**Topic:** **Life Cycle of *Selaginella***

# Life Cycle of *Selaginella*

*Selaginella* is a very large genus of about 700 tropical to temperate species growing almost everywhere on this Earth. Although so large, the genus shows a uniformity lacking in the genus *Lycopodium.* The genus is more abundant in the tropical rain forests in weak light and is also common in the warmer plains of India where *Lycopodium* does not survive. Some species are also xerophytic.

Most of them grow perennially by vegetative propagation while some are annual.
Some of the species are rather small (a few centimstres) resembling mosses while others may grow even to a length of 20 metres. 58 species are recorded by Alston (1945) from India which include *Selaginella rupestris, S. pentagona, S. megaphylla, S. proniflora, S. ciliaris, S. delicatula, S. chiysocaulos, S. pallidissima, S. sanguinolenta, etc. S. kraussiana* from Africa is commonly grown in greenhouses as an ornamental plant.

*Selaginella* shows considerable variation in the symmetry of the plant but most species are prostrate and creeping, a few are even climbing. A few xerophytic species (e.g., *S. lepidophylla and S. pilifera*) typically roll up the leaves and become ball-like but open up into normal green plants when put in water even when dead. These are often sold inside bottles as curiosities.

*Selaginella* shows great uniformity even cytologically. Most species show the basic number n = 9. A few species are polyploids. However, the genus *Selaginella* has been divided into two subgenera according to the sporophytic form. In the subgenus *Homoeophyllum (Selaginella rupestris, etc.),* the plant body has a tendency to be upright with radially arranged, more or less uniform (isophyllous) leaves.

In the sub-genus *Heterophyllum* the plant body is more or less dorsiventral and prostrate with a distinct *heterophylly (anisophyily)* of the leaves. There are only about 50 species, in the subgenus *Homoeophyllum* while all the rest are in the subgenus *Heterophyllum.* As the latter is the commoner and more typical form this is being described in what follows. The most typical species is *Selaginella kraussiana.*

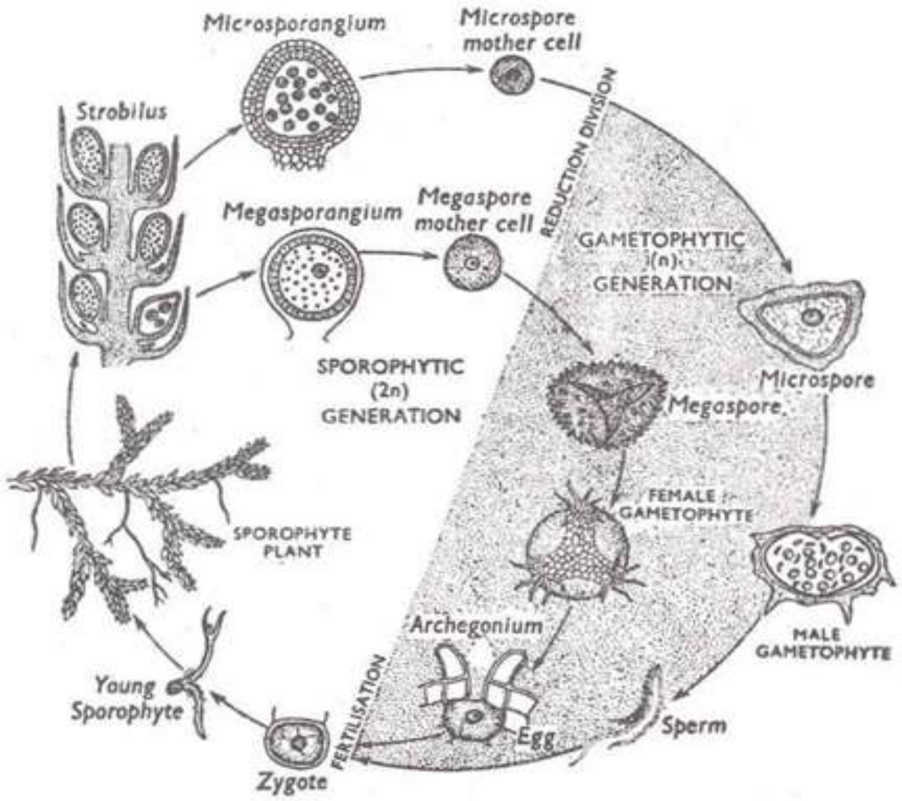


Fig. 553. Life cycle of *Selaginella*.

**The Sporophyte:**

The common *Selaginella (viz., S. kraussiana— Fig. 546A & B)* has a horizontal creeping stem branching along one plane giving rise to a more or less dorsiventral plant body. The branching is dichotomous but often appears to be monopodial because of stronger growth of the main stem. Here and there rhizophores grow vertically down from the forking's of the dichotomies.

Adventitious roots develop where the rhizophores meet the soil. Plants are often 'floating' being kept propped up by the rhizophores.

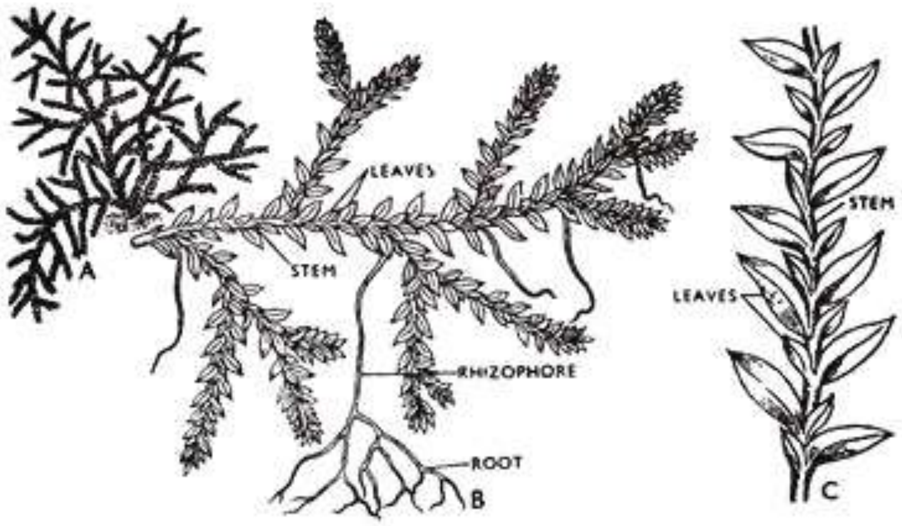


Fig. 546. *Selaginella kraussiana*. A. General habit. B. A bit of sporophyte. C. A bit of stem showing leaf arrangement.

In the *Heterophyllum* subgenus of *Selaginella* the leaves are of two types (dimorphic). There are four rows of leaves—two rows of smaller leaves on the upper side and two rows of larger leaves on the lower side. Actually, the leaves are arranged in an artiso-phyllous opposite order (Fig. 546C) though in some species the arrangement may look spiral.

At each node there is one small leaf on the upper side and one large leaf on the lower side. Flattening (dorsiventrality) of the stem may disturb this arrangement.

The leaves (Fig. 546C) are microphyllous with a single median vein and lanceolate to ovate in shape becoming narrower at stem attachment. In some species the smaller leaves become filiform. Each leaf bears on its upper surface near its base a small, membranous, tongue-like outgrowth called the ligule. The ligule shrinks and becomes inconspicuous in mature leaves.
The original embryonic root is short-living. All other roots are adventitious from the tips of the rhizophores.

The apical growth of most species is by a single pyramidal cell with three cutting faces. But, in a few species a group of meristem cells has been observed.

The anatomy of the mature stem is very distinct. A t.s. of *S. kraussiana* (Fig. 547A) shows a single layer of epidermal sclerenchymatous fibres without any stomatal opening.
Below it is the cortex of angular parenchymatous cells usually without intercellular spaces. The outer cortex cells are thickened in some, specially, xerophytic species.

The vascular cylinder in *Selaginella* species varies from protostelic to siphonostelic and monostelic to polystelic (with 2 to 16 separate steles). But, on the whole the stelar arrangement is simpler than in *Lycopodium. S. kraussiana* is distelic. The course of the steles is shown in Fig. 547B.

Each stele is surrounded by an endodermis which is a normal compact ring is very young stems but each cell becomes greatly elongated in the axis radial to the stele and also laterally separated from one another by big air gaps in the mature stem. Thus, the endodermal cells in the mature stem are the trabeculae of long radiating cells bridging the wide space between the steles and the inner face of the cortex.

In spite of this radial elongation, the endodermal cells still retain the transverse girdles of casparian strips. Inside each endodermis is one layer of pericycle enclosing a simple protostele.

In the stele there is an exarch xylem at the centre, the metaxylem showing tracheides and a protoxylem lies towards the circumference. The xylem is surrounded by one or two layers of parenchyma which again is surrounded by a single layer of sieve tubes with sieves on lateral walls forming the phloem outside which is the pericycle.

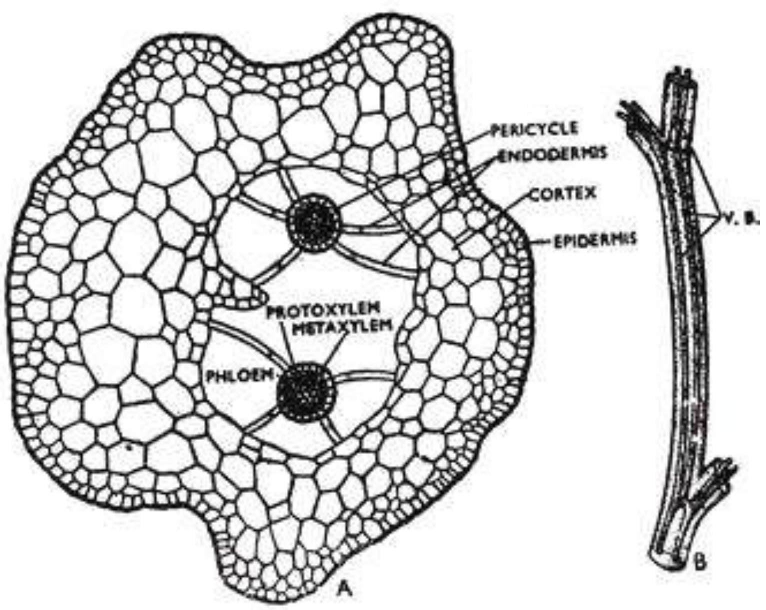


Fig. 547. *Selaginella kraussiana*. A. T.s. of stem. B. L.s. of stem showing course of steles (marked V.B.)

In some other species of *Selaginella* some complexities are noted in the stele. While secondary growth is not normal, in *S. selagirvlloides* a few secondary xylems do develop.

In certain species *(e.g., S. rupestris, S. densa, S. arizonica, S. rupicola)* the metaxylem is almost wholey formed of true vessels formed by the dissolution of end walls with only a few trachcides inter mixed. These are usually species showing spiral arrangement of vegetative leaves.

The adventitious roots (all roots in a mature plant are adventitious) are delicate, sparingly branched structures. AT.S.. of a root shows a very simple arrangement with a small monarch stele.

A T.S. of the rhizophore which shows a monarch arrangement is also as simple as that of a root. This fact, combined with its positively geotropic nature, has led some to believe that it is a root. But, its exogenous origin, lack of a cap and the experimental production of leafy shoot from the apices of decapitated rhizophores seem to prove that it is actually only a modified stem. Bower (1908) and Goebel (1905), however, concluded that it is an organ of sui generis which is neither a root nor a stem.

A T.S. of the leaf (Fig. 548A) shows a simple organization. There is a simple vascular bundle at the centre. The epidermis is one layer thick and the stomata are usually present on the lower epidermis only. The mesophyll is uniformly formed either of all spongy or all pallisade-like elongated cells full of air spaces. Mesophyll cells have single cup- shaped or many chloroplastids according to species.

In all cases there are several spindle-shaped, pyrenoid-like bodies at the centre of each chloroplast. The bodies may be transpapent through ligule at base of leaf, formed into rudimentary starch grains. The only other embryophyte with similar chloroplasts is the Anthocerotopsida.

The ligule (Fig. 548B) is differentiated rather early. It matures and withers away also early. It has a cup-shaped sheath at base. The sheath cells in *S. kraussiana* have casparian strips as in an endodermis. Immediately above the sheath is the hemi-spherical Glossopodium formed of large cells full of a greatly vacuolated protoplasm.

The structure of the ligule has suggested that it is a water-absorbing or exuding structure serving for the protection of the growing leaf or the sporangium.

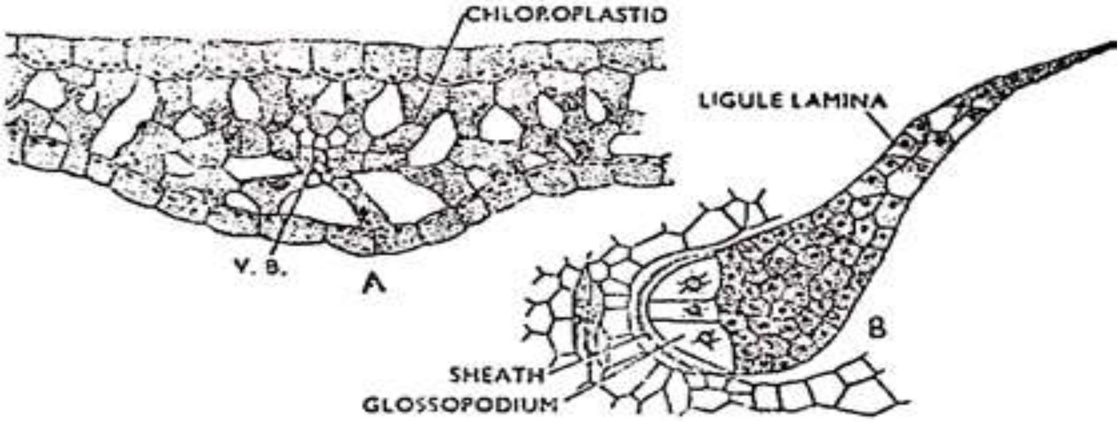


Fig. 548. *Selaginella kraussiana*. A. T.s. of leaf. B. Vertical l.s. through ligule at base of leaf.

When the plants become mature the branches terminate in the sporangiferous spike or strobili. The sporophylls are all alike resembling the larger vegetative leaves but the sporangia are of two types—microsporangia and megasporangia . So that the sporophylls also are called microsporophylls and megasporophylls.

The sporophylls are spirally arranged on the stem roughly forming four vertical rows. In most species microsporophylls and megasporophylls are borne on the same strobillus but in a few cases they may be in different strobili. The position of the micro- and megasporophylls vary in the different species.

In some the microsporophylls are on top and the megasporophylls below, in others the microsporophylls are on one side of the strobili while the megasporophylls are on the other vertical half. In *S. kraussiana* (Fig. 549A) the megasporophylls occupy a part of the base on one half.

In the development of the sporangium, each sporangium develops from a group of initials (it has been disputed that in some cases there is a single initial) either on the stem immediately on the sporophyll or at the axil of the sporophyll (Fig. 549B & G).

When mature, the sporangium is always located at the axil of the sporophyll below the ligule and is reniform or obovoid in appearance with a stalk. The initial cells divide into the upper jacket initials and the lower archesporial cells.

The former develops a jacket two cells in thickness and the later differentiates into an outer tapetum and an inner group of spore mother cells. In the microsporangium (Fig. 549D) most of the spore mother cells are functional and give rise to the microspore tetrads on reduction division. In the megasporangium only one spore mother cell remains functional.

On reduction division this gives rise to a tetrad of megaspores arranged tetrahedrally. The megaspores increase greatly in size with the megasporangium so that a megaspore is much larger than a microspore and a megasporangium is larger than a microsporangium.

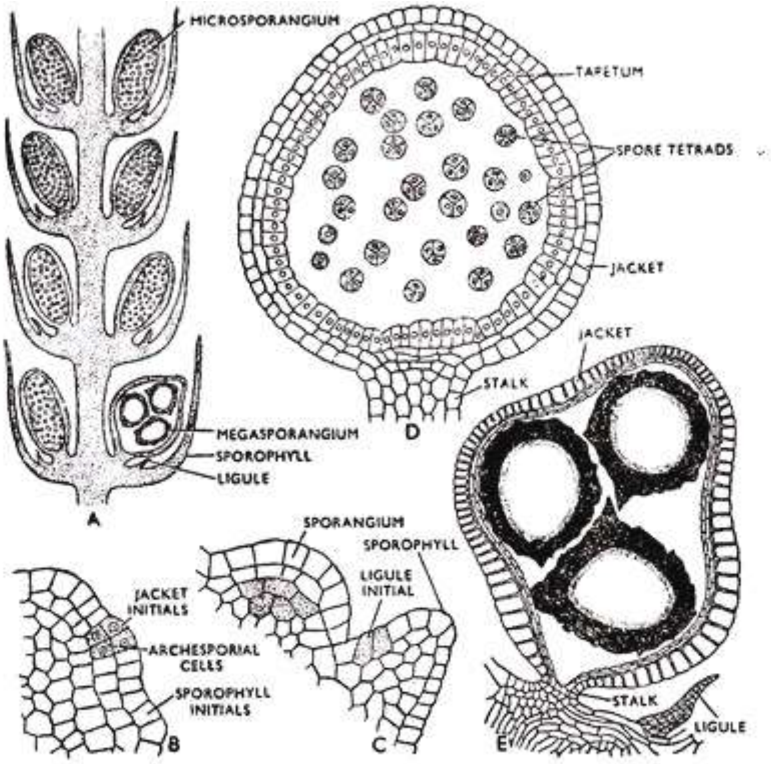


Fig. 549. *Selaginella kraussiana.* A. Median l.s. of strobilus. B–C. Stages of development of sporangium, sporophyll and ligule. D. Microsporangium. E. Megasporangium (3 out of 4 megaspores visible in one plane).

Enlargement of the megaspores cause the megasporangium (Fig. 549E) to have a four-lobed appearance, each lobe enclosing a megaspore. This pressure and the drying up of the sporangial wall cause a splitting of the megasporangium into two valves along an unthickened vertical line on the wall.

In some cases some of the four megaspores may even fail to enlarge giving rise to megasporangia with 1, 2 or 3 megaspores.

**The Male and the Female Gametophytes:**

The microspores are very small and with a 2-layered wall (exine and intine). The exine is usually ornamented with spines. Its shape is more or less tetrahedral with one side rounded. This soon germinates to form the male gametophyte. A small lens- shaped prothallial cell is cut off on one side and the other large cell becomes the aniheridial Initial (Fig. 550A).

The antheridial initial develops an antheridium which shows four central primary somatogenous cells surrounded by a jacket of 8 cells (Fig. 550B). The microscope may be shed from the plant during any of these stages. After shedding, the primary spermatogenous cells undergo repeated divisions forming up to 256 sperm cells.

Meanwhile, the exine cracks and the jacket cells with the prothallial cell disintegrate so that the bi-ciliated sperms (Fig. 550D) swim freely inside the mature gametophyte (Fig. 550C).

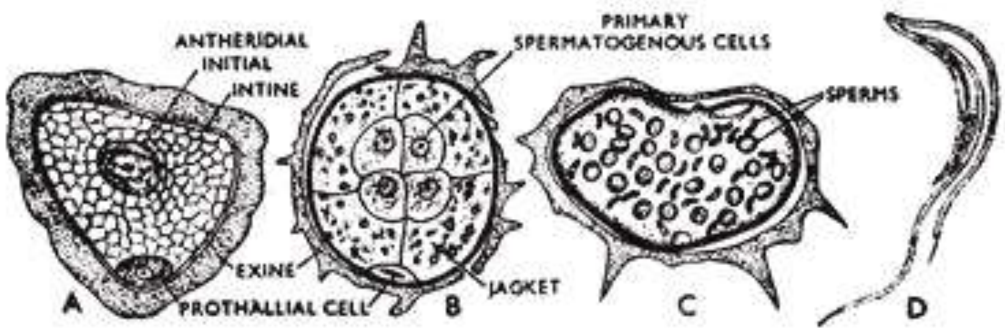


**Fig. 550.** Development of male gametophyte of *Selaginella kraussiana*. A–B. Stages of developmen C. Mature stage. D. A sperm.

The megaspore also shows a 2-layered wall with a very thick and sculptured exine and a thin inline. A triradiate ridge is prominent on the top of the tetrahedral structure (Fig. 551 A).

The stage at which the megaspore is shed is extremely variable. It may be shed from the sporangium before any trace of cellular organisation, shortly after the first archegonia are formed or it may be retained within the sporangium until after fertilization and a considerable development of the embryo. Development of the female gametophyte begins with a conspicuous enlargement of the megaspore.

The megaspore nucleus divides repeatedly without immediate formation of cell walls (free cell formation). A conspicuous central vacuole with many free nuclei around it in a gradually thickening peripheral cytoplasm is organised (Fig. 551B).

Very often, the outer thickened part of the megasporangial wall grows much faster than the thinner inner wall leaving a gap between the two as seen in Figure 551B. In the next stage, a cellular tissue 2 or 3 cells in thickness is formed by wall formation at the pyramidal end of the female gametophyte.

This tissue is separated from the rest of the gametophyte by a conspicuous diaphram below which the free nuclei remain round the central vacuole (Fig. 551C). Eventually the central vacuole is obliterated by the increasing cytoplasm but this lower part remains multinucleate until the embryo begins to develop.

The apical tissue now becomes exposed by the cracking of the spore wall above it along the triradiate ridge. The exposed tissue may become green and on falling to ground, rhizoids may develop on it in patches (Fig. 551D).

However, this photosynthetic tissue and rhizoids are of minor importance as far as the nutrition of the gametophytes is concerned as the reserved food in the lower part is of much greater importance for the nutrition of the gametophyte and the growing embryo. All superficial cells on the apical tissue are potential archegonial initials.

An archegonial initial divides periclinally to form a primary cover cell and a central cell (Fig. 551E). The central cell again divides periclinally to form a primary neck canal cell and a primary ventral cell.

The primary ventral cell forms a ventral canal cell and an egg by another periclinal division. The cover cell forms a 2-tiered neck which protrudes out and spreads apart to open the inner passage (Fig. 551F). The primary canal cell does not divide so that there is a single canal cell. While the archegonia are being formed, the free nuclei below form walls and organise into large cells (Fig. 551G).

This tissue below is nutritive to the archegonia and the future embryo above so that this is the endosperm of *Selaginella* which is a gametophytic tissue as distinguished from the triploid endosperm .of the Angiosperms.

Fertilization may take place while the female gametophyte is still within the unshed megasporangium on the plant or after it is shed. Apogamy and parthenogenesis are known in several species. Embryos are known to arise out of archegonial initials, eggs in unopened archegonia and also out of sporophytic cells in species not forming microspores.

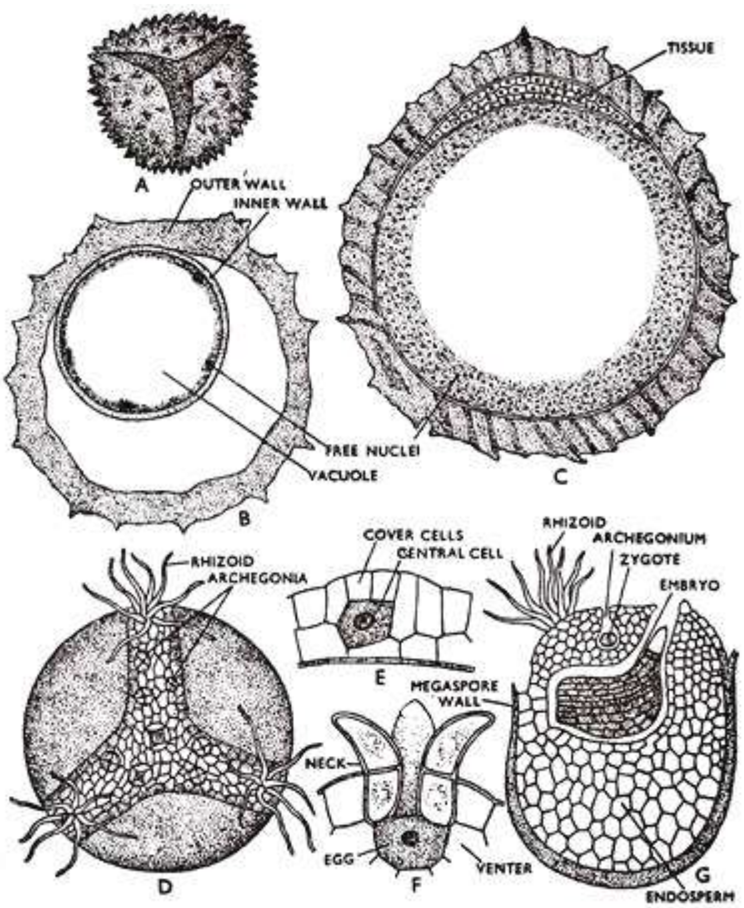


Fig. 551. *Selaginella kraussiana*. A. A megaspore. B–D. Stages of development of female gametophyte. E–F. Stages of development of archegonium. G. A fully mature female gametophyte.

**The New Sporophyte:**

The first division of the zygote is usually transverse (Fig. 552A). The upper cell gives rise to the one or more celled suspensor and the lower cell to the embryo. The embryo initial divides vertically (Fig. 552B). The two resultant cells again divide vertically to form four cells one of which cuts off the stem initial from its base (Fig. 552C).

Gradually, the embryo organizes into sectors on one side of which is the stem between two cotyledons, on the other side is the foot (for sucking food material from the endosperm) occupying a major part of the base and the rhizophore initial on the top of it (Fig. 552D).

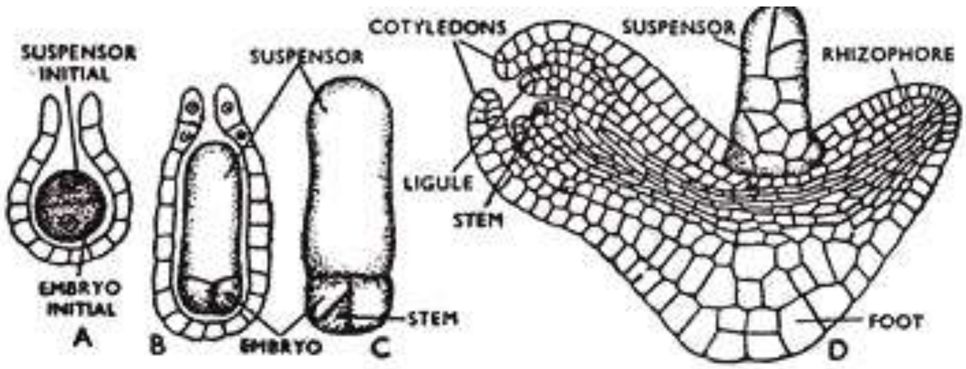


Fig. 552. A–D. Stages of development of *Selaginella* embryo (after Bruchmann).

The new sporophyte eventually pierces through the surrounding gametophyte and establishes itself as an independent plant after growing adventitious roots from the rhizophore. It is to be noted that, unlike most Pteridophytes, it shows two cotyledons and even a hypocotyl.

**References:**

1. https://www.biologydiscussion.com/plants/life-cycle-of-selaginella-with-diagram-plants/58829
2. Studies In Botany (Volume-I). Jatindra Nath Mitra, Debabrata Mitra, Salil Kumar Choudhuri, Moulik Library,2000, ISBN: 978-93-81676-01-1.

(All the above mentioned information including the figures are collected from the above references and will be solely used for teaching and learning purposes).