Reproduction in Ephedra

- Ephedra is dioecious, and the two sex organs are present on different plants. In E.foliata, however, monoecious individuals are also common. Occasionally, an ovulate flower may be replaced by a staminal flower, and thus the strobilus becomes bisporangiate as in E. campylopoda.
- Ephedra is heterosporous, i.e., two types of spores (microspores in male flowers and megaspores in the female flowers) are present. The male and female flowers are present in the form of cone-like, compound male and female strobili, respectively.

Male Strobilus

- The male strobili are compound structures arising in clusters from the nodes of the branches (Fig. 14.6). Each strobilus develops in the axil of a scaly leaf (bract).
- A male strobilus is a round or ovoid body (Fig. 14.7) with a strobilus axis in its centre. Two to eight pairs of bracts remain arranged in opposite decussate manner on the strobilus axis (Fig. 14.8). All the bracts are fertile except a few on the lower side. A single male or staminate flower arises in the axil of each bract (Fig. 14.9).

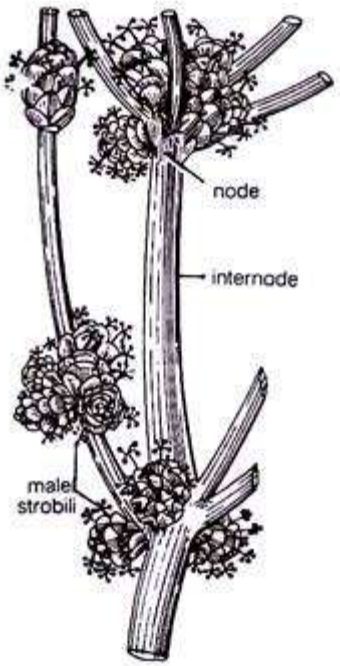

Fig. 14.6. *Ephedra viridis*. A part of male plant.

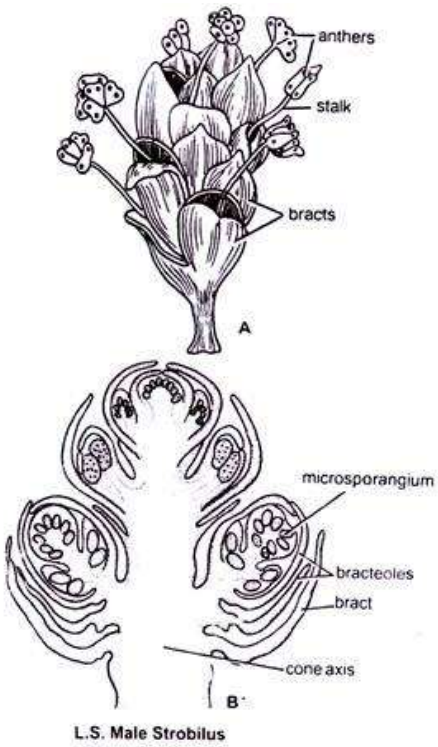

Fig. 14.7. *Ephedra viridis*. A, Compound male strobilus; B, L.S. male strobilus.

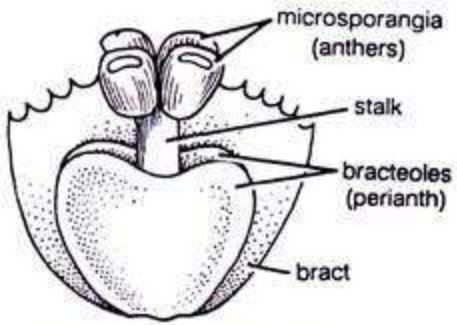

Fig. 14.9. *Ephedra*. A single male flower.

Development of Microsporangia

- The microsporangium starts to develop (Fig. 14.10) from a group of hypodermal cells which function as archesporium. The archesporial cells are larger in size with more dense cytoplasm and quite prominent nuclei in comparison with the other adjacent cells. These cells divide periclinally into outer primary parietal cells and inner primary sporogenous cells.
- The parietal cells divide repeatedly and form one-celled thick wall and also the tapetum.
- The sporogenous cells divide several times irregularly and form many microspore mother cells. The latter divide meiotically to form spore tetrads arranged tetrahedrally. The haploid microspores are later on separated. Rarely, the spores are arranged iso-bilaterally.

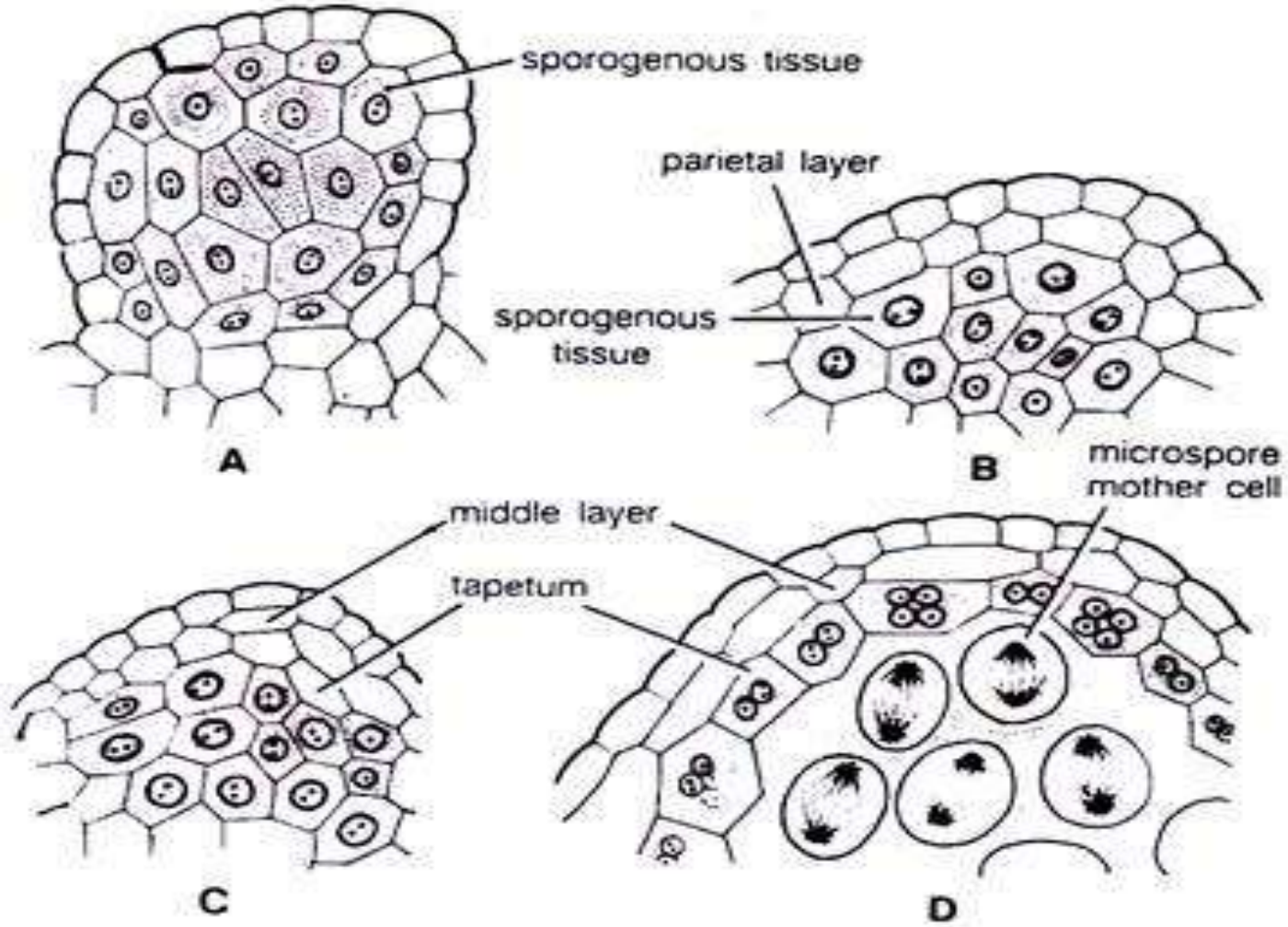

Fig. 14.10. *Ephedra*. Development of microsporangium

Female Strobilus

- The ovulate or female strobili are elongated and pointed structures (Figs. 14.11,14.12). Similar to male strobili they also develop in the axil of leaves in the whorls of 2, 3 or 4 at the nodes of small green branches. Each female strobilus is sessile and smaller than male strobilus. Pairs of bracts are more in number in female strobilus than male strobilus Bracts are arranged in opposite decussate manner.
- All bracts, except the uppermost pair, are sterile. Two ovules are present in the axil of uppermost pair of bracts, out of which generally only one survives. The female strobili appear on the plants in the month of April and the mature seeds are seen in September in Ephedra gerardiana.

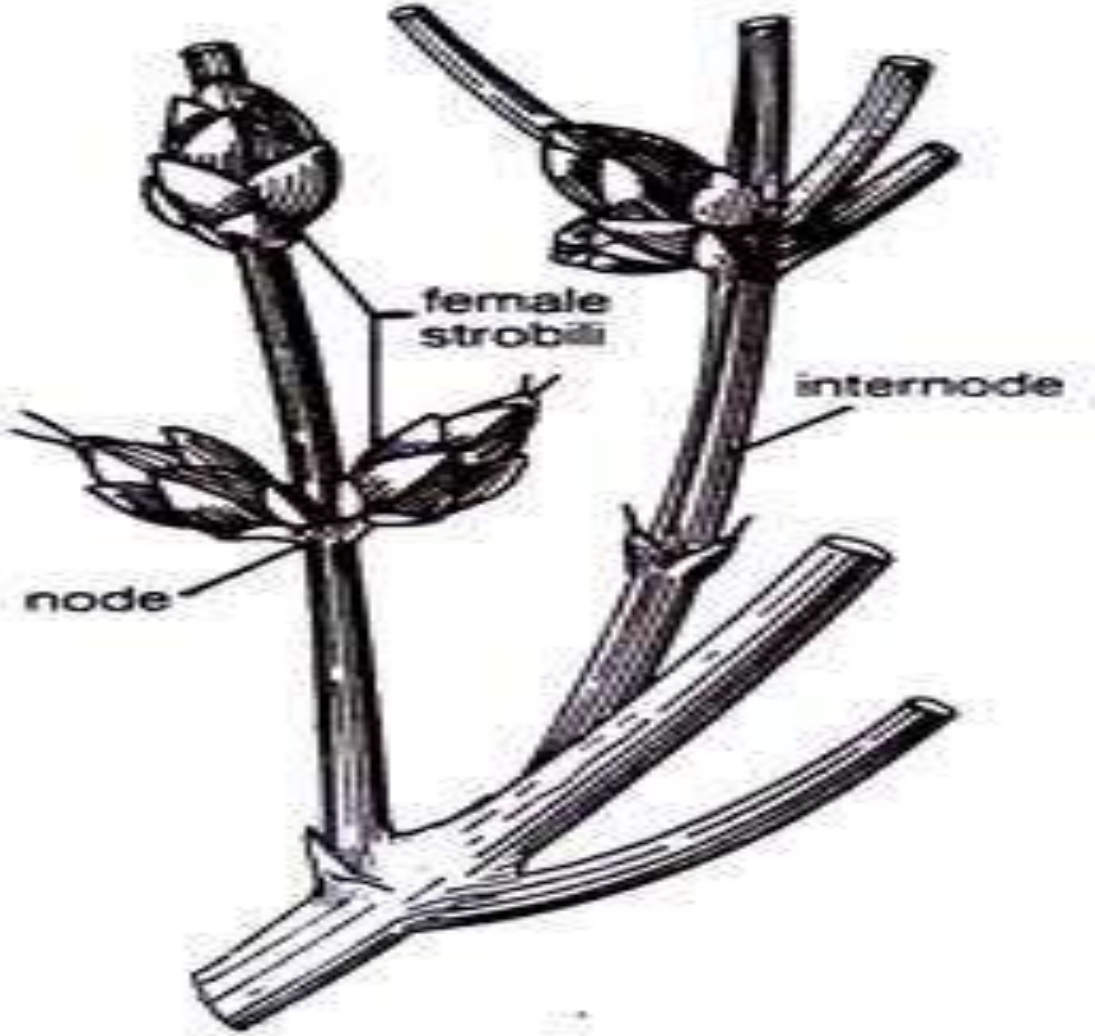

Fig. 14.11. *Ephedra viridis*. A part of female plant.

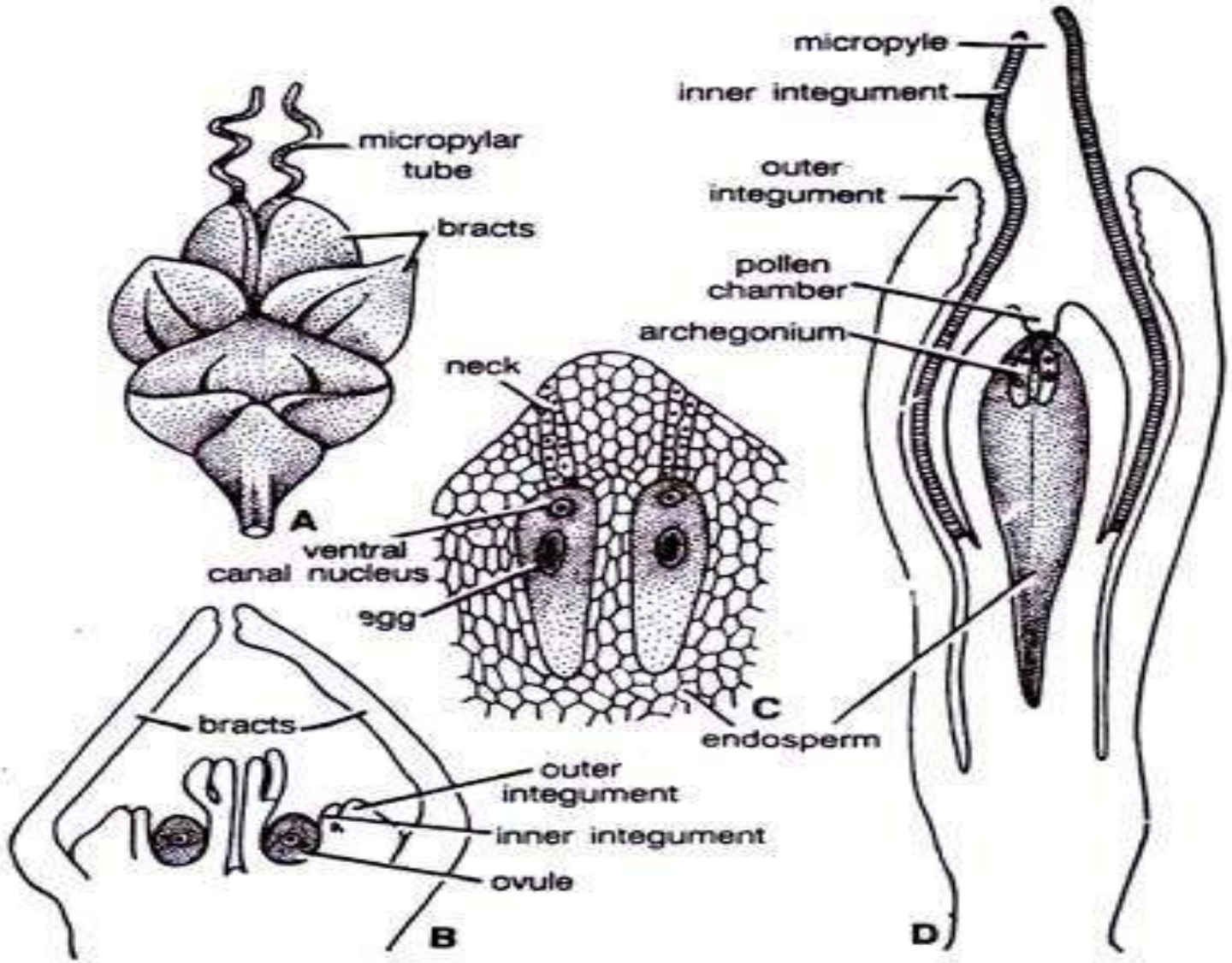

Fig. 14.12. *Ephedra*. A, A single female spike; B, L.S. female flower; C, Endosperm with two archegonia; D, L.S. ovule.

Ovule

- The ovule remains covered by a cup-shaped outer integument and an inner integument. The outer integument remains attached at the basal portion of the ovule. The inner integument protrudes out in the form of a long tubular micropyle. The integuments enclose the nucellus.
- A small pollen chamber develops near the micropyle in the nucellus. Pollen chamber in Ephedra is deepest known among the Gymnosperms. The female gametophyte is centrally located (Fig. 14.13), and the archegonia are present in the female gametophyte near the micropylar end. The haustorial region is present near the chalazal end and bears some haustorial processes.

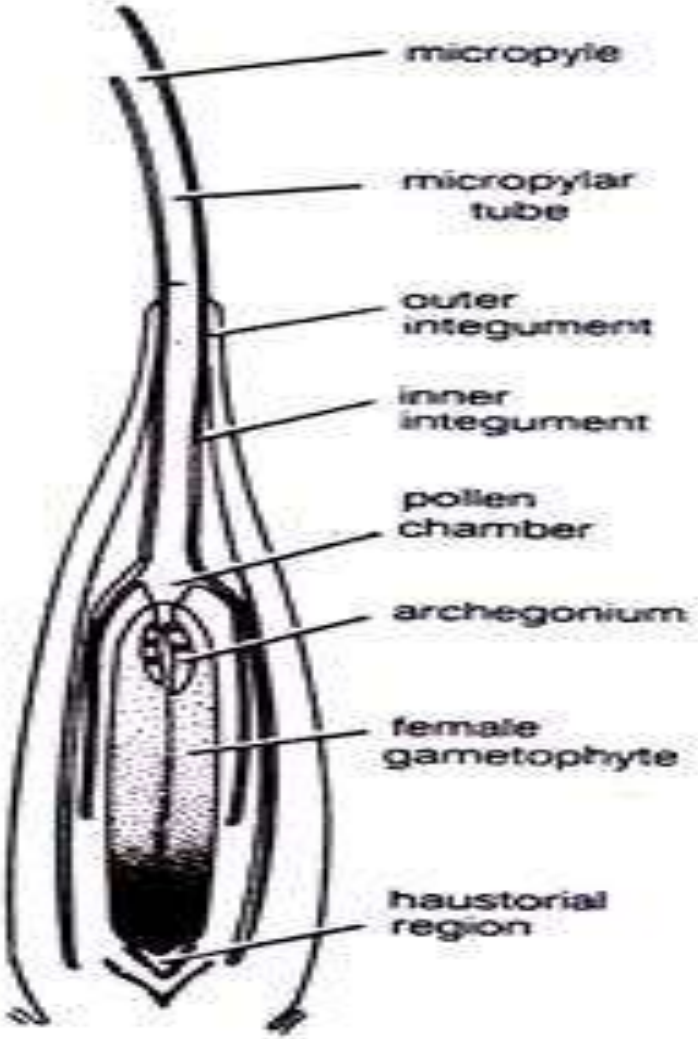

Fig. 14.13. *Ephedra trifurca*. L. S. Ovule (after Land, 1904).

Microsporogenesis and Male Gametophyte

- The microspore is the first cell of the male gametophyte. It is wingless, inaperturate and has a thick exine. The germination of microspore starts within the microsporangium. At the time of germination, the microspore elongates and divides to form a prothallial cell (Fig. 14.14 A).
- The second division results in the formation of a 2nd prothallial cell (Fig. 14.14B).
- But according to Mehra (1938) a wall is present around the second prothallial nucleus in E. gerardina and E. saxatilis but it soon breaks down. The antheridial initial soon divides into a tube cell and a generative cell (Fig. 14.14C, D).
- The generative cell soon divides into the nuclei of stalk cell and body cell (Fig. 14.14E, F). A common mass of cytoplasm surrounds the nuclei of stalk cell and body cell and they are never separated by a cell wall (Land, 1904). Pollens are shed at this five-celled stage and are carried up to the micropyle of ovule with the help of wind.
- Upon reaching the ovule, the exine of the pollen grains ruptures and the intine comes out in the form of a tube. The generative cell divides and forms two male nuclei (Fig. 14.15).

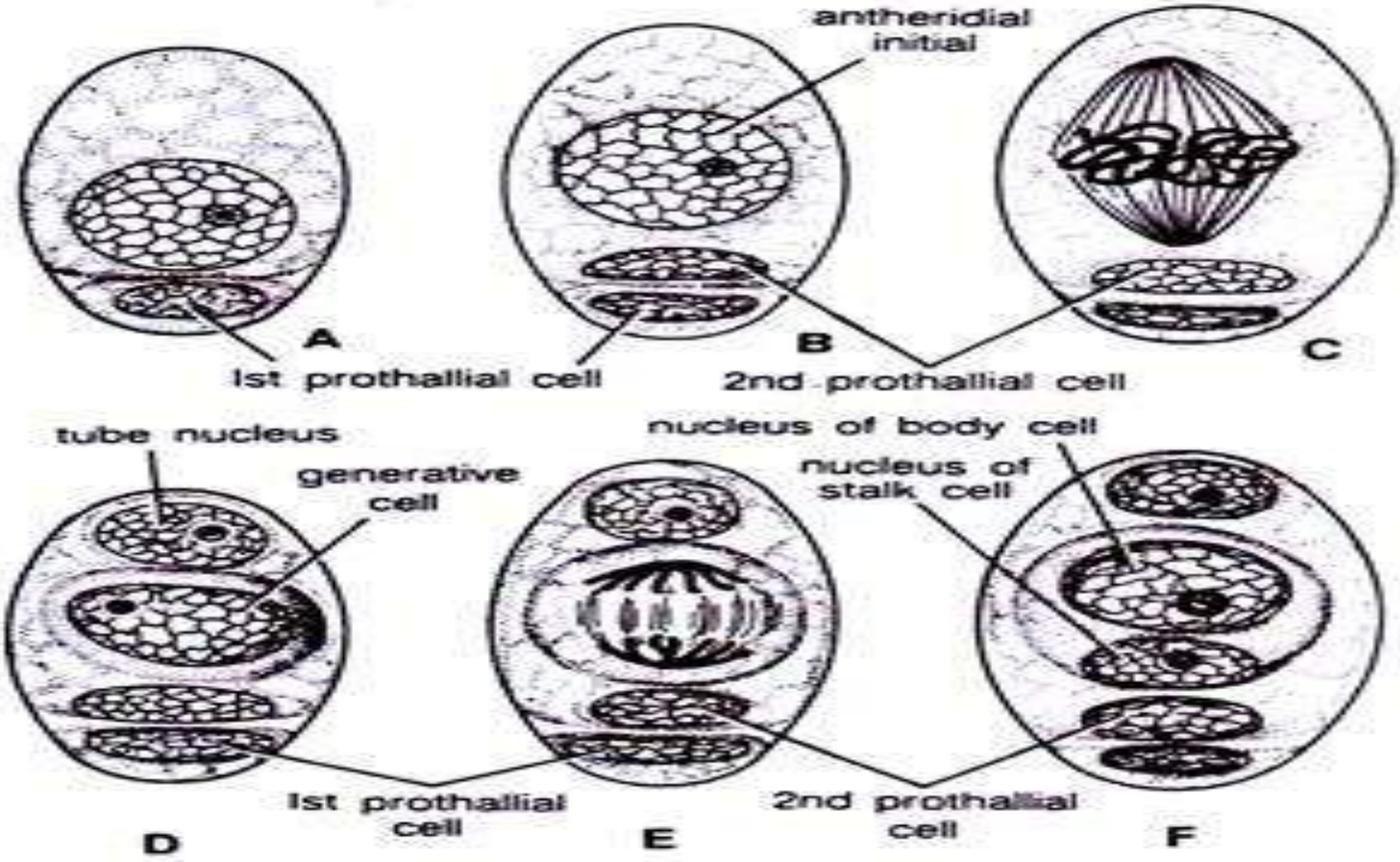

Fig. 14.14. *Ephedra trifurca*. Development of male gametophyte (after Land, 1904).

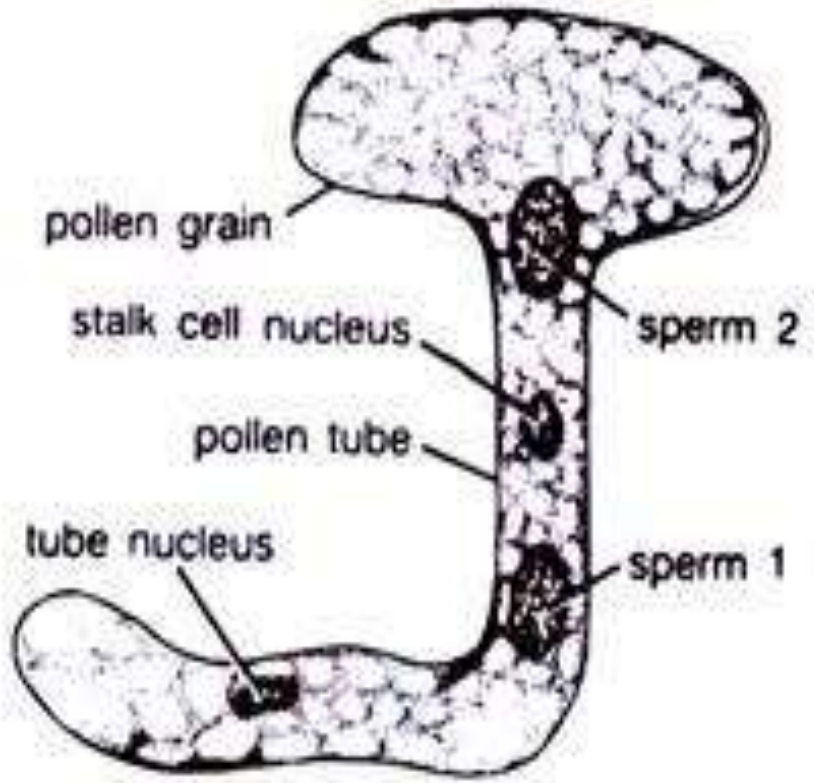

Fig. 14.15. *Ephedra trifurca* showing germination of pollen grain. (after Land, 1904)

Female gametophyte

- The functional megaspore is the first cell of the female gametophyte. It enlarges and its nucleus divides several times by many free-nuclear divisions.
- The free-nuclear divisions continue for about twenty days. The nuclei get themselves arranged around the central vacuole on the periphery of the megaspore. The free-nuclei are evenly distributed throughout. The wall formation starts from outside, proceeds rapidly towards the centre making the complete structure ultimately cellular.
- In this cellular female gametophyte, the cells of the upper reproductive region are large and elongated as compared to that of the lower nutritive region. The nutritive region gets further differentiated into upper storage region and lower haustorium. Archegonia develop in the micropylar region.

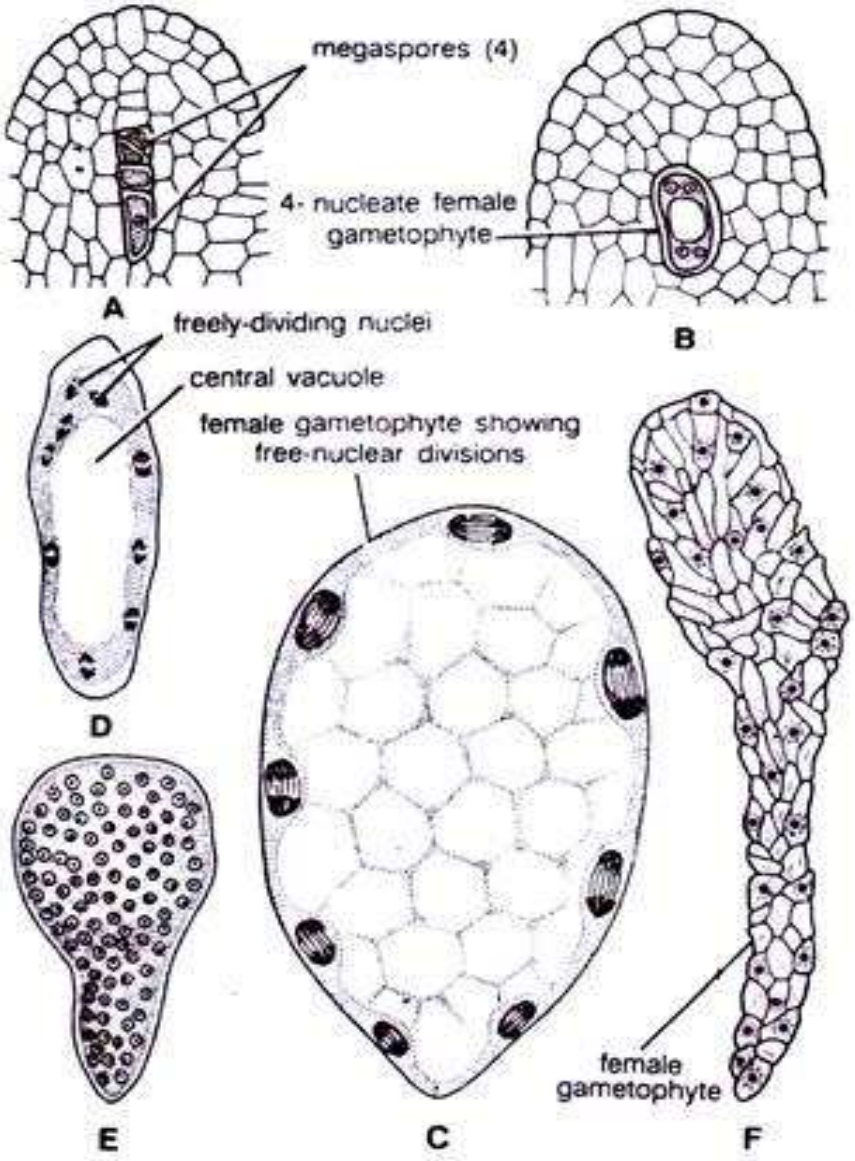

Fig. 14.16. *Ephedra*. Development of female gametophyte A-B, *E. foliata*; C, *E. trifurca*; D-F, *E. gerardiana*.

Archegonium

- The number of archegonia in Ephedra varies from 1 -3 but their usual number is 2. An archegonial initial divides periclinaly to form an upper primary neck cell and an inner central cell (Fig. 14.17A). The primary neck cell divides several times to form 4-5 or more tiers and then appear anticlinal divisions.
- More than 32 neck cells are formed after anticlinal divisions (Fig. 14.17 B, C). Due to certain irregular divisions in neck cells, its tissue sometimes becomes undistinguishable from the surrounding cells of the female gametophyte. The archegonial neck in Ephedra may sometimes become as long as 40 cells.
- The central cell enlarges (Fig. 14.17B) and its nucleus divides into a ventral canal nucleus and an egg nucleus (Fig. 14.17C). There is no wall formation between these two nuclei. The ventral canal nucleus may or may not move down towards the egg nucleus. The cells adjacent to central cell may divide transversely to form a clear 2-3 layered jacket.
- A mature archegonium (Fig. 14.17C) thus consists of a long multilayered neck and a central cell containing a ventral canal nucleus and an egg nucleus. The long columnar neck appears similar to the transmitting tissue in the style of angiosperms. The archegonium in Ephedra is rich in protein but poor in polysaccharides and RNA. The mature egg is Feulgen negative.

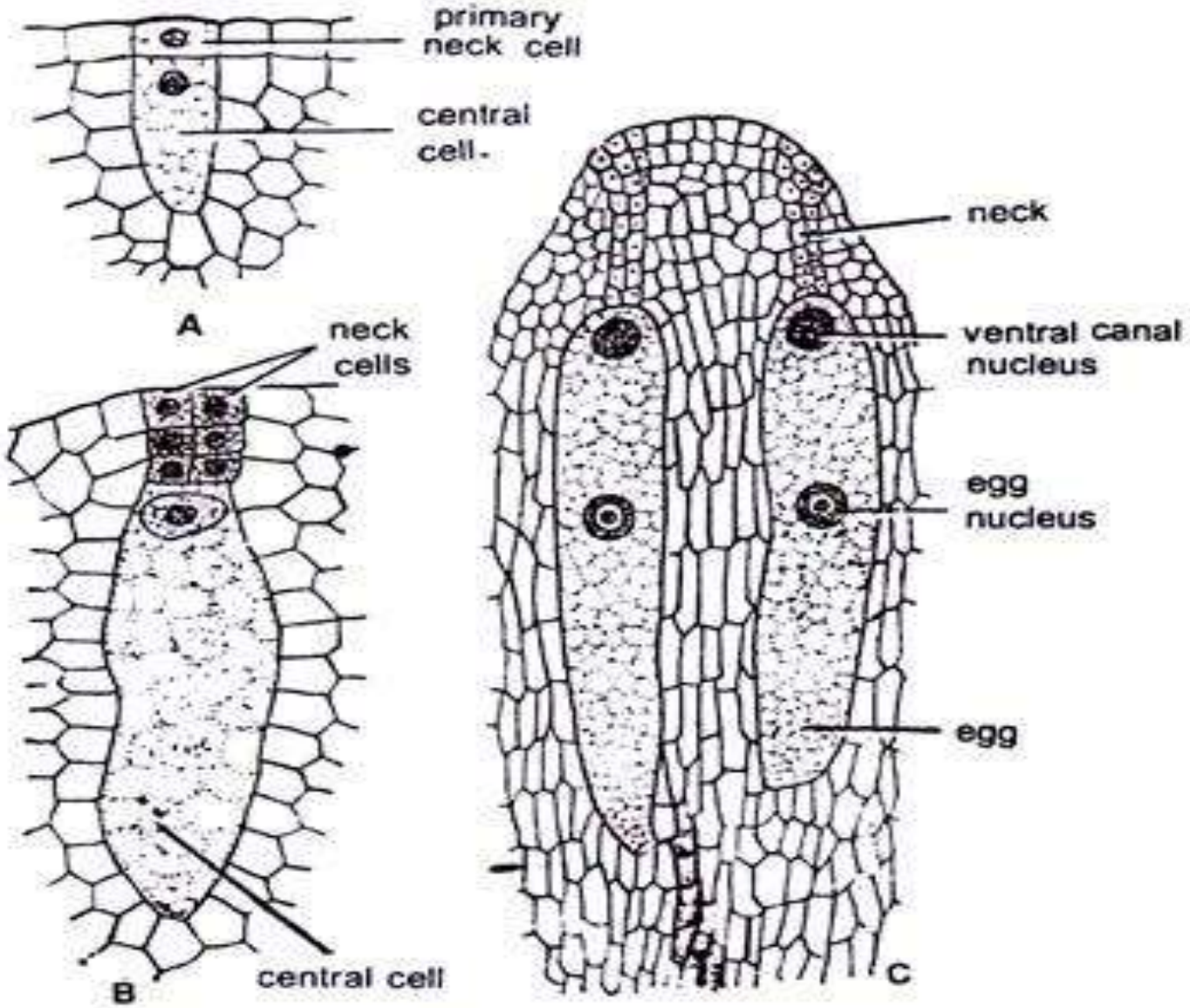

Fig. 14.17. *Ephedra*. Showing development of archegonium.

Fertilization

- At the time of fertilization, the pollen tube penetrates the archegonium and discharges its contents into the egg cytoplasm (Fig. 14.18). One of the two male nuclei fuses with the egg nucleus and forms an oospore or zygote. The other male nucleus may fuse with the ventral canal nucleus exhibiting the phenomenon of ‘double fertilization’.

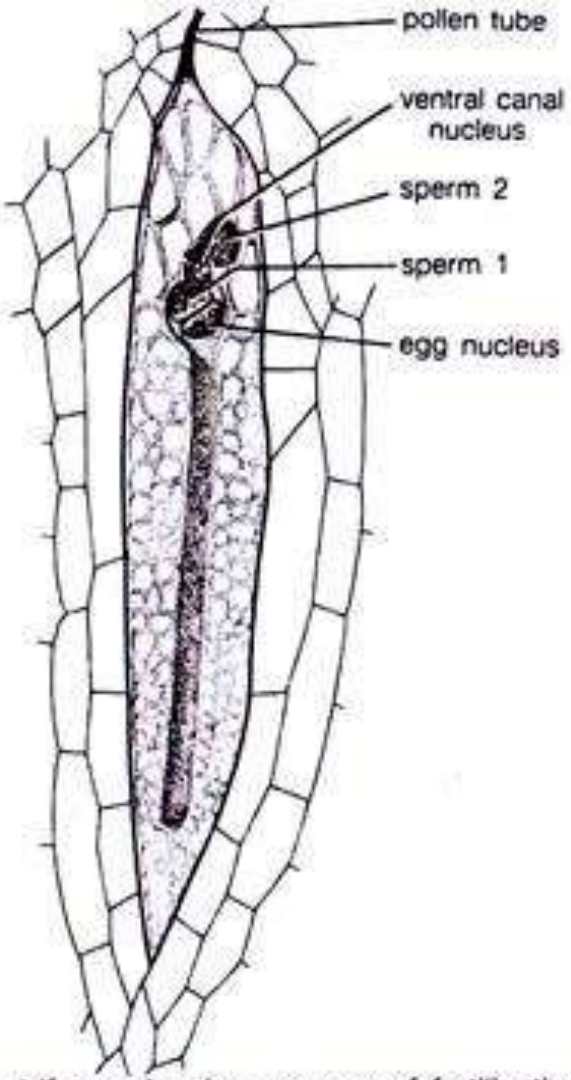

Fig. 14.18. *Ephedra trifurca* showing process of fertilization (after Land, 1907).

Embryogeny

- The zygotic nucleus undergoes free-nuclear divisions resulting into eight free-nuclei which remain evenly distributed throughout the cytoplasm. A cell gets organised around each of these nuclei, and each of such cell functions as a potential pro-embryo.
- Such a stage represents polyembryony without any cleavage, and Ephedra is unique among gymnosperms to show such type of polyembryony.
- A tubular outgrowth, called suspensor tube, develops from the pro-embryo. Its nucleus also divides simultaneously into two nuclei i.e., embryo nucleus and suspensor nucleus. The wall between the two nuclei is formed.
- The embryo nucleus passes into the tube which develops continuously and carries the lower embryonal cell deep into the female pro-thallus. The embryonal cell divides and develops into the embryo-proper which contains two cotyledons.

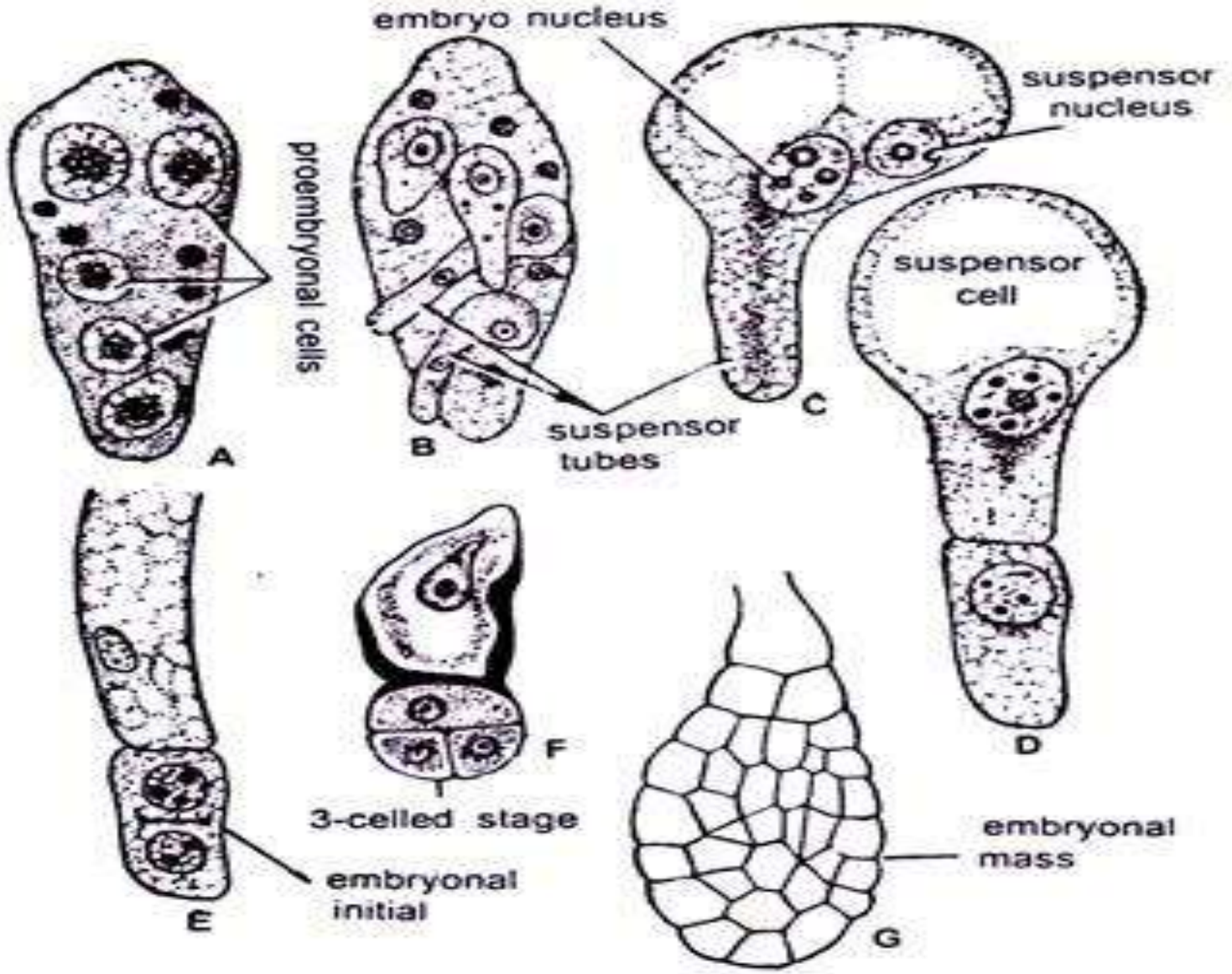

Fig. 14.19. *Ephedra*. Development of embryo (Post-fertilization changes).

Seed

- The seed contains a dicotyledonous embryo. It remains situated at the tip of the elongated suspensor and remains embedded within the tissue of the female gametophyte. The remnants of nucellus are seen in the form of a dis-organised sheath of cells.
- The seed coat consists of two separate layers derived from two layers of the envelope. At maturity the subtending adjacent bracts of the strobilus in Ephedra foliata become thick and fleshy and form an additional covering over the seed (Fig. 14.20). Thus the seed remains covered by three envelopes.

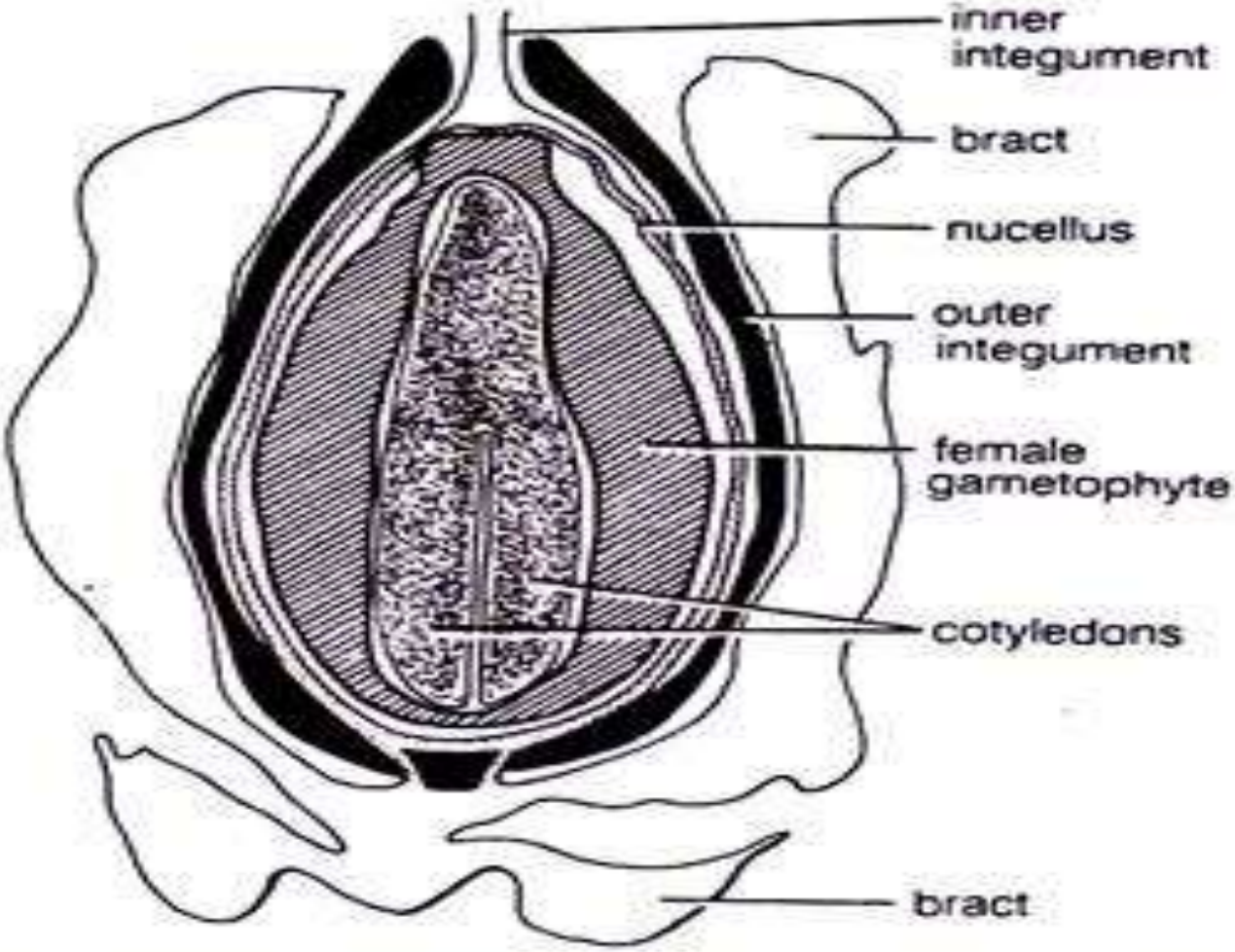

Fig. 14.20. *Ephedra foliata*. L.S. mature seed (after Khan, 1943).

Seed Germination

- The seed germinates without any resting period and the germination is of epigeal type. Sometimes the seed may even germinate within the parent strobilus. The cotyledons grow steadily until they become several centimeters long.

Economic Importance of Ephedra

- Besides some ornamental species, an antibiotic, ‘ephedrine’ is obtained from several species of Ephedra, such as E gerardiana, E. intermedia and E. nebrodensis. Ephedrine is effective in treating asthma, bronchitis, cough and hay-fever.
- In Russia a decoction, prepared from the roots and stem of several species of this genus, is used in the treatment of syphilis and rheumatism. Tincture of E. gerardiana is effective as a cardiac and circulatory stimulant.