Coleochaete* is a **soil alga** in the order Coleochaetales, subfamily Charophyceae, which **produces a small vegetative thallus as the major, haploid part of its life cycle**
- (https://www.youtube.com/watch?time_continue=173&v=fuwSkVjbjyc).

- Pteridophyta constitutes the earliest known vascular plants.

"Vascular plants are those plants that contain the vascular tissue that is the conducting tissues of xylem and phloem. "

- Sometimes all vascular plants are included in one division **Tracheophyta** . This is to emphasize the advance nature of vascular tissue over the simple conducting cells of some Bryophytes and Algae.

- Presence of vascular tissue is a feature of the sporophyte generation, which in the bryophytes is small and dependent on the gametophyte.
- The occurrence of vascular tissue in the sporophyte is one reason why sporophyte generation has become the dominant one in all vascular plants.
- The vascular tissue of pteridophytes shows certain primitive features compared with flowering plants. The **xylem** of pteridophytes contains mostly **tracheids** rather than vessels

Distinguishing characters of Pteridophytes

1. The life cycle shows distinct heteromorphic alternation of generation.
2. Plant body of Sporophyte is dominant phase.
3. Sporophyte is differentiated into true root, stem and leaves.
4. Vascular tissue i.e xylem and phloem are present. (**Xylem lacks vessels but tracheids are present. In phloem sieve tubes and companion cells are absent**).
5. Asexual reproduction takes place by spores.
6. Most pteridophytes are homosporous **(i.e they produce one type of spores)**. A few show heterospory **(i.e they produce two types of spores microspores and megaspores).**
7. Spores are produced from spore mother cells after meiosis in multi-cellular sporangia.

8. Sporangia bearing leaves are called sporophylls.
9. Spores on germination develop into gametophyte which is haploid, multicellular, green and an independent structure.
10. The plant develops multi-cellular sex organs. The male sex organ is called antheridium and the female sex organ is callednbarchegonium.
11. Sex organs have a sterile jacket.
12. Antherozoids are spirally coiled and **multiflagellate**.
13. Fertilization takes place inside archegonium.
14. Opening of sex organs and transfer of male gametes to archegonium for fertilization are dependent on water.
15. Fertilized egg (zygote) develops into embryo.

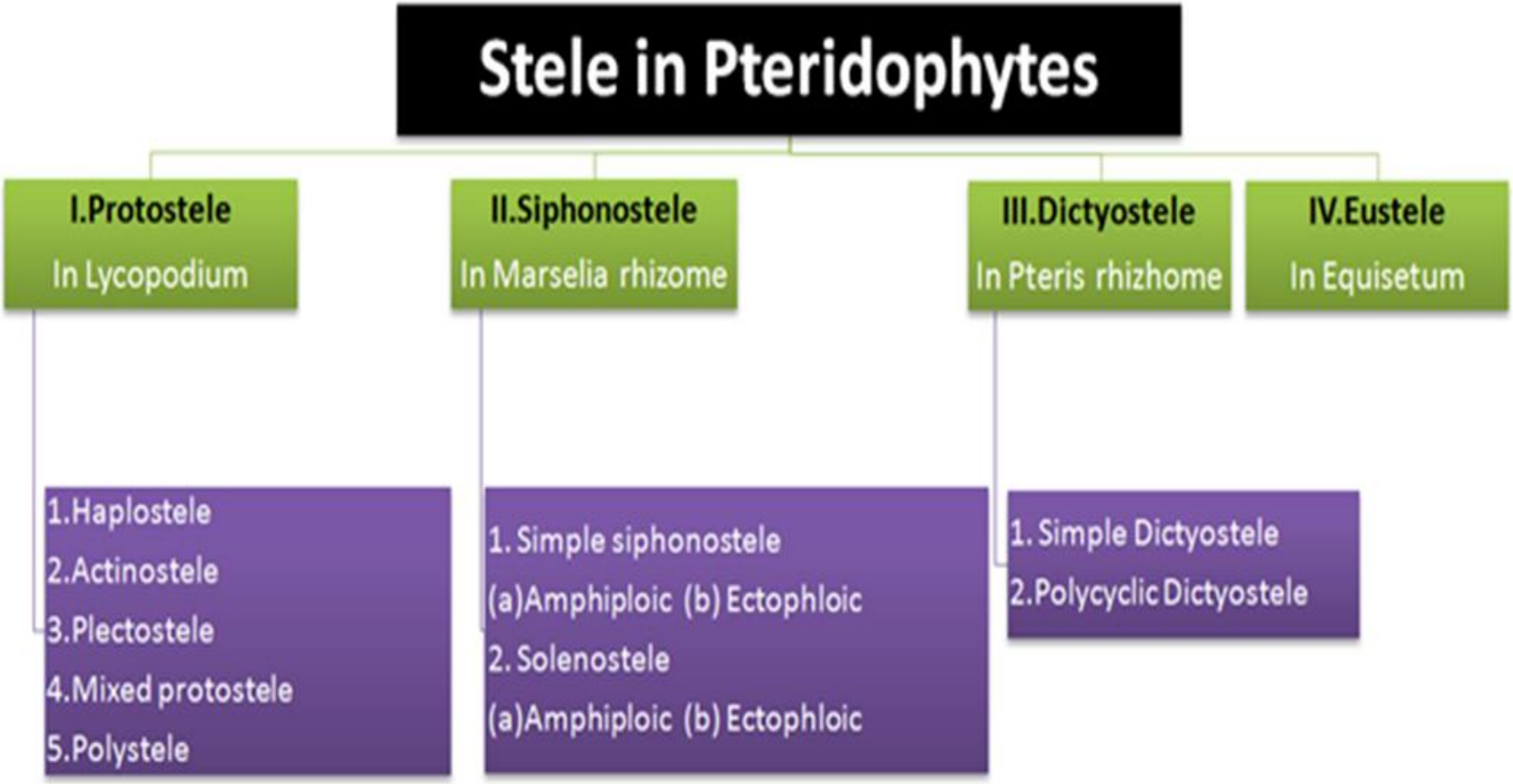
Roles of vascular tissue

- Vascular tissue has two important roles to perform:
- **Firstly**, it forms a **transport system**, conducting water and food around the multicellular body, thus leading to the development of large, complex bodies.
- **Secondly**, xylem, one of the vascular tissues, **supports these large bodies** since xylem contains lignified cells of great strength and rigidity.

Vascular structure in Pteridophyta (The stele)

- Stele is defined as the central vascular cylinder, with or without pith.
- Endodermis is the boundary between cortex and stele.
- Xylem and ploem are the components of the stelar structure.
- In Pteridophytes, the nature and arrangement of xylem and phloem differ in different groups.
- Basically, there are 4 groups:

1. Protostele 2. Siphonostele 3. Dictyostele 4. Eustele



- **Exarch**: Protoxylem develops externally.
- **Mesarch**: prtoxylem develops at the middle of the stele.
- **Endarch:** protoxylem develops internally.
- Endarch more advanced than mesarch, which , in turn, more advanced than exarch.

Protostele: the vascular structure consists of central core of xylem completely surrounded by phloem. This is the most primitive and simplest stele.

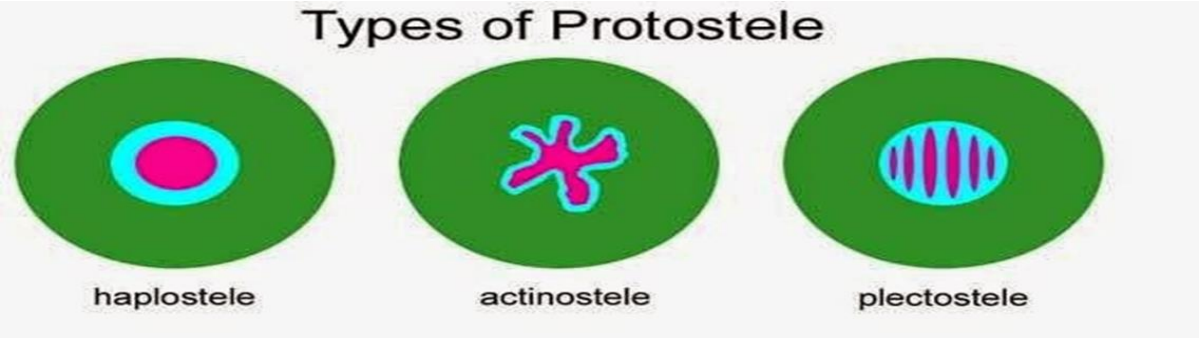
a. Haplostele: the most primitive type of protostele. A central solid core of xylem surrounded by a layer of phloem e.g. *Selaginella.*

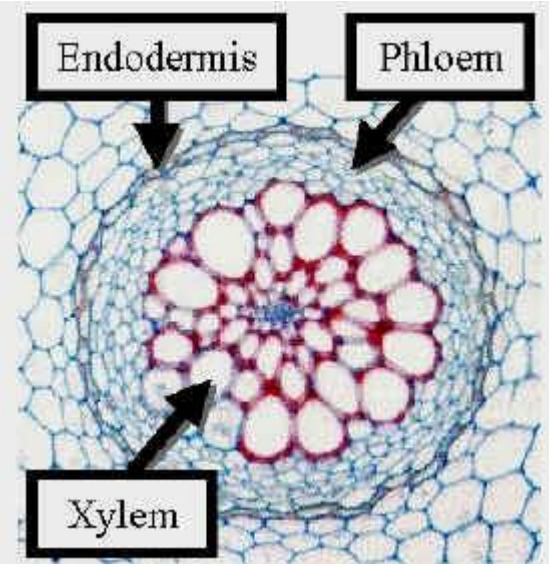
b. Actinostele: central xylem core with radiating ribs or a star shaped appearance surrounded by phloem. More advanced than haplostele. e.g. lower region of *Psilotum* stem.

c. Plectostele: xylem is plate like arranged parallel to each other and each plate is surrounded by phloem. More advanced than actinostele. e.g *Lycopodium clavatum* stem.

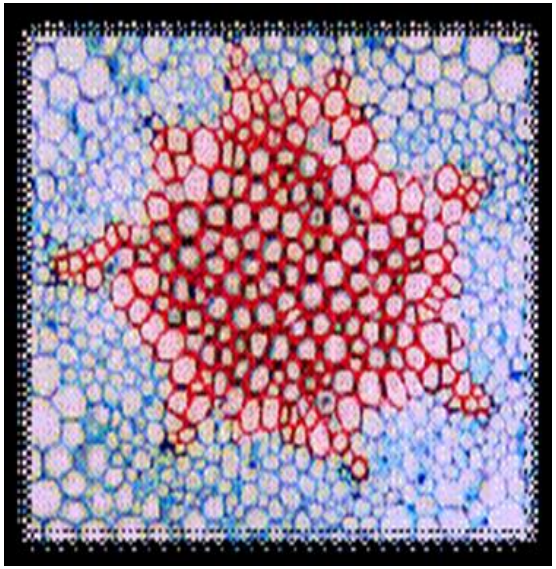
d. Mixed protostele: xylem and phloem uniformly distributed . Xylem elements break up into small groups surrounded by phloem. Most advanced protostele. Transitional between true protostele and siphonostele.

e. Polystele: Generally in protostele, there is a single stele in the centre but in *Selaginella*, the stem has several steles in parallel arrangement (distelic or polystelic.

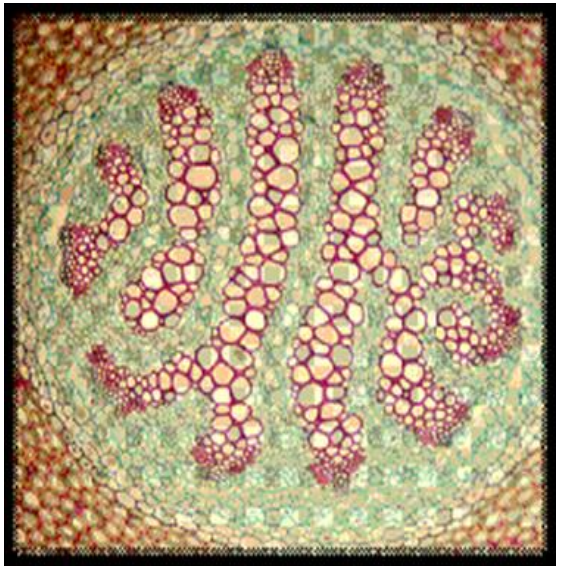




Haplostele

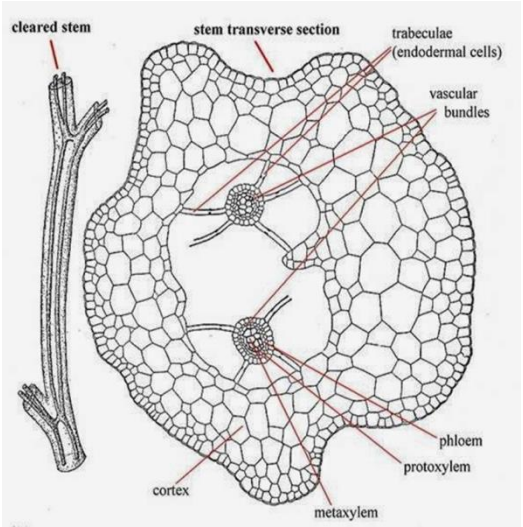


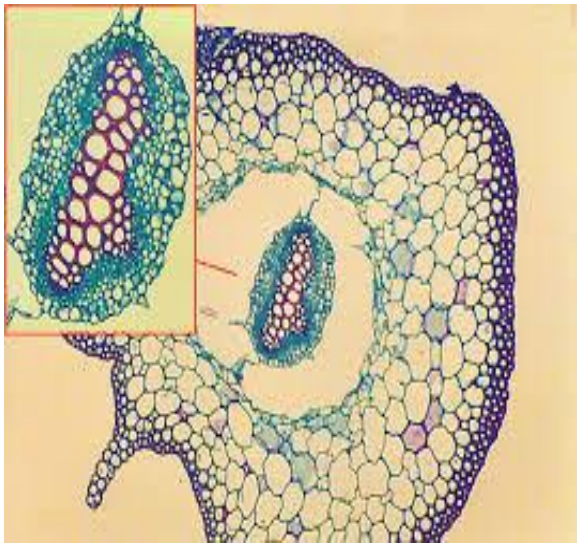
Actinostele



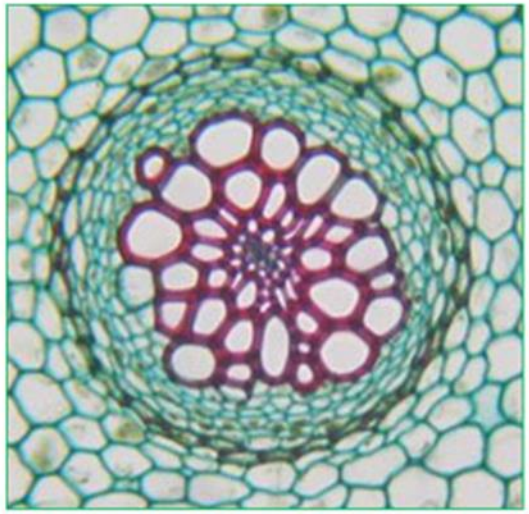
Plectostele

Mixed protostele

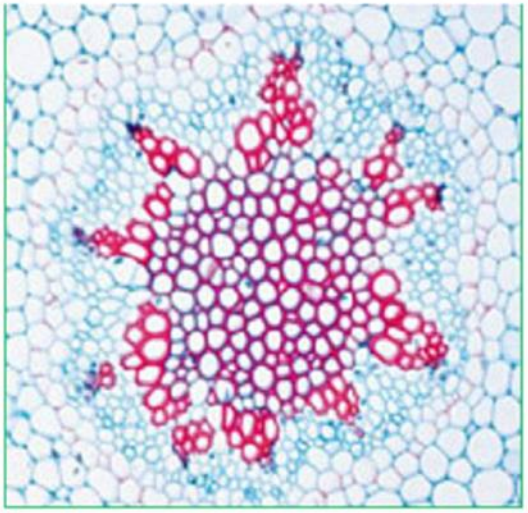




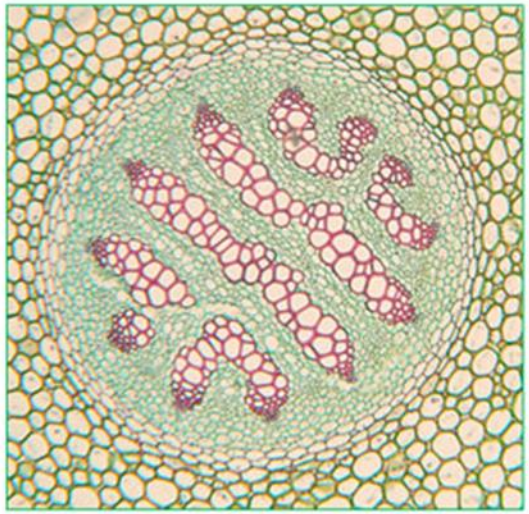
Polystele



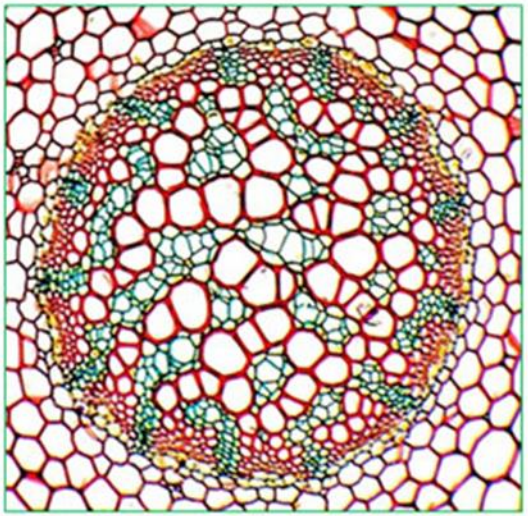
Haplostele (*Lygodium*)



Actinostele (*Psilotum*)



Plectostele
(*Lycopodium clavatum*)



Mixed Protostele
(*Lycopodium cernuum*)

- Siphonostele: it is the modified protostele with a central pith region or medullated protostele.

a- Simple siphonostele :this type of stele has central pith which may be parenchymatous or sclerenchymatous:

1. Ectophloic siphonostele:- this type of stele has central Pith, which is surrounded by concentric rings of Xylem followed by phloem only.

2. Aphiphloic siphonostele:- in this type of stele the centre is occupied by pith. Xylem is surrounded on both external and inner sides by ring of phloem.

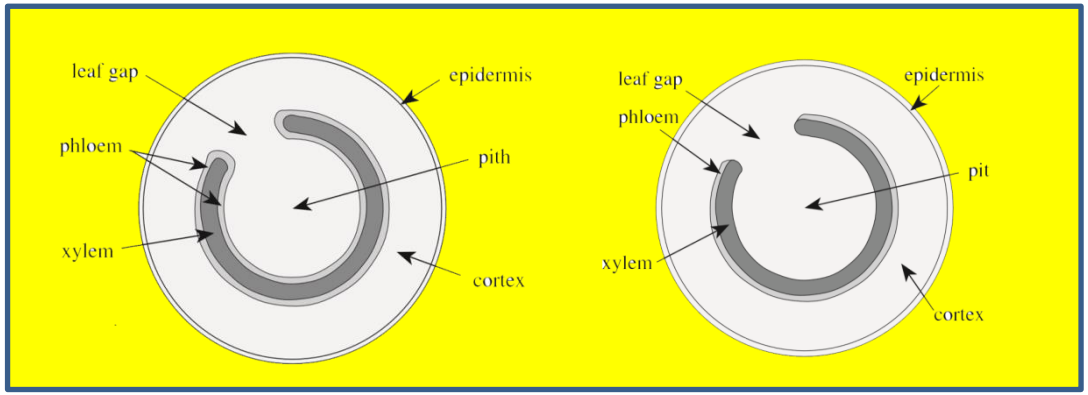
B- Solenostele:

A siphonostele with

a leaf gap on **one point.**

It may be **ectophloic** or

amphiphloic.



c. Dictyostele: siphonostele is splitted into a number of strands known as meristeles due to development of leaf gaps.

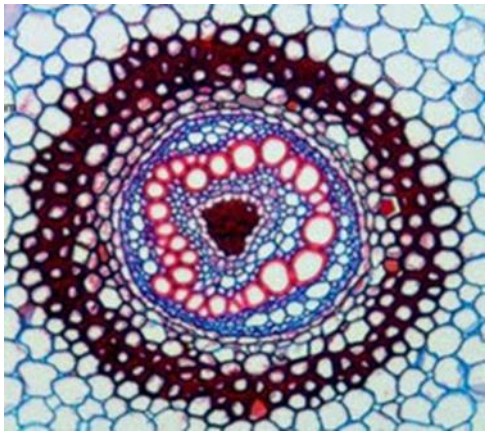
1. **Monocyclic:** meristeles arranged in one cycle.
2. **polycyclic:** meristeles arranged in more than one cycle.

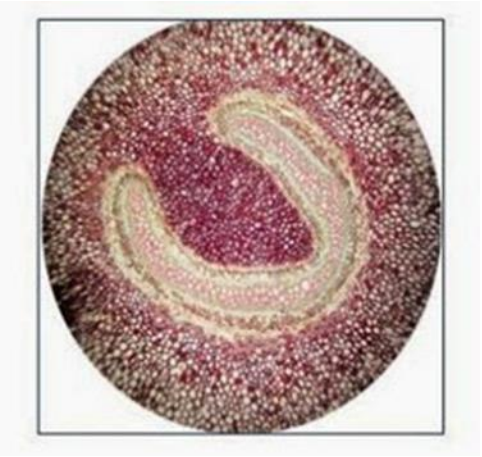
d- Eustele: the primary stem vascular system consists of collateral or bicollateral conjoint vascular bundle situated on the edges of the pith.

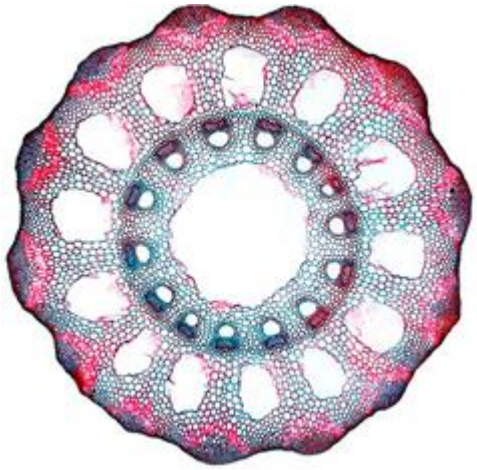
Atactostele: similar to **eustele**

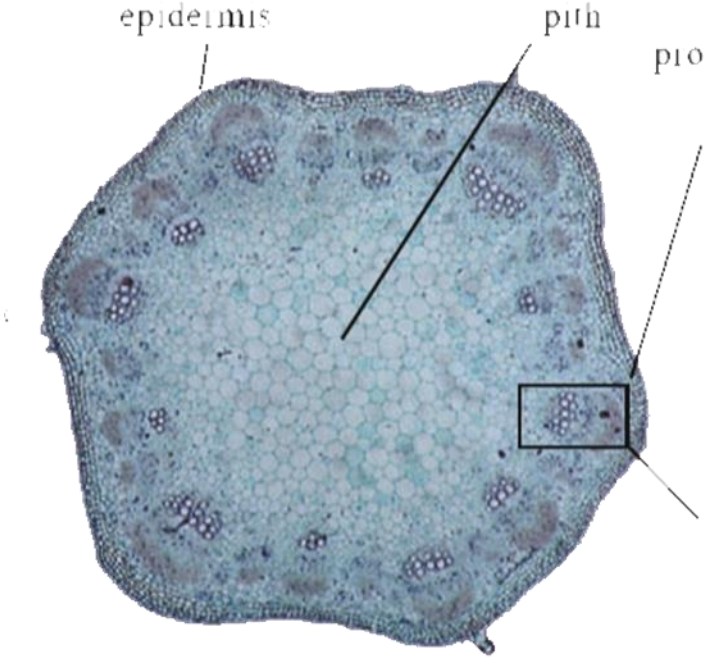
But vascular bundles are scattered and distributed in the ground tissue .

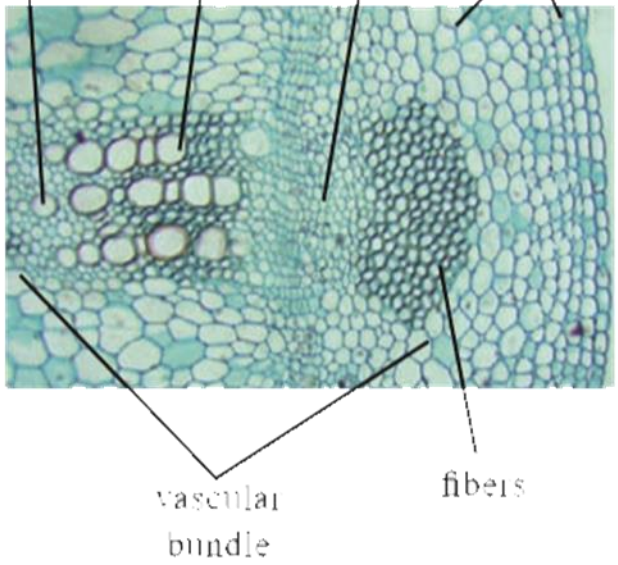
e.g. : **monocot stem**








epidermis
pith


protoxylem
xylem
phloem
cortex
vascular bundle
fibers

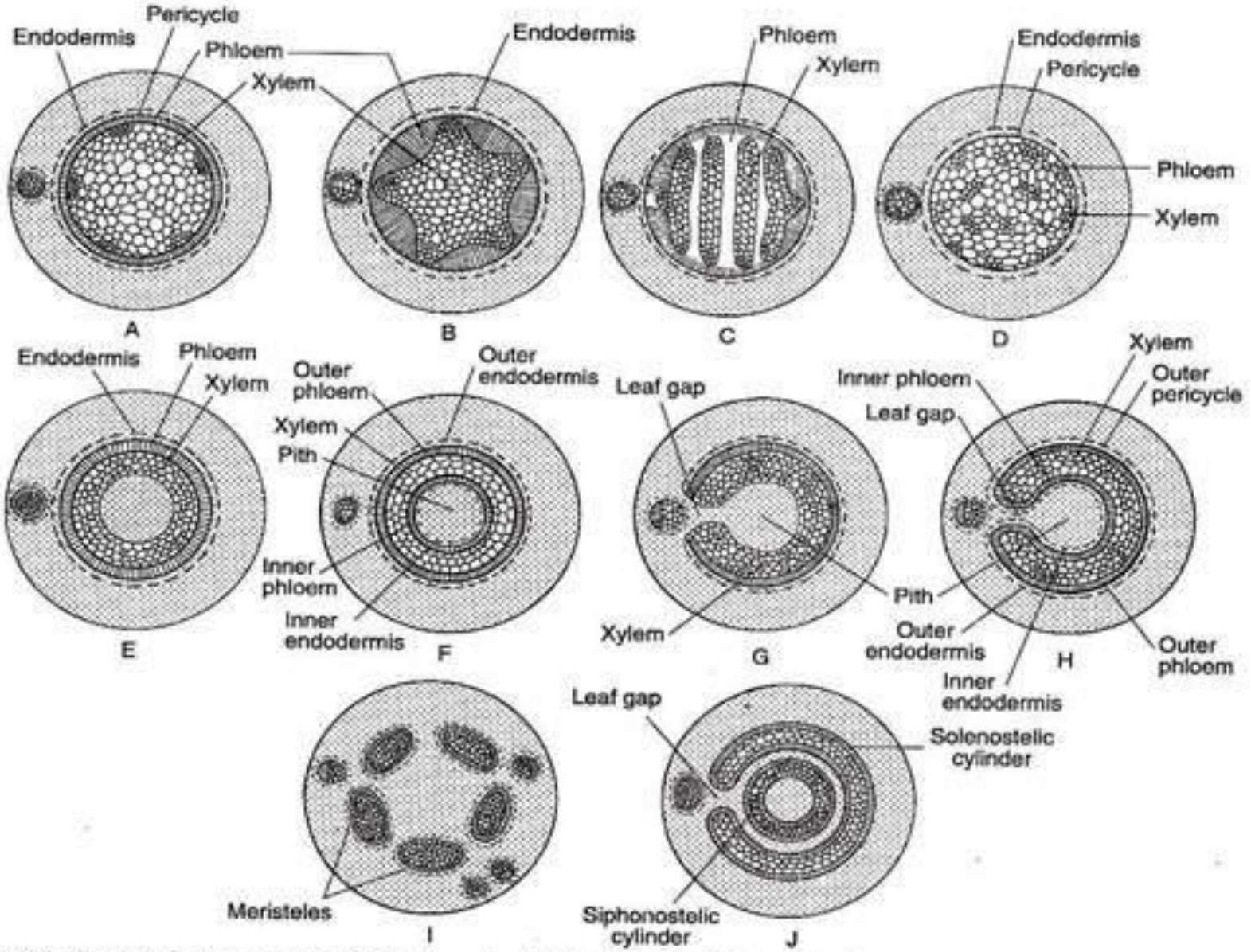
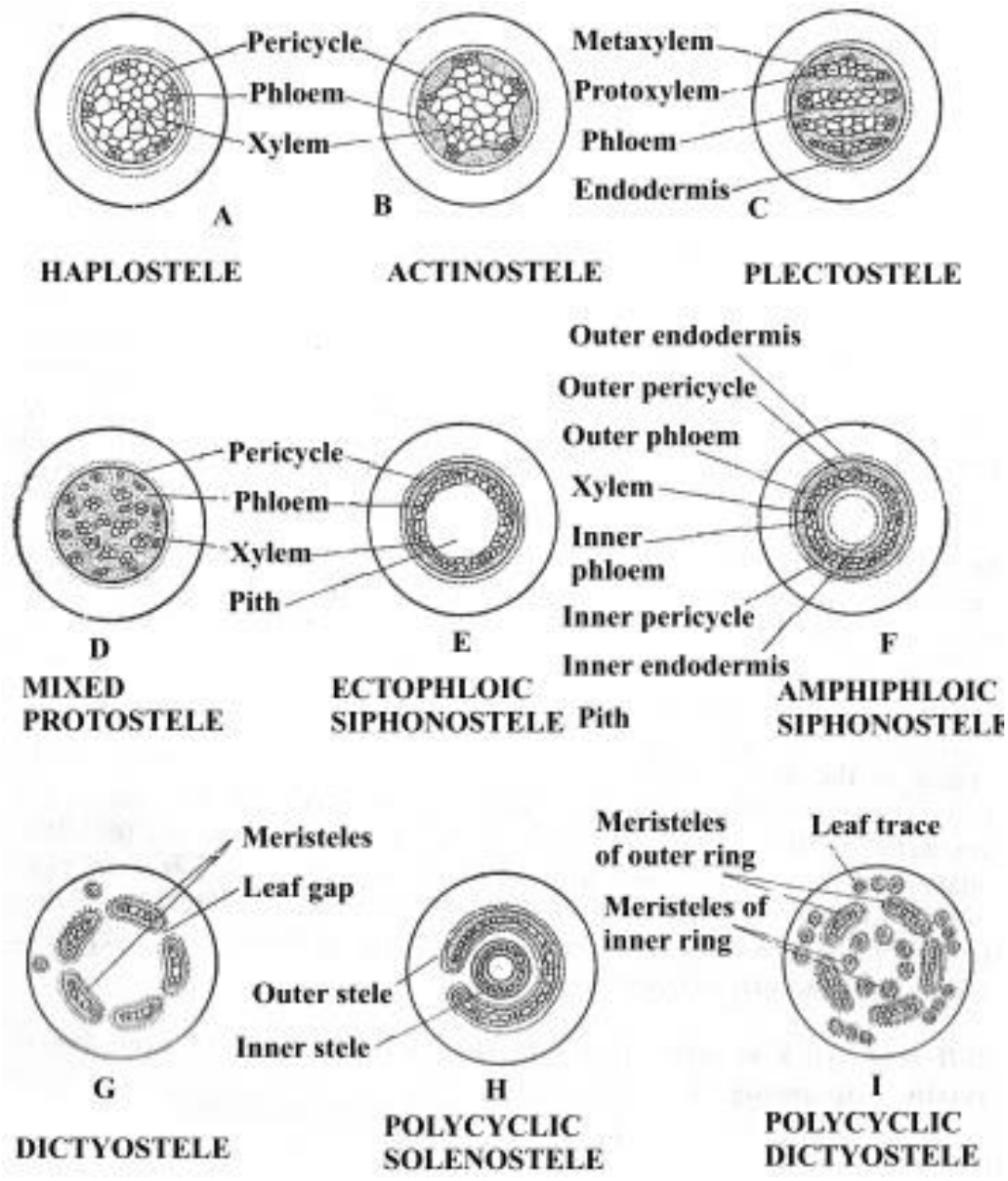


Fig. 7.133 : Types of steles in pteridophytes : A. Haplostele, B. Actinostele, C. Plectostele, D. Mixed protostele, E. Ectophloic siphonostele, F. Amphiphloic siphonostele, G. Ectophloic solenosele (with leaf gap), H. Amphiphloic solenostele (with leaf gap), I. Dictyostele, J. Polycyclic solenostele


Pericycle
Phloem
Xylem
A
B
Metaxylem
Protoxylem
Phloem
Endodermis
C
HAPLOSTELE
ACTINOSTELE
PLECTOSTELE
Pericycle
Phloem
Xylem
Pith
D
E
MIXED
PROTOSTELE
ECTOPHLOIC
SIPHONOSTELE
Outer endodermis
Outer pericycle
Outer phloem
Xylem
Inner
phloem
Inner pericycle
Inner endodermis
Pith
F
AMPHIPHLOIC
SIPHONOSTELE
Meristeles
Leaf gap
G
DICTYOSTELE
Outer stele
Inner stele
H
POLYCYCLIC
SOLENOSTELE
Meristeles
of outer ring
Meristeles of
inner ring
Leaf trace
I
POLYCYCLIC
DICTYOSTELE

Class(1): Psiolophyta

Order(1): Psilophytales

Family(1):Rhyniaceae

e.g. *Rhynia*

Family(2):Asteroxylaceae

e.g. *Asteroxylon*

Order(2): Psilotales

Family: Psilotaceae

e.g. *Psilotum*

Class(1): Psiolophyta

- The most primitive Pteridophytes.
- Sporophytes rootless.
- Sporophytes are composed of subterranean rhizome carrying rhizoids and leafless aerial shoots(rarely, they carry very small veinless leaves).
- 25 genera of fossil plants and 2 genera of living plants: the fossil members are assembled in order Psilophytaleswhile the living ones in order Psilotales.

Rhinia

Division: Pteridophyta

Class(1): Psiolophyta

Order(1): Psilophytales

Family (1): Rhiniaceae

e.g. *Rhinia*

- **Leafless plant with terminal sporangia.**
- **Sporophyte consists of:**

A horizontal dichotomously branched rhizome bearing groups of unicellular rhizoids at intervals.

The tips of some branches of the rhizome turns upwards and grow to give aerial stems.

The aerial stems dichotomously branch (may reach 50 cm height, 6 mm diameter)

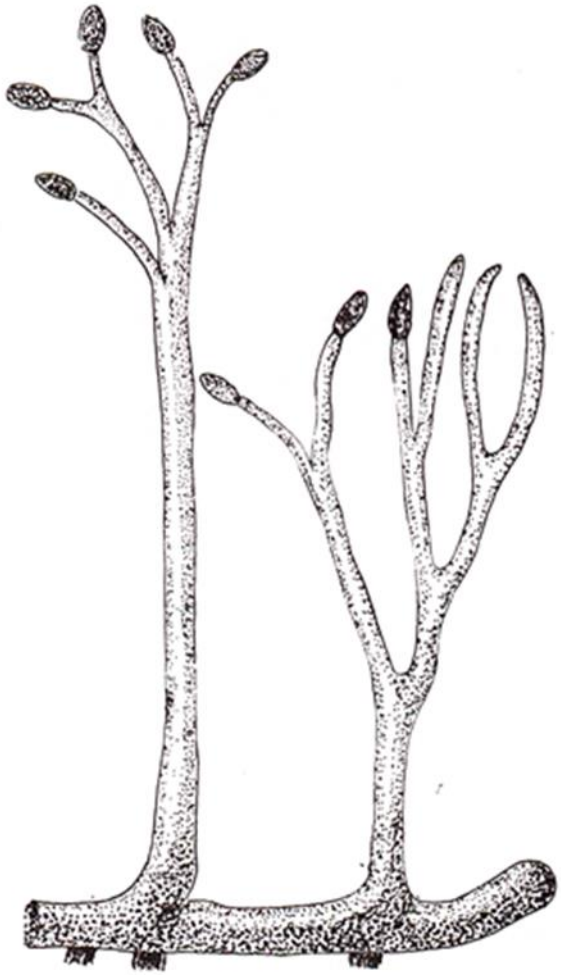


Fig. 11. Reconstruction of *Rhynia major* (After Kidston & Lang)

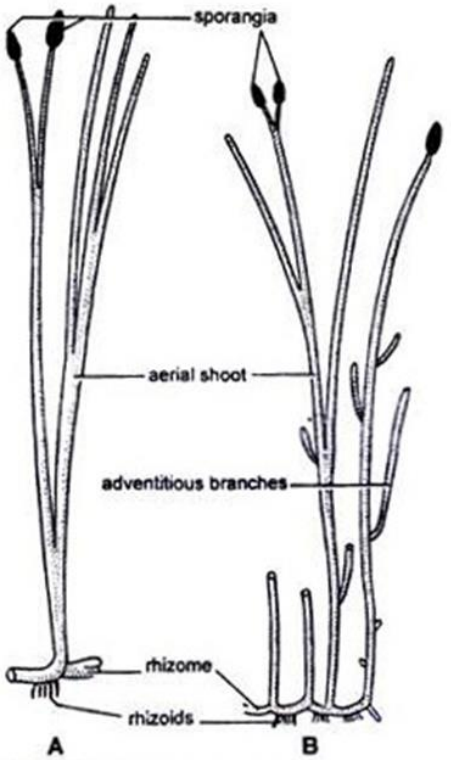


Fig. 1 (A–B). *Rhynia*. External features. A. *R. major*, B. *R. gwynne-vaughani*

Aerial stems are leafless and some of them terminates in cylindrical sporangia (up to 12mm long).

Internal structure: **internally also it exhibits many primitive features.**

(1) The stem:

- In T.s. it appears round in shape.
- Epidermis is covered by cuticle and the stomata are few.
- Presence of stomata indicates the photosynthetic nature of aerial stem and branches.
- The cortex is differentiated into:

Outer cortex: narrow zone, 1-4 cells thick , denesely packed cells& **Inner cortex**: with many intercellular spaces and in direct contact with stomata **(which one is the main photosynthetic tissue??)**

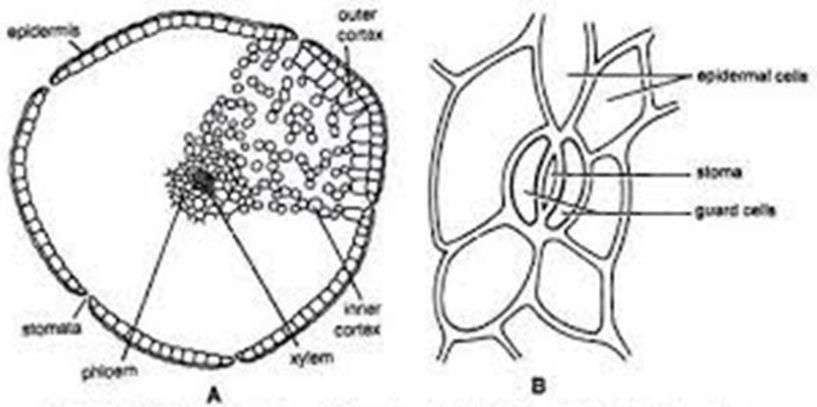
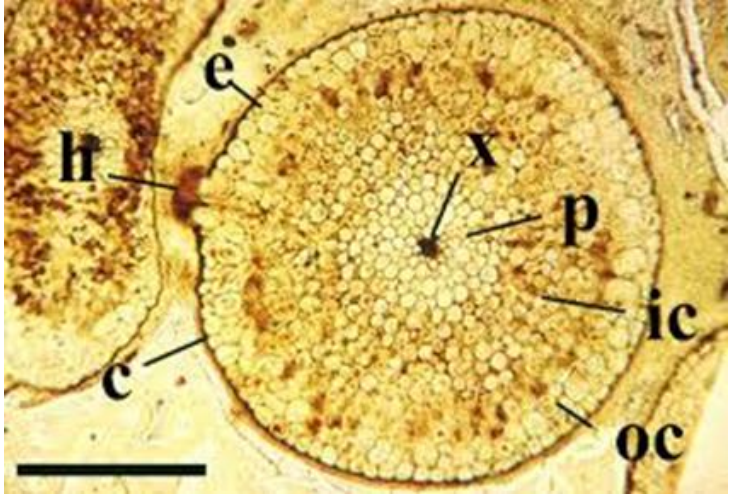


Fig. 2 (A–B). Rhynia. Internal Structure : A. T. S. of aerial shoot, B. a stoma

- Inside the cortex, there is a solid protostele (haplostele) a central mass of xylem surrounded by phloem.
- The xylem consists of tracheids, in some stems the central tracheids are smaller than the outer tracheids.
- The phloem consists of 4 or 5 layers of thin walled cells.

(2) The sporophyte:

- Almost cylindrical in shape.
- cylindrical spore sac tapers towards the distal end and towards the base it has a stout stalk similar to stem in structure.
- Wall 5 cells in thickness.
- The outermost layer (epidermis) is covered by a thick cuticle.
- There seems to be no specialized dehiscence mechanism.
- Large numbers of spores still attached in tetrads.
- Presence of spores proves that the plant bearing them is the ….. generation.
- The other generation (?) has not yet been discovered (A new interpretation on the morphology of Rhynia.doc)
- Spores have cutinised walls typical of pteridophytes.



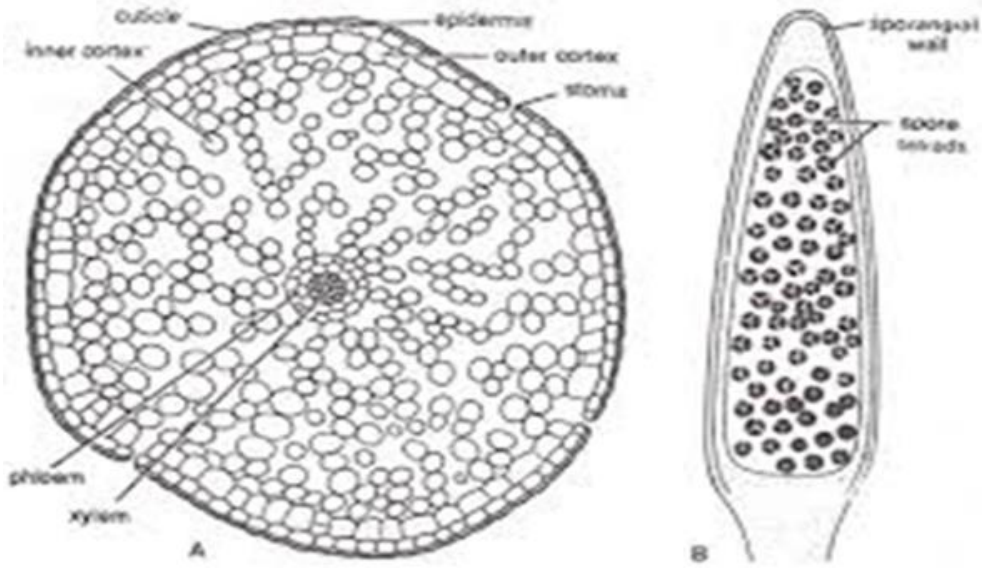
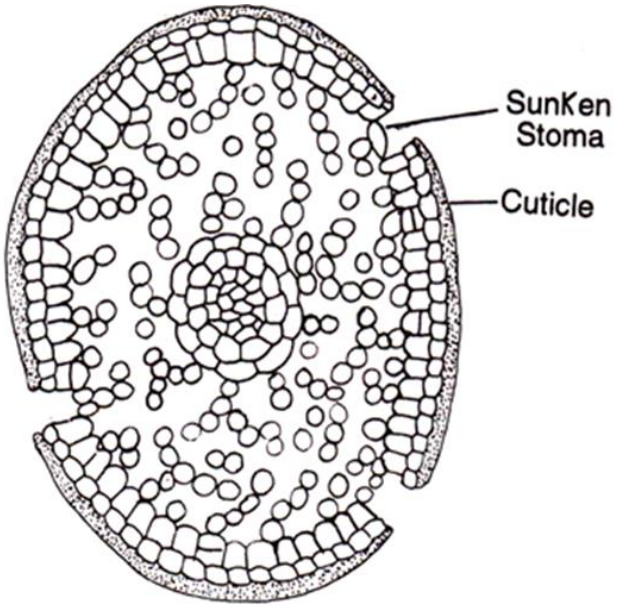


Fig. 207. Rhynia. A, T.S. rhizome; B, L.S. sporangium



A

Fig 12. T.S. of Aerial Shoot of *Rhynia major*

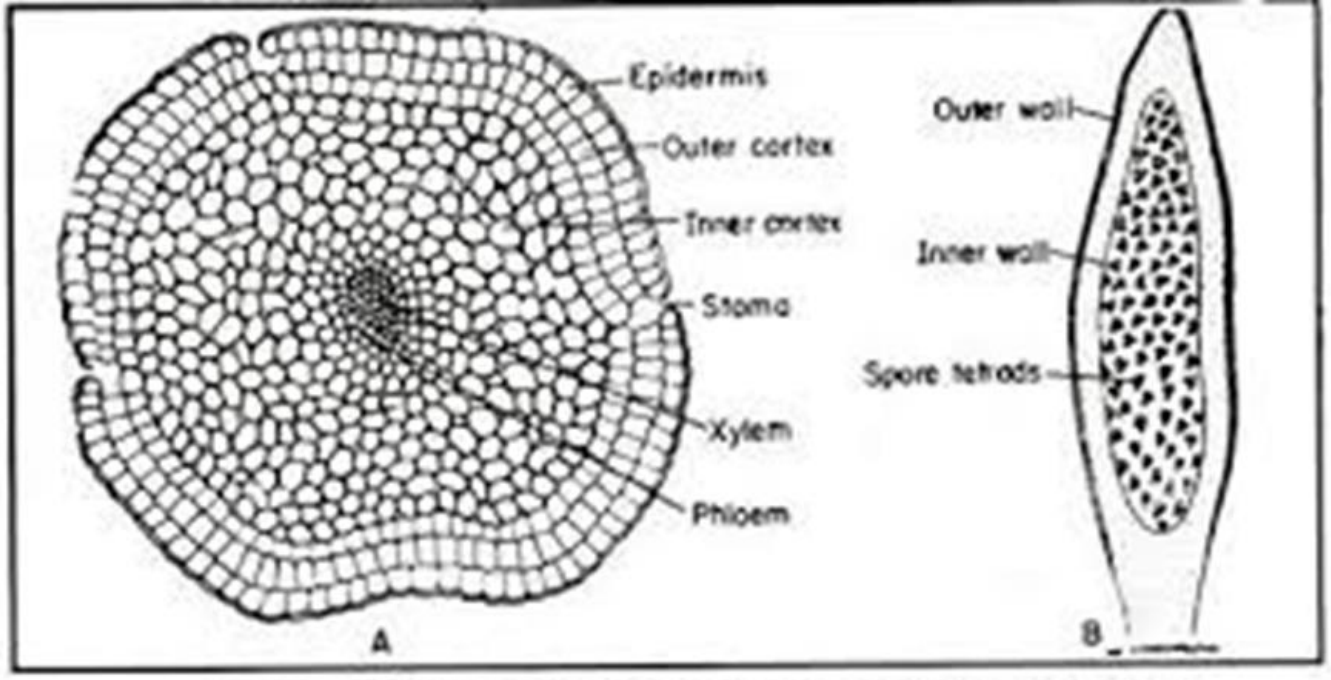


Fig 8.2 A – T. S. of stem of Rhynia Sp., B – L.S. through sporangium.

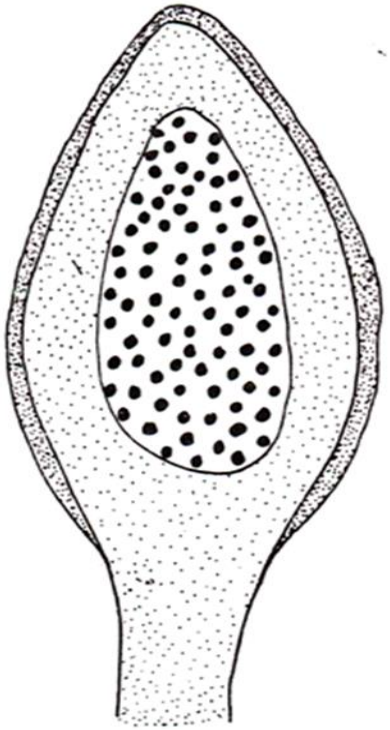


Fig. 13. A Sporangium of *Rhynia major*

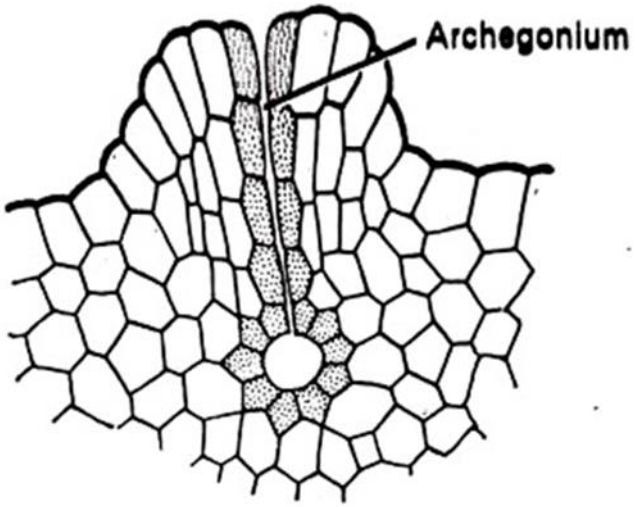


Fig. 15. Archegonium of *Rhynia gwynne vaughnii*

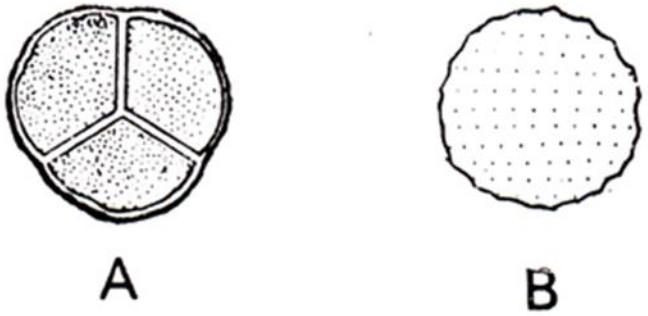


Fig. 14. Spore Tetrad (A) and a Single Spore of *Rhynia gwynne vaughnii*

Asteroxylon

Division: Pteridophyta

Class(1): Psiolophyta

Order(1): Psilophytales

Family (1): Asteroxylaceae

e.g. *Asteroxylon*

External Morphology:

- The plant has a horizontal rootless dichotomously branched underground rhizome.
- Some of the dichotomies grow upward to give leafy aerial branches.
- Other dichotomies give rise to leafless underground branches, which penetrates deeper in the soil.
- The leafy branches are densely covered with leaves.

T.S. of leafy stem:

- The name of the plant is derived from the fact that the xylem was star shaped (actinostele).
- Xylem was 4-10 rayed with protoxylem located mediately.
- Xylem elements mainly spiral tracheids.
- Xylem was ensheathed with phloem, made of long thin walled cells with pointed ends.
- The cortex was differentiated into 3 zones:

1. **Internal:** closely fitted parenchyma.
2. **Middle:** elongated trabeculae with radially extended air spaces.
3. **Outer:** closely fitted cells.

- Epidermis: one cell in thickness, with stomata.

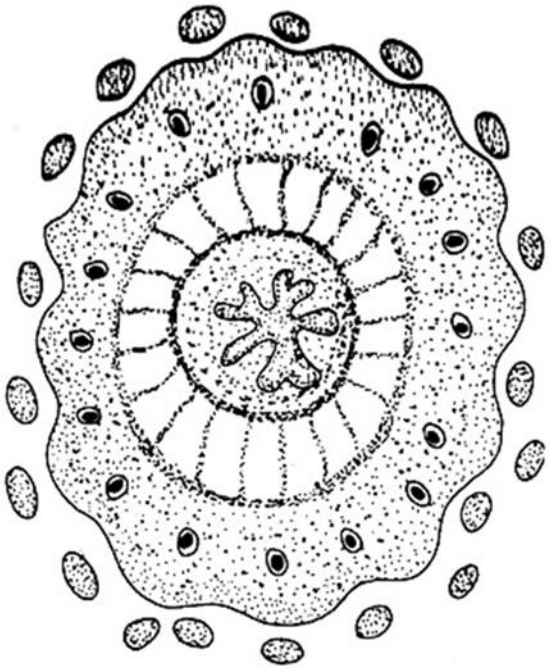


Fig. 17. T.S. of Aerial Shoot of *Asteroxylon mackie*

- Sporangia were carried out at the apices of dichotomously branched leafless aerial branches.
- Sporangia were pear-shaped with thick walled jacket.
- The epidermal cells at the top of the sporangium had radial and inner wall thickening (dehiscence of sporangium was probably apical).

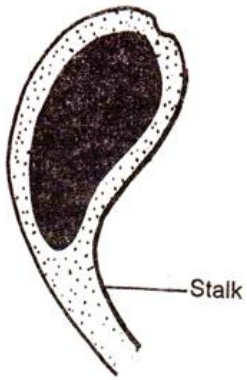


Fig. 18. A Sporangium of *Asteroxylon mackie*

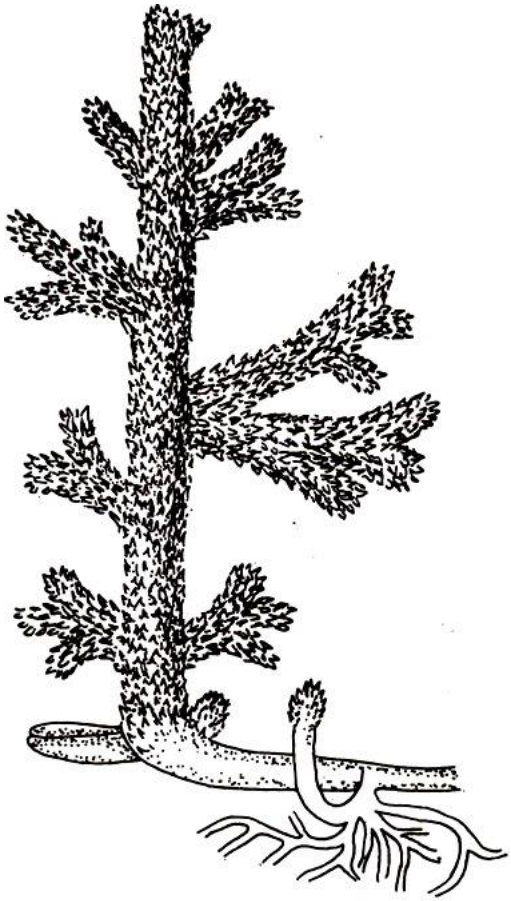


Fig. 16. Reconstruction of *Asteroxylon mackie*

Psilotales

- Very similar to Psilophytales, **but** its members **are living.**
- Includes only two genera: *Psilotum* and *Tmesipteris*.
- The two genera with dichotomously branched rootless rhizome.
- The dichotomies may develop into aerial branches.

Tmesipteris	*Psilotum*
❑ Aerial shoot usually unbranched and leafy. ❑ Leaves increase gradually in size from base to top. ❑ The top leaves subtending sporangia are bifurcate. ❑ Sporangia are united in pairs to form synangia.	❑ Aerial shoots branched dichotomously. ❑ Leaves are small scales with irregular distribution. ❑ Sporangia are formed on very short stalks in the axil of small bifurcate leaves. ❑ Sporangia are united in triads (synangia).

Tmesipteris **(The hanging fork fern)**

Psilotum **(the whisk fern)**

Division: Pteridophyta

Class(1): Psiolophyta

Order(2): Psilotales

Family: Psilotaceae

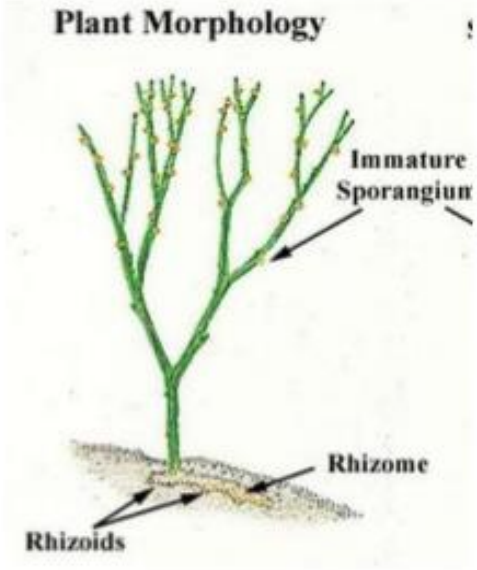
e.g. *Psilotum*

- A living plant, in tropics and sub-tropics, some species are epiphytes on tree trunks.
- The sporophyte is dominant in the life cycle.

External Morphology of the sporophyte:

- Simple sporophyte consists of:

1. **Rhizome**: grows horizontally, above the soil, with bicellular rhizoids (no roots).
2. **Aerial branches**: green, dichotomously branched, with small appendages.
3. **Spores:** similar, in the axil of appendages, in tri-locular synangia.



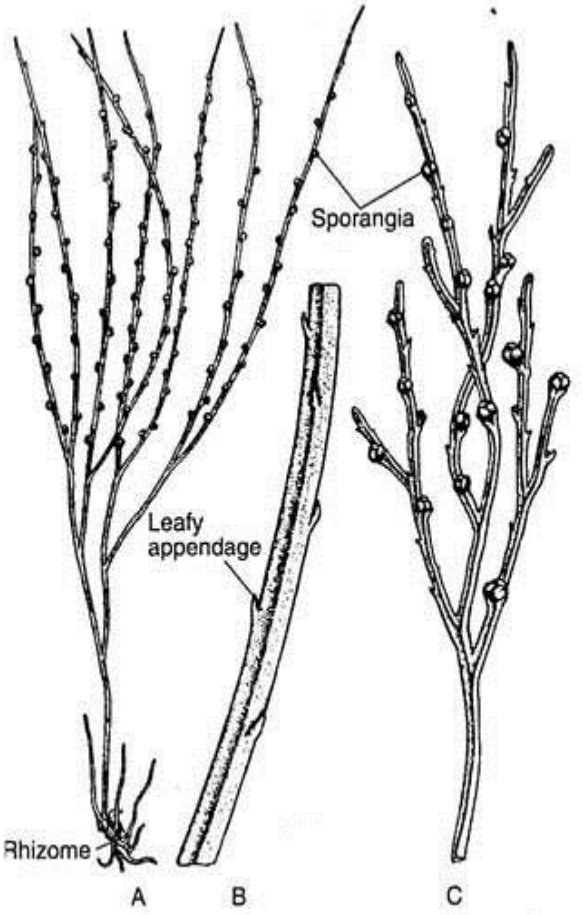


Fig. 7.11 : *Psilotum nudum* : A. A sporophyte plant, B. An enlarged part of stem showing scaly appendage, C. A fertile twig

- Perennial, aerial branches may reach 1 m in length, smooth cylindrical at the base, then get flattened with external ridges (wavy in T.S.) upwards, The basal part of the aerial axis is smooth but the distal part bears small, scaly appendages and synangia .
- Aerial branches are photosynthetic, they are xerophytic in appearance in spite of growing in wet habitat.

T.S. in aerial stem of *Psilotum*:

1. **Epidermis:** heavily cutinized and provided with stomata.
2. **Cortex:** differentiated into 3 zones: Outer 2-5 layers of chlorenchyma with intercellular spaces and starch grains, middle sclernchymatous (support) and inner paranchymatous devoid of chloroplasts with more starch grains.

- The stele is delimited from the cortex by the endodermis characterized by casparian strips on the radial walls.

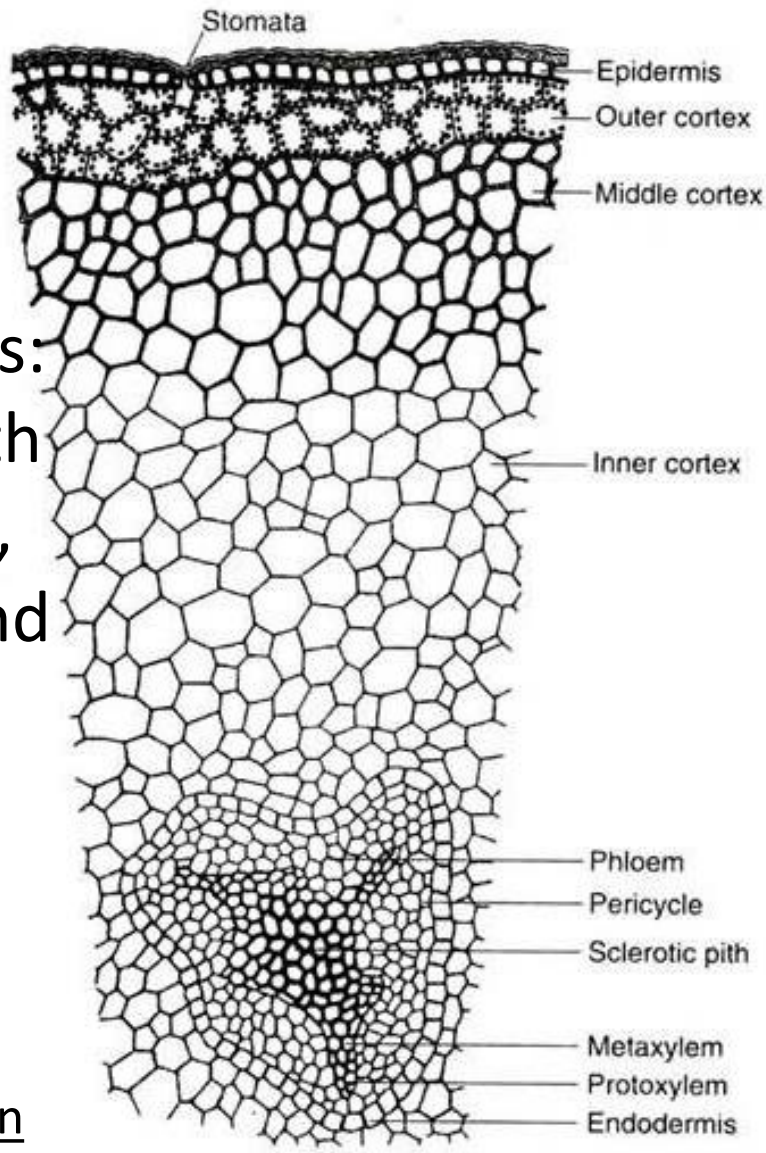
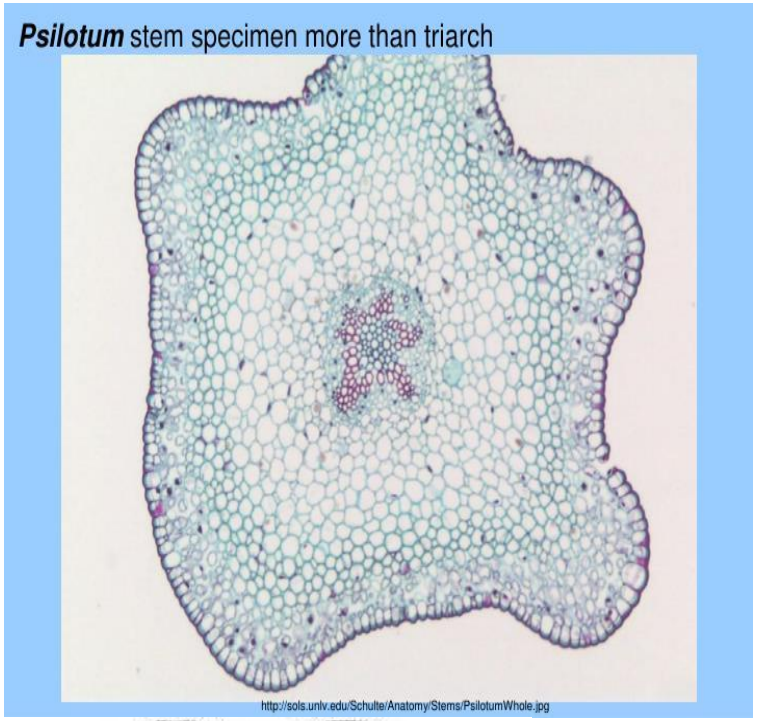
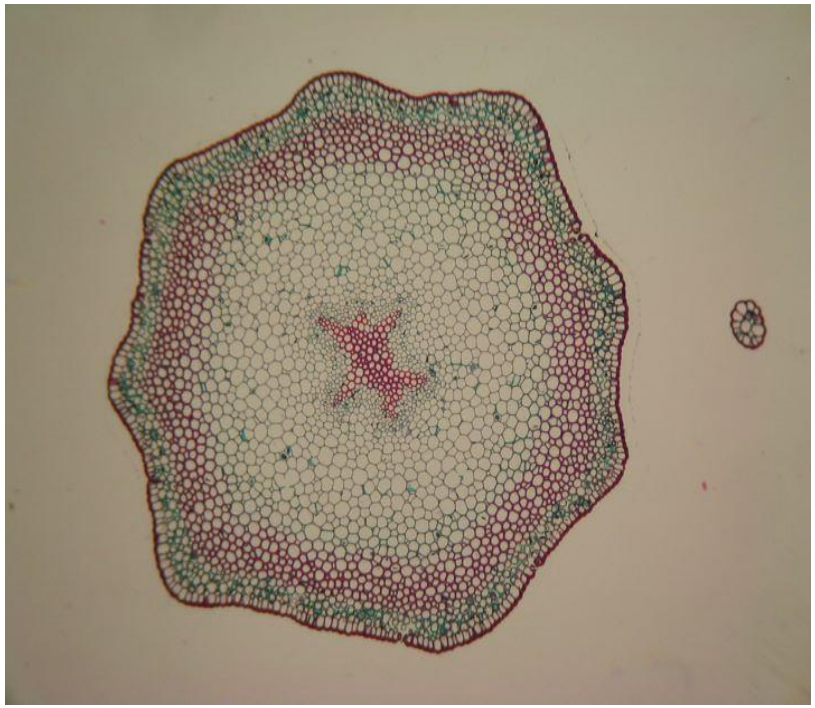


Fig. 7.13 : An enlarged view of a segment of T.S. of *Psilotum nudum* stem

T.s. in *Psilotum* stem





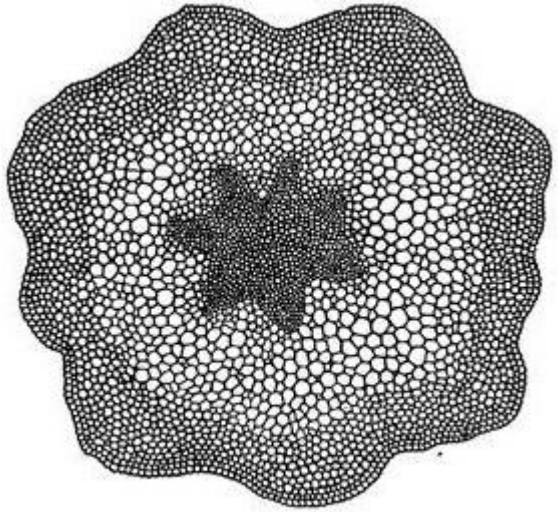


Fig. 7.12 : T.S. of stem of *Psilotum nudum*

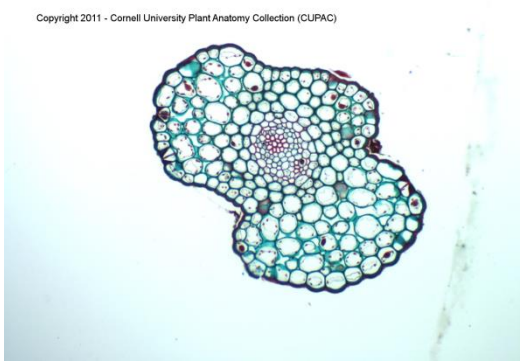
3. **The stele:** exarch actinostele.
- Xylem with 6 rays with protoxylem at their tips.
- Phloem is thin walled elongated cells, but typical sieve tubes not recorded in it.

- At the extreme base, the stem is protostelic (actinostelic). In the middle portion the stele is siphonostelic as the centre of the xylem is occupied by a patch of elongated sclerenchymatous cells (sclerotic pith).
- In *Tmesipteris*:

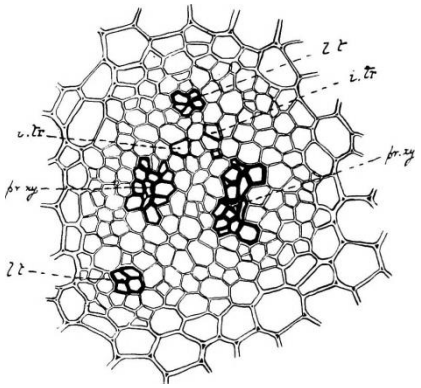
a. The stele is exarch solenostele.

b. Phloem is provided with sieve tubes which are , atypically, lignified.

c. Cortex is lacking the sclerenchymatous zone.



Tmesipteris tannensis. Transverse section of the sterile region, high up. The proto- xylem (fir. xy.) is mesarch. The xylem of the stele is fading out, and being replaced by parenchyma; three of the tracheides (/. tr.) show incomplete development; there is no longer a complete ring, and the leaf-trace bundles (/. r\) enter the gaps which result, in much the same way as in a phyllosiphonic type. There is no definite endodermis. X150. the xylem into distinct bundles.

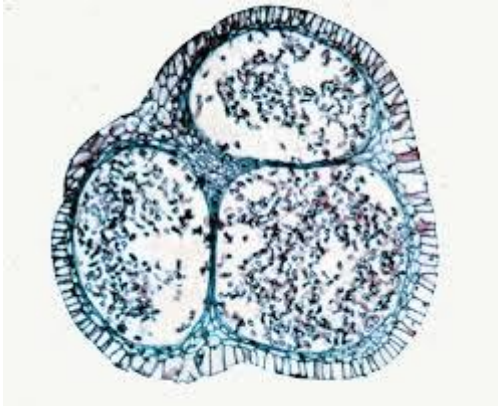


Life cycle (Reproduction by spores):

- Trilocular sporangia (synanga) are produced at maturity by aerial shoots. The mature synangium is generally a three-lobed, each lobe corresponds to a sporangium.
- The synangia located at the tip of very short axis (1-2mm) in diameter and closely associated with a forked, foliar appendage.
- Dehiscence of synangium is loculicidal .

spores are produced as a result of meiosis of the spore mother cells. The spores are of equal size and shape (i.e., homosporous), bilaterally symmetrical, colourless and kidney-shaped

L.s. in synangia of *Psilotum*



T.s. in synangia of *Psilotum*

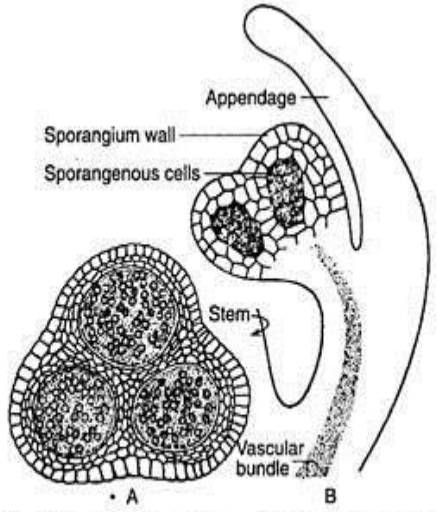


Fig. 7.17 : *Psilotum nudum* : A. T.S. of synangium, B. V.S. of fertile axis through a synangium

The gametophyte (n):

- Spores germinate to form the gametophyte.
- The mature gametophyte shows a striking similarity with rhizome. It grows as saprophyte with an associated fungus.
- The mature gametophytes are brown, cylindrical, subterranean, **radially symmetrical and usually dichotomously branched, but may sometimes become irregular.**
- The surface of the gametophyte is covered by long unicellular, brownish rhizoids.
- The gametophyte grows by means of apical meristem.

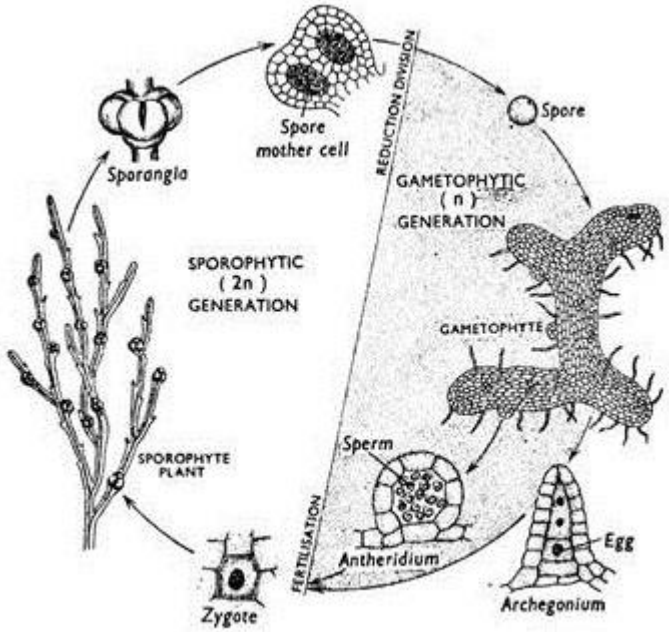


Fig. 7.22 : Life cycle of *Psilotum*

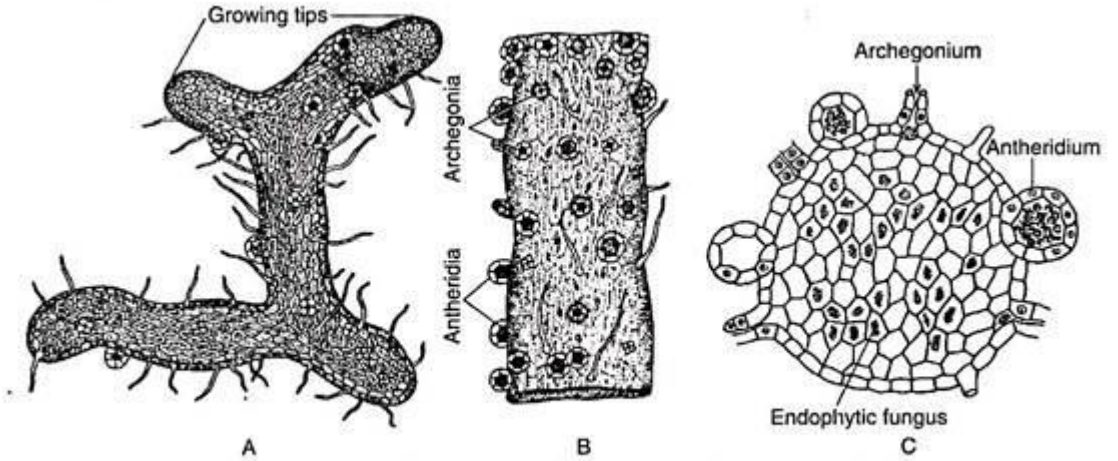


Fig. 7.18 : *Psilotum nudum* : A. A gametophyte, B. An enlarged portion of the gametophyte showing sex organs and rhizoids, C. T.S. of gametophyte

- The gametophyte of *Psilotum* is monoecious (homothallic).
- Sex organs i.e., antheridia and archegania, are superficial and scattered over the surface of the gametophyte.
- Generally, antheridia are more in number than archegonia.

The gametophyte of the *Psilotum* & *Tmesipteris* is:

- ***Poorly developed.***
- ***Thallose.***
- ***Usually devoid of chlorophyll.***
- ***Live saprophytically on dead organic material through the assistance of symbiotic phycomycetous fungi living within their cells.***