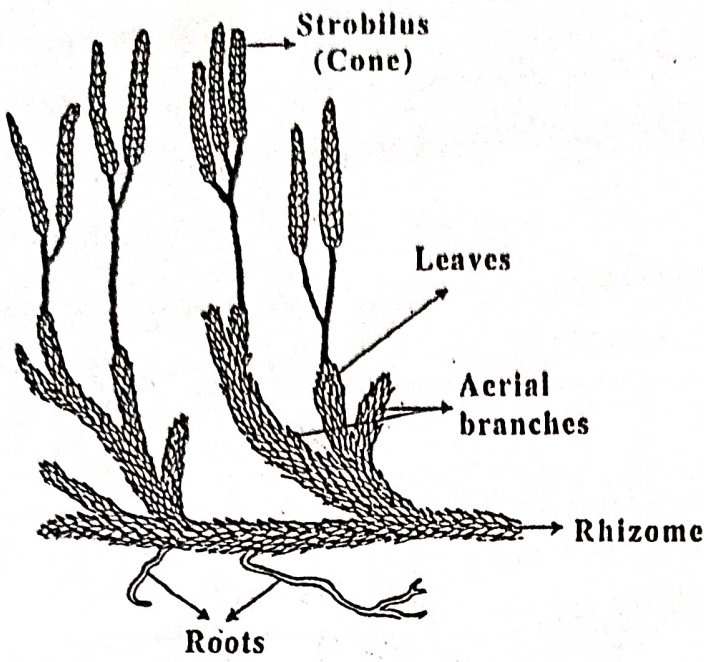
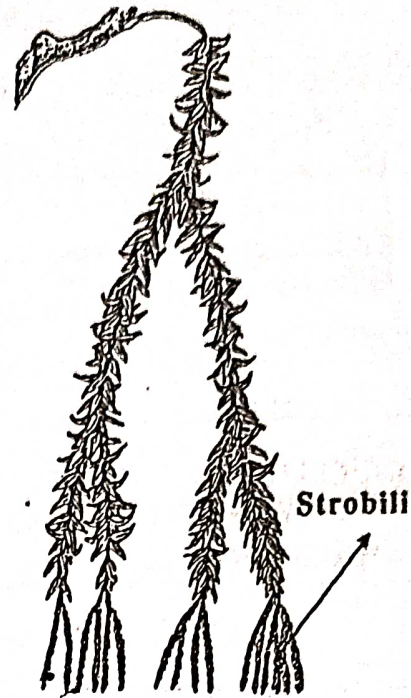


at the apices of the branches. The strobili are the sporangia containing structures. The sporangia are the spore producing structures."



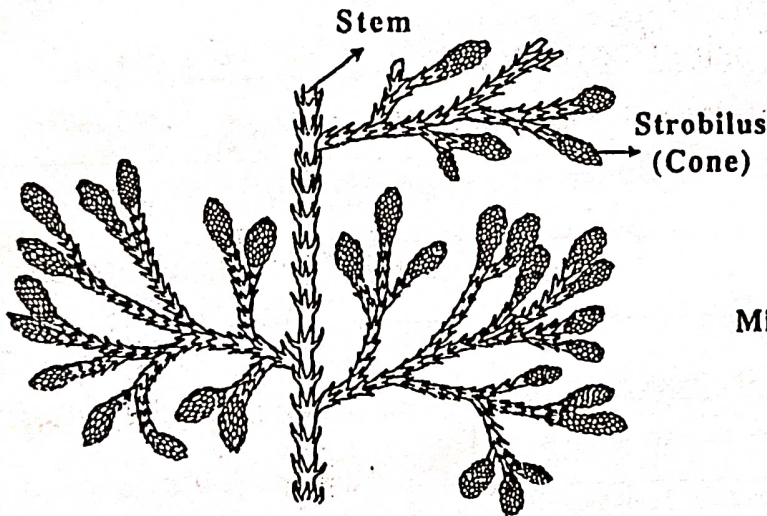
A

Lycopodium clavatum



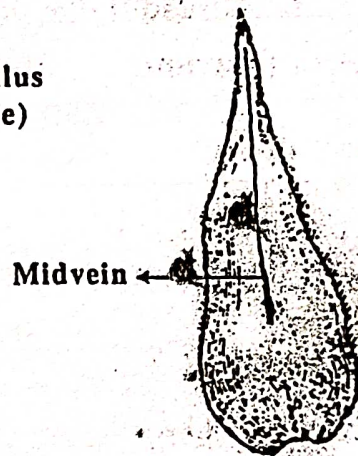
B

Lycopodium phlegmaria



C

Lycopodium cernuum



D

Leaf

Fig. 106(A-D). PTERIDOPHYTA: *Lycopodium* - External features of sporophyte.

INTERNAL FEATURES OF STEM (T.S.):

The stem is circular and wavy in outline in T.S. It is with ridges and furrows. The T.S. shows following internal structures.

- (i) Epidermis.

... layer of the stem. It is made up of a single layer of parenchymatous cells. It is provided with stomata.

Cortex:

It is present just below the epidermis. It is differentiated into outer cortex, middle cortex, inner cortex and endodermis.

Outer cortex:

It is present just below the epidermis. It is made up of many layers of chlorenchymatous cells below the ridges and of sclerenchymatous cells below the furrows.

Middle cortex:

It is present just below the outer cortex. It is made up of many layers of parenchymatous cells without intercellular spaces.

Inner cortex:

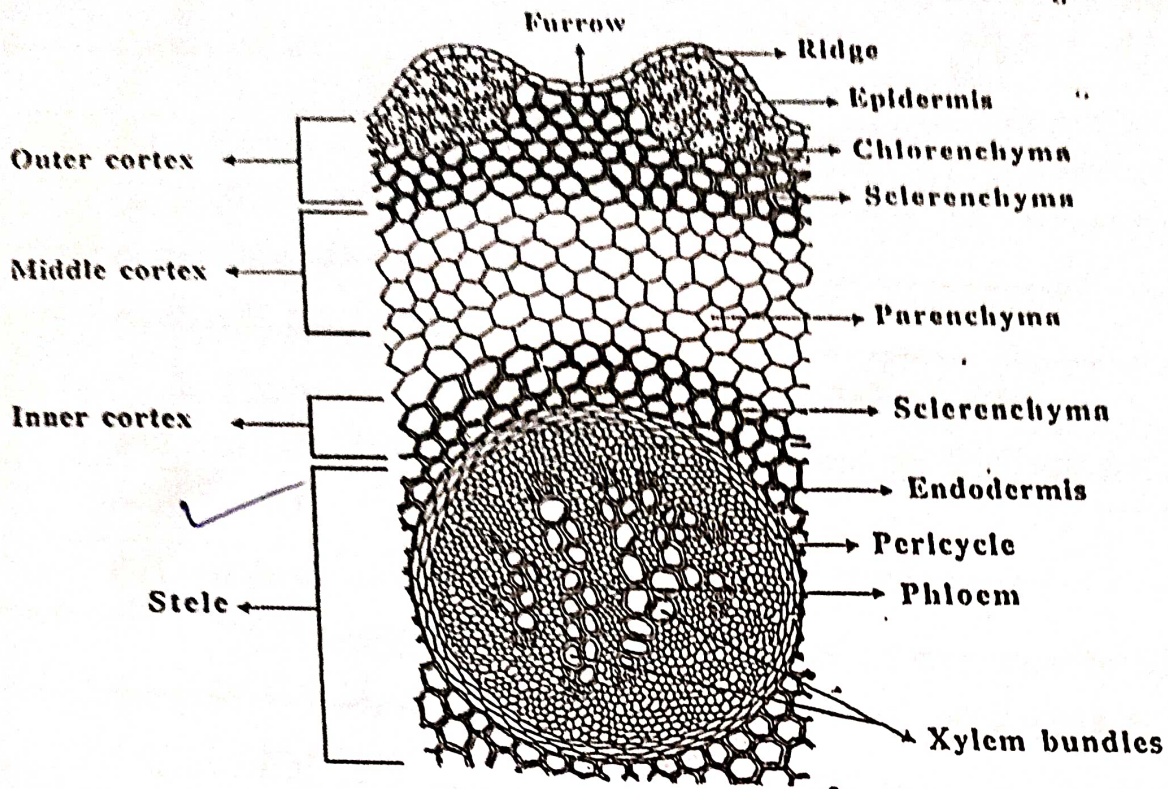
It is present just below the middle cortex. It is made up of many layers of sclerenchymatous cells.

Endodermis:

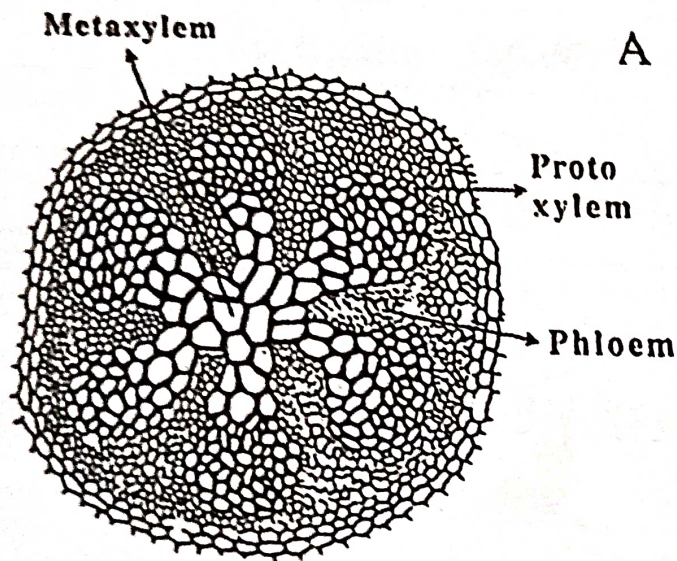
It is the innermost layer of inner cortex. It is made up of single layer of barrel shaped cells. It has thickenings on radial walls called the **casparian strips** in young stems. The endodermis may not be well defined in old stems.

Stele:

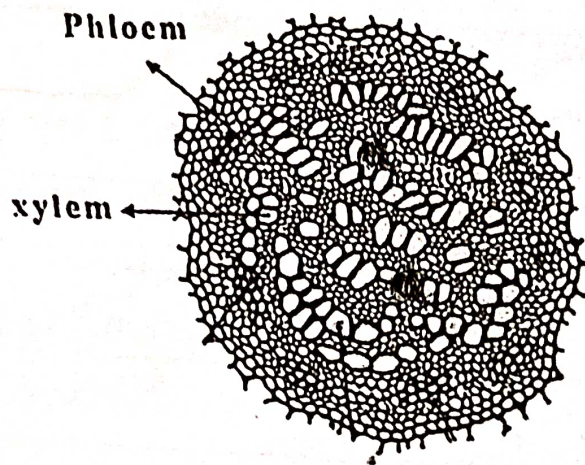
It is present just below the endodermis. It is a **protostele** (stele without pith). It is composed of pericycle and vascular bundles. The pericycle is 1-2 layered and made up of parenchymatous cells. The vascular bundles are **exarch**. On the basis of shape and location of the



T.S. of stem *L. Clavatum* (Plectostele)



T.S. of stem *L. serratum*
(Actinostele)



T.S. of stem *L. cernuum*
(Mixed protostele)

Fig. 107(A-C). PTERIDOPHYTA: *Lycopodium* - Internal structure.
A. Plectostele (*L. clavatum*) B. Actinostele (*L. serratum*); C. Mixed protostele (*L. cernuum*).

xylem in the vascular bundles, the stele is of three types in different species of *Lycopodium* i.e. **plectostele**, **actinostele** and **haplostele** or mixed protostele.

Plectostele:

The exarch protostele in which the xylem and phloem bundles are in the form of plate like bands, alternate and more or less parallel to each other is called as the plectostele e.g. *L. clavatum* and *L. complanatum*

Actinostele:

The exarch protostele in which the xylem bundles are star shaped and surrounded by the phloem is called as the actinostele e.g. *L. serratum*

Mixed protostele:

The protostele in which the xylem bundles are scattered or mixed irregularly in the phloem is called as the mixed protostele or haplostele e.g. *L. cernuum*

REPRODUCTION:

Lycopodium reproduces asexually and sexually.

Asexual reproduction:

The dominant, long lived sporophyte of the *Lycopodium* is mainly concerned with the asexual reproduction. The asexual reproduction takes place by the formation of strobili. The strobili are certain cone like structures, present at the apex of mature branches of *Lycopodium*.

Structure of strobilus:

A strobilus has a central axis called the **strobilar axis**. The central axis bears certain small, pale green, leaf like structure called the **sporophylls**. The sporophylls are arranged spirally on the central axis. They bear a spore producing structure called the **sporangium** near the base on the adaxial side (on upper side).

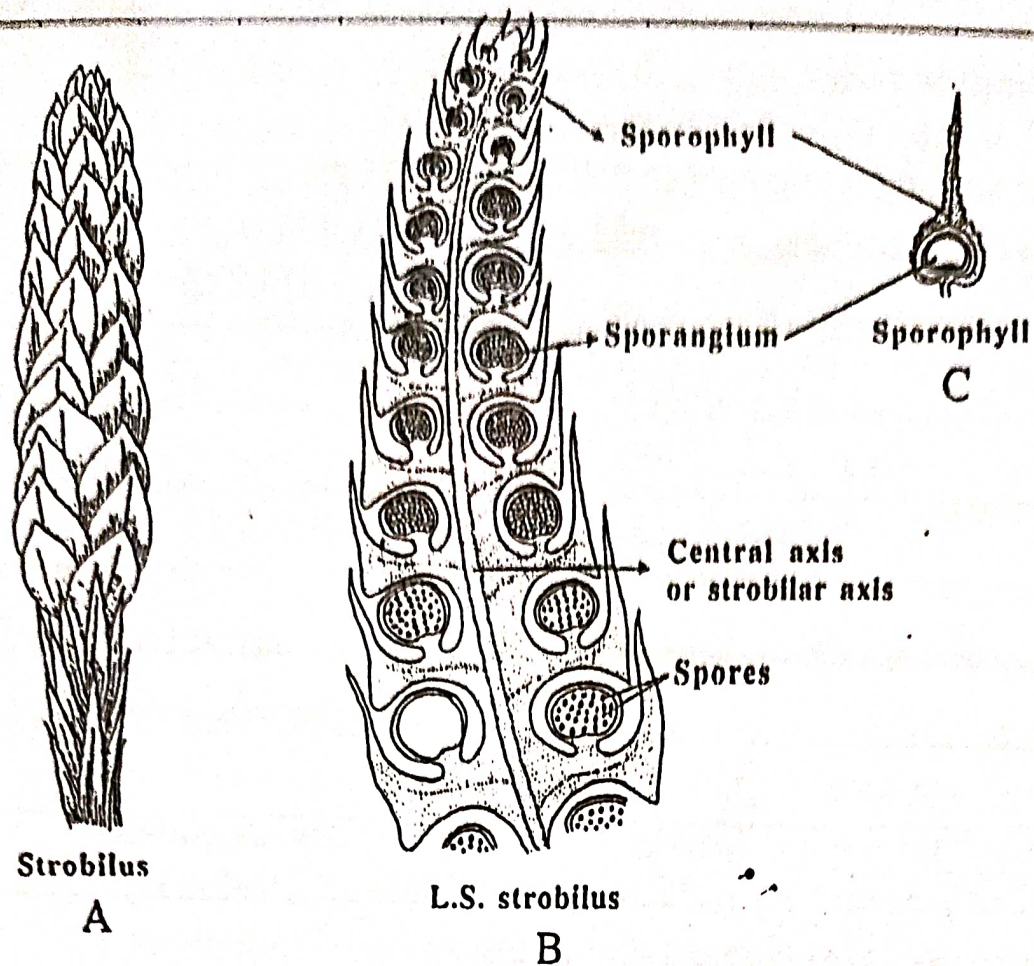


Fig. 108(A-C). PTERIDOPHYTA: *Lycopodium*-Structure of strobilus

Structure of sporangium:

The sporangia are the spore producing structures. They are developed in the strobili on the upper surface near the base of the sporophylls. The development is of **eusporangiate** type (i.e. they are developed from a group of superficial sporangial initials). The sporangia are kidney shaped and black in colour. A mature sporangium has the massive stalk and curved, reniform or kidney shaped body called the **capsule**. The stalk is short or it is just represented by a cushion of cells. It is narrow or broad. It bears the capsule at the apex. The capsule is unilocular and contains a mass of **sporogenous** tissues. The sporogenous tissues are surrounded by a three or more layer of the sporangial wall is called as the **tapetum**. The cells of the tapetum are prominent due to the granular nature of their cytoplasm and bigger nuclei. They contain nutritive substances and provide to the developing spores in the sporangium. The tapetum maintains its identity throughout the life of the sporangium. The sporogenous tissue is made up of many

diploid cells called the spore mother cells. In a mature sporangium the spore mother cells separated from each other and become rounded. They undergo meiosis or reduction and result into the formation of many tetrads of haploid cells. The haploid cells of the tetrad secrete their own wall and behave as the spores. Thus many tetrads of haploid spores are formed.

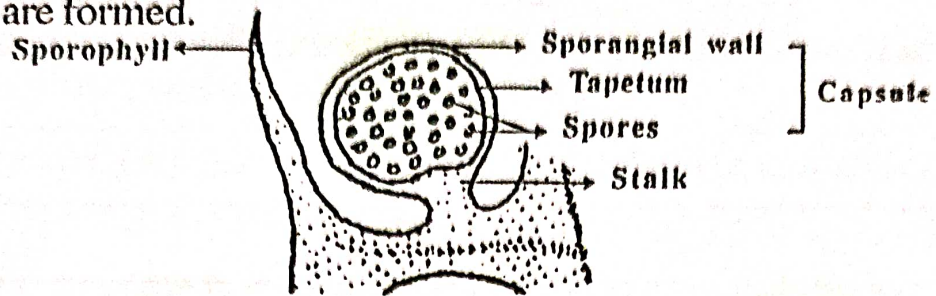


Fig. 109. PTERIDOPHYTA: *Lycopodium*- Structure of sporangium.

Structure of spore:

The spores are of one type only. Hence the *Lycopodium* is homosporous. The spores are very small (minute) globose, unicellular, uninucleate, haploid structures. They are arranged in tetrads in the sporangium. They have a very thick, double layered wall. The outer thick, spiny or sculptured layer is called **exine** and inner thin membranous called the **intine**. The spores are with **triradiate ridges** on the surface.

When the spores mature, they are liberated outside. During the process of liberation, the axis of the strobilus elongates. The sporophylls bend backward due to which the sporangia get exposed. The exposed sporangia rupture transversely and the spores are liberated and carried by wind.

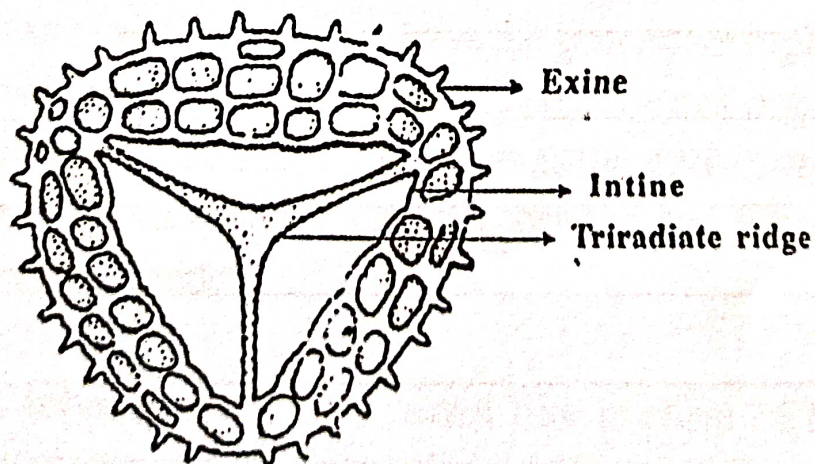


Fig. 110. PTERIDOPHYTA: *Lycopodium*- Structure of spore.

The spores of *Lycopodium* are used as reducing agents in gunpowder. They are also used as coating for pills. The spores of *Lycopodium* germinate and give rise to a new haploid, individual called the gametophyte or **prothallus**. On the basis of form and structure the gametophyte of *Lycopodium* is of four types.

- i) Autotrophic gametophyte (It grows on the surface of the soil and it is photosynthetic e.g. *L. cernuum*).
- ii) Subterranean gametophyte (underground, tuberous, non green saprophytic e.g. *L. complanatum*).
- iii) Slightly subterranean gametophyte (It grows on tree trunks just below the surface of humus and on rotting barks of trees).
- iv) Epiterranean gametophyte (It grows above the ground)

Structure of prothallus (*L. complanatum* type):

The prothallus of *L. complanatum* is of sub terranean type. It is underground, tuberous, nongreen, saprophytic gametophyte. It is brown or yellowish in colour. It is carrot shaped. It is about 1-2 cm in length. It is divided into two parts. The upper broad part called the **generative region** and the lower part called the **conical region**.

Generative region:

It is the broad, expanded, upper part of the prothallus. It is made up of a certain specialized tissue called the **generative tissue**. The generative tissue is meristematic along the margin called the **marginal meristem**. The cells of the marginal meristem divide, redivide and result into the formation of a **lobed crown** above the generative region. The lobes of the crown contain the sex organs. The male sex organs are called as the **antheridia** and female sex organs as the **archegonia**. Thus the prothallus is **monoecious**. The sex organs are wholly embedded in the generative tissues.

Conical region:

It is the lower, tuberous, conical, carrot like portion of the prothallus. The conical region in *L. S.* shows three different regions

- i) Epidermis.

iii) Cortical region.

Epidermis:

It is outermost protective layer of the conical regions. It bears rhizoids.

Central region:

It is composed of sponge tissue. The cells of the sponge tissue store large amount of food material. Hence it is also called as the storage region.

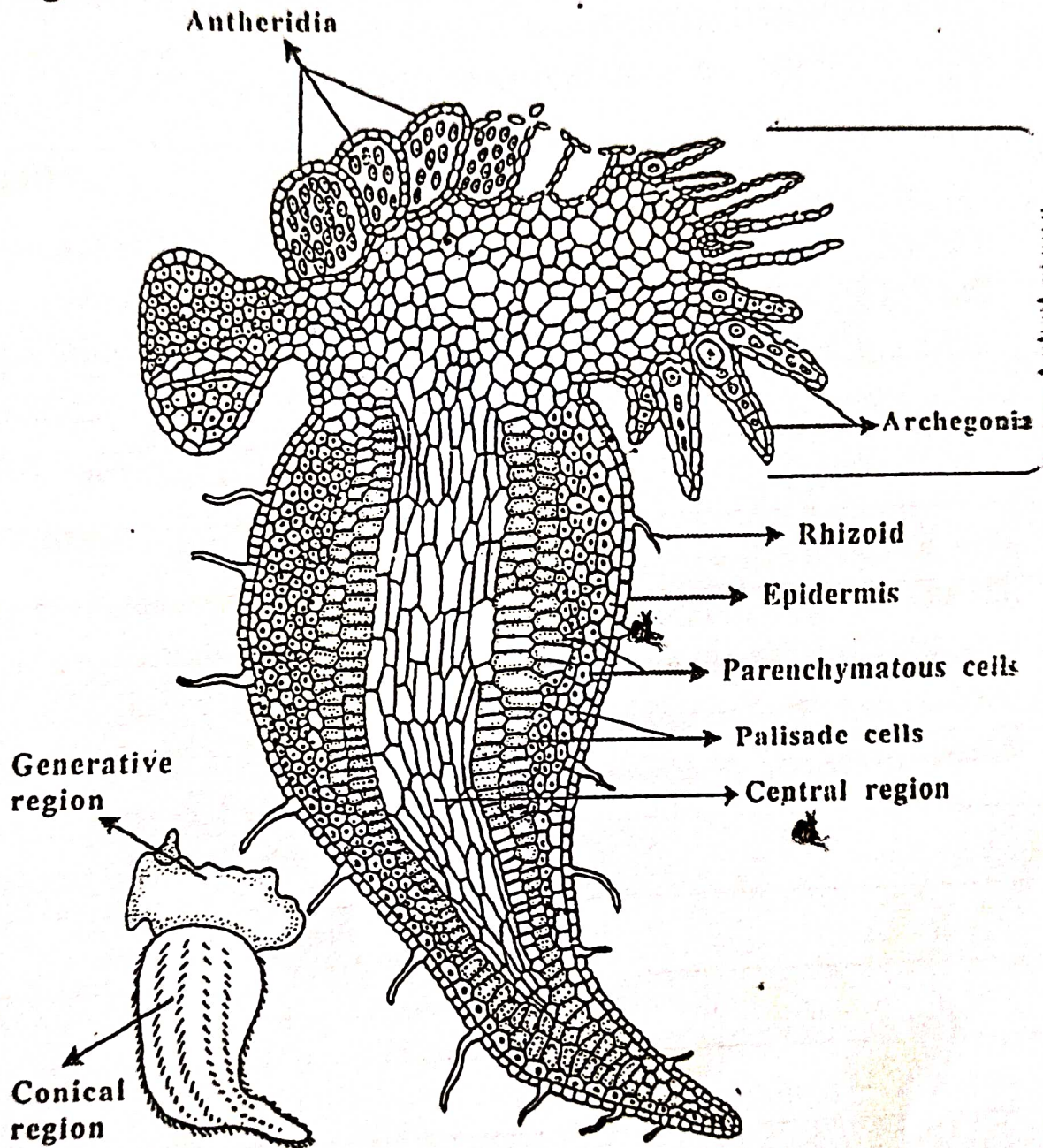


Fig. 111. PTERIDOPHYTA: *Lycopodium*- L.S. of prothallus (complanatum type).

Cortical region:

It is present just below the epidermis. It is differentiated into outer and inner cortical regions or zones. The outer cortical zone is composed of tightly packed parenchymatous cells. The inner cortical zone is composed of tightly fitted palisade cells. Both the outer and inner cortical zones are highly infected by the mycorrhizal fungi.

Sexual reproduction in *Lycopodium*:

The gametophyte of *Lycopodium* is mainly concerned with the sexual reproduction. The sexual reproduction in *Lycopodium* is of oogamous type. It takes place by the formation of sex organs.

Sex organs:

The sex organs are developed on the same gametophyte. Hence the *Lycopodium* is monoecious. The male sex organs are called as the antheridia and the female as the archegonia. Both the sex organs are developed in the lobes of expanded, broad lobed crown of the generative region of the gametophyte.

Antheridium:

It is the male sex organ. It is developed in the lobes of the generative region. It is small, rounded or spherical in shape. It has an outer protective, single layered jacket. The antheridium contains number of haploid antherozoid mother cells. The antherozoid mother cells metamorphose into the haploid antherozoids. The antherozoids are fusiform and biciliate.

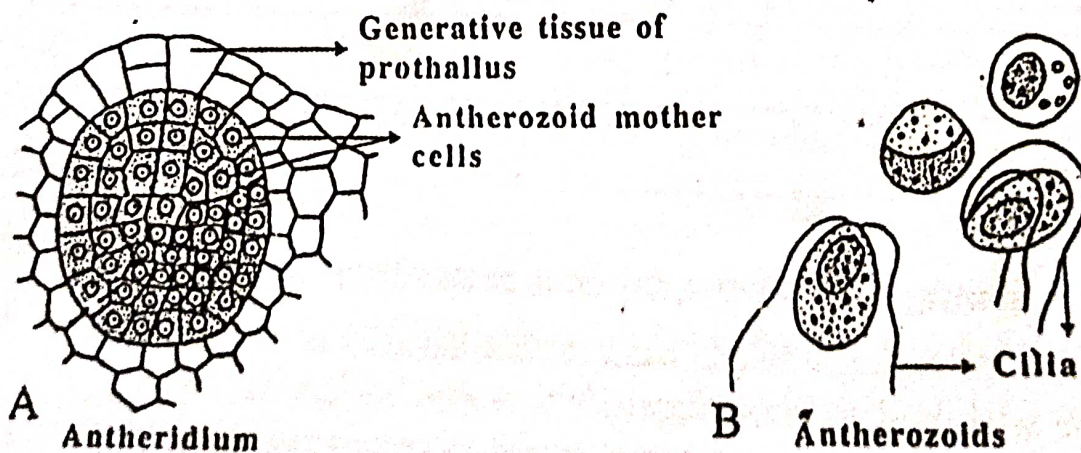


Fig.112 (A-B).PTERIDOPHYTA: *Lycopodium*- Structure of antheridium

It is the female sex organ. It is developed in the lobes of the generative region of the gametophyte. It is narrow, flask shaped structure. The basal swollen portion of the archegonium is called a venter and distal narrow portion as the neck. The venter completely embedded in the generative tissue but the neck portion slightly protrudes above the prothallus. The venter has a venter canal cell and an egg cell. The neck is small and elongated. It has four specialized cells at the apex called the cover cells. It is composed of 4 to 5 rows of cells. It has 2 to 16 neck canal cells. The number of neck canal cells is different in different species of *Lycopodium*. When the archegonium matures the egg cell in the venter metamorphoses into an egg or ovum. The venter canal cells and the neck canal cells disorganise creating an open passage.

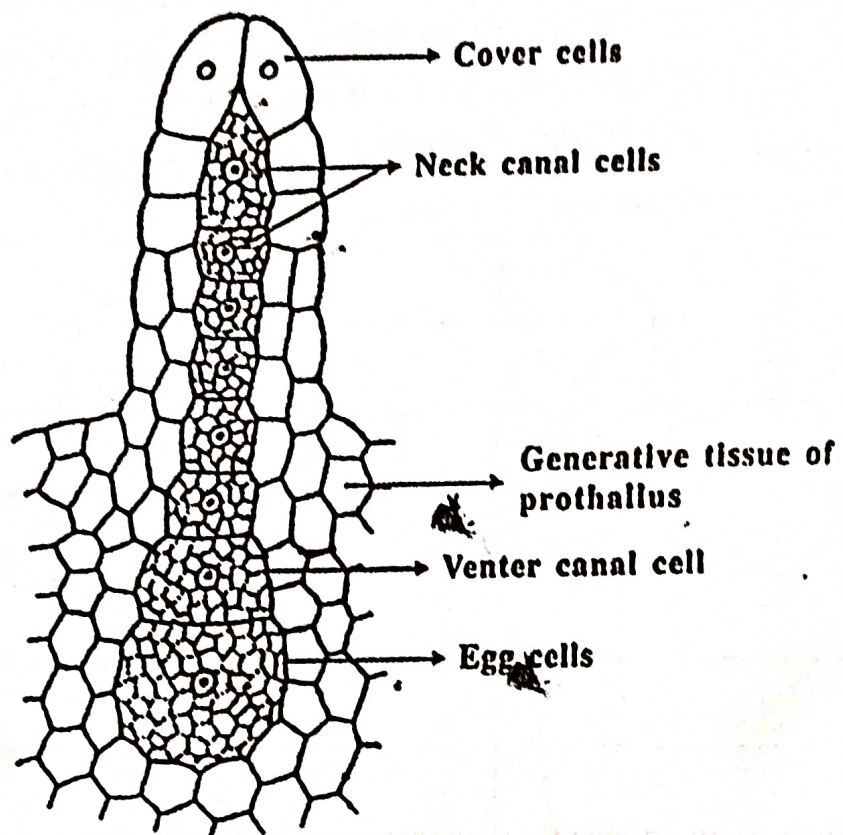


Fig.113. PTERIDOPHYTA: *Lycopodium*-Structure of archegonium.

Fertilisation:

The fertilisation takes place only in the presence of water. During the process of fertilisation a sticky fluid is formed in the archegonium due to disorganization of the neck canal cells and the venter canal cell. The sticky fluid attracts the male gametes or anthozoids in search of

female gamete for fertilisation. Large number of antherozoids are entered in the archegonium and gather around the egg. As a rule one of the antherozoids fuses with the egg. The wall of contact between the two fusing gametes dissolves and **plasmogamy** takes place. The plasmogamy is followed by the **karyogamy**. The karyogamy results into the formation of the **diploid zygote** in the venter of the archegonium. Soon after the formation, the zygote secrets a thin wall around it and undergoes rest. The zygote represents the first cell of the sporophytic generation.

The zygote undergoes transverse division and results into the formation of two cells. The upper cell is called as the **epibasal cell** or suspensor cell. The lower cell is called as the **hypobasal cell** or the embryonic cell. The suspensor cell grows, elongates and functions as suspensor. It push the embryonic cell deep into the prothallus. The embryonic cell grows and gives rise to the **embryo**. The embryo gives rise to the new diploid, leafy, branched **sporophyte** of the *Lycopodium*.

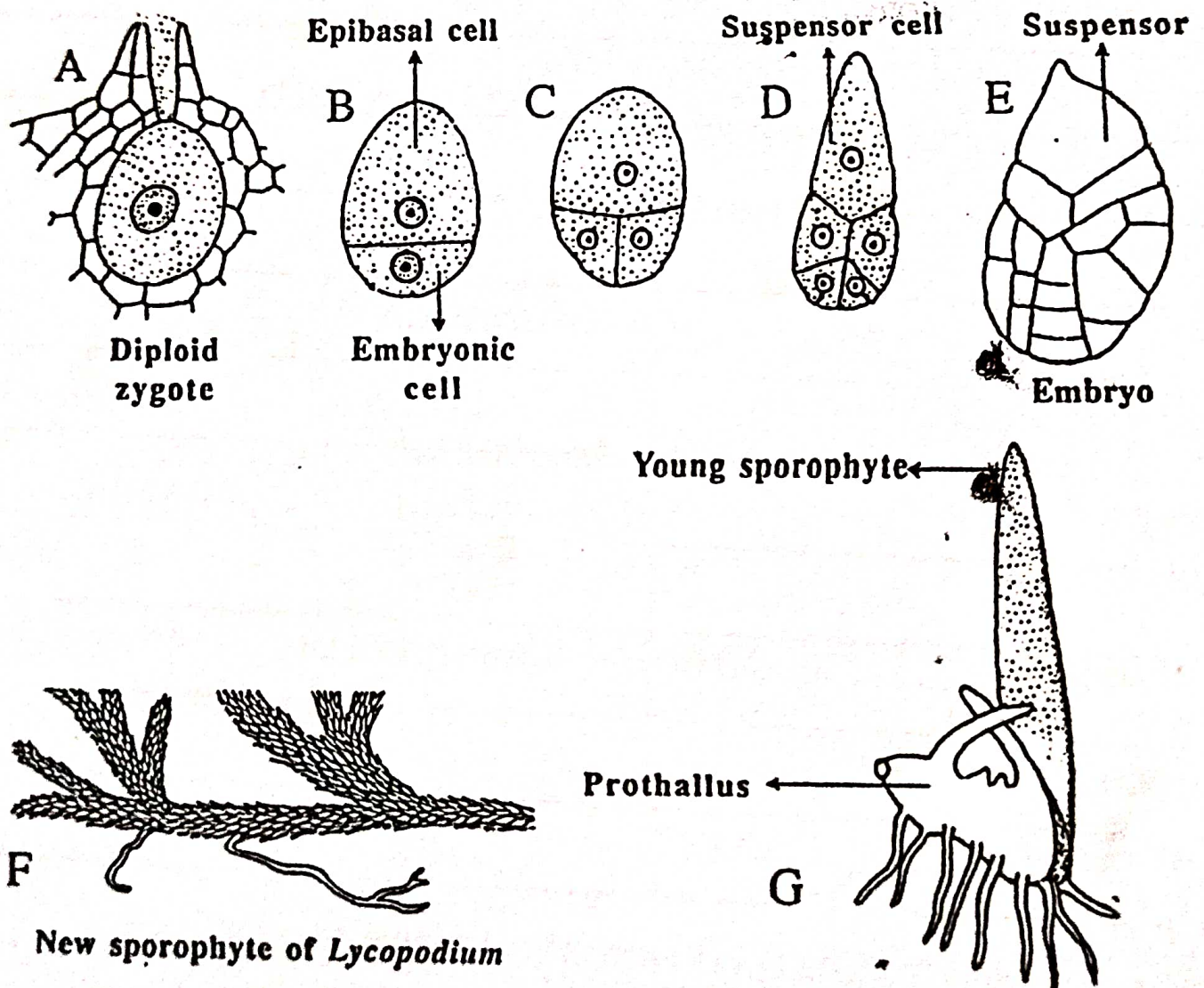


Fig.114 (A-G). PTERIDOPHYTA: *Lycopodium*. Steyer in the

GRAPHIC LIFE CYCLE:

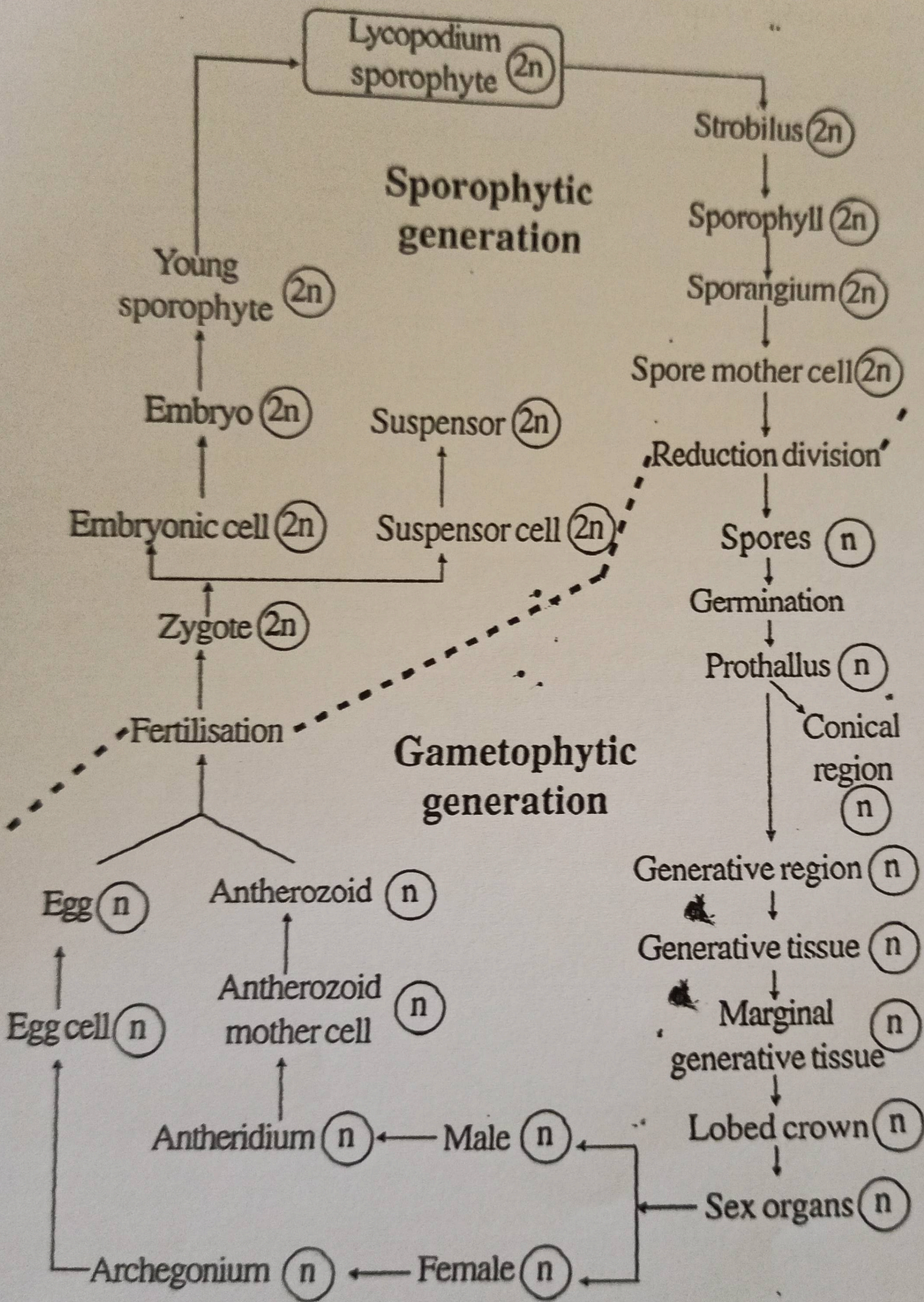


Fig.115.PTERIDOPHYTA: Lycopodium-Graphic life cycle.