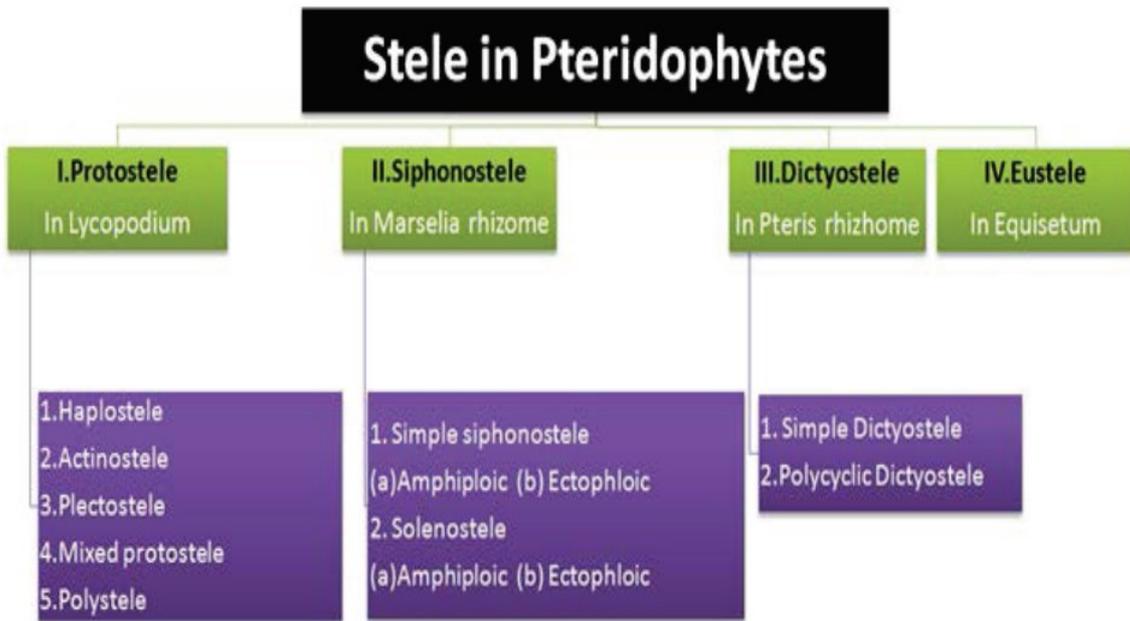


1.5. Stelar Evolution

The stele is defined as a central vascular cylinder, with or without pith. Endodermis is the boundary between cortex and stele. Xylem and phloem are the components of vasculature. In Pteridophytes, the nature and arrangement of xylem and phloem differ in different groups.



Basically, there are four types of steles:

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

I. Protostele

The vasculature consists of central core of xylem completely surrounded by phloem. This is the most primitive and simplest of steles.

Types of Protostele



a. Haplostele

This is the most primitive type of protosteles. Here the central solid core of xylem is surrounded by a layer of phloem, e.g., *Salvinella* sp.

b. Actinosteles

Central xylem core with radiating ribs or a star shaped appearance surrounded by phloem. More advanced than haplosteles.

E.g., *Psilotum* stem lower regions

c. Plectosteles

Xylem is plate like arranged parallel to each other and each plate is surrounded by phloem. More advanced than actinosteles.

E.g., *Lycopodium clavatum*

d. Mixed Protosteles

In this case xylem and phloem are uniformly distributed. Xylem elements break up into small groups and all get surrounded by phloem. Most advanced among protosteles and considered as a transitional type between true protosteles and siphonosteles

E.g., *Lycopodium complanatum*, *Gleichenia* sp., *Osmunda* sp.

e. Polysteles

Generally in a protosteles, the stem has a single stele in the centre. But in *Salvinella*, the stem axis has several steles in parallel arrangement (di-stelic or polystelic). Each stele is a protosteles with xylem core surrounded by phloem with pericycle and endodermis.

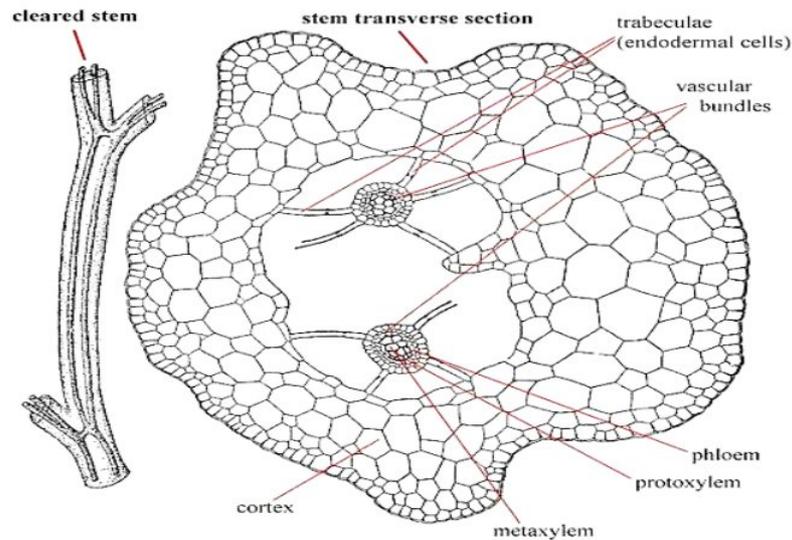


Fig 1.38. *Selaginella* stem

II. Siphonostele

It is a modified protostele with a central pith region or medullated protostele.

- Pith region is often parenchymatous rarely sclerenchymatous
- Pith formed may be intra stelar in origin or by invasion of cortical tissue.

1) Simple Siphonostele

This type of stele has centre pith which may be parenchymatous or sclerenchymatous. That is tube like or siphonous. Otherwise this is a protostele with a pith at the centre or medullated protostele. E.g: *Psilotum* a. Ectophloic Siphonostele: This type of stele has centre pith which is surrounded by concentric rings of xylem followed by phloem.

b. Amphiphloic Siphonostele

In this type of stele the centre is occupied by pith. Xylem is surrounded on both external and inner sides by rings of phloem

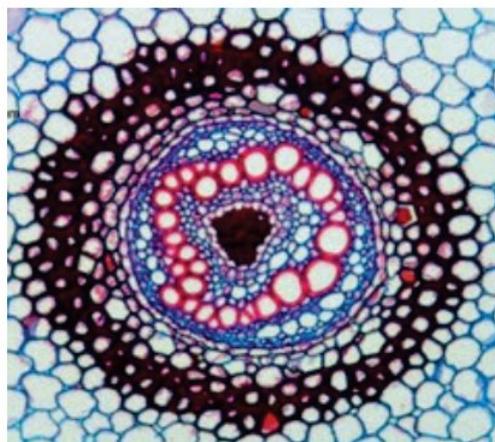
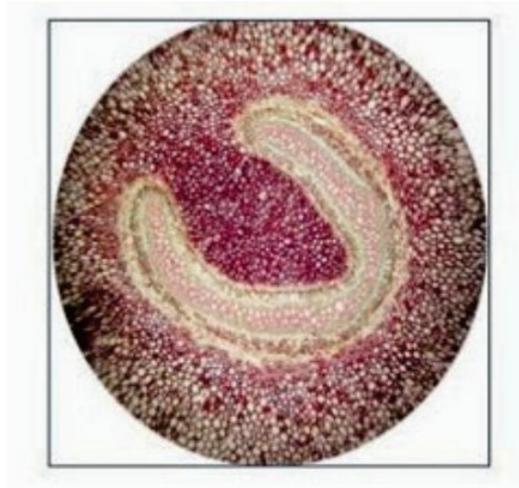


Fig 1.38 e.g. *Marsilea* rhizome

c. Solenosteles

A solenostele possesses a leaf gap on one point. It may be ectophloic or amphiphloic.



Amphiphloic solenostele

In this type of stele, the centre is occupied by pith. Xylem is surrounded on both sides by rings of phloem. In *Adiantum* and *Marselia* rhizome at leaf arising regions.

Ectophloic solenostele

Xylem is surrounded only on the outer side by phloem. In *Osmunda*

III. Dictyostele

Solenosteles with overlapping leaf gaps form dictyostele. The portion of vascular tissue which lies in between two gaps is termed as Meristele. Each meristele is protostelic in nature e.g. Fern

- Simple dictyostele: Dictyosteles arranged in single ring.
- Polycyclic dictyostele: Dictyosteles arranged in two or more rings.



A typical polycyclic stele possesses two or more concentric rings of vascular tissue eg: Pteris rhizome.

IV: Eustele

The vascular system consists of a ring of collateral, conjoint vascular bundles situated on the edges of the pith.

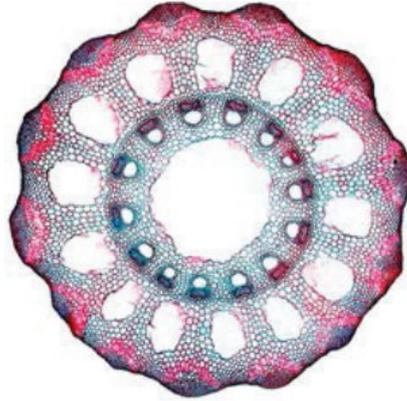


Fig 1.39: T.S. of *Equisetum* stem

1.5.1. Homospory

- Homospory or isospory is the production of a single type of spores. These spores are similar in size and sex.
- The germination of these spores results in a bisexual gametophyte, which develops both male and female gametangia within the same gametophyte.
- Here, archegonia are the female gametangia that produce egg cells. On the other hand, antheridia are the male gametangia that produce sperm cells.
- Since both male and female reproductive structures occur in the same gametophyte, these plants tend to undergo intergametophytic self-fertilization. Homospory occurs in lower vascular plants including ferns, club mosses, and horsetails as well as in bryophytes.

1.5.2. Heterospory

- Most of the Pteridophytes produce one kind of similar spore. Such Pteridophytes are known as homosporous and this phenomenon is known as homospory.
- However, there are some Pteridophytes which produce two different types of spores (differing in size, structure and function).
- Such Pteridophytes are known as heterosporous and the phenomenon is known as heterospory.

- The two types of spores are microspores and megaspores. Microspores are smaller in size and develop into the male gametophyte while the megaspores are large and develop into female gametophyte.
- According to Rashid (1976) only 9 genera of Pteridophytes are heterosporous. These are *Selaginella*, *Isoetes*, *Stylites*, *Marsilea*, *Pilularia*, *Regnellidium*, *Salvinia*, *Azolla* and *Platyzoma*.

Origin of Heterospory:

The origin of heterospory can be better discussed on the basis of evidences from paleobotany, developmental and experimental studies.

1. Palaeobotanical evidences:

- It has been suggested that heterospory arose due to degeneration of some spores in a few sporangia. As more nutrition becomes available to less number of spores, the surviving spore grow better, hence increase in their size.
- Palaeobotanical evidences show that the earlier vascular plants were all homosporous and the heterosporous condition appeared subsequently in the lowermost upper Devonian. A number of heterosporous genera belonging to the Lycopodiida, Sphenopsida and Pteropsida were known in the late Devonian and early Carboniferous periods.
- During this period important heterosporous genera were *Lepidocarpon*, *Lepidostrobos*, *Mazocarpon*, *Plaeuromeia*, *Sigillariostrobus* (members of Lycopodiida) *Calamocarpon*, *Calamostachys*, *Palaeostachys* (members of Sphenopsida). Some of these forms even arrived at the seed stage.
- According to Williamson and Scot (1894) two species of *Calamostachys* form the initial stage that might lead to the heterospory. These species were *C. binneyana* and *C. casheana*. In *C. binneyana* most of the sporangia were with large number of small spores in tetrads but in some sporangia spores were large.
- However, in *C. casheana* two different types of spores-microspores and megaspores were present in different sporangia. Similar type of abortion of spores was also observed in *Stauropteris* (Chaloner, 1958 *Lepidocarpon* and *Calamocarpon*).

2. Evidences from Developmental Studies:

- In heterosporous Pteridophytes the development of micro and megasporangia follow the same pattern. They have identical organization but for their size. While in

megasporangia most of the spore mother cells degenerate but in microsporangia only a few mother cells are disorganize.

- The phenomenon of heterospory becomes distinct either before or after meiosis. In *Selaginella Isoetes* it is distinct before meiosis. In the microsporangium all the sporocytes undergo meiosis and form a large number of microspores. However, in megasporangium, a part of the sporogenous tissue degenerates they provide nutrition to growing sporocytes (megaspores).
- In *Isoetes* there are only 50-300 megaspores in megasporangium. In *Selaginella erythropus* megasporangium contains only one megaspore which is functional.
- In *Marsilea*, *Salvinia* and *Azolla* the phenomenon of heterospory becomes distinct after meiosis. In *Marsilea* 64 microspores and 64 megaspores are formed after meiosis in microsporangium and megasporangium respectively. In microsporangium all the microspores are functional while in megasporangium one megaspore is functional and rest degenerate.

3. Evidences from Experimental Studies:

- Experimental studies on *Selaginella* (Goebel, 1905) and *Marsilea* (Shattuck, 1910) suggest that nutritional factors mainly govern the heterospory.
- Under conditions of low light intensity, the photosynthetic activity of *Selaginella* was retarded and it produced microsporangia.
- By sudden lowering of the temperature, the size of the microspores in the sporocarp of *Marsilea* increases by six times.

Biological Significance of Heterospory:

The phenomenon of heterospory is of great biological significance on account of the following facts:

1. The development of the female gametophyte starts while the megaspore is still inside the megasporangium.
2. Same is true of microspores i.e., they also start germinating into male gametophytes while they are still inside microsporangium.
3. The female gametophyte derives its nourishment from the sporophyte i.e., female gametophyte is dependent on sporophyte for its nourishment.

4. The dependence of female gametophyte on sporophyte for its nourishment provides better starting point for the development of new embryo than an independent green prothallus which has to manufacture its own food.

1.5.3. Seed Habit in Pteridophytes

The adoption of heterospory and the retention and germination of a single megaspore within megasporangium to form a female gametophyte, led to the phenomenon of “seed habit”, a characteristic feature of the spermatophytes. A seed is that ovule which contains an embryo developed as a result of fertilization.

The origin of seed habit is associated with the following:

- (i) Production of two types of spores (heterospory).
- (ii) Reduction in the number of megaspores finally to one per megasporangium.
- (iii) Retention and germination of the megaspores and fertilization of the egg.
- (iv) Continued development of the fertilized egg into the embryo while still in situ.

Similarities Between Homospory and Heterospory

- Homospory and heterospory are two conditions of spore production.
- Generally, the sporophyte produces spores.
- The germination of spores produces the gametophyte.

Difference Between Homospory and Heterospory

Homospory refers to the production of a single kind of spore, neither microspore nor megaspore, while heterospory refers to the production of two types of spores differing in size and sex, the male microspore and the female megaspore. Thus, this is the main difference between homospory and heterospory.

From the above observations it is concluded that the life history of Selaginella approaches towards seed habit because of the following features:

1. The occurrence of the phenomenon of heterospory.
2. Germination of megaspore inside megasporangium.
3. Retention of megaspore inside megasporangium either till the formation of female gametophyte or even after fertilization.
4. Development of only one megaspore per megasporangium for example, in *Selaginella monospora*, *S. rupestris*, *S. erythropus* etc.

Questions

1. Enumerate the general characters of pteridophytes
2. Elucidate the classification of pteridophytes
3. Describe the reproductive structure of *Marsilea*
4. Give an account of stellar evolution in pteridophytes.
5. Give an account of seed habit.
6. Write a detailed account on morphology, reproduction and life cycle of *Psilotum*
7. Give an account of stellar evolution in pteridophytes.