Chapter 9

Pteridophyta

- Seedless vascular plants, also known as **ferns and fern allies**, are a diverse group of plants consisting of about **10,000 species**.
- Pteridophyta claims a special position as the **first land plants**.
- Pteridophytes are also called **vascular cryptogams** as they possess **xylem and phloem (vascular tissues)**. Thus they are included as the **first group in tracheophyta**.
- In pteridophytes, xylem lacks **true vessels**. In phloem, **companion cells and sieve tubes are absent instead sieve cells are present**.
- Pteridophytes are nicknamed as **botanical snakes** as they evolved after bryophytes (botanical amphibians).
- During the **carboniferous period**, they were the **dominant land plant**.
- Pteridophytes were the **precursors to** modern seed bearing plants.

General characters

- Pteridophytes are mostly terrestrial.
- Grow well on **moist shady localities**.
- *Salvinia, Azolla* and *Ceratopteris* are **true aquatic ferns**.
- Some species of *Selaginella* and *Adiantum* are xerophytes.
- *Marsilea* occurs as a terrestrial, amphibious as well as an aquatic plant.
- The main plant body is sporophytic.
- They are generally herbaceous, rarely climbers.
- The plant body is differentiated into true roots, stem and leaves.
- The root system is of **adventitious type**.
- The roots possess a stele bound by **endodermis and pericycle**.
- The stem may be **aerial** or **rhizomatous**.
- Vasculature of stem shows different type of **stelar organisation**.
- The leaves are **microphyllous** or **macrophyllous**.
- Leaves may be scaly (*Lycopodium*, *Equisetum*) or simple (*Selaginella*, *Pleopeltis*) or pinnate (*Pteridium*, *Dryopteris*).
- The leaves may possess ligule (*Selaginella*). They may be sessile or petiolate.
- The leaves show **chlorenchymatous mesophyll** which may be uniform in aquatic forms or may be differentiated into **palisade** and **spongy parenchyma**.
- The stomata are generally present on the **abaxial** surface of the leaf.
- In *Isoetes* the plant body is distinguishable into a corm like rhizomorph bearing roots and leaves.
- Secondary growth is absent in pteridophytes except *Isoetes*.

Sporophyte

- Meiospores are formed inside **sporangia.**
- Borne on leaves called **sporophylls**.
- On the basis of development the sporangia have been classified by **Goebel**, (**1881**) into **two categories - eusporangiate** and **leptosporangiate**.
- **Eusporangiate** - A large sporangium developing from **several initial cells** producing many spores. These are sometimes fused to form **synangia**.
- **Leptosporangiate** - Small, specialized sporangia developing from a **single initial cell** producing a small, definite number (< 128) of spores. These often occur in a cluster (sorus) that is often covered by a flap of tissue known as an **indusium**.
- Sometimes sporangia form compact cone like structures bearing spores, called strobili (*Selaginella, Equisetum*).
- Sometimes sporangia are produced inside

specialised structures called **sporocarps** (eg *Marsilea, Salvinia, Azolla*).

- Most pteridophytes are **homosporous** *(Lycopodium, Equisetum*), which means that they produce one type of spore that contains both male and female parts.
- A few pteridophytes are **heterosporous** (*Selaginella, Marsilea)* which means they produce distinct male and female spores.

Gametophyte

- The gametophytes is called **prothallus**. The prothalli may be **monoecious** or **dioecious**.
- Gametophyte is small or inconspicuous and is usually **independent** and **bear sex organs**.
- The gametophyte are **exosporic in homosporous forms** and **endosporic in heterosporous form**.
- Sex organs are **multicellular** and jacketed.
- Antheridia are **completely embedded** in the prothallus while archegonia are **partially embedded**.
- Archegonia consist of **neck** which usually project from the surface prothallus.
- Archegonia contain **1-2 neck (14 in** *Lycopodium***)** canal cells. Venter is **absent**.
- Antheridia are generally **sessile**.
- The antheridia are having single layered jacket.
- Antherozoids are **uninucleate, spirally coiled biflagellate** or **multiflagellate structures** (ferns).
- Fertilization is affected by **water medium**. The antherozoids are attracted towards the egg by a **chemotactic stimulus** provided by the degeneration of neck canal cells and venter canal cell in the form of **malic acid**.
- The zygote (2n) formed after fertilization undergoes divisions wholly (holoblastic) or partially (meroblastic) to form embryo.
- The **young sporophyte is dependent** on the gametophyte in earlier stages for food which is drawn with the help of its foot.
- They show **heteromorphic alternation of generation**.

Stele

- The **conducting system of pteridophytes consists of xylem and phloem** and **associated parenchyma cells**, all of which are organised into **a stele** (L. *stela*, rod or column) that is generally separated from the outer cortex by a layer of endodermis.
- On the basis of the kind of stelar organisation that occur in different pteridophytes, an evolutionary sequence can be recognised among different groups of them.
- **Protostele** is the **simplest**, and **considered to be the most primitive type of stele**. It consists of a solid core of xylem surrounded by a cylinder of phloem, enclosing no pith.
- All other types of steles have evolved from it in the course of evolutionary specialisation. **Protosteles** are **most common in psilophytes and lycophytes**, but they occur also in the juvenile stems of ferns.
- Variation of the protostele include, the haplostele, actinostele, plectostele, and mixed-protostele.
- **Haplostele** is protostele with central solid and smooth core of xylem surrounded by phloem. This particular type of protostele has been **regarded as the most primitive among the different types**. It occurred in primitive psilophytes like *Rhynia*, and is found in a number of living genera, e.g. *Selaginella kraussiana*.
- **Actinostele** – In a number of pteridophytes, the central xylem core of a protostele is not smooth but is thrown into radiating ribs with the protoxylems at the extremities and phloem alternating with its rays, when seen in a cross section.
- **Mixed-protostele** – In *Lycopodium cernuum*, the xylem when seen in a cross section, appears in the form of irregular groups that are embedded in the ground mass of phloem. This type of protostele is called the mixed-protostele.
- A kind of stele in which there is present a pith in the central region is called a **siphonostele** or **medullated protostele**.
- This type of stele is thought to have been evolved from a protostele by a degradation or reduction of tracheary elements into parenchyma, and represents a stage in evolutionary advance.
- In siphonostele, the vascular tissues are arranged in the form of a hollow cylinder, with a distinct pith in the centre. The siphonostele and its variations are found frequently in the ferns.
- According to the distributional patterns of the xylem and phloem, the siphonostele has been classified into two types – **ectophloic siphonostele**, **amphiphloic siphonostele**.
- In the **ectophloic siphonostele**, the phloem occurs only on the outer surfaces of xylem cylinder. It is

found in *Equisetum* and some ferns, like *Osmunda* and *Schizaea.*

- In the **amphiphloic siphonostele**, the phloem may be both external and internal. An amphiphloic siphonostele is **also known as a solenostele**. It is found in the ferns, like *Adiantum* and *Marsilea*.
- In its simples form, the siphonostele has no leaf gaps, *e.g.,* some species of *Selaginella*. A siphonostele, which has no leaf gap is termed as **cladosiphonic siphonostele**.
- A siphonostele with gaps caused by leaf traces is termed **phyllosiphonic siphonostele**, e.g., *Marsilea*.
- Another modification of the siphonostele is seed in the internode of *Equisetum*. Here, the vascular system consists of collateral or bicollateral vascular strands, that is, they have xylem on the inside and phloem on the outside. Such arrangement is called a **eustele**.
- In some ferns, *e.g., Pteridium*, a complex type of stelar anatomy is seen in which there are two or more concentric vascular systems that are interconnected at intervals and usually all contributing to the leaftraces. Such stele is said to be **polycyclic**.

Classification of pteridophytes

- There are 4 major types of pteridophytes – **psilopsida**, **lycopsida (club moss)**, **sphenopsida (horse tail)**, and **filicopsida (ferns)**.

Psilopsida

- These are the **most primitive and oldest known land inhabiting plants**, which are **rootless**.
- Presence of rhizoids borne over the rhizome.
- Aerial stems are often dichotomously branched, green and photosynthetic.
- Leaflike enations may be present, leaf usually absent.
- Only stem contains vascular tissue – xylem and phloem.
- Sporangia are terminal or axillary, spores produced are homospores.
- Most of the plants include fossil genera – *Rhynia, Horneophyton*;
- **Living representatives** are only 2 – *Psilotum* and *Tmesipteris*, **both of them bear compound sporangia or synangia**.

Lycopsida

- Lycophytes are commonly referred to as **club moss** or **ground pine**, although they are neither moss nor pine, e.g. *Selaginella, Lycopodium.*
- The plant body is a **sporophyte** which is **differentiated into root, stem and leaf**.
- The leaves are **microphyllous** with spiral, whorled or opposite phyllotaxy.
- The stele is a **protostele**. But sometimes siphonostele or polystele may be present.
- Generally the sporophylls aggregate in the form of **cones** or **strobili**.
- The sporophyll bear a single large sporangium on the **adaxial surface**.
- The plants may be **homosporous** (*lycopodium*) or **heterosporous** (*Selaginella*).
- The gametophytes may be **endosporic** (within the spore wall as in flowering plants) or **exosporic** (spore germination with plant development outside the spore).
- Secondary growth absent except in *Isoetes*.
- In lycophytes, the gametophyte generation often depend on fungus for survival, as they **cannot produce their own food**.
- *Selaginella* show great variation in morphology as prostrate, sub-erect, climbers, etc.
- Leaves may be dimorphic or uniform in shape and size, presence of ligule and glossopodium (secretory leaf base).
- A leafless, colourless positive geotropic elongated cylindrical structure growing downward from point of bifurcation of stem is called **rhizophore**.
- Root is protostelic, monarch, with exarch xylem.
- In stem stele is diarch and exarch.
- In leaf stomata are present only on lower epidermis, no differentiation of mesophyll tissues, chloroplasts with pyrenoids.
- Vegetative reproduction is by fragmentation, bulbils, tubers, or apogamy.
- The strobiles or spike bears both megasporophylls (female) and microsporophylls (male).
- Development of sporanguim is eusporangiate.
- The microspore consists of 1 prothalial, 8 jacket cells and 4 primary androgonial cells.
- Antherozoids are spirally coiled and biflagellate.
- Archegonium consists of very short neck, single neck canal cell, a venter having ventral canal cell and an egg.
- Heteromorphic alternation of generation.
- Lycopsida includes both **fossils** and **living forms**.

Sphenopsida

- The members of this class are commonly called **horse tail**. All the forms except *Equisetum* are fossils.
- *Equisetum* is the **sole living representative of a large group of sphenopsids**.
- The sporophyte has true roots, stem and leaves.
- The stems are jointed having distinct **nodes** and **internodes**. The internodes are hollow and are longitudinally ribbed and furrowed.
- The leaves are scaly and found as whorl around the node.
- The stele may be a **protostele** or **siphonostele**.
- The sporangia develop on special structures called **sporangiophores**. The sporangiophores aggregate to form **strobili**.
- All species of sphenophyta are **homosporous** with autotrophic gametophytes or prothalli.
- The prothalli (gametophyte) may be monoecious or **dioecious** and **exosporic**.

Filicopsida

- The members of the class filicopsida are commonly called "**ferns**". These are the widely distributed vascular cryptogams, e.g. *Marsilea, Adiantum, Pteris*.
- The plants are **perennials**, widely distributed in damp shady places of the tropics.
- The plant body has roots, stem and leaves but in some roots may be absent.
- The stem is mostly **rhizomatous** and the **roots are of adventitious type**.
- The leaves are **macrophyllous** and are commonly called "**fronds**".
- Young leaves show **circinate vernation** (spirally coiled).
- **Furcate venation** is a fern character.
- The young leaves, young parts of rhizomes petiole and rachis of mature leaves are covered over by brown to black scales called **paleae** or **ramenta**.
- The stele may be **protostele, siphonostele or dictyostele**.
- Sporangia are born on the margins on the **abaxial surface** of the leaf, forming **sori**.
- In *Marsilea, Azolla, Salvinia* etc. the sori are present in a box like structure called **sporocarp**.
- The sorus may be naked or covered in **indusium** which may be true or false.
- **True indusium** is a membranous sheath of sorus specially developed to cover sorus whereas **false indusium** is formed by curving of the sporophyll margins.
- The plants are **homosporous** (*Pteris*) or **heterosporous** (*Marsilea*).
- Spores on germination gives rise to gametophytes (n) that produce antheridia and archegonia.
- Antherozoids are multiflagellated.
- The prothallus is usually monoecious **heart shaped, small, green** and **independent**.
- Vascular cylinder shows meristele (smaller units), xylem mesarch in *Dryopteris*.
- In roots xylem is exarch and diarch.

- *Selaginella lepidophylla* is called **resurrection plant**.
- Almost all coal is formed from the **pteridophytes**.
- Psilotales like *Rhynia* were **first tracheophytes**.
- **Smallest** pteridophyte is *Azolla* (an aquatic fern) and **largest** is *Cyathea* (tree fern).
- Bower and Goebel named **rhizophore** of *Selaginella* as an ***organ sui-generis*** *i.e.,* an organ having the characters of both *i.e.* stem as well as root, but independent in origin.
- The sporophytes reproduce asexually producing spores in sporangia.
- When similar type of spores are formed *i.e.* same size, the phenomenon is called as **homospory**.
- In some pteridophytes, two types of spores are formed which differ significantly in their size as also in function. This phenomenon is called as **heterospory**. Eg, *Selaginella*, *Isoetes*, *Stylites*, *Marsilea*, *Azolla*, *Salvinia*.
- The term **apogamy** was **coined by De Bary**, 1878. It is defined as formation of sporophyte from a gametophytic cell other than egg without fertilization. It was observed in several plants, eg. *Lycopodium*, *Selaginella*, *Marsilea* etc.
- The formation of gametophyte from a sporophytic cell without meiosis is called as **apospory**, *e.g. Pteridium*.
- Formation of sporophyte from egg without fertilization is called as parthenogenesis, *e.g. Selaginella*, *Marsilea*.

- In leaves, both bicollateral or concentric and collateral vascular bundles (in smaller Meres) are seen.
- In *Dryopteris* indusium is true, spores are monolete and bilateral type and homosporous.
- Prothallus is protandrous (antheridia mature first)
- Venter lacks a covering or jacket.
- *Psilotum* is a primitive fern with **no root system**. Leaves are small and veinless.

Table : Common names of some pteridophytes

Rootless pteridophyte	*Salvinia*
Xerophytic fern	*Woodsia elongata, Drynaria, Adiontum insicum*
Annogramma leptaphylla	Smallest fern.
Lycopodium	Club moss
Selaginella	Spike moss
Selaginella rupestris	Bird's nest moss
S. bryopteris	Sanjeevini
Adiantum	Walking fern
Dryopteris	Male shield fern

Economic importance

- Several pteridophytes, particularly the species of *Lycopodium*, *Selaginella*, *Lygodium* are ornamental.
- The plants of *Selaginella* are marketed as curiosities in the name of resurrection plants.
- *Lycopodium* is **used in skin diseases**, a few others species are used as kidney stimulant.
- *Azolla* is a water fern used as biofertilizer.

Evolutionary aspects of pteridophytes

- The **pteridophytes (vascular cryptogams) 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 the presence of water.
  - Encapsulation of embryo in the archegonium.
  - Dependence of early embryo (sporophyte) upon the gametophyte.
  - They exhibit regular alternation of generations.
- **The pteridophytes differ from bryophytes in the** following features –
  - In the 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 the 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 be stems with leaves but there are no roots.
  - All the vegetative organs of the sporophyte of pteridophyte possess vascular supply whereas bryophytes do not possess vascular tissue.
- 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 soprophytic 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 of xylem parenchyma, vessels being absent. Phloem consists of sieve-tubes and phloem parenchyma, the companion cells being absent.
- **Difference between pteridophytes and spermatophytes** –
  - Pteridophytes differ from the spermatophytes in that they do not produce flowers, fruits or seeds.
  - In pteridophytes, excepting few cases, the spores or gametophytes developed from them are invariably liberated from the 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.

End of the Chapter