Classification of Pteridophytes
Reimers, 1954

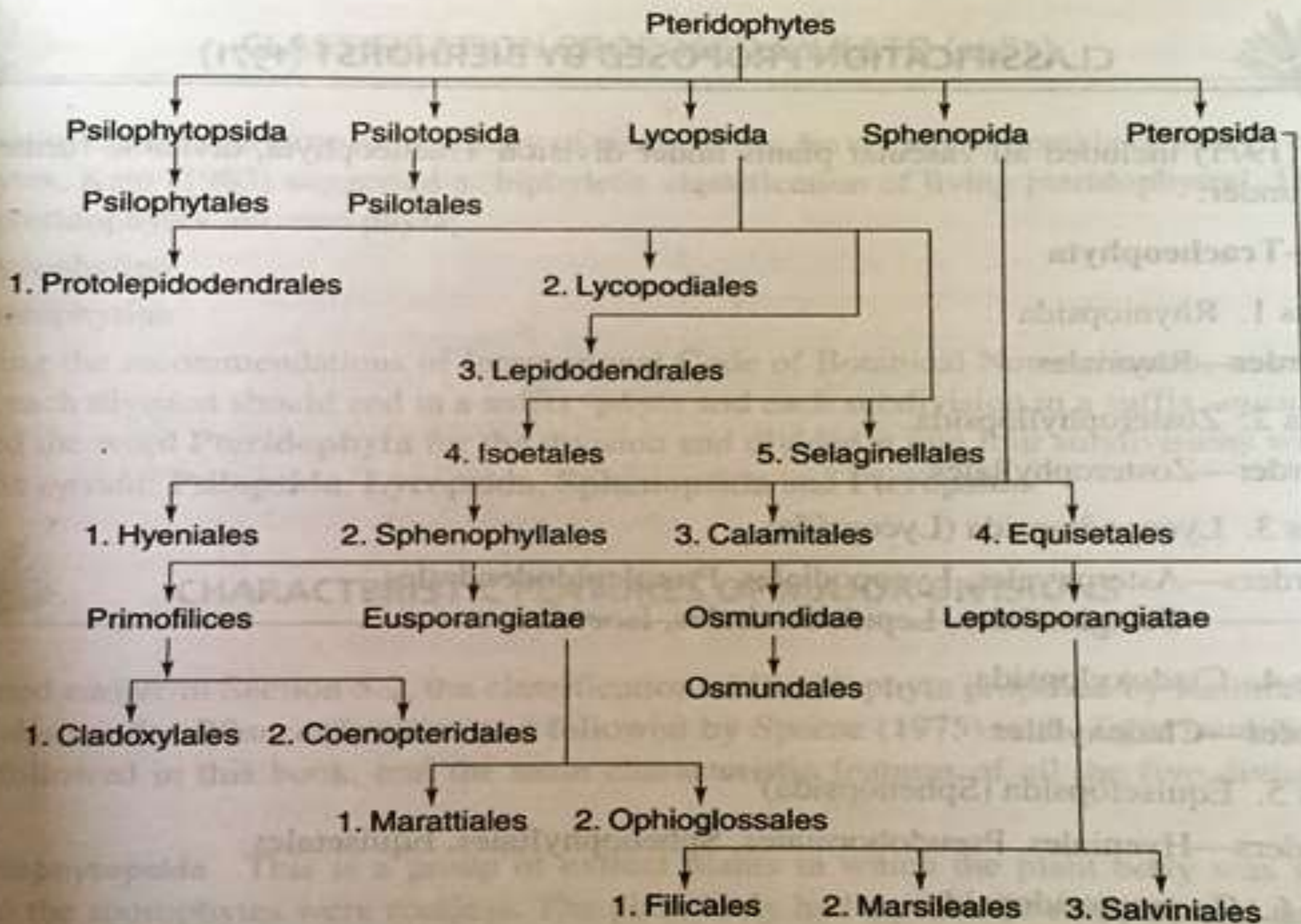


Fig. 5.2 An outline of classification of Pteridophyta [Reimers (1954) and Sporne (1966)].

Division Psilophytopsida

- Single order
  - Order – Psilophytales
    - Family- Rhyniaceae
      - Genera – Rhynia, Horneophyton, Cooksonia, Yarravia
    - Family – Zosterophyllaceae
      - Genus – Zosterophyllum
    - Family – Psilophytaceae
      - Genus – Psilophytum
    - Family – Asteroxylaceae
      - Genus –Asteroxylon

Family Rhyniaceae:

- The Rhyniaceae are the simplest of the Psilophytales, often compared with the sporophyte of Anthoceros. The most important genera are Rhynia and Homeophyton from the Middle Devonian in Scotland.

Genus Rhynia:

- The genus Rhynia from the Rhynie chert beds (Middle Devonian) in Scotland was discovered by Mackie in 1913 and fully described by Kidston and Land in 1917. This discovery established the Psilophytales as a separate and distinct taxon. Three species are known of which *Rhynia major* and *R. gwynne-vaughani* are the better known.

- The plants, apparently, grew in swampy marshes near volcanoes where the atmosphere contained sulphurous vapour and the soil was acid. The reconstructions are from silicified petrifications.

Sporophyte of rhynia

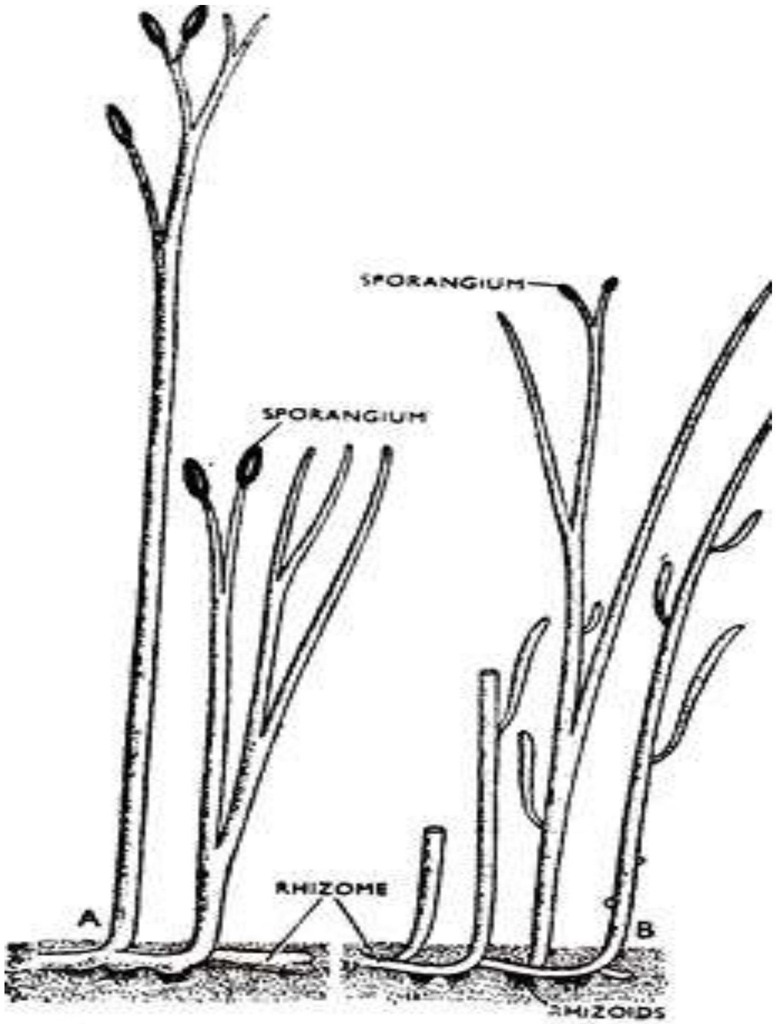


Fig. 517. *A. Rhynia major.* B. *Rhynia gwynne-vaughani* (After Kidston and Lang).

The Sporophyte:

- ✘ The plant body was a herbaceous sporophyte with dichotomously branching horizontal rhizomes bearing rhizoids on the underside and some of the branches growing up abruptly forming aerial shoots.

- ✘ The aerial shoots of *R. major* were up to 50 cm long and 6 mm in diameter while those of *R. gwynne-vaughani* were shorter and more slender.

- ✘ The aerial branches were cylindrical and sparsely dichotomously branched. These were naked being devoid of any appendage of leaf and usually tapering upwards ending in a point or in an erect sporangium.

- *R. gwynne-vaughani* shows hemispherical, oval or lenticular protuberances arising from the lower parts (more mature) of the aerial shoots or from the rhizomatous parts.

- These are constricted at the points of attachment and, in mature ones, have their own vascular bundles not connected with those of the main stems.

- They are found to be readily detachable and, possibly; was a means of vegetative propagation germinating into new shoots.

- The anatomy of the stem is very simple.
- In the centre is a slender, hadrocentric protostele with a small central xylem formed of simple annular tracheides which, in some larger specimens, become smaller towards the centre.
- This is surrounded by four or five layers of elongated cells with oblique ends which represent the phloem although sieve plates have not been observed.
- There is no endodermis or pericycle. All round this vascular bundle is a massive inner cortex of loose, rounded, parenchymatous cells with lots of air spaces.

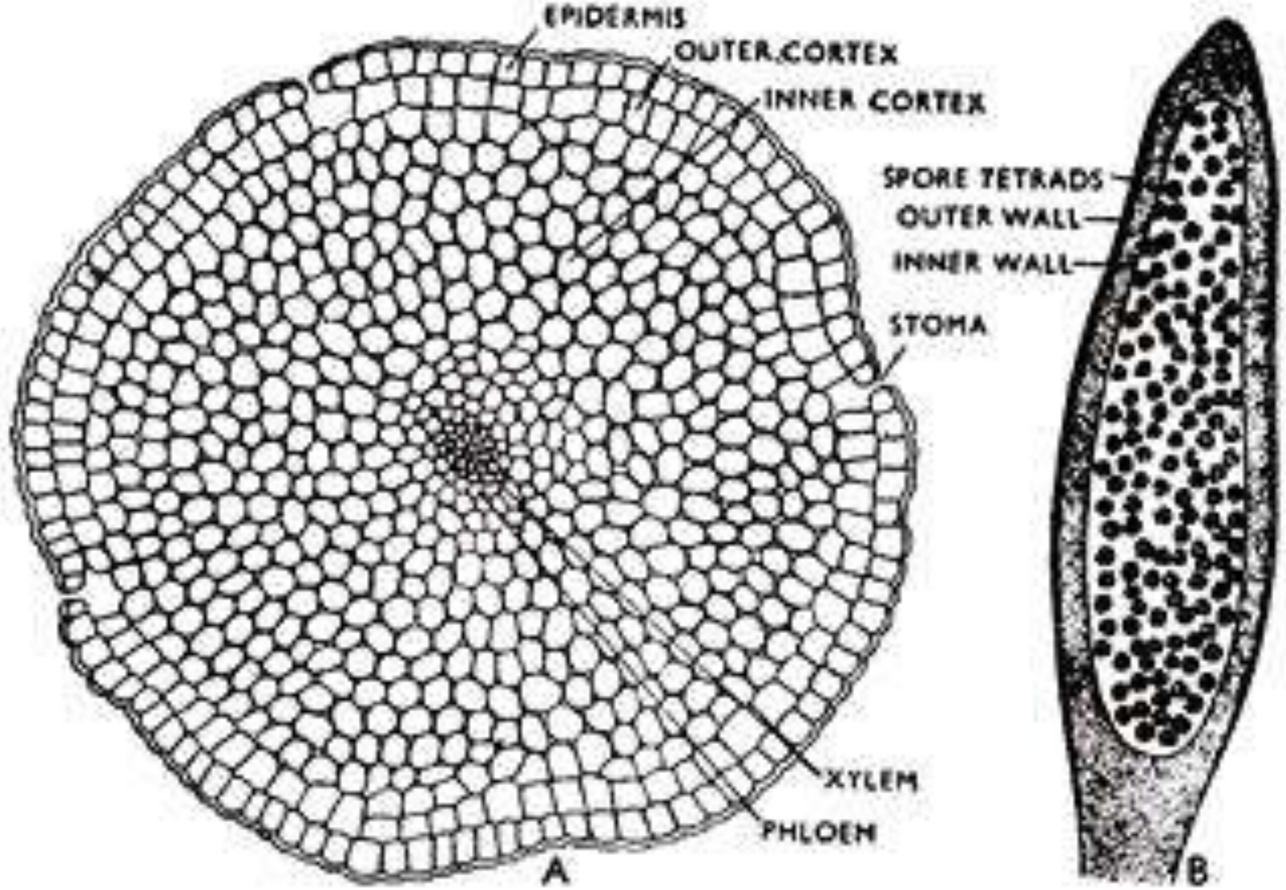


Fig. 518. A. T.s. of stem and B. L.s. of sporangium of *Rhynia gwynne-vaughani* (after Kidston and Lang).

- The vascular bundle fills most of the stem and was probably the main photosynthetic tissue.

- The outer cortex is formed by one or two layers of somewhat, larger, comparatively angular, compact (except below stomata) cells at the hypodermal region.

- The epidermis is a compact layer of cells broken here and there only by the stomata with pairs of guard cells as in other vascular plants.

- This is externally covered by a heavy cuticle. Often the smallest branches show no vascular supply.

- The sporangia are oval or cylindrical structures with pointed ends at the apices of the dichotomies.
- They may be slightly constricted at the bases though continuous with the stem and are always wider.
- Those of *R. major* were rather big (about 12 mm long and 4 mm in diameter).
- The sporangium wall is thick and multi- layered with the outer cells thick-walled and no method of dehiscence is observed.
- The thinner, inner cells probably represent the tapetum.
- The whole interior is filled with spore tetrads or free spores.
- The spores are spherical, large (up to 65µ in diameter in *R. major*) and covered with a thick cuticle.

The Gametophyte:

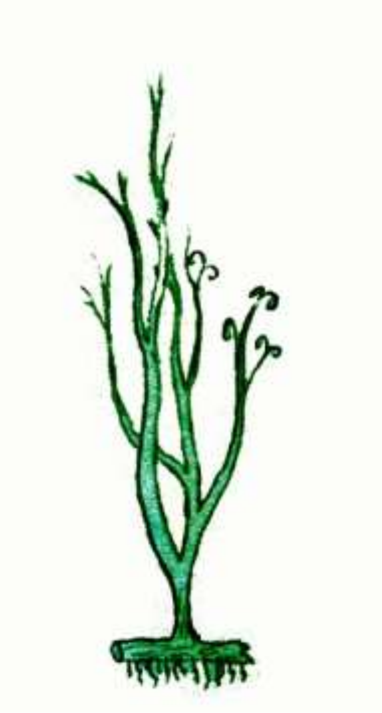
- As in all the Psilophytopsida, the gametophytes are not known. Lyon (1957) found some germinating spores within the same Rhynie chert beds which show multicellular structures developing at the ends of germ tubes. These may represent the gametophytic germination.

- Merker (1959 and 1961) has suggested that it is not possible that the gametophytes of such a big group were not fossilised while the large algae had been preserved.

- He argued that the underground creeping parts of Rhynia and Honuoph) ‘on are the gametophytes and not rhizomes. But no sex organ has been found on these underground parts and the strong vascular bundle is not normal in a gametophyte. His view is, till now, mere speculation.

Fossil Psilophytales

Zosterophyllum



Horneophyton

Asteroxylon

Psilophyton

Psilotum sporophyte Habit

Tmesipteris

Lycopodium

Selaginella sp.,

S. kraussiana

S. lepidophylla

Isoetes

Class Lycopsida

1 **Protolepidodendrales***

Drepanophycaceae* *Aldanophyton,* Baragwanathia,* Drepanophycus**

Protolepidodendraceae* *Protolepidodendron**

2 **Lycopodiales**

Lycopodiaceae *Lycopodites,* Lycopodium, Phylloglossum*

3 **Lepidodendrales***

Lepidodendraceae* *Lepidodendron,* Lepidophloios,**

Bothrodendraceae* *Bothrodendron**

Sigillariaceae* *Sigillaria**

Pleuromeiaceae* *Pleuromeia**

4 **Isoetales**

Isoetaceae *Nathorstiana,* Isoetes, Stylites*

5 **Selaginellales**

Selaginellaceae *Selaginellites,* Selaginella*

General Features of Lycopsida

(i) It includes both fossil (e.g., Lepidodendron) and living Pteridophytes (five living genera e.g., lycopodium, Phylloglossum, Isoetes, Stylites and Selaginella).

(ii) Its history indicates that these Pteridophytes developed during the Devonian period of the Palaeozoic era.

(iii) The plant body is sporophytic and can be differentiated into root, stem and leaves.

(iv) The leaves are small (microphyllous), simple with a single mid vein.

(v) They are usually spirally arranged, sometimes in opposite fashion and or even in whorls.

(vi) In some cases the leaves are ligulate (e.g., Selaginella, Isoetes). The ligule is present at the base of each leaf.

(vii) The vascular tissue may be either in the form of plectostele, siphonostele or sometimes even polystele.

(viii) Leaf gaps are absent.

(ix) Sporangia are quite large in size and develop on the adaxial surface of the leaves (sporophylls). Sporophylls are loosely arranged and form strobilus.

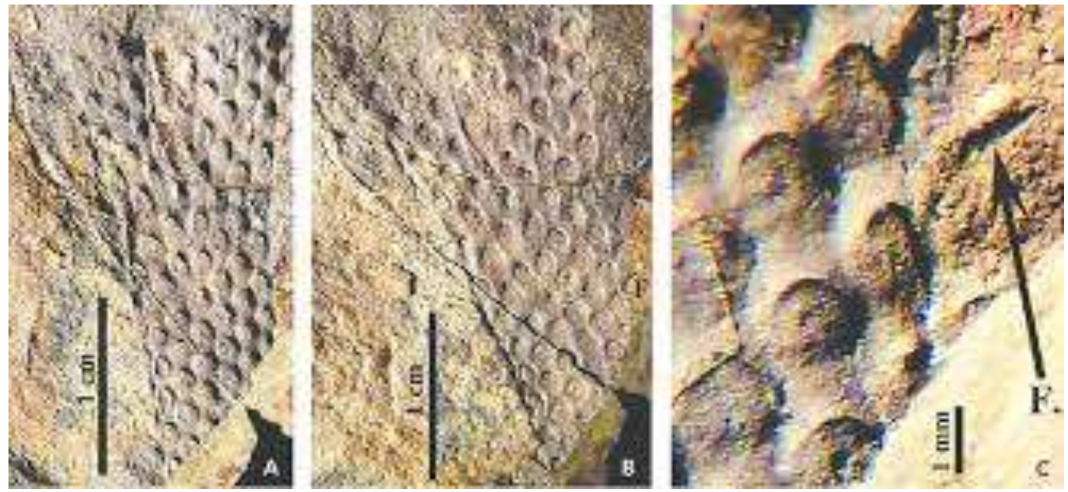
(x) Some members are homosporous (e.g., Lycopodium) while others are heterosporous (e.g., Selaginella).

(xi) Antherozoids are biflagellate or multiflagellate.

(xii) Gametophytes which are in the form of prothalli are formed by the germination of spores.

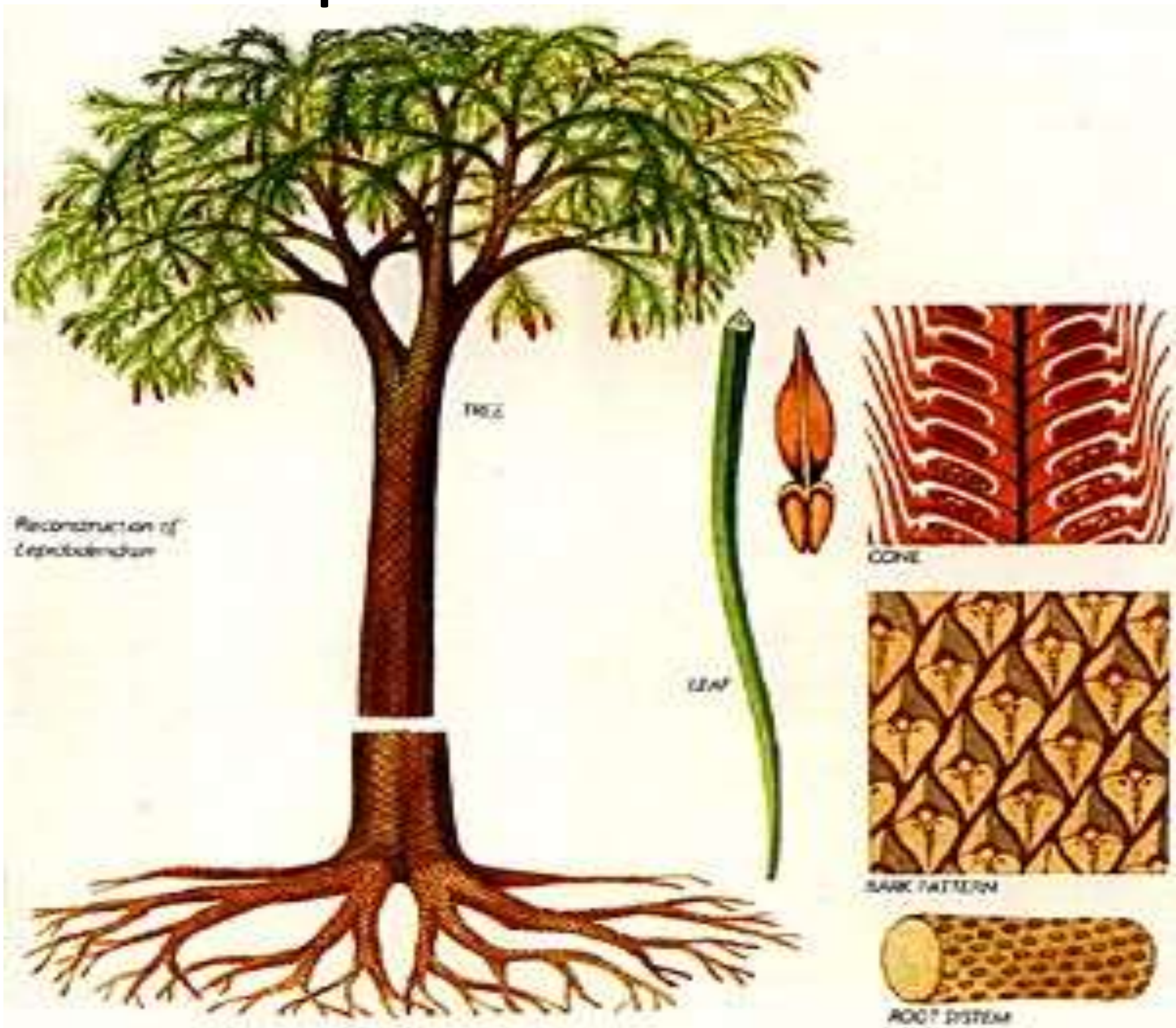
(xiii) Heterosporous forms have endoscopic gametophytes while in homosporous forms the gametophyte is exoscopic.

Protolepidodendron



Lycopodium and Phylloglossum

Lepidodendron



Isoetes coramendalina

S. krausiana

S. sinensis

S. rupestris

Class Sphenopsida- **Salient Features**

1. The stems and branches are jointed with nodes and internodes. The internodes are with longitudinal-oriented ridges and furrows.

2. The leaves are extremely reduced and borne in whorls at the nodes of aerial branches and stems.

3. Branches arise in whorls.

4. The sporangia develop on a peltale appen-dage called sporangiophore. Sporangial walls are thick.

5. Most of the” members are homosporous including Equisetum. However, some extinct forms were heterosporous (e.g., *Calamites casheana*).

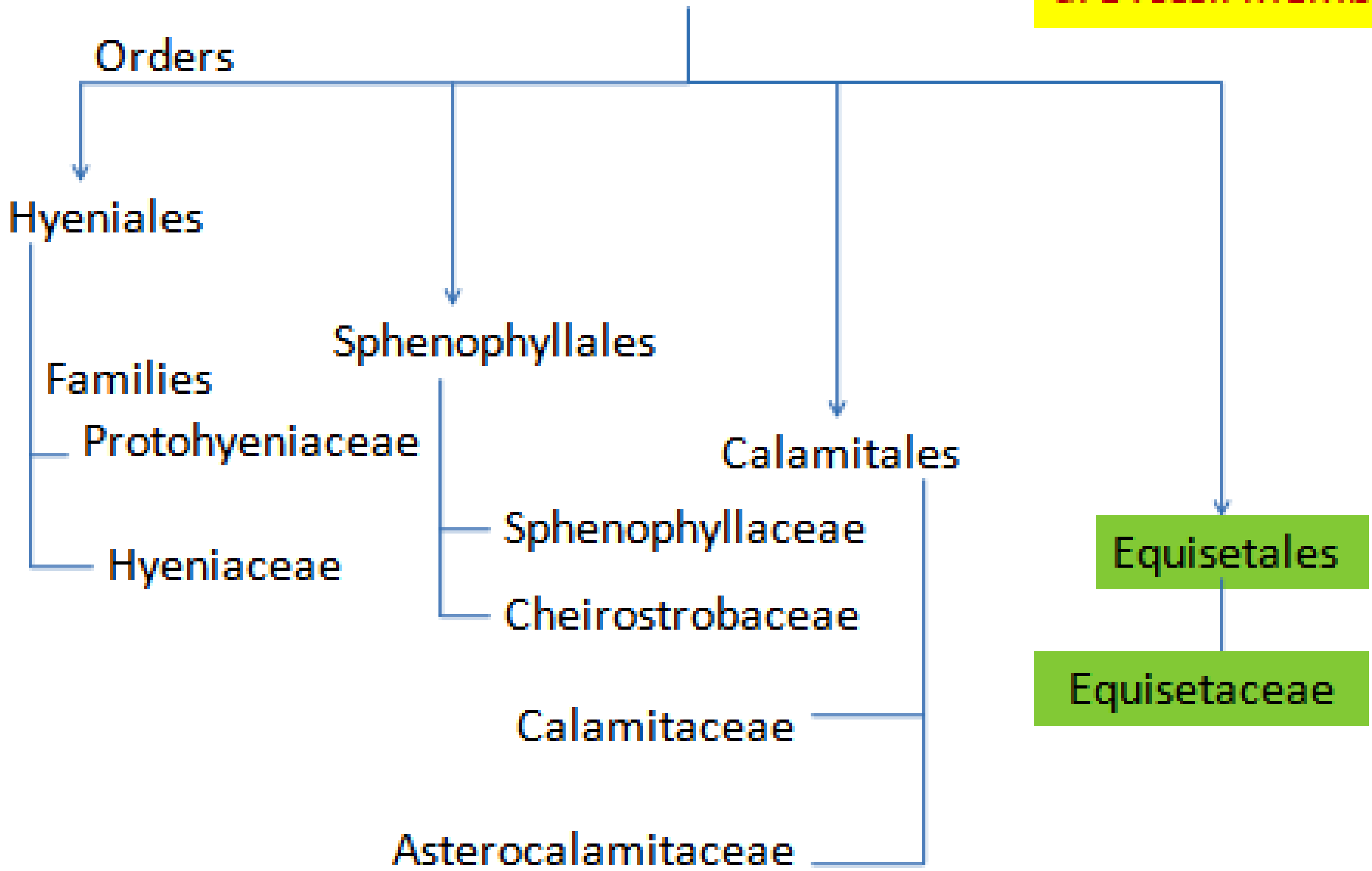
6. The gametophytes are exosporic and green.

7. Antherozoids are multiflagellated.

8. The embryo is without suspensor and is exo- scopic in nature.

Except **Equisetum**, all Sphenopsida are fossil members

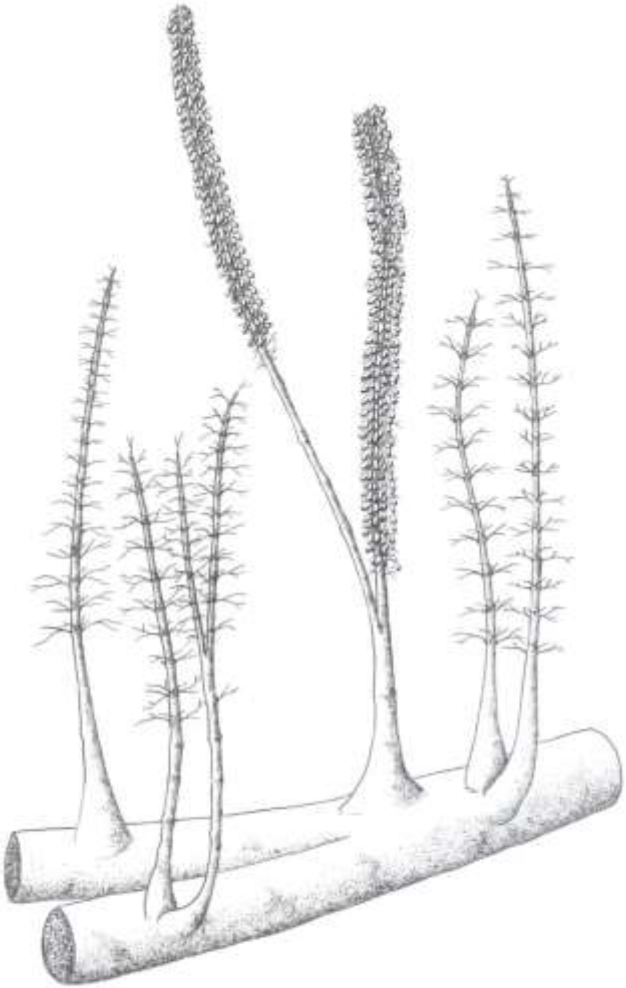
Class Sphenopsida



Order Hyeniales

- Present in the Middle Devonian period(about 398 to 385 million years ago). They lack some significant characters of Sphenopsida but certain features make them retained in this Class.
- *Protohyenia, Hyenia and Calamophyton*
- *Hyenia* grew as a robust rhizome up to 5 cm (2 inches) in diameter and parallel to the soil surface.
- Upright branches up to 15 cm (about 6 inches) in height arose from the rhizome in a low spiral. Some branches divided several times to form flattened leaflike structures.
- Others bore additional smaller branches tipped with a pair of elongate sporangia that opened along a lateral slit to release spores

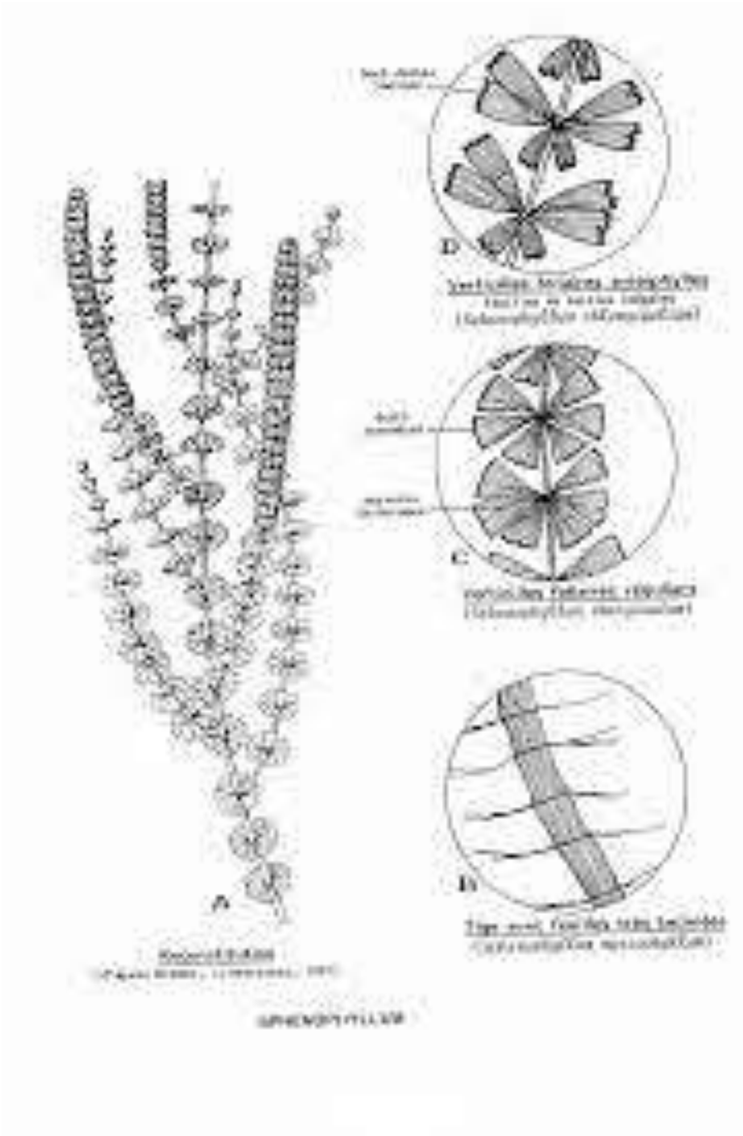
Hyenia



Order Sphenophyllales

- Appeared in full swing during Upper Carboniferous – early Permian until Lower Triassic era.
- The plant body was sporophytic and the sporophytes were herbs, shrubs.
- Stem had nodes, internodes and leaves at nodes in whorls.
- Leaves simple, wedge shaped or dichotomously lobed.
- Stele –actinostelic plectostele.
- Strobilus well organised.
- *Sphenophyllum, Sphenophyllostachys, Bowmanites*

Sphenophyllum



Order Calamites

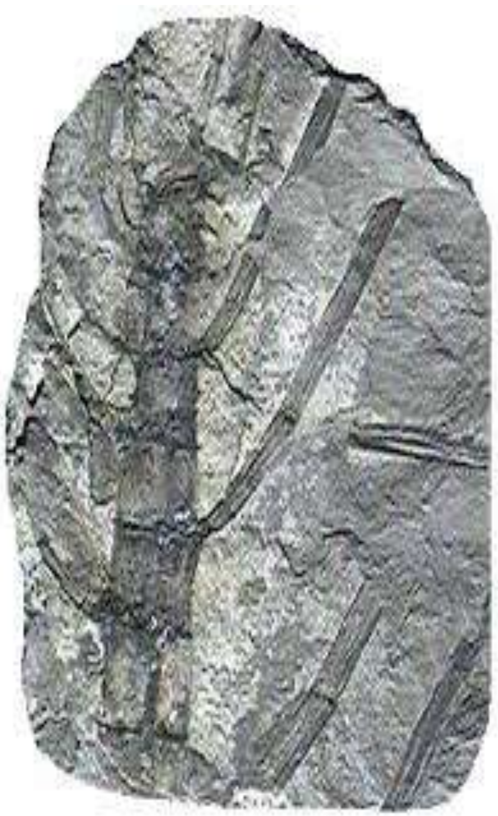
13.14 CALAMITALES

13.14.1 General Characteristics

1. Members of this fossil order of Sphenopsida appeared first on the land in Upper Devonian, flourished well during Carboniferous and became extinct in the early Triassic period (Smith, 1955).
2. The plant body was sporophytic, and the sporophytes were very large and tree-like.
3. Stems and branches showed considerable secondary growth.
4. Whorls of sporangiophores, usually alternating with the sterile bracts, were present in strobili.

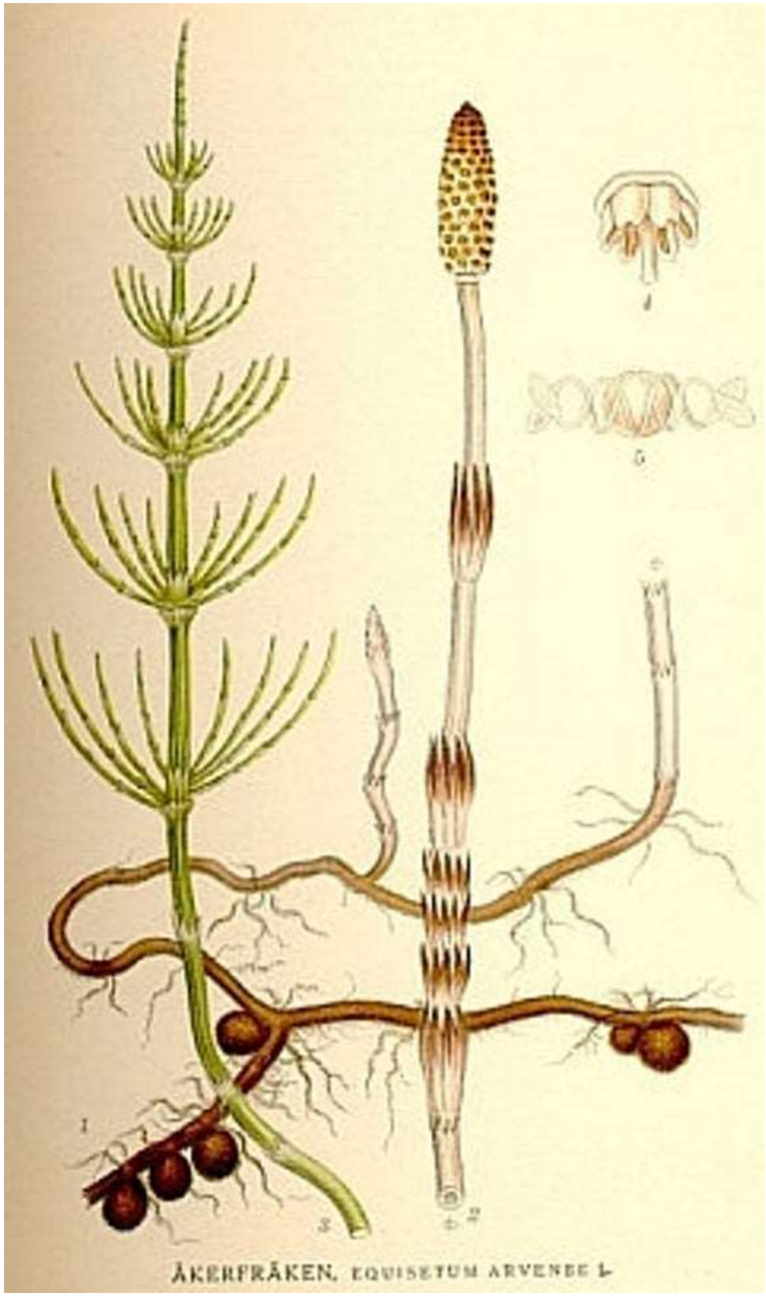
Reimers (1954) divided Calamitales in two families (Calamitaceae and Asterocalamitaceae). Only alamitaceae is briefly discussed here.

Calamites



Order Equisetales

Equisetum



Class or Division Pteropsida

Sub Class/sub division

Primofilices

Orders

- **Cladoxylales (2)**
  - Cladoxylaceae
  - Pseudosporochnaceae
- **Coenopteridales (3)**
  - Zygopteridaceae
  - Stauropteridaceae
  - Botryopteridaceae

Eusporangiatae

- **Marattiales (5)**
  - Asterothecaceae
  - Angiopteridaceae
  - Marattiaceae
  - Danaeaceae
  - Christenseniaceae
- **Ophioglossales (1)**
  - Ophioglossaceae

Osmundidae

- **Osmundales**
  - Osmundaceae

Leptosporangiatae

- **Filicales (19)**
  - Schizaeaceae, Gleicheniaceae
  - Hymenophyllaceae, Dicksoniaceae
  - Matoniaceae, Dipteridaceae
  - Cyatheaceae, Dennstaedtioideae
  - Pteridoideae, Davallioideae
  - Oleandroideae, Onocleoideae
  - Blechnoideae, Asplenioideae
  - Athyrioideae,Dryopteridoideae
  - Lomariopsidoideae,Adiantaceae
  - Polypodiaceae
- **Marsileales (2)**
  - Pilulariaceae, Marsileaceae
- **Salviniales (2)**
  - Salviniaceae
  - Azollaceae

Families

Salient Features of Pteropsida

- •Generally called as ferns, Represented by 300 genera and 10,000 species, by megaphyllous pteridophytes.
- •Found as back as the Devonian period but less in Carboniferous period, profoundly evolved in Triassic, Jurassic and Cretaceous eras to present time.
- •Plant (Sporophytic) body is distinguished into roots, stem and spirally arranged leaves, well developed and vast schlerenchmya is found in roots and stem
- •Habitat – moist and shady – humid tropical forests. Mostly land plants, some are epiphytic (eg. *Ophioglossum*), aquatic (*Azolla, Marsilea, Salvinia*)
- •Habit- small prostrate herbs (*Azolla*, *Marsilea*) to huge tree like (*Cyathea*)
- •Leaves are large with **branched veins**. Compound, so called as **fronds.** In *Ophioglossum*, leaves are simple
- •Leaf base may be enlarged and functions in starch storage

Salient Features of Pteropsida

- Stele shows a wide variety of modifications: simple to advanced (Protostele-siphonostele-solenostele-dictyostele conditions)

- Vegetative propagation – fragmentation, adventitious buds, stem tubers, apogamy

- Spores- sporangia are grouped – sorus in marginal or abaxial surface of leaf blades. Special outgrowth called Indusium is seen

- In most of the genera, leaves are dual in function- photosynthetic and reproductive

- Sporangium development may be eusporangiate (from more than one sporangial initial) or leptosporangiate (from a single sporangial initial). Spores –homosporous or heterosporous

Some members of Pteropsida

Marattia sp.,

Angiopteris sp.,

Danaea sp.,

Some members of Pteropsida

Lygodium sp.,

Gleichenia sp.,

Ophioglossum sp.,

Some members of Pteropsida

Stelar Evolution in Pteridophytes

The term stele has been derived from a Greek word meaning pillar. **Van Tieghem and Douliot** (1886) recognized only three types of steles.

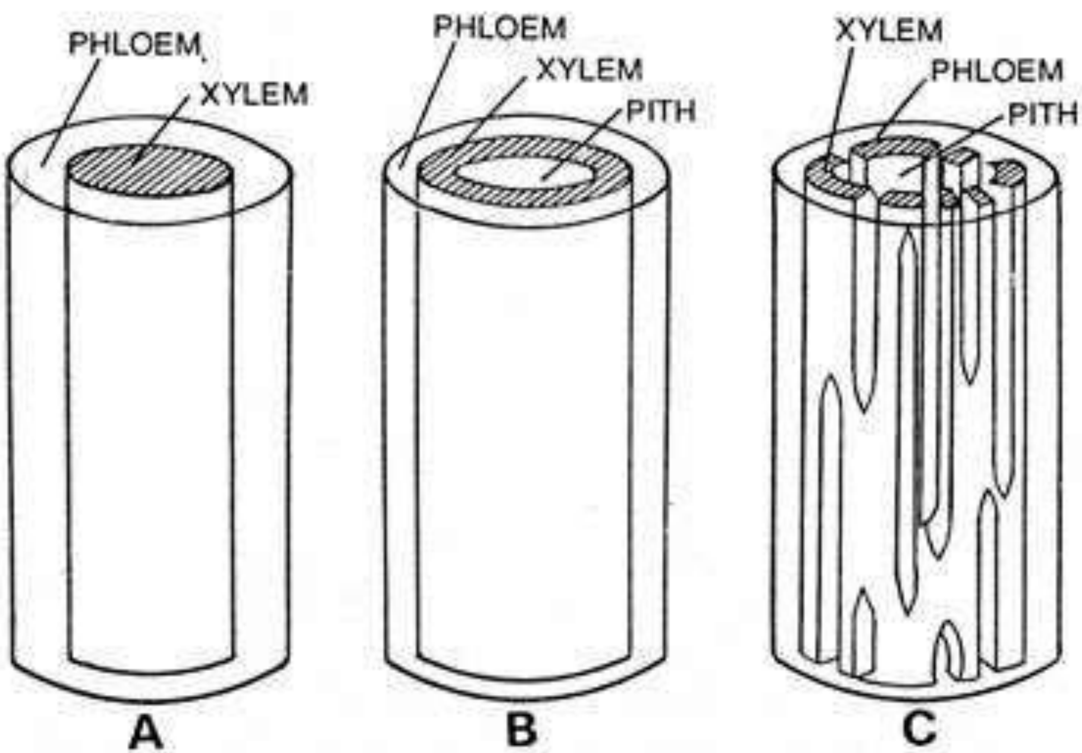


Fig. 37.42. Types of arrangements of vascular tissues in steles. A, protostele; B, siphonostele; C, dictyostele.

(a) Haplostele:

This is the most primitive type of protostele. Here the central solid smooth core of xylem remains surrounded by phloem (e.g., in Selaginella spp.).

(b) Actinostele:

This is the modification of the haplostele and somewhat more advanced in having the central xylem core with radiating ribs (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 (e.g., in Lycopodium).

(d) Mixed-pith stele:

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.).

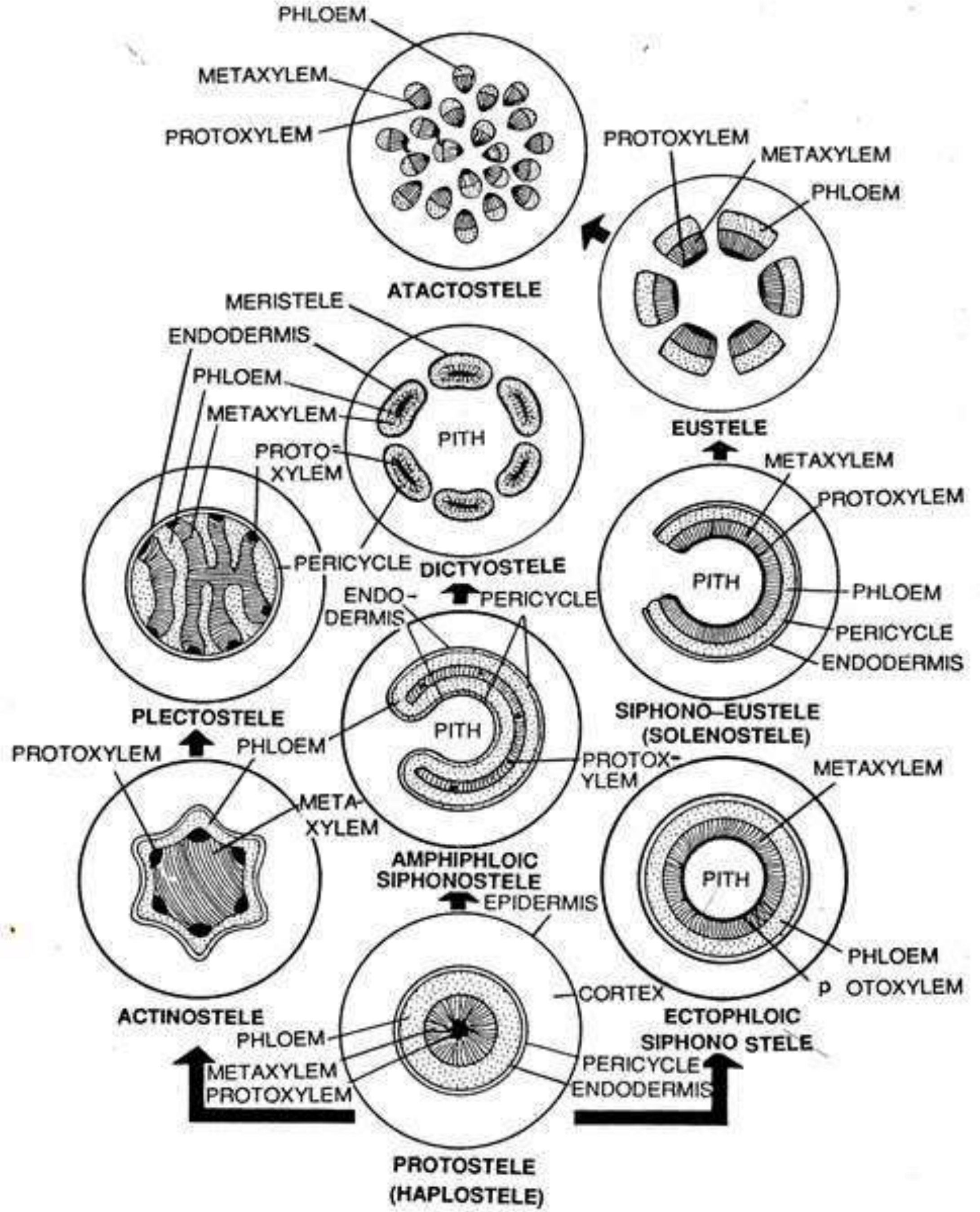


Fig. 37.43. The stelar system. Different types of steles arranged in evoluntionary sequence.

Siphonostele

This is the modification of protostele. A stele in which the protostele is medullated is known as 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 gap immediately above the branch traces only or immediately above leaf and branch traces.

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.**

Ectophloic Siphonostele:

The pith is surrounded by concentric xylem cylinder and next to xylem the concentric phloem cylinder.

Amphiphloic Siphonostele:

The pith is surrounded by the vascular tissue. The concentric inner phloem cylinaer 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)

Solenostele:

The vascular plants have been divided into two groups on the basis of the presence or absence of the leaf gaps. These groups are—Pteropsida and Lycopsida. The ferns, gymnosperms and angtosperms are included in Pteropsida, whereas the lycopods, horse-tails, etc., are included in Lycopsida.

Dictyostele:

In the more advanced siphonosteles of Pteropsida, the successive gaps may overlap each other. Brebner (1902) called the siphonosteles with overlapping gaps as dictyosteles. In such cases the intervening portion of the vascular tissue between lateral to such leaf gaps is known as **meristele**. Each meristele is of protostelic type. The dictyostele with many meristeles looks like a cylindrical meshwork.

Polycylic Stele:

This type of stelar organization is the most complex one amongst all vascular cryptogams (pteridophytes). Such type of steles are siphonostelic in structure. Each such stele possesses an internal vascular system connected with an outer siphonostele. Such connections are always found at the node.

A typical polycyclic stele possesses two or more concentric rings of vascular tissue. This may be a solenostele or a dictyostele. Two concentric rings of vascular tissue are found in *Pteridium aquilinum* and three in *Matonia pectinata*

Eustele:

Here the vascular system consists of a ring of collateral or bicollateral vascular bundles situated on the periphery of the pith. In such steles, the inter-fascicular areas and the leaf gaps are not distinguished from each other very clearly. The example of this type is Equisetum.

Types of Stele in Plants

Protostele
(Stele without Pith)

- **Haplostele**
  Smooth central xylem
  Xylem surrounded by phloem
  Eg. *Rhynia, Lygodium*
- **Actinostele**
  Star shaped xylem
  Phloem between star arms
  Eg. *Lycopodium serratum*
- **Plectostele**
  Xylem as plates
  Phloem between xylem plates
  Eg. *Lycopodium clavatum*
- **Mixex protostele**
  Xylem as patches in phloem
  Eg. *Lycopodium sernuum*
- **Mixed protostele with pith**
  With pith like parenchyma
  Eg. *Hymenophyllum*

Siphonostele
(Stele with Pith, no leaf gap)

- **Cladosiphonic Siphonostele**
  Without leaf gap
  Eg. *Selaginella*
- **Ectophloic siphonostele**
  Phloem external to xylem
  Eg. *Osmunda*
- **Amphiphloic siphonostele**
  Phloem both sides of xylem
  Eg. *Marsilea* rhizome

Solenostele
(Stele with pith and leaf gap)

- **Ectophloic Solenostele**
  Phloem external to xylem
- **Amphiphloic solenostele**
  Phloem both sides of xylem
  Eg. *Adiantum pedatum*
- **Dictyostele**
  Many meristels
  Eg. *Pteris*
- **Polycyclic stele**
  Many circles of VB
  Eg. *Pteridium aquilinum*
- **Eustele**
  VB arranged as a broken ring
  Eg. *Dicot Stem*
- **Atactostele**
  Scattered arrangement of VB
  Eg. *Monocot Stem*

Stelar System Evolution
(in Pteridophytes & Higher Plants)

HOMOSPORY, HETEROSPORY, SEED HABIT IN PTERIDOPHYTES

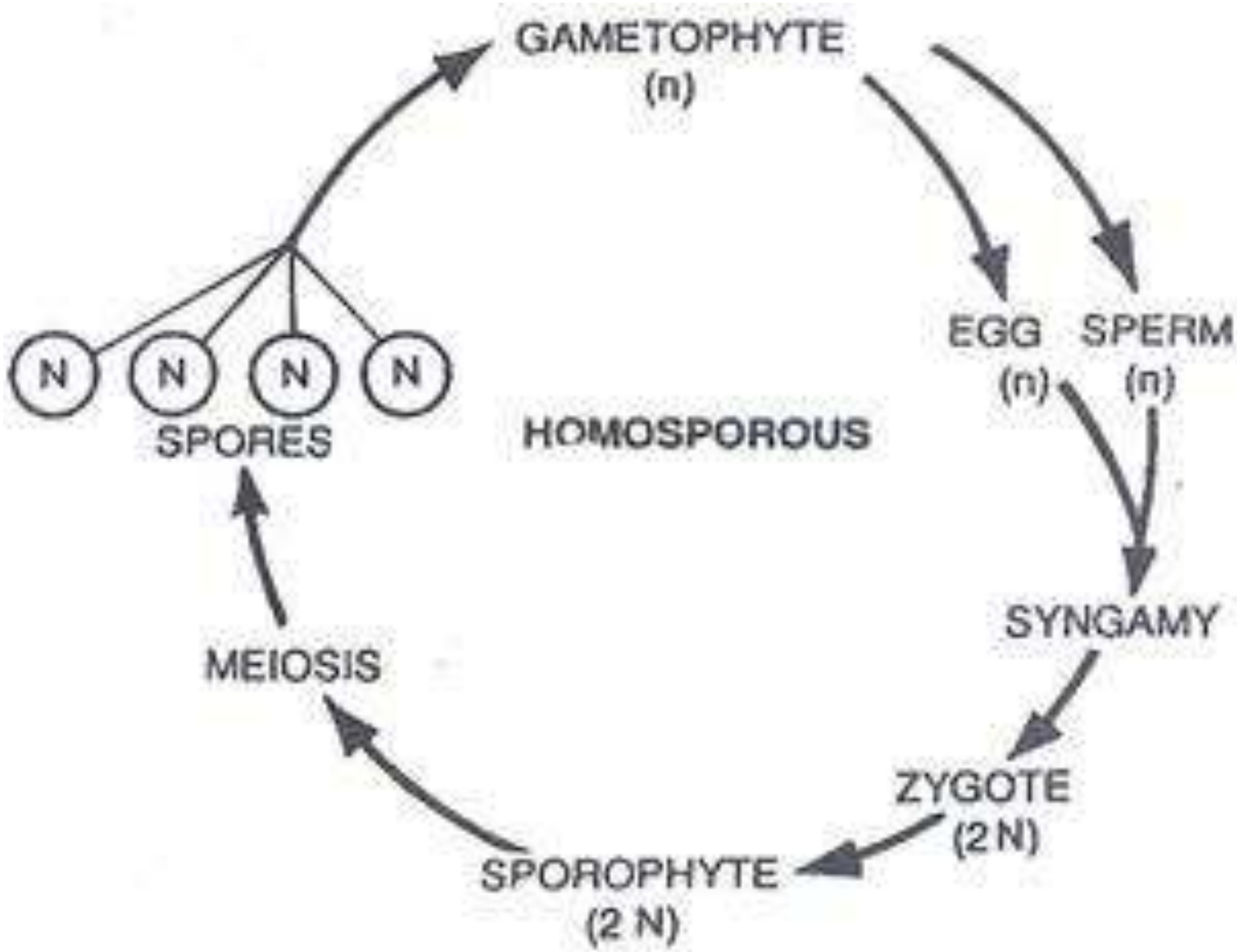


Fig. 25.3. Alternation of generations in Pteridophytes. Life-cycle pattern in homosporous pteridophytes.

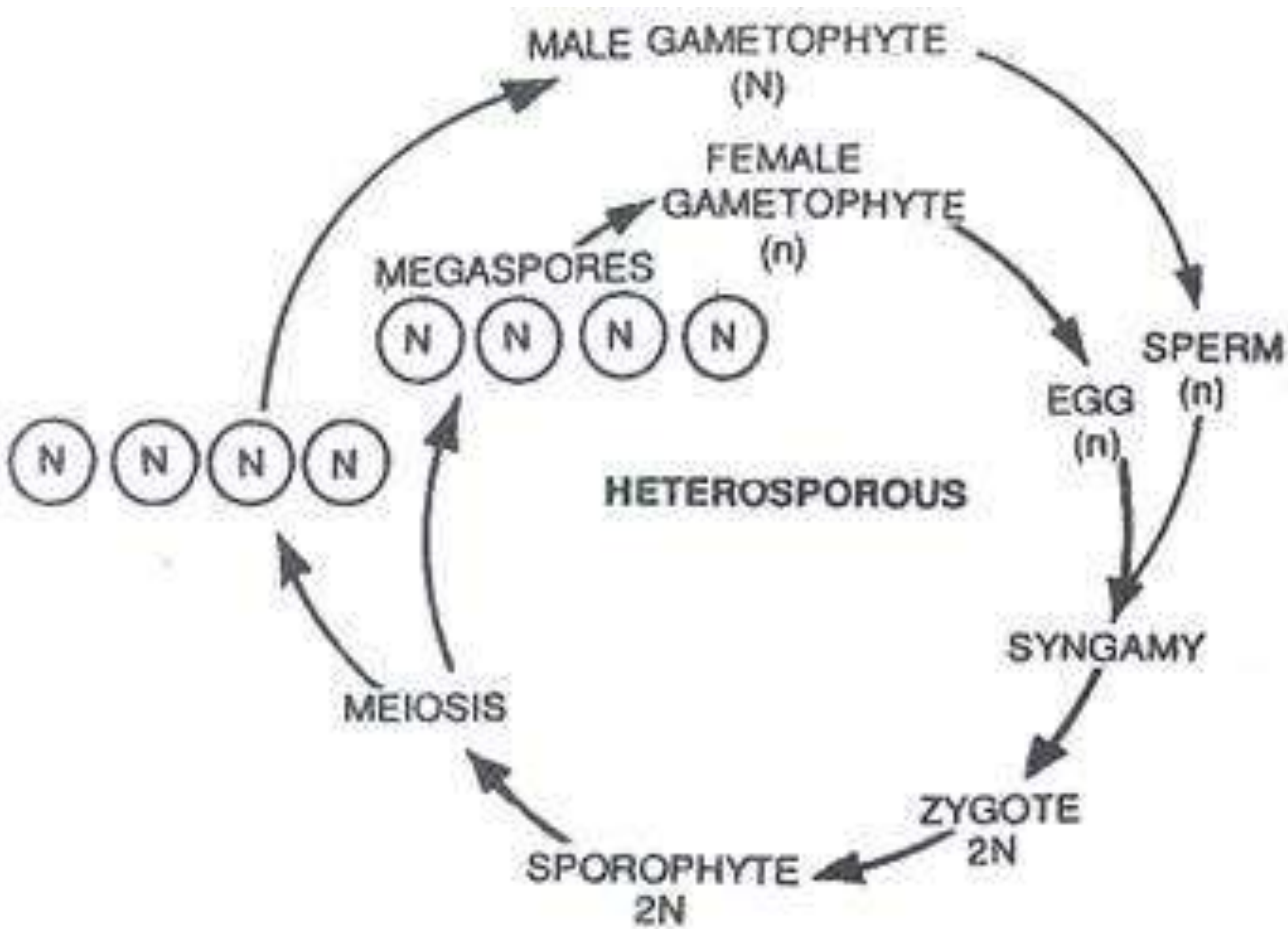


Fig. 25.4. Alternation of generations in Pteridophytes. Life cycle pattern in heterosporous pteridophytes.

HETEROSPORY

- 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. Megaspores are large and develop into female gametophyte.

- **According to Rashid(1976), only 9 genera of pteridophytes show heterospory,i.e., Selaginella, Isoetes, Stylites, Marsilea, Pilularia, Regnellidium, Salvinia, Azolla and Platyzoma**

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

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.

A number of heterosporous genera belonging to the Lycopsida, Sphenopsida and Pteropsia were known in the late Devonian and early Carboniferous periods.

Lepidocarpon, Lepidostrobus, Mazocarpon, Plaeuromeia, Sigillariostrobiis (members of Lycopsid) Calamocarpon, Calamostachys, Palaeostachys (members of Sphenosida).

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.

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.

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

(i) The development of the female gametophyte starts while the megaspore is still inside the megasporangium.

(ii) Same is true of microspores i.e., they also start germinating into male gametophytes while they are still inside microsporangium.

(iii) The female gametophyte derives its nourishment from the sporophyte i.e., female gametophyte is dependent on sporophyte for its nourishment.

(iv) 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.

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*.

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.

ECONOMIC IMPORTANCE OF PTERIDOPHYTES

- The pteridophytes which include the ferns and a group of vascular plant of ancient or primitive land plant with worldwide distribution.

- They are found in all the continents excepts Antarctica and most islands, favoring moist temperate and tropical regions.

- The economic value of pteridophytes have been known to men for more than 2000 years and have been found as an important source of food and medicine.
- Pteridophytes are usually useful but few are harmful.

Pteridophytes are used in various fields---

1. As soil conservation
2. As bio fertilizer
3. As food
4. As ornamental
5. As entertainment
6. As medicinal used
7. As chemical production
8. As manufacturing
9. Metal accumulators

AS SOIL CONSERVATION

- Usually pteridophytes plants are terrestrial so they protect the upper part of soil.
- They protect soil from heavy rainfall.
- They help in stopping soil erosion.

  e.g. *Pteris*, *Dryopteris*, *Nephrolepis* etc.

Pteris

Dryoptris

AS BIOFERTILISERS

- Pteridophytes plants are very helpful for the formation of **biofertilisers**.

- ***Azolla*** spp. are very helpful for the formation of biofertiliser because root have ***Anabena*** help **nitrogen fixation.**

AS FOOD

Many plants are edible and used in form of vegetable.

- ***Ampelopteris*** **prolifera**, **Isoetes** used as food.
- ***Osmunda cinnamomea*** use as vegetable.
- ***Azolla*** also used as food production they have higher carbohydrates and protein values.

Ampelopteris

Azolla

Osmunda

- *Equisetum arevense* whole plant are used in food production.
- The tuber of *Isoetes* are used as food.
- *Neprolepis biserrata* rhizome are edible.

Equisetum

Isoetes

AS ORNAMENTALE

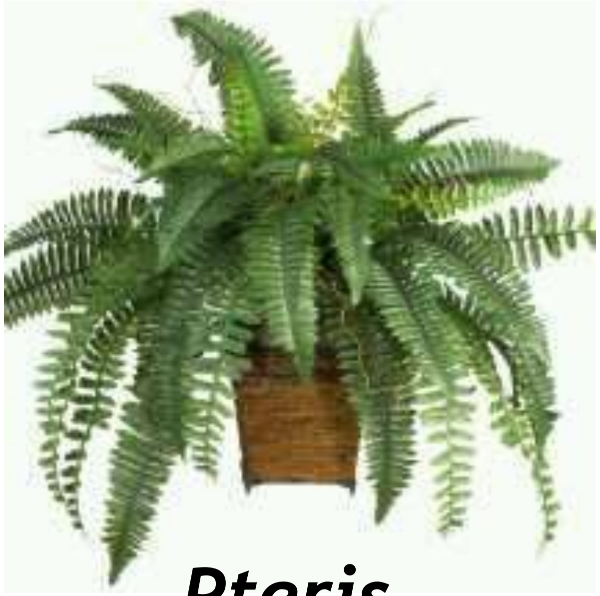
Few pteridophytes are used as ornamental

- *Lycopodium obscurum* called “Christmas tree” are used as grassland during Christmas festival and for purpose of decoration.

- *Lycopodium volubile* is very commonly used by decoration.

- *Selaginella* plant also used during Christmas festival as grassland and various type of table decoration.

- A few species are grown in pots for their beautiful colored moss like foliage.
- Many ferns are used as decoretary e.g. *Pteris* and *Dryopteris* are used as ornamentally in home.



Pteris

Selaginella

ENTERTAINMENT

Few species of ***Selaginella*** such as ***Selaginella lepdophylla*** and ***S.pilifera*** are called resurrection plant.

As MEDICINE

Plant	Medicinal uses
Pteris multifold	used in cancer, diarrhoea hepatitis..
Ophioglassum costatum	Used in antiviral, antidote to snake bite, their rhizome used in bleeding nose.
Marsilea condensata	Leaves are used, diuretic and plant used in snake bite diarrhoea.
Lygodium japonicum	Used for expulsion of intestional worms.

Plants	Use
Adiantum capillms	Anticancerus and Antibacterial plants.
Adiantum lunulatum	as blood related diseases
Adiantum candatum	skin disease
Actinopteris rediata	antimalarial
Aspelnium falcatum	antihelmintic and tapeworms reducer
Azolla pinnata	Antifungal and antibacterial.
Equisetum ramosissimum	diuretic and used in diarrhoea
Selaginella boryoides	liver diseases
Dryopteris cochleata	used antibacterialin
Pteridium revolutum	gastric and intestinal diseases

As CHEMICALS

Plants	Yields chemical
Pteris vittata	Phenols
Psilotum nudum	Psilotic acid, Gibberellin
Pteridium aquilinum	Protein, sugar, starch, H.C.N,beta-carotene
Azolla pinnata	Protein, carotinoids
Diplazinum esculentum	Iron ,calcium
Equisetum arvense	Oxalic acids, malic acid, vinilic acid

VITAMINS

Plants	Yields vitamins
Diplazinum esculentum	Vitamin B
Equisetum arvense	Vitamin C
Asplenium yoshinagae	Vitamin K3

OIL YIELDING

Plants	Product
Lycopodium inundataum	These are produced a high amount of fixed oils.
Ophiogloosum vulgatum	They produced fixed oils.

DYE YIELDING

Plants	Obtain Dye
Asplenium ensiformis	red dye
Equisetum arvense	red dye
Pteridium aquilinum	yellow dye

MANUFACTURING

Plants	Use
Adiantum pedatum	Basket manufacturing.
Lygodium microphyllum	Basket manufacturing
Metathelypteris gracilescens	Yields fibers.

METAL ACCUMULATORS

Plants	Metals
Lycopodium clavatum	Zinc Arsenic
Lygodium japonicum	Arsenic, Calcium, Copper
Equisetum arvense	Tin, Cobalt, Zinc
Pteris vittata	Arsenic

HARMFUL ACTIVITIES

- Pteridophytes are mostly useful but few are harmful.
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- Few pteridophytes are abnoxious weeds so they are harmful for animal and for crop plant.
- *Pteridium aquilinum* they are cosmopolitan they are poisonous for Cattle and Horse.