

Course- B.Sc.Part-I Botany Subsidiary

PAPER-I

Topic - Anatomy of Stem of Equisetum and Reproduction in Selaginella (Pteridophyta)

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Stem of Equisetum

Stem (Anatomy)

To study the internal structure of the stem, the transverse and longitudinal sections passing through the nodes and internodes are required. This way the internodal and nodal anatomy of the aerial stem may be studied separately. It is as follows:

The stem is covered over by a single layered epidermis interrupted by stomata situated in the grooves of furrows. The epidermis is always impregnated with a thick layer of silica. The deposition of the silica on the epidermal layer gives the rough appearance- to the stem, and therefore, the Equisetum plants are also known as 'scouring rush or scouring rushes'.

The stomata are found in grooves of the aerial shoots. The development of the stomata is somewhat peculiar in the sense that the initial divides twice by successive longitudinal divisions and this way the two innermost cells develop into the guard cells, whereas, the two outermost cells develop into accessory cells on being mature of the stomata, the two accessory cells completely overarch the guard cells and the stoma. In majority of the species, e.g., *E. hymeale*, *E. ramosissimum* etc., the stomata are sunken, whereas in some other species, e.g., *E. palustre*, *E. pratense* etc., they are situated on the surface of the epidermis. The silica is deposited in the wall of guard cells in transverse radial bands.

Just underneath the epidermis, there is broad cortex. The cortex consists of mechanical and assimilatory tissue. In the outer cortex, just beneath each of the ridges, there is a strand of sclerenchyma. Usually the sclerenchyma is restricted to the periphery but in *Equisetum giganteum* it extends inward to the endodermis. These columns of sclerenchyma are chief mechanical elements of the shoot. In addition to the above mentioned sclerenchymatous columns, the sclerenchyma strands are also found in the furrows. Here, each strand is situated in between the curved strands of chlorenchyma. The chlorenchyma possess well developed intercellular spaces. These spaces are very much distinct below the stomata. These chlorenchymatous bands are found beneath the sclerenchymatous strands situated underneath the ridges. The ends of the chlorenchymatous bands touch the epidermis in the grooves. Since the leaves are small, scaly and have a smaller number of chloroplasts the chlorenchyma of the cortex of the shoot is the major photosynthetic tissue. The inner cortex is composed of thin walled parenchyma with well-developed intercellular spaces. In this region of the cortex the air spaces known as vallecular canals are also present Usually vallecular canals are found

opposite the furrows in the deeper tissue of the cortex. They are alternate to the vascular bundles. These canals are filled up with air.

The endodermis is the last layer of the cortex. In *E. arvense*, *E. telmateia*, *E. palustre* and certain other species, the endodermis surrounds the entire stele. In *E. giganteum*, *E. limosum* and some other species, each vascular bundle is surrounded by separate endodermal layer. In other cases, e.g., *E. hyemale*, *E. ramosissimum* etc., there is a common internal endodermis inside the ring of bundles delimiting the pith and common outer endodermis found outside ring of bundles. Just beneath the endodermis a single layered pericycle is found. The pericycle is the outermost layer of the stele.

Equisetum arvense anatomy of stem

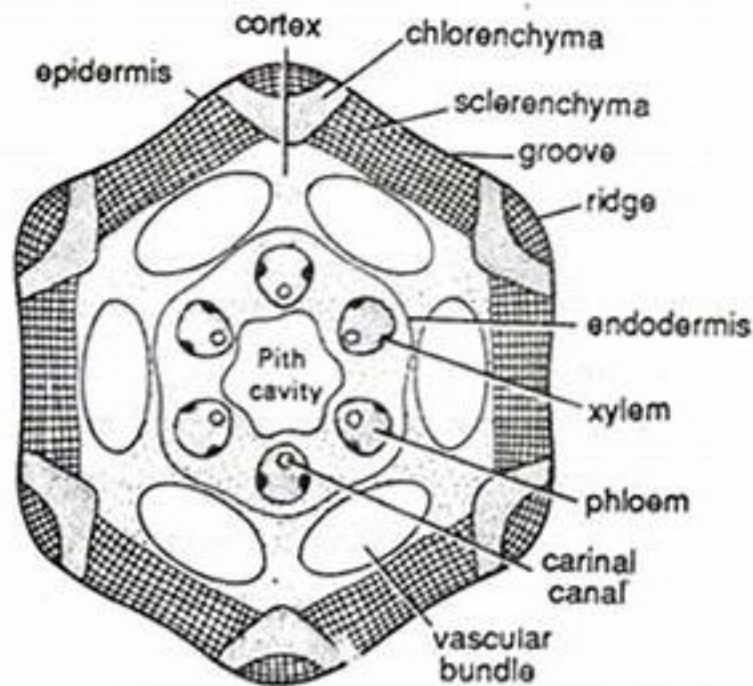
The vascular skeleton, i.e., stele of *Equisetum* is siphonostelic. The separated vascular bundles are arranged in a ring. The vascular bundles are situated opposite the ridges and alternate to the vallecular canals. The number of bundles varies from species to species. In each internode, as many vascular bundles are found as there are leaves at the node. The vascular bundles alternate to each other in their position in the successive nodes. The internodal portions are longitudinally perforate, and each perforation runs the length of an internode. The perforations in the internode are situated above the traces. These perforations are not branch gaps. The vascular bundles are collateral type and resemble to some extent to that of monocotyledons. The vascular bundles contain both metaxylem and protoxylem. A carinal canal is developed in each bundle, because of the disintegration of the early-formed tracheids of the protoxylem during elongation of the surrounding cells of the internode. The remaining protoxylem elements are composed of few tracheids. These protoxylic elements are found arranged to the margin of carinal canal. The metaxylem elements are found in two groups. The two groups are found arranged on the margin of the carinal canal towards outside. The protoxylem lies in between the two groups of metaxylem. The metaxylem elements are composed of reticulate, scalariform or pitted tracheids. Sometimes spiral and annular tracheids are also found. The protoxylem is endarch and as supported by Eames (1909) and Miss Barrat (1920) the development of xylem is centrifugal. The phloem is composed of sieve tubes and phloem parenchyma. The sieve plates may also be seen. The companion cells are not found. The secondary growth is altogether absent. The central region of the stem is occupied by a hollow pith. The carinal canals are filled up with water.

Nodal Anatomy

The alternate vascular bundles of the successive internodes are connected to each other by short branches and this way a continuous ring of the vascular cylinder is found in the node. Eames (1909) reported that the bundles at the nodes do not have carinal canals. Here, the protoxylem elements are intact and completely occupy the lacuna or carinal canal. At the node, the pith is not hollow and it forms a diaphragm separating the two successive internodes.

Rhizome

The anatomy of the rhizome is quite identical to that of the aerial shoot. However, the assimilatory tissue and the stomata are not found in the rhizome. The mechanical tissue, i.e., sclerenchyma is poorly developed as compared to that of the aerial shoot. In *E. arvense*, the pith is solid, whereas in certain other species, the pith and the vallecular canals are very much reduced.



Equisetum. T. S. internode of aerial sterile shoot (diagrammatic).

Reproduction in *Selaginella*

Selaginella is heterosporous. Two types of sporangia (larger ones megasporangia and smaller ones microsporangia) containing larger and smaller spores are borne on sporophylls which form cones terminally either on the stem or branches.

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 (or macrosporangia) 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 strobilus 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 mega-sporophylls below, in others the microsporophylls are on one side of the strobili while the megasporophylls are on the other vertical half. In *S. kraussiana* the megasporophylls occupy a part of the base on one half.

Development of Sporangia

In the development of the sporangium, each sporangium develops from a group of initials either on the stem immediately on the sporophyll or at the axil of the sporophyll .

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 latter differentiates into an outer tapetum and an inner group of spore mother cells. In the microsporangium most of the spore mother cells are functional and give rise to the microspore tetrads on reduction division. In the mega-sporangium 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 mega-sporangium so that a megaspore is much larger than a microspore and a mega-sporangium is larger than a microsporangium.

Enlargement of the megaspores cause the mega-sporangium 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 mega-sporangium 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 mega-sporangia with 1, 2 or 3 megaspores..

At the time of liberation, the male gametophyte normally consists of 13 cells; one small prothallial cell, eight jacket cells and four androgonial cells. The microspore divides unequally to produce bigger antheridial cell and a smaller prothallial cell. The antheridial cell divides to produce four cells which intersect at the centre of spore.

Each of these cells cuts off one primary androgonial or spermatogenous cell towards inside and one jacket cell towards outside. The androgonial cells undergo further divisions to produce 128 or 256 biflagellate antherozoids which are liberated when the spore wall cracks open along the triradiate mark. The sperms in Selaginella are the smallest among vascular plants.

The stage at which the megagametophyte is shed is variable. It may be liberated as a single cell or after the differentiation of archegonia. Rarely it is retained in the sporangium. Development of megagametophyte is initiated by free-nuclear divisions in megaspore and with the appearance of a large vacuole these nuclei get dispersed to the periphery.

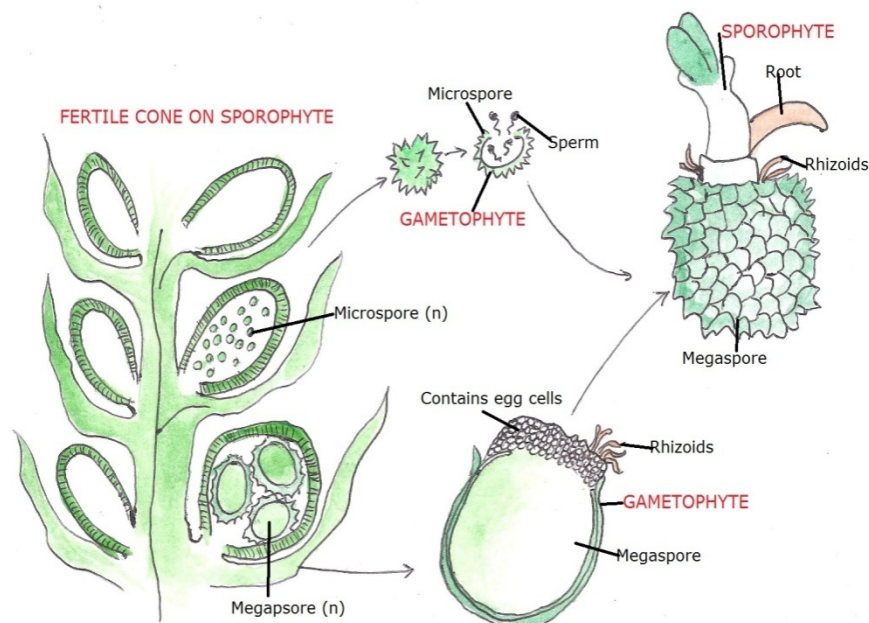
This is followed by cell wall formation and a cushion-shaped tissue differentiates beneath the triradiate mark and ultimately the vacuole is obliterated by the formation of cells. In some species the lowermost cells of cushion become thickened and form a diaphragm separating it from the rest of the gametophyte.

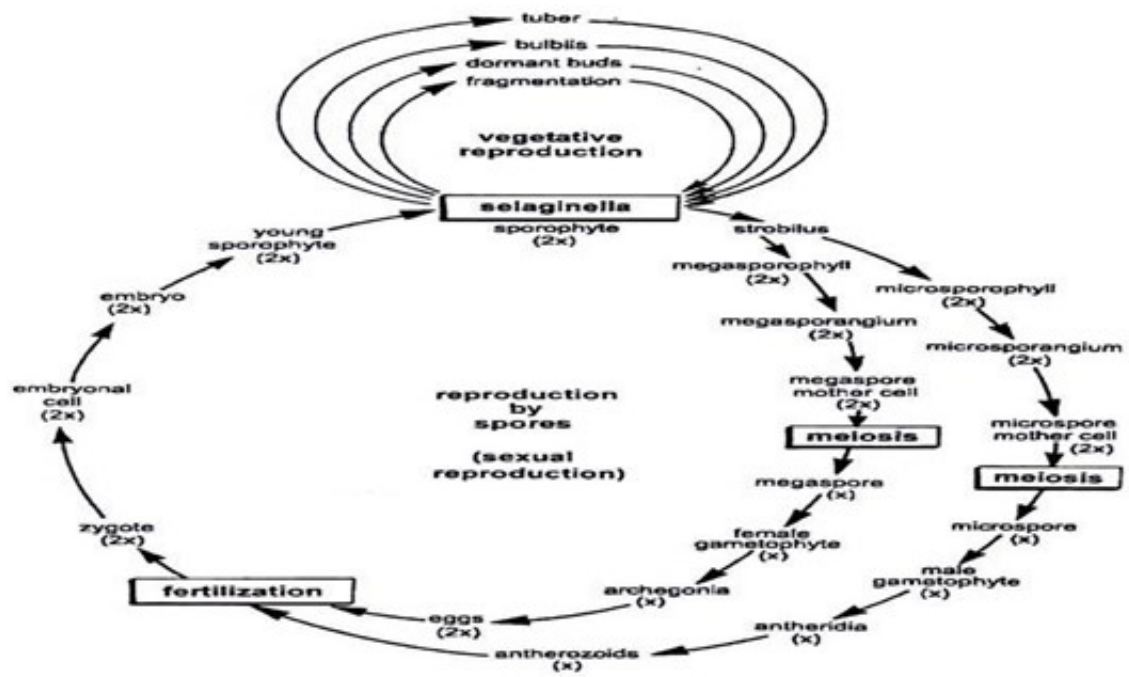
Archegonial initials differentiate on the surface of cushion . The archegonia are embedded in the gametophyte at the venter region and their two-celled necks project at the gametophytic surface. The axial row comprises one neck canal cell, one venter canal cell and an egg.

Embryogeny

The first division of fertilized egg is transverse forming a suspensor cell above and an embryonic cell below. The contributions of these cells to embryo, its position and organization are variable in different species. In some species the embryo develops in the cushion region whereas in *S. kraussiana* venter of the archegonium extends carrying the embryo deeper in nutritive tissue.

Otherwise normally elongating suspensor serves this purpose . In *S. martensii*, which represents typical embryogeny, outer cell forms the suspensor, and the lower embryonic cell forms embryo with shoot apex, root apex, and swollen foot. Contrary to this, in *S. denticulata* all parts of the embryo are derived from outer cell. In between these two extremes are *S. kraussiana* and *S. galeotti*. In the former the outer cell forms the vestigial suspensor and also the foot, and in the latter suspensor, foot, and root are derived from the outer cell.





Selaginella : schematic life cycle