PTERIDOLOGY

Evolution of Pteridophytes

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- **Origin of Pteridophytes:**
- The pteridophytes evolved in the Silurian period and subsequently got diversified in the Lower Devonian. There are controversies regarding their origin and evolution.
- There are two broad theories about their origin: according to one, **pteridophytes have originated from algal ancestor**, while the other school supported the **bryophytic origin hypothesis of pteridophytes**.

- **I. Algal Origin:**

- Many scientists believe that pteridophytes have originated from algae, though they are not unanimous about the type of ancestral algae.
- The concept of algal origin of pteridophytes is based on the similarity between algae (specially chlorophyceae) and pteridophytes.

- **The common characteristics for both the groups are:**
- 1. Thalloid gametophytes,
- 2. Similar photosynthetic pigments (chlorophyll a, b; carotenoids a
- 3. Cell wall made up of cellulose,
- 4. Starch as reserve food,
- 5. Flagellated sperms
- 6. Water essential for fertilisation.
- 7. Cell plate formation during cytokinesis, cell division features a complex network of microtubules and membrane vesicles (the "phragmoplast").

- **a. Lignier's Hypothesis:**
- Lignier (1908) supported the algal origin of land plant. He postulated that the pteridophytes arose from the Chlorophyta with dichotomising parenchymatous thallus. For the transmigration from water to land, the basal part entered the soil for anchorage and absorption purposes.
- The erect parts retained the photosynthetic function and the aerial portion with terminal sporangia became the primitive three-dimensional dichotomous branching system (e.g., Rhynia).

- **b. Church’s Hypothesis:**
- Church (1919) is believer of polyphyletic origin of pteridophytes and proposed the theory in his essay “Thallasiophyta and the sub-aerial Transmigration”.
- According to Church, a hypothetical group of advanced marine seaweeds called Thallasiophyta formed the ancestral stock for land plants (both bryophytes and pteridophytes).
- This transmigrant algae had metabolic efficiency of Chlorophyceae, somatic equipment and reproductive scheme of the Phaeophyceae.

- **The principal points of this theory are:**
- 1. The surface of the earth in ancient times was covered by a common ocean.
- 2. The marine algae were planktonic in nature.
- 3. There was upheaval of the ocean bottom due to geological plate tectonic revolution.
- 4. Subsequently, there was emergence of land and those planktonic forms became benthic in the shallow seas.
- 5. Further transmigration of those benthic forms to the subaerial conditions led to the establishment of a large advanced group of extinct seaweeds called Thallasiophyta.

- 6. Both the bryophytes and pteridophytes originated from this hypothetical Thallasiophyta group. The new terrestrial environment gradually allowed introduction of the various adaptive features like roots, leaves and vasculature in land plants.

The geological phenomena do not support Church's hypothesis. The difference in pigmentation between ancestral marine algae and early land plants also is a demerit of this hypothesis.

- **c. Fritsch's Hypothesis**:
- Fritsch (1916, 1945) suggested that Chaetophoraceous (green algae) ancestor gave rise both to the bryophytes and the pteridophytes. These algae had heterotrichous habit, comprised of prostrate and upright systems.
- An apical growing point was established in upright branches, thus the heterotrichous thallus gave rise to erect land plants (early vascular plants) by elaborating the erect portion and by diminishing the prostrate part.

- **d. Andrews' Hypothesis:**
- Based on the fossil marine algae such as Nematothallus, Protosalvinia, Crocelophyton, Andrews (1950, 1959) hypothesised that these algal groups independently gave rise to different groups of early vascular plants. The morphological diversities in Psilopsida, Lycopsida, Sphenopsida and Pteropsida support the above view.

- **e. Mehra’s Hypothesis:**
- Mehra (1969) proposed a polyphyletic origin of pteridophytes. He opined that both the bryophytes and pteridophytes have originated from the same hypothetical Protoarchegoniate group’. This hypothetic group arose earlier from its ‘Chaetophoraceous ancestors’.
- The Protoarchegoniate group gave rise to ‘Psilophytaceous line’ on one hand and to the ‘Lycopodiaceous line’ on the other hand.

- **II. Bryophytic Origin:**
- Many hypotheses have been put forward in support of bryophytic origin of pteridophytes, although there is no unanimity regarding the ancestral stock as well as the mode of origin. The bases of these hypotheses lies on the similarity between the early vascular plants and the sporophytes of certain mosses and hornworts.
- **The characteristics common for both the groups are:**
- 1. Heteromorphic life cycle,
- 2. Multicellular sex organs,
- 3. Motile and flagellated sperms,
- 4. Thalloid gametophytes,
- 5. Water necessary for fertilisation,
- 6. Retention of zygote within the female sex organs and embryo develops from it,
- 7. Plant and spore surfaces are covered with cutin (cuticle).

- Some of the theories in support of bryophytic origin of pteridophytes are described:
- **a. Anthocerotean Theory:**
- This theory was advocated by Campbell (1895). According to this theory, the sporophyte of Anthoceros shows many characteristics comparable to the sporophytes of early vascular plants. These include:
- (i) Sporophytes bear rhizoids instead of roots,
- (ii) Mechanism for indefinite growth through meristematic tissue,
- (iii) Presence of columella (e.g. Horneophyton),
- (iv) Limited tissue for spore production,
- (v) Capsules comprises of photosynthetic tissue and provided with stomata.

- Thus, the early vascular plants like Rhynia are derived directly from Anthoceros-like ancestor.
- Smith (1955) supported the anthocerotean hypothesis as proposed by Campbell with some modifications. He postulated that the anthocerotean sporophyte had shifted the meristematic region from the base to the apex. Thus, initiation of dichotomy was established by the apical meristem and the spore formation became restricted at the branch apices.
- The columella eventually evolved to form the vasculature of the land plant (e.g., Rhynia). So, in the course of evolution, the Sporogonites (an early hornwort or moss?) evolved.

- The Sporogonites consist of many parallel oriented sporangial stalks that terminate in elongate capsules containing a central colu-mella.
- Later, Horneophyton evolved from Sporogonites through the distal dichotomy. The lower parenchymatous corm and columellate capsule of Horneophyton are interpreted as a transitional form between Anthoceros and Rhynia type vascular plants. The further elaboration of basal part of Horneophyton eventually gave rise to the rhizomatous stem of Rhynia.

- **b. Strobilar Theory:**
- Bower (1894, 1908) was the propounder of this theory. According to Bower, the pterido-phytes have evolved from Anthoceros-Xype ancestor. He suggested that a well-differentiated sporophyte evolved by progressive sterilisation of the potentially sporogenous tissue

- **In this theory, Lycopodium selago (in which sporophylls are arranged singly throughout the body surface without organising into a definite stobilus) arose from Anthoceros ancestor through the following steps:**
- (i) Formation of continuous sporogenous tissue just outside the central columella (e.g., Anthoceros).
- (ii) The sporogenous tissue became superficial.
- (iii) The sporogenous tissue was segmented into separate masses by intercalated sterile tissues. This has been evidenced in some members of Anthocerotales.
- (iv) The isolated, segmented sporogenous masses became more superficial, thus alternating masses of sporogenous tissue and green sterile tissue were formed.
- (v) The green tissue expanded laterally to form leaf, thus sporogenous tissue (sporangium) came adaxially to the base of the leaf (e.g., Lycopodium selago).

- **c. Phyton Theory:**
- This theory was put forward by Celekovsky (1901). According to this theory, the fundamental part of the sporophyte was a leaf and not the axis (stem) and the axis formed later by the fusion of the leaf bases.

- **d. Protocorm Theory:**
- This theory was proposed by Treub (1890). According to this theory, the sporophyte of primitive pteridophytes was an undifferentiated mass, very much like a gametophyte. This has been substantiated by the occurrence of protocorm in some species of Lycopodium.
- Treub hypothesised protocorm to be an archaic sporophyte and an early transitional stage in the evolution of the sporophyte. The presence of permanent protocorm in Phylloglossum supports the protocorm theory.
- Bower (1907, 1935) discarded the protocorm theory and concluded that the protocorm is merely an adaptive structure to certain special environmental conditions.

- **Modern Interpretation:**
- Modern studies of cell ultrastructure, bio-chemical 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.
- Thus, Coleochaete is an excellent model for the algal ancestor of land plants and may be a modern representative of the algal group that gave rise to the land plants.

- **The evidences in support of the above view are:**
- (a) 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.
- (b) This thallus produces egg cells toward its periphery.
- (c) Once the eggs are fertilised, the zygotes are retained in this position on the parent thallus and supplied with nutrients through specialised transfer cells.
- (d) Zygote undergoes cell divisions while still retained on the parent plant.

- (e) There is greater number of meiotic products (8-32).
- (f) Reproduction with specialised male gamete similar to males of Bryophytes.
- (g) Phragmoplast cell division pattern like those of land plants.
- (h) Sporopollenin in the inner wall of the zygote.
- (i) Presence of lignin (a principal component of land plants).
- (j) Group II introns in the chloroplast genome like land plants.

- Thank You