



COURSE-III: PTERIDOLOGY, GYMNOSPERMS AND PALAEOBOTANY (BSCBO-103)

BLOCK-I- PTERIDOPHYTES General Features and Classification

By
Dr. Prabha Dhondiyal
Department of Botany
Uttarakhand Open University Haldwani
E-mail: pdhondiyal@uou.ac.in

CONTENTS

- Introduction
- General features
- Classification
- Keywords
- Suggested Readings

INTRODUCTION

The term Pteridophytes is derived from Greek word **Pteron** meaning a feather and **Phyton** meaning a plant therefore, pteridophytes is a group of plants with feather like appearance. This group includes higher cryptogams which are also known as **Vascular Cryptogams**.

The term cryptogams (kruptos= hidden, gamos= wedded) was suggested by Linnaeus in 1754 for all non-flowering plants that reproduce by means of spores and do not produce seeds. The term **vascular** indicates the presence of vascular tissues (xylem and phloem) for the conduction of water and food.

Thus, the vascular cryptogams or pteridophytes can be defined as an assemblage of seedless vascular plants that have successfully invaded the land and reproduce by means of spores.

The main features of pteridophytes are:

- These plants have an independent gametophyte and an independent sporophyte. This is contrast to the bryophytes where the sporophyte is a parasite on gametophyte and the gymnosperms and angiosperms where the gametophyte is a parasite on sporophyte.
- The dominant phase of life-cycle is the sporophyte.
- This was the first group of vascular plants to invade the land.
- This was the first group to have a vascular system (xylem and phloem).
- They do not produce seeds but produce spores.

GENERAL FEATURES OF PTERIDOPHYTES

Habit and Habitat: The plant body is sporophytic, differentiated into root, stem and leaves (except in the most ancient fossil pteridophytes and the most primitive living members of the group). They show much variation in their form, size and habit. They range from small annuals (e.g. *Azolla*, *Salvinia*) to large tree like perennials (*Angiopteris*, *Osmunda*). The branching of the stem shows a range of variation. It may be monopodial and dichotomous. The adventitious roots arise on the stem or in many ferns on the petiole.

Most of the living pteridophytes are terrestrial, growing in moist and shady places. Some members (*Azolla*, *Marsilea*, *Savinia* etc) are aquatic and few forms grow (*Equisetum arvense*) in xerophytic habitats.

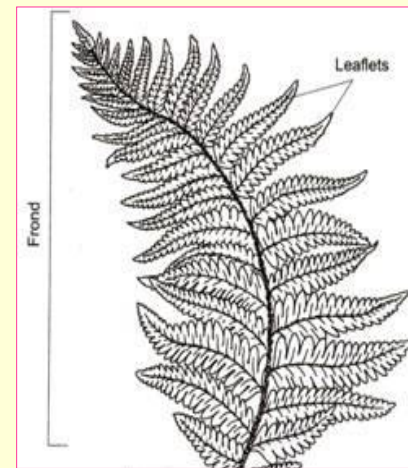
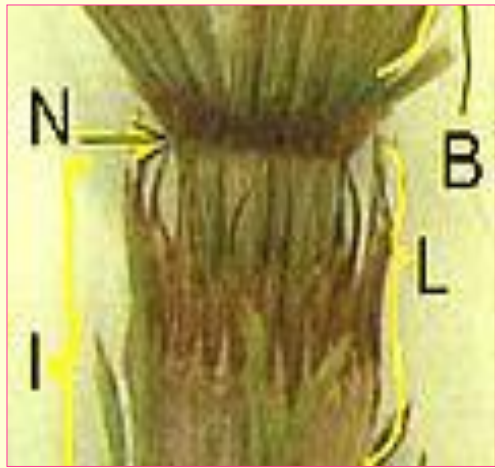


Range of habitat A- Aquatic (*Salvinia*); B- Xerophytic (*Equisetum*)

The leaves are scaly (*Equisetum*), small and sessile (*Lycopodium*) or large, petiolate and compound e.g. ferns. Based on size and venation pattern the pteridophytes are:

- **Microphyllous:** Includes plants with small leaves. The microphyll is distinguished from the megaphyll by its simple venation (e.g. *Equisetum*, *Lycopodium*).

- **Megaphyllous:** Includes plants with large leaves. Megaphyll is distinguished from microphyll by its complex venation (e.g. ferns).



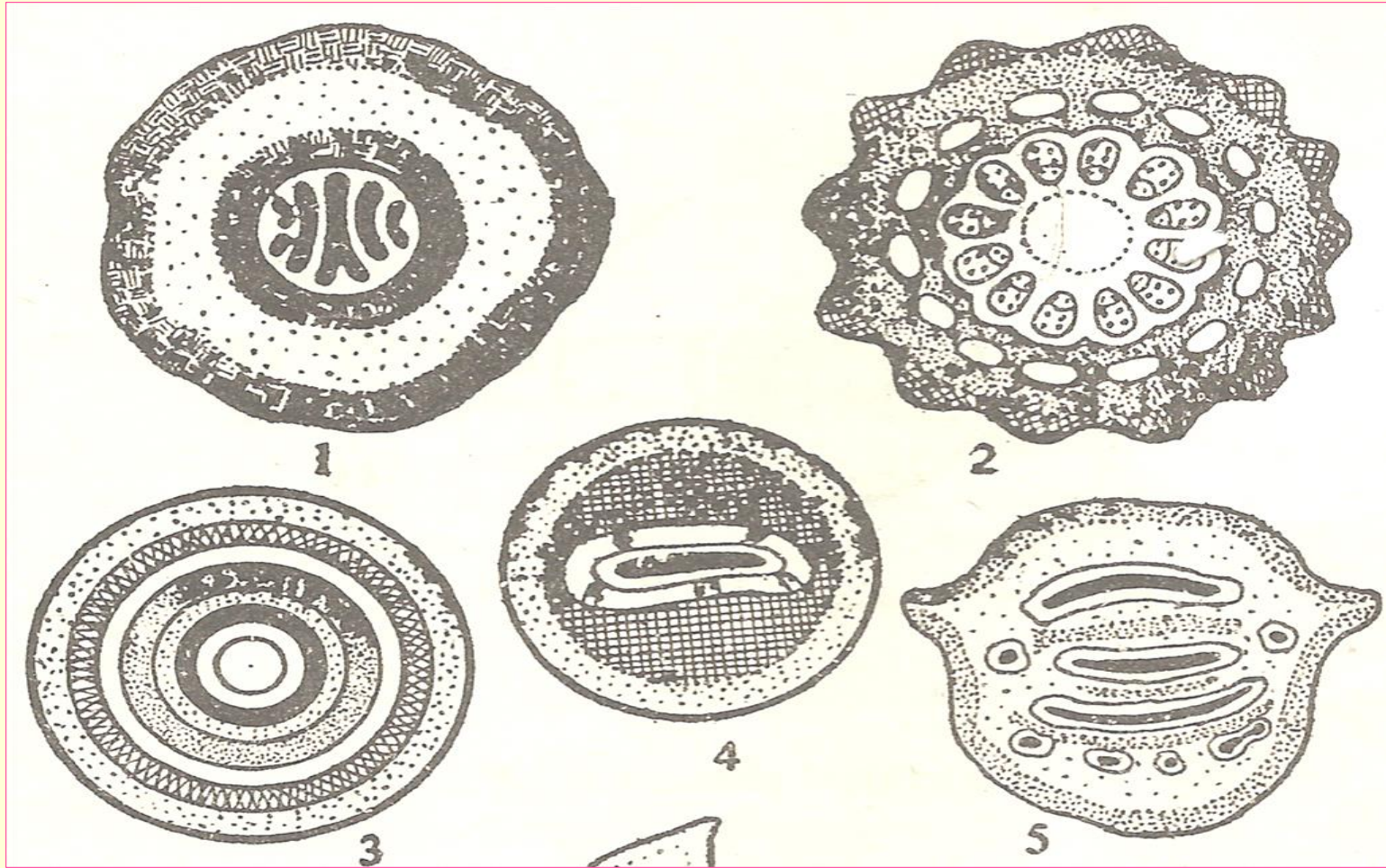
Leaves in pteridophytes; A- scale leaves (Equisetum); B-microphyll (Lycopodium); C-megaphyll (Dryopteris)

Anatomical structure

The root and stem have well developed vascular system composed of xylem and phloem. Only the sporophyte shows any appreciable development of conducting tissues. The recorded instances of such tissue in gametophytes are rare and amount of xylem and phloem are scanty.

The stellar organizations are haplostelic protostele (*Selaginella*), plectostele (*Lycopodium*), siphonostele (*Equisetum*), dictyostele (*Pteris* and *Pteridium*) and polycyclic (*Marattia*).

The xylem is made up of tracheids and phloem has sieve tubes only. Except for lower group the photosynthetic tissue is restricted only to leaves. The megaphyll show differentiation of the mesophyll into palisade and spongy tissues. The root shows a diarch structure which is almost constant throughout the pteridophytes and has been regarded as a conservative organ.

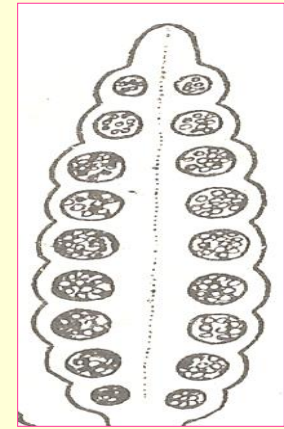
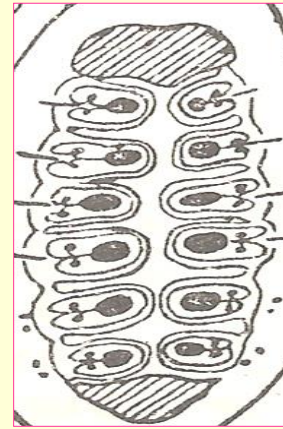
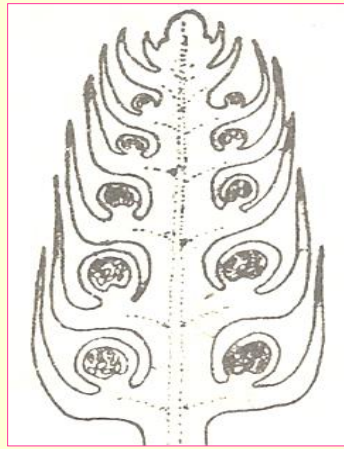


Variation in stele in pteridophytes. 1-Plectostele (*Lycopodium*); 2-Siphonostele (*Equisetum*); 3-Polycyclic stele (*Marsilea*) 4- Haplostele (*Selaginella*); 5- Dictyostele (*Pteridium*)

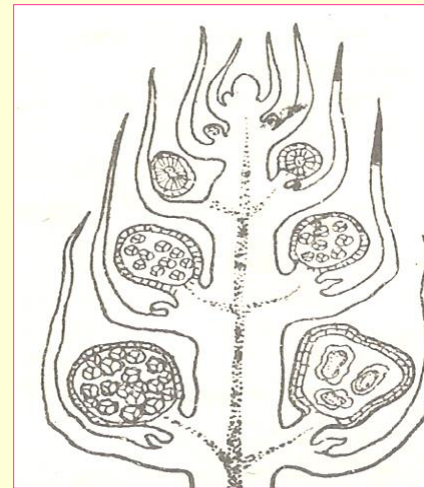
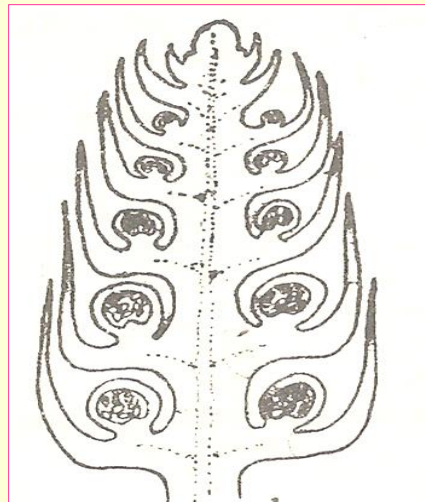
Sporangia: Pteridophytes reproduce by spores produced in sporangia. The sporangia are borne either on the leaves called sporophylls or in axils between the leaves and the stem.

Sporophylls are either uniformly distributed (*Pteris*) or are aggregated into compact ones (**strobilii**) at the apex of the stem (*Equisetum*). In aquatic forms like *Azolla* and *Marsilea* the sporangia are present within specialized structure called sporocarps.

In some pteridophytes e.g. Filicales; the sporangia are aggregated in clusters known as **sorus/sori**. Most of the pteridophytes produce only one type of spores and known as **homosporous** (*Lycopodium*) while some produce two different kinds of spore and known as **heterosporous** (*Selaginella*).



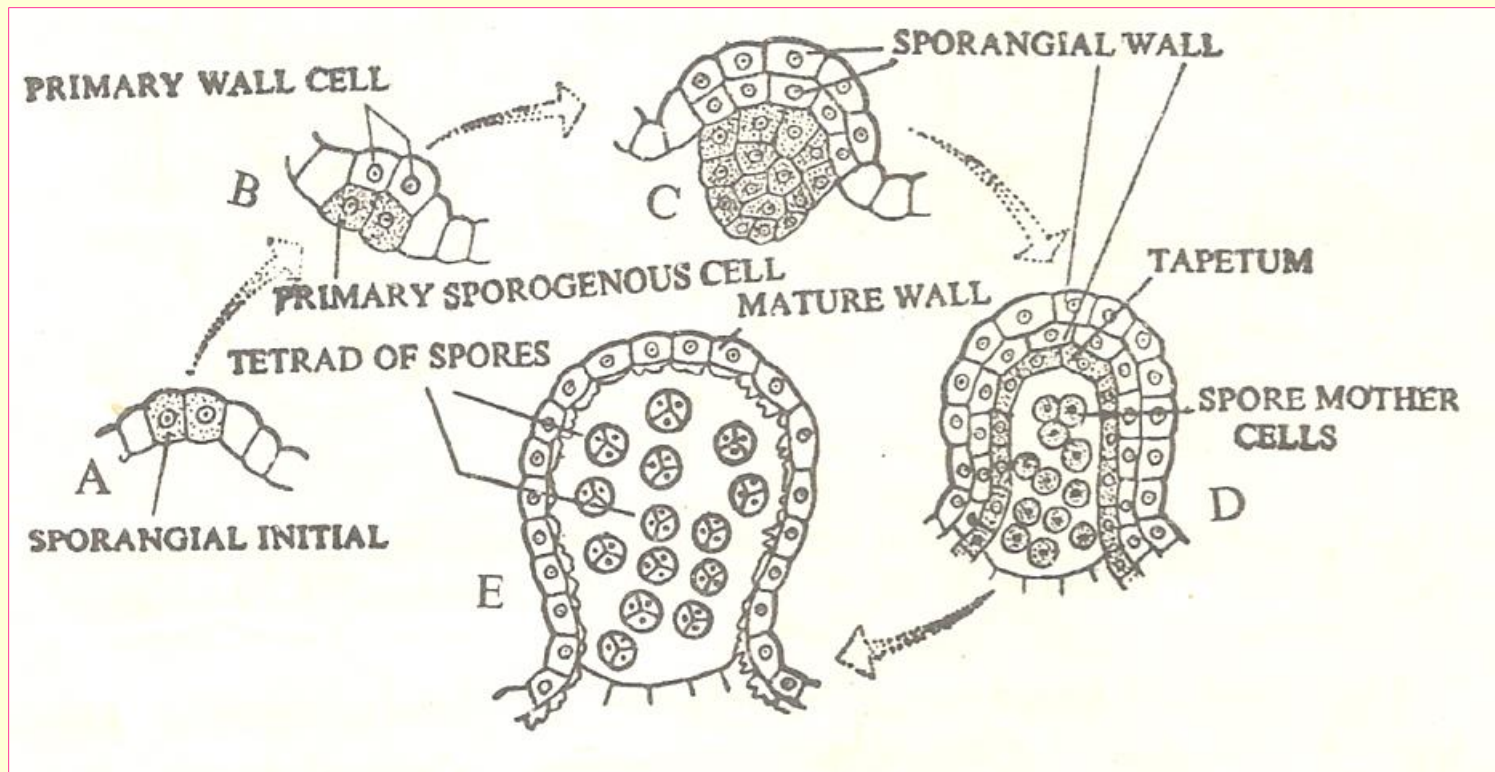
Range of sporangial structure in pteridophytes A- Sporophyll (Dryopteris); B- Cone (Lycopodium); C- Sporocarp (Marsilea); D-Sori (Ophioglossum)



Types of sporangium A-Homosporous (Lycopodium); B- Heterosporous (Selaginella)

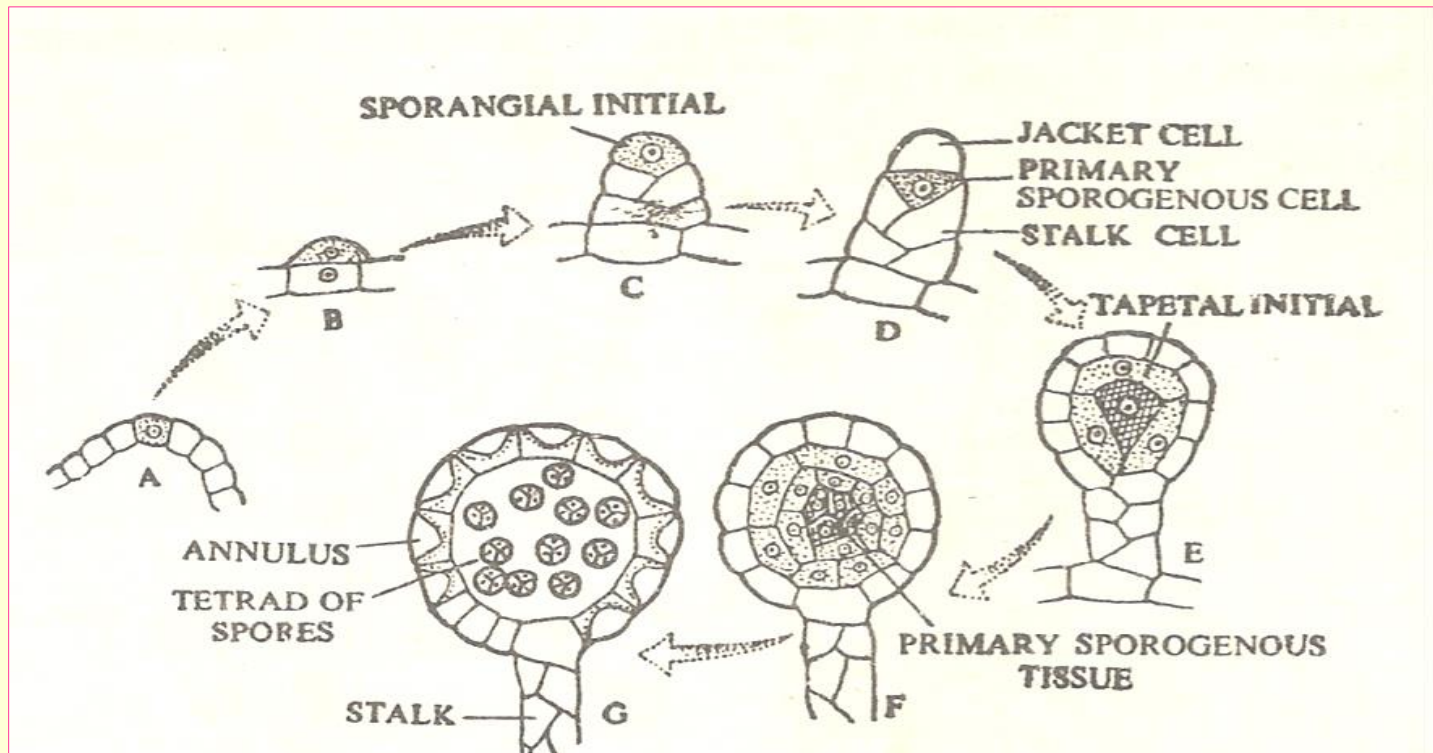
The development of sporangia may be

- **Eusporangiate**- The large sporangium initiated from a group of superficial cells which by periclinal division gives rise to outer layer of primary wall cell and inner layer of sporogenous tissue e.g., *Psilotum*, *Lycopodium*.



Eusporangiate type of sporangial development

- **Leptosporangiate-** The relatively small sporangium develops from a single initial cell which by periclinal division forms an outer and inner cell, the former forms the entire sporangium, its contents and stalk and the latter do not take part in this process e.g. *Salvinia* and *Marsilea*.



Leptosporangiate type of sporangial development

Gametophyte: The haploid spores on germination give rise to the haploid gametophyte or prothallii. One of the most characteristic feature of pteridophytes is that the sporophyte has become the dominant part of life-cycle while the gametophyte has much been reduced.

The gametophytes are of two types i.e. homosporous and heterosporous. In homosporous forms the gametophyte grows upon the soil and form independent plant. Such gametophytes are known as is exosporic gametophytes (*Psilotum*, *Lycopodium* and *Ophioglossum*).

In heterosporous species gametophyte for most of its part is retained within sporangium and is called endosporic gametophytes (*Selaginella*, *Marsilea* and *Isoetes*). There is much variation in the shape and the size of the gametophytes.

In most of the vascular cryptogams, the exosporic gametophyte grow exposed to light and remain attached to the ground by many rhizoids.

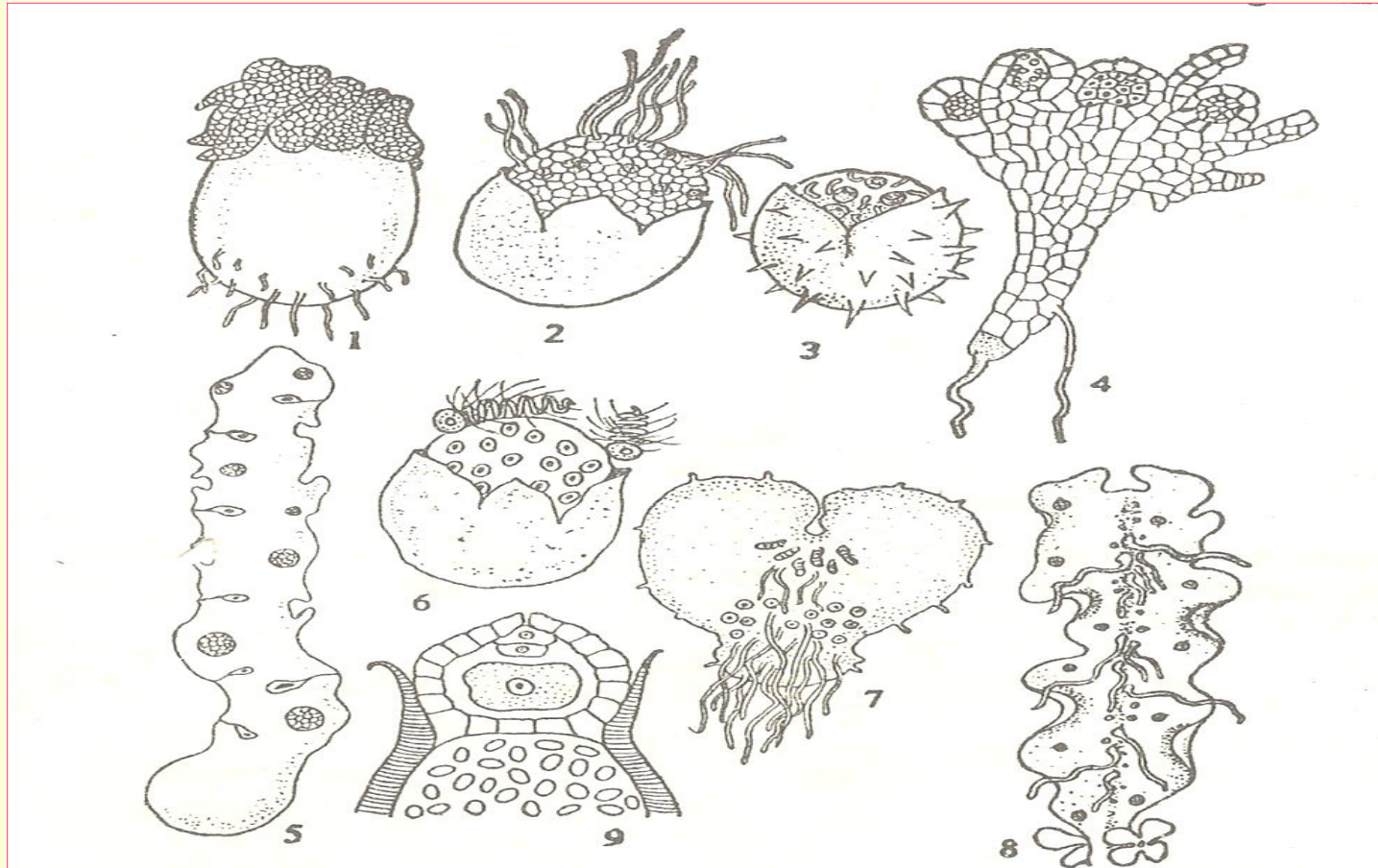
In such cases they produce their food and live an independent life e.g. ferns. In some pteridophytes, exosporic gametophytes are devoid of chlorophyll and obtain their food by the symbiosis through mycorrhiza e.g. *Psilotum*. Such gametophytes are saprophytic in nature.

The endosporic gametophytes are greatly reduced structures. They develop largely or entirely within spore wall and live on food deposits in the spore.

Sex organs: The gametophyte or prothallus bears the sex organs, the antheridia and archegonia. Gametophyte of homosporous species is monoecious means both antheridia and archegonia are born on the same gametophyte.

In heterosporous species, gametophyte is dioecious that is antheridia and archegonia develop on different gametophytes.

Antheridia may be embedded in the tissue of gametophyte or they may project from it. Former are embedded antheridia (*Lycopodium*, *Selaginella*) while the later are called projecting antheridia (leptosporangiate ferns). At maturity, antheridia are a globular structure with large number of androcytes. Each androcyte gives rise to a single motile antherozoid. The archegonium is a flask shaped structure consisting of a basal swollen embedded structure, the venter and a short neck. The venter encloses venter canal cell and neck canal cell are present inside neck. At maturity, the apical cell separate, the neck canal cell disintegrates forming a passage for antherozoid to reach egg.



Variations in the gametophyte of pteridophytes. 1-Lycopodium; 2-Selaginella (female); 3-Selaginella (male); 4-Equisetum; 5-Ophioglossum; 6- Marsilea (male) 7-Pteridium; 8-Osmunda; 9- Marsilea (female)

Fertilization: In all the cases fertilization takes place by the agency of water. The fusion of male gamete and egg gives rise to a diploid zygote.

Embryo: The zygote divides to form an embryo which undergoes repeated divisions to form a new sporophyte

The pteridophytes occupy an intermediate position between bryophytes and spermatophytes; therefore, they show certain similarities with bryophytes on one hand and the spermatophytes on the other.

Resemblances with Bryophytes

The pteridophytes (vascular cryptograms) resemble the bryophytes in the following features:

➤ Terrestrial habit.

- Like the bryophytes, they reproduce asexually by means of spores.
- The spores are formed in the same manner in both the groups.
- The sex-organs, the antheridia and archegonia are essentially identical as regards to their structure and ontogeny.
- In both the groups, the sex-organs have sterile jackets around them.
- The male gametes, *i.e.* the sperms are ciliated.
- Fertilization takes place in presence of water.
- Encapsulation of the embryo in the archegonium.
- Dependence of early embryo (sporophyte) upon the gametophyte.
- They exhibit regular interval of generations.

Differences between Pteridophytes and Bryophytes

The pteridophytes differ from bryophytes in the following features:

- In bryophytes, the gametophyte is the dominant and conspicuous generation, the diploid sporophyte being nothing more than a spore bearing structure and is dependent on the gametophyte for the nourishment. In pteridophytes, it is sporophyte rather than the gametophyte which constitutes a large, conspicuous and dominant phase in the life cycle, while the gametophyte is always small and inconspicuous.
- Plant body in pteridophytes shows differentiation into true roots, stem and leaves. In bryophytes, there may stem with leaves but there are no roots.
- All the vegetative organs of sporophyte of pteridophytes possess vascular supply whereas bryophytes do not possess vascular tissue.
- All bryophytes are homosporous, while pteridophytes may be homosporous or heterosporous.

Resemblances with Spermatophytes

The pteridophytes resemble the seed-bearing plants (spermatophytes) in the following features:

➤ In both the groups, the sporophyte is the large, conspicuous, freely existing, independent and dominant phase in the life cycle. The sporophytic plant body is differentiated into true roots, stem and leaves.

➤ All the vegetative parts of the sporophyte have typical xylem and phloem cells. The xylem consists of tracheids and xylem parenchyma, vessels being absent in majority of the pteridophytes (except *Selaginella* and *Marsilea*) and gymnosperms (except Gnetales). Phloem consists of sieve-tubes and phloem parenchyma. The companion cells being absent.

Differences between Pteridophytes and Spermatophytes

- Pteridophytes differ from the spermatophytes in that they do not produce flower, fruits and seeds.
- In pteridophytes, excepting few cases, the spores or gametophytes developed from them are invariably liberated from sporangia, instead of being permanently retained within them.
- In spermatophytes, water is not necessary for fertilization.
- Steles are more advanced in spermatophytes than those of pteridophytes.

CLASSIFICATION

The present system of classification of plants began with the publication of “Species Plantarum” in 1753 and “Systema Naturae” in 1761 by Linnaeus; the author of the binomial system of nomenclature Linnaeus recognized 24 major categories of plants. Twenty three of these often called Phanerogams and include vascular plants with visible flowers and the last Cryptogamia with plants having hidden flowers not visible to naked eye.

The cryptogamia of Linnaeus included ferns and fern like plants, mosses, liverworts, algae and fungi. This group has now been divided into a number of separate categories.

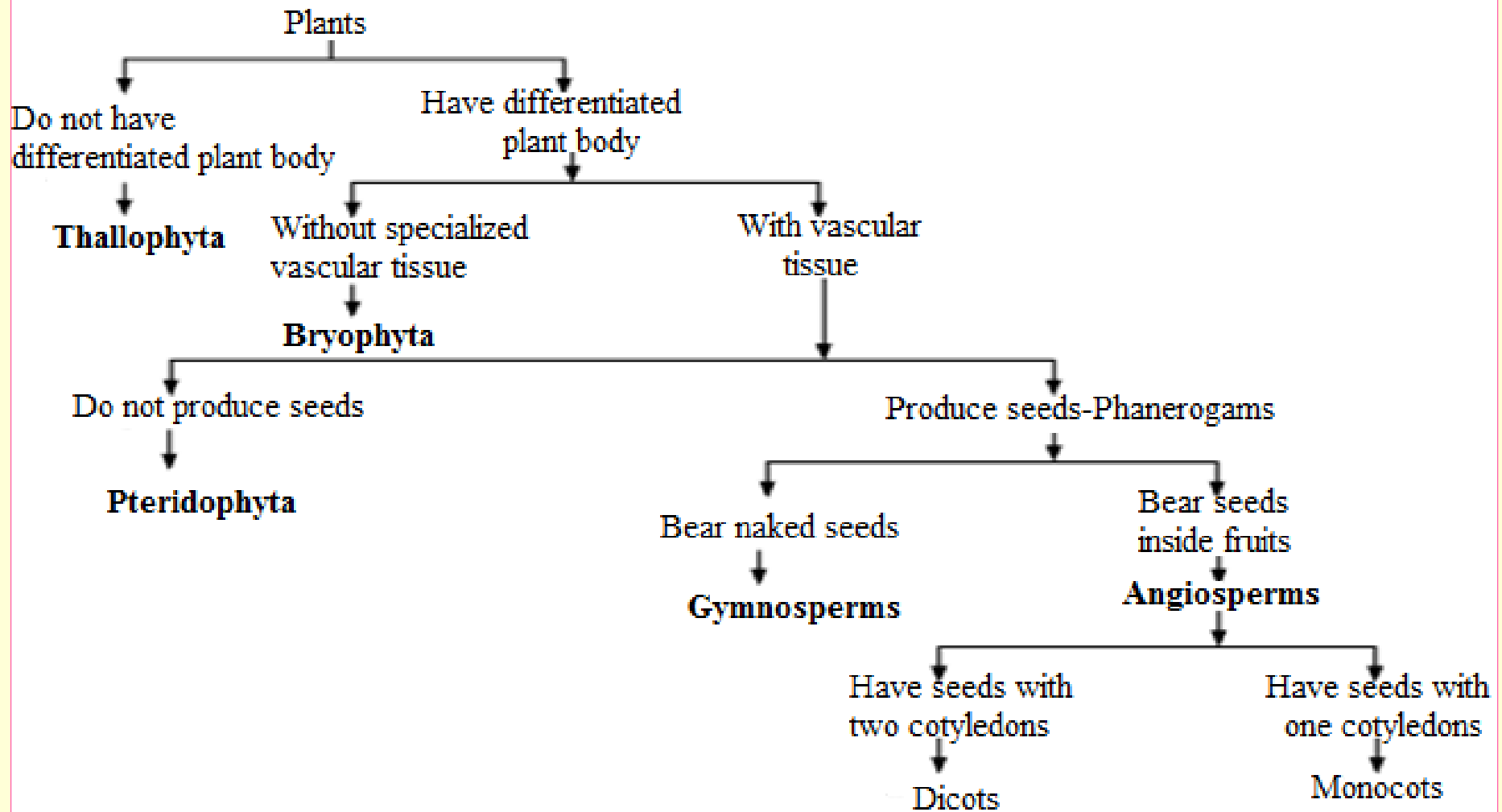
In 1880, the cryptogams of the plant kingdom were divided into three large divisions: Thallophyta, Bryophyta and Pteridophyta.

The name-Thallophyta was first introduced by Endlicher in 1836, who called this division, a kingdom. Later on in 1866 Haeckel introduced the names Bryophyta and Pteridophyta.

Long ago botanist divided vascular plants into two groups: **Pteridophyta** that include plants that do not produce seeds.

Spermatophyta that include plants that do produce seeds. This system of classification was based on possession of seeds.

In some system of classification all vascular plants are included in a single division **Tracheophyta** including plants with vascular tissue and taking their name from tracheids of xylem.



Early system of classification showing position of Pteridophyta in plant kingdom

In 1936 Eames divided Tracheophyta into four groups:

Division: Tracheophyta

Group 1. Psilopsida (Psilophytales and Psilotales)

Group 2. Lycopsida (Lycopodiales, Selaginellales, Lepidodendrals, Pleuromeiales and Isoetales)

Group 3. Sphenopsida (Hyeniales, Sphenophyllales and Equisetales)

Group 4. Pteropsida (Filicineae, Gymnospermae and Angiospermae)

In 1950, the International Code of Botanical Nomenclature amended and recommended that all names of divisions end in the suffix-phyta class in the suffix opsida, order in the suffix ales and family with suffix aceae.

The most accepted system of Classification of vascular cryptogams that is based on Smith (1955), Bold (1957), Benson(1957) and Takhtajan(1964) may be referred to as follows:

DIVISION- PSILOPHYTA

Class -Psilophytopsida

Order –Psilophytales*

Class -Psilotopsida

Order –Psilotales

DIVISION LYCOPHYTA

Class -Eligulopsida

Order –Lycopodiales

Class -Ligulopsida

Order –Selaginellales

Order-Lepidodendrales*

Order- Isoetales

Order-Pleuromeiales*

DIVISION- SPHENOPHYTA

Class- Sphenophyllopsida

Order-Sphenophyllales

Class- Calamopsida

Order-Calamitales*

Order-Hyeniales*

Order-Equisetales

DIVISION- FILICOPHYTA

Class- Primofilicopsida

Order-Cladoxylales*

Order-Coenopteridales*

Class-Eusporangiopsida

Order -Ophioglossales

Order-Marattiales

Class-Protoleptosporangiopsida

Order -Osmundales

Class- Leptosporangiopsida

Order- Filicales

Order-Marsileales

Order-Salviniales

(* Known as fossil without any living representative)

The characteristic features of these divisions are as follows:

Division Psilophyta:

- The sporophyte is differentiated into a rhizoid bearing subterranean rhizome and dichotomously branched aerial shoots.
- The true roots are absent although rhizoids are present on the rhizome. The leaves are usually absent or if present they are small, simple and spirally arranged.

- The vascular system is of protostelic type which consists of a central cylinder of xylem composed of tracheids and surrounded by ill defined phloem (*Rhynia*). In some species actinostele is present with radiating xylem strand (*Psilotum*). Leaf gaps are absent from vascular cylinder.
- The terminal sporangia are borne singly at the tips of short or long branches and are thick walled. The sporangia are homosporous i.e. produce only one type of spores.
- The gametophyte is subterranean colourless and associated with mycorrhizal fungi.
Antherozoids are multiciliate.

Division Lycophyta:

The sporophyte is differentiated into stem, roots, and leaves, representing an advance over Psilophyta.

The leaves are microphyllous, though a few of the fossil genera (*Lepidodendron*, *Pleuromia*) had leaves several feet long.

- The leaf is generally with a single unbranched vascular bundle (vein) but the leaf trace leave no gap in the stele.
- The vascular strands or steles may be protostelic, siphonostelic, or polystelic. Vascular tissue consists of xylem tracheids and phloem.
- Sporophylls produce a single sporangium on the adaxial side near its base. The sporophylls are borne in strobili. They are homosporous (*Lycopodium*) or heterosporous (*Selaginella*).
- The antherozoids are biflagellate or multiciliate.
- Secondary growth does not take place except *Isoetes*.

Division Sphenophyta:

- The sporophyte is differentiated into stem, roots and leaves.
- The stem possesses distinct ridges and furrows and is jointed with distinct node and internode. The branches arise in whorls from the node.

- The foliage leaves are borne in transverse whorls upon stems and their branches. The leaves are short lived and form a sheath around each node.
- The vascular cylinder is protostelic or siphonostelic. The leaf-gaps are absent.
- The sporangia are produced upon a specialized structure, the sporangiophores present at the apex of the stem. They are homosporous though some extinct forms were heterosporous.
- The antherozoids are multiciliate.
- The embryo lacks a suspensor and embryogeny is exosporic.

Division Filicophyta:

- The sporophyte is differentiated into stem, leaves and roots. In some genera roots are absent.
- The leaves are large in relation to the size of the stem and generally known as fronds.
- The stems are protostelic, siphonostelic, dictyostelic and sometimes polystelic. Except protostelic form they possess leaf-gaps in their vascular cylinders.
- The leaf bears many sporangia on either the margin or upon the abaxial face of the leaves. Mostly they are homosporous, but a few are heterosporous.
- The sex organs are found on the ventral surface of the heart-shaped prothallus (gametophyte).
- The antherozoids are multiflagellated.

Keywords

Cryptogams: Plants whose sexual reproductive organs are not conspicuous and without stamens, ovaries and seeds. These plants produce spores.

Dichotomous: The type of branching in plants that result when growing point divides into two equal growing points which in turn divide in a similar manner after a period of growth and so on.

Dictyostele: A siphonostele that is broken up by crowded leaf gaps into a network of distinct vascular stands or meristemes, each surrounded by an endodermis.

Fern: Any of numerous flowerless and seedless plants having true roots from a rhizome and fronds that uncurl upward and reproduce by spores.

Fertilization: The union of two similar or dissimilar gametes to form a diploid zygote.

Gametophyte: A gametophyte is a gamete bearing plant. It develops

from the meiospores produced by sporophyte by meiosis or reduction division. Gametophyte is a haploid structure.

Habit: The general external appearance of a plant, including size, shape, texture and orientation

Habitat: The place where a plant lives; the environmental conditions of its home.

Heterospory: The condition of producing two types of spores differing in size.

Homospory: The condition of producing only one type of spores.

Leptosporangiate: Sporangia developing from a single initial cell.

Life-cycle: In most of the plants multicellular diploid sporophyte phase alternates with a multicellular haploid gametophyte phase. This cycle is known as life-cycle or alternation of generation.

Monopodial: The mode of stem branching in which the main axis is formed by a single dominant meristem.

Pteridophyte: Plants having vascular tissue and reproducing by spores

Siphonostele: A medullated protostele.

Sorus: A group of sporangia as in ferns.

Spore: A haploid propagule produced by meiosis in diploid cells of a sporophyte that can germinate to develop a multicellular gametophyte.

Sporophyte: A sporophyte is the diploid multicellular stage in the life cycle of a plant. It develops from the zygote when a haploid egg cell is fertilized by a haploid sperm and each sporophyte cell therefore has a double set of chromosomes. The sporophyte produces spores by meiosis (hence the name sporophyte means spore bearing plant).

Stele: The central vascular cylinder of the axis (stem and root) taken as whole.

Vascular: An adjective referring to the conducting tissues (xylem and phloem) in vascular plants.

SUGGESTED READINGS

- *Biology and morphology of Pteridophytes*. Central Book Depot Allahabad By Parihar, N.S.
- *An introduction to Pteridophyta: Diversity and Differentiation*. Vikas Publishing House Pvt Ltd, New Delhi By A. Rashid
- *A Text Book of Pteridophyta*. Vikas Publishing House Pvt Ltd, New Delhi By Pandey, S.N., P.S. Trivedi and S.P. Misra
- *Botany for Degree students: Pteridophyta*. S. Chand Publications, Meerut By B.R. Vashishtha.