## POLYTRICHALES (hair-cap-mosses)

In this order there are two families, Polytrichaceae and Dawsoniaceae, representing large mosses with tissue differentiation - conducting strand. It comprises, hydroids and leptoids. In this account are presented *Pogonatum* and *Polytrichum*. A presence of hairy covering - calyptra - over the capsule makes these mosses known as the 'hair-cap mosses'.

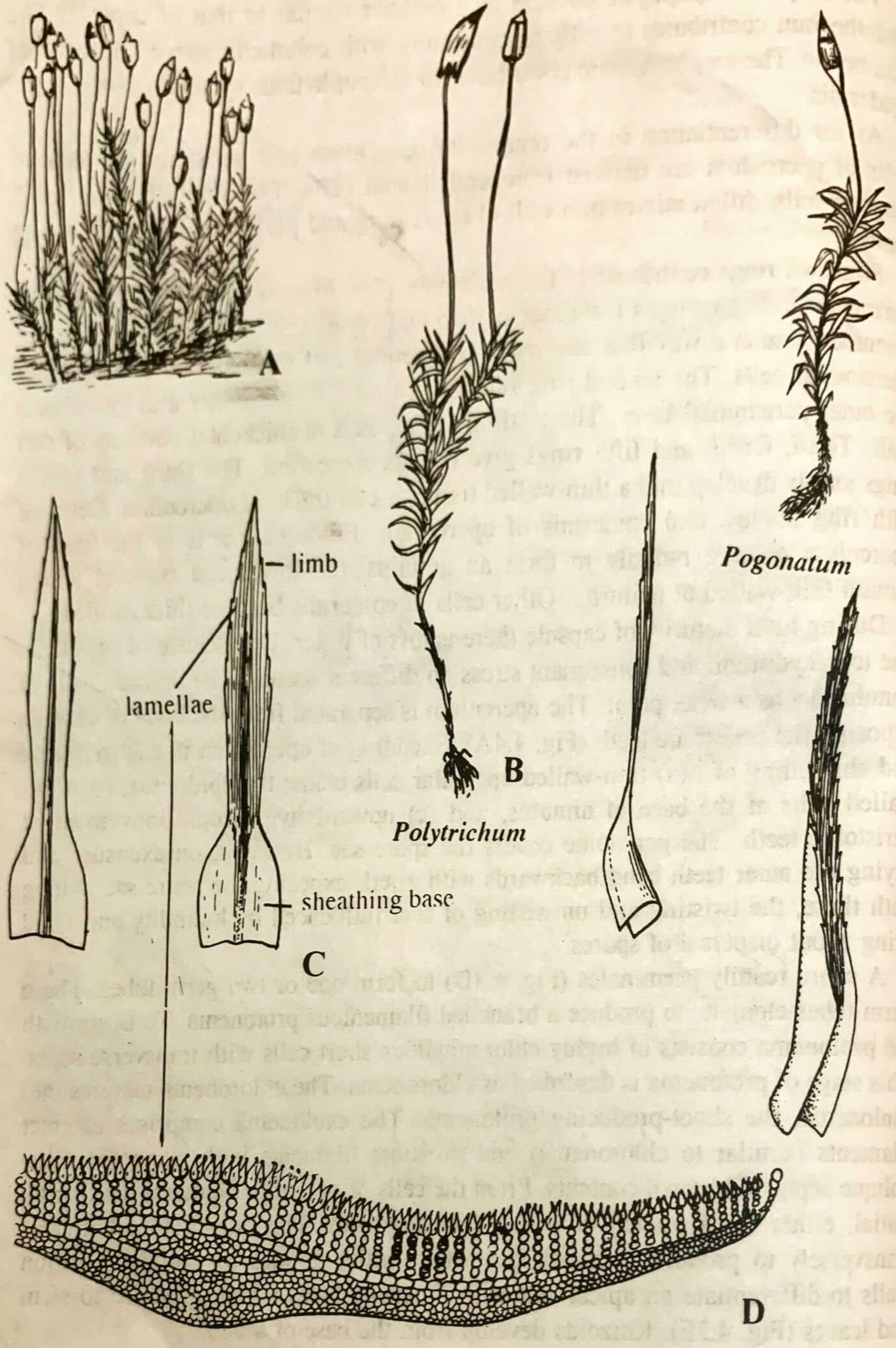


**Fig. 4.5.** ***Pogonatum*** **and** ***Polytrichum*** **gametophyte and sporophyte.**
A, a patch of *Pogonatum* gametophytes bearing sporophytes. B, a female plant of *Polytrichum commune* with sporophytes; one of the capsules is covered with a calyptra, also shown is a female plant of *Pogonatum* bearing a sporophyte. C, Leaves of *Pogonatum* in ventral, dorsal and lateral views showing sheathing base, also shown is a leaf of *Polytrichum commune*. D, t.s. of a leaf of *Pogonatum* through the limb. (B, C, after Parihar and after Udar)

*Pogonatum* and *Polytrichum* are relatively large mosses capable of growing in wide range of habitats throughout the world; temperate as well as tropical regions.

These mosses grow on damp soil, moist rock, swamp and can also grow on fully exposed area of forest. However, the growth is luxuriant in shaded sites, particularly under shade of a tree. In India *Pogonatum* grows extensively in Himalayas and hills of south India. *Polytrichum* is relatively rare in hills of south India, it inhabits higher altitudes, 5000—8000 ft. of Himalayas.

The plants are erect gametophytes (Fig. 4.5A) differentiated into stem, leaves and rhizoids. A large number of erect shoots arise from basal rhizome-like portion. It is densely covered with rhizoids. The rhizoids, serving for anchorage and absorption, are very prominent dense brown branched filamentous structures with oblique septa. On the basal portion of stem are distantly placed scale-like leaves (Fig. 4.5B), in three-ranked spiral arrangement. Higher up are normal green leaves close together and with a disturbed 3-rowed arrangement, usually 6-8 ranked.

The leaves (Fig. 4.5C) are costate with long lanceolate lamina and an expanded colourless base that ensheaths the stem. The sheathing base usually lacks chlorophyll and forms an effective external capillary conducting system. The transition from sheath to blade is often abrupt with a "hinge tissue". This tissue, by swelling and shrinking, controls outward and inward movement of leaf blade. The leaves are divergent when moist, exposing their upper surfaces for maximum illumination and optimal photosynthesis. When the leaves are dry they are imbricated, reducing water loss.

Internally, the gametophytes of these mosses attain maximum tissue differentiation. There is well-defined conducting system in stem and leaves.

In the rhizomatous stem (Fig. 4.6A, B) numerous rhizoids are the extensions of epidermal cells. Next to epidermis is the cortex, of thick-walled cells, stereids. At times the cortex is divisible into two zones. The outer cortex has stereids whereas the inner cortex consists of thin-walled cells. The cortex is separated from broad central strand by a single layer of enlarged cells, interpreted as endodermis. The central portion of rhizomatous stem is composed of thick-walled supportive cells stereids, amongst which are water-conducting cells, the hydroids. On the outer part of central strand there are 3 clusters of metabolite-conducting cells, termed as leptoids.

In the stem of aerial branches there are similar layers. However, the central strand (Fig. 4.6C, D) is made up of only hydroids and is encircled by a discontinuous layer of leptoids. There is a broad cortex but there is no layer resembling endodermis.

The hydrome-leptome conducting system (Fig. 4.6C) of these plants is comparable to xylem-phloem of vascular plants.

The hydroids and leptoids are also present in costa of leaf as scattered cells amongst the thick-walled supportive cells. On the dorsal surface of leaf, especially on costa, are a few to many filaments (Fig. 4.5D) of richly chlorophyllous cells - the lamellae- which constitute an efficient photosynthetic area of leaf. The spaces in between lamellae serve for gaseous exchange and retain water to keep the leaf moist. The blade extending from lamellae is unistratose and the blade margins

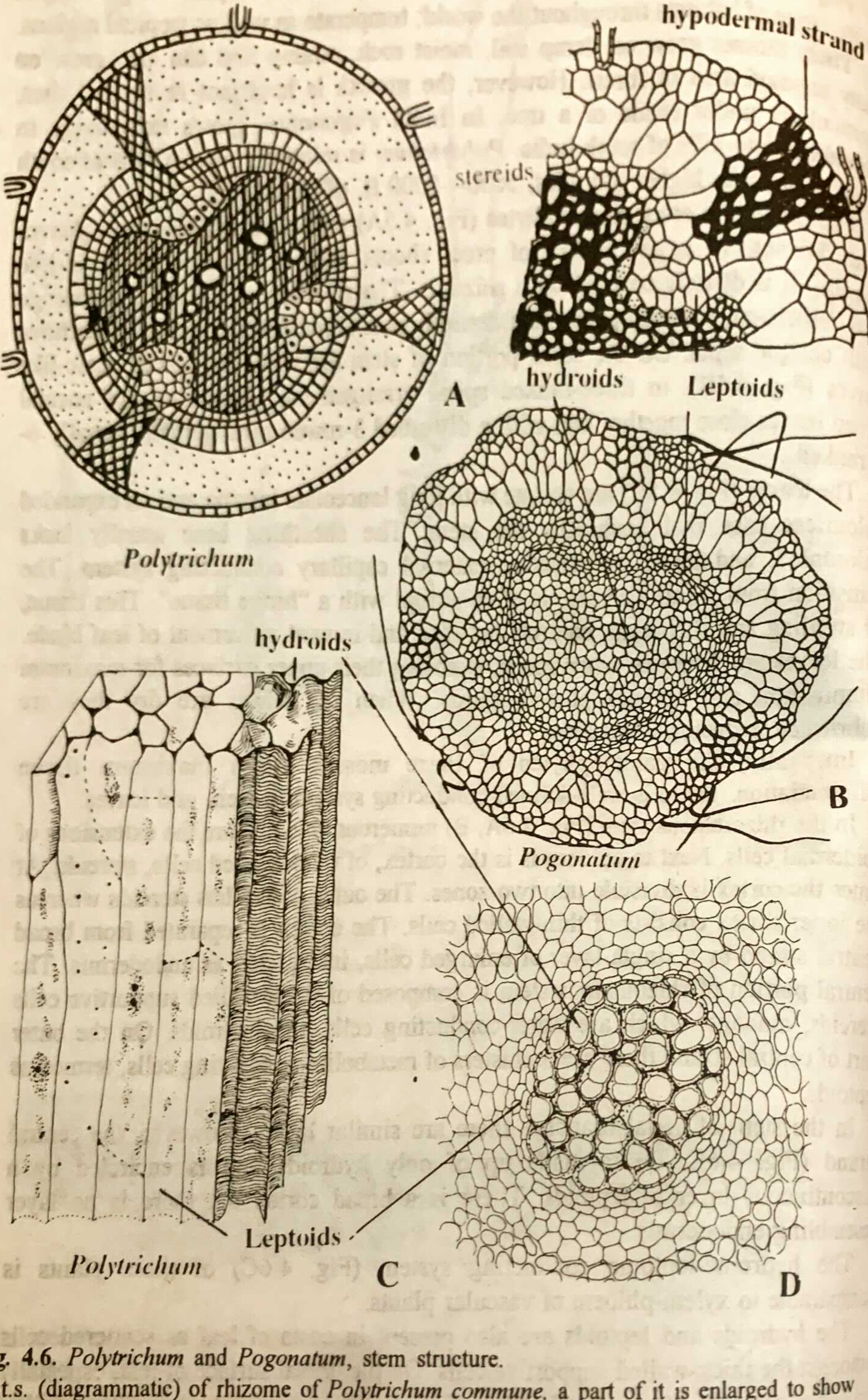


**Fig. 4.6.** *Polytrichum* and *Pogonatum*, stem structure.
A, t.s. (diagrammatic) of rhizome of *Polytrichum commune*, a part of it is enlarged to show cellular details. B, t.s. of rhizome of *Pogonatum*, in it also can be seen radial strand, stereids, leptoids and hydroids. C, *Polytrichum commune*, 3-D representation of conducting strand showing hydroids and leptoids. D, the cells of central strand enlarged to show hydroids and encircling leptoids.

may fold over lamellae, preventing water loss, as seen in *Polytrichum juniperinum.*

In *Atrichum* is seen a reduction of this elaborate structure, where the lamellae are restricted to costa and are only a few cells in height. There is no sheathing base and entire leaf is chlorophyllous and bistratose.

## Reproduction

Most species of *Pogonatum* and *Polytrichum* are dioecious.

On a female plant are formed 3-6 archegonia (Fig. 4.7A). After production of archegonia the growth of a female plant ceases, as the apical cell is utilized in the formation of last archegonium. However, if fertilization fails to occur, a lateral branch is formed, it becomes archegonial and tends to dominate the main branch.

On male plants antheridia are formed on a small antheridial head (Fig. 4.7B) at the position of a lateral branch. A male plant may have several antheridial heads. A male stump is conspicuous by its broad perigonial leaves, forming a cup-shaped structure around antheridia.

The sex organs, antheridia as well as archegonia, are associated with filamentous structure - paraphyses.

Development of an antheridium is similar to that described for *Funaria.* Mature antheridia are club-shaped structures associated with uniseriate parahyses.

Development of an archegonium is also similar to one described for *Funaria.* A mature archegonium is long-necked, with six rows of neck cells and multilayered venter. Lower portion of neck also becomes bilayered. The multilayered venter forms a calyptra to protect the developing sporophyte. The superficial cells of calyptra produce papillate outgrowths, which elongate and in later stages develop thick walls. Because of this hairy covering on the sporophyte these mosses are known as hair-cap mosses.

The sporophyte (Fig. 4.5A; 4.8A,B) has distinct foot, seta and capsule. The foot is tapered (Fig. 4.7D) and penetrates inside the gametophyte for anchorage and absorption. In continuation with foot is a long seta, it is made up of thick-walled cells and a central conducting strand (Fig, 4.8C) of hydroids and leptoids. In the region of capsule the seta merges with an indistinct apophysis in *Pogonatum* and a distinct apophysis in *Polytrichum,* at times there is a prominent bulge at the point where apophysis merges with the main body of capsule. The capsule is elongate cylindrical in *Pogonatum* to conspicuously four-angled in *Polytrichum,* and to broadly bell-shaped in *P. commune.* The operculum of capsule is conical in *Pogonatum* and conical to apiculate in *Polytrichum.*

The young sporophyte is green and photosynthetic. However, with age cell walls turn brown, dark brown to red. The wall of capsule is multistratose (Fig.4.8D), the outermost layer differentiates as epidermis with a thickened outer cell wall. The epidermis usually bears stomata in *Polytrichum,* which are confined to groove in between the apophysis and main body of capsule. Stomata have two guard cells with an opening but at times guard cells are incompletely separate. Therefore, a single annular binucleate guard cell with a slit may also be present.

In the centre of capsule, extending from apophysis to opercular region, is a strand of sterile thin-walled cells; the columella (Fig. 4.8B,D).The fertile

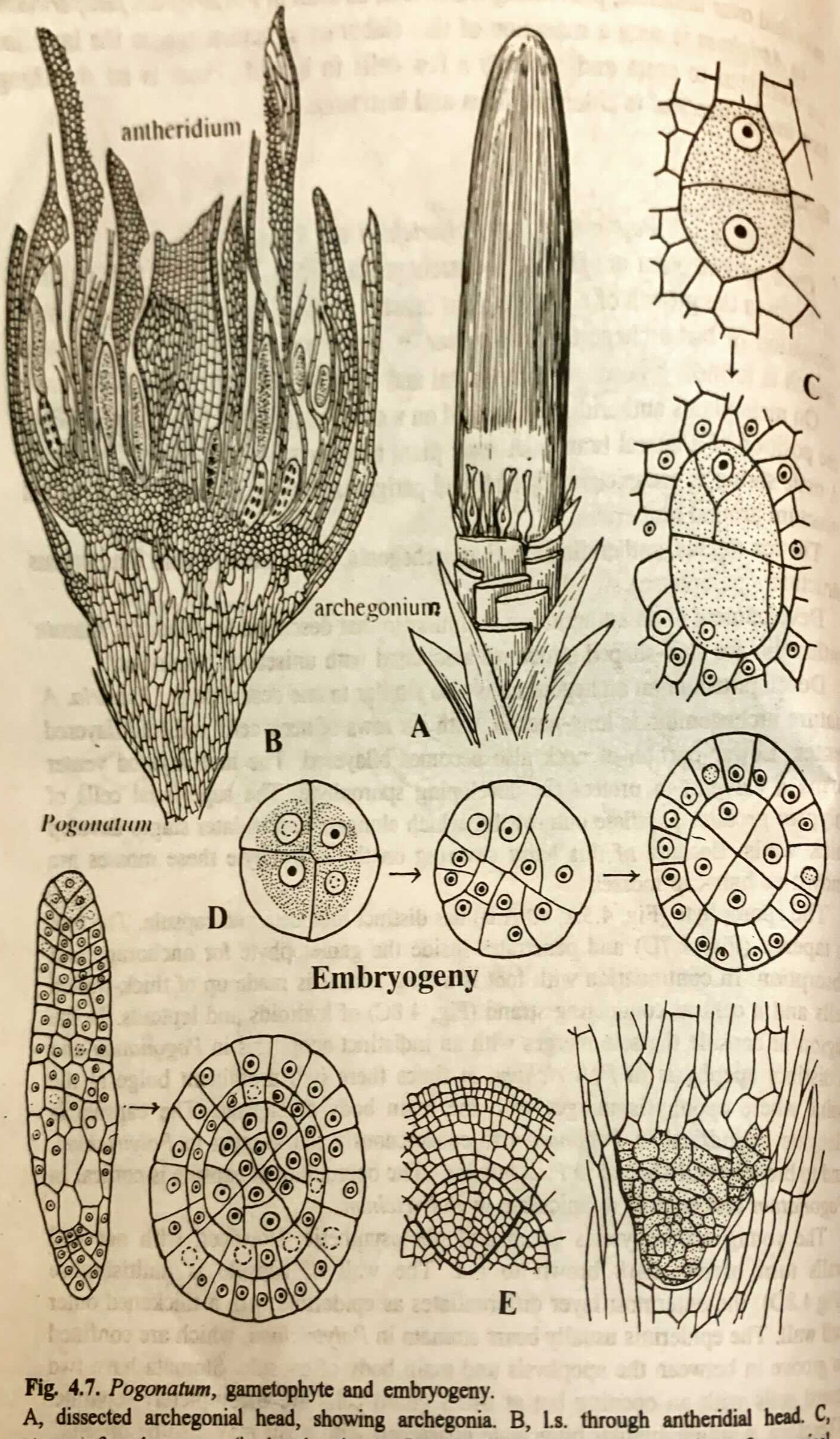


**Fig. 4.7.** *Pogonatum*, gametophyte and embryogeny.
A, dissected archegonial head, showing archegonia. B, l.s. through antheridial head. C, stages of embryogeny (in longisections); first division of embryo, formation of an apical cell, and bipolar embryo. D, stages of embryogeny (in t.s.). E, l.s. of sporophyte at the base showing haustorial foot and cells of seta.

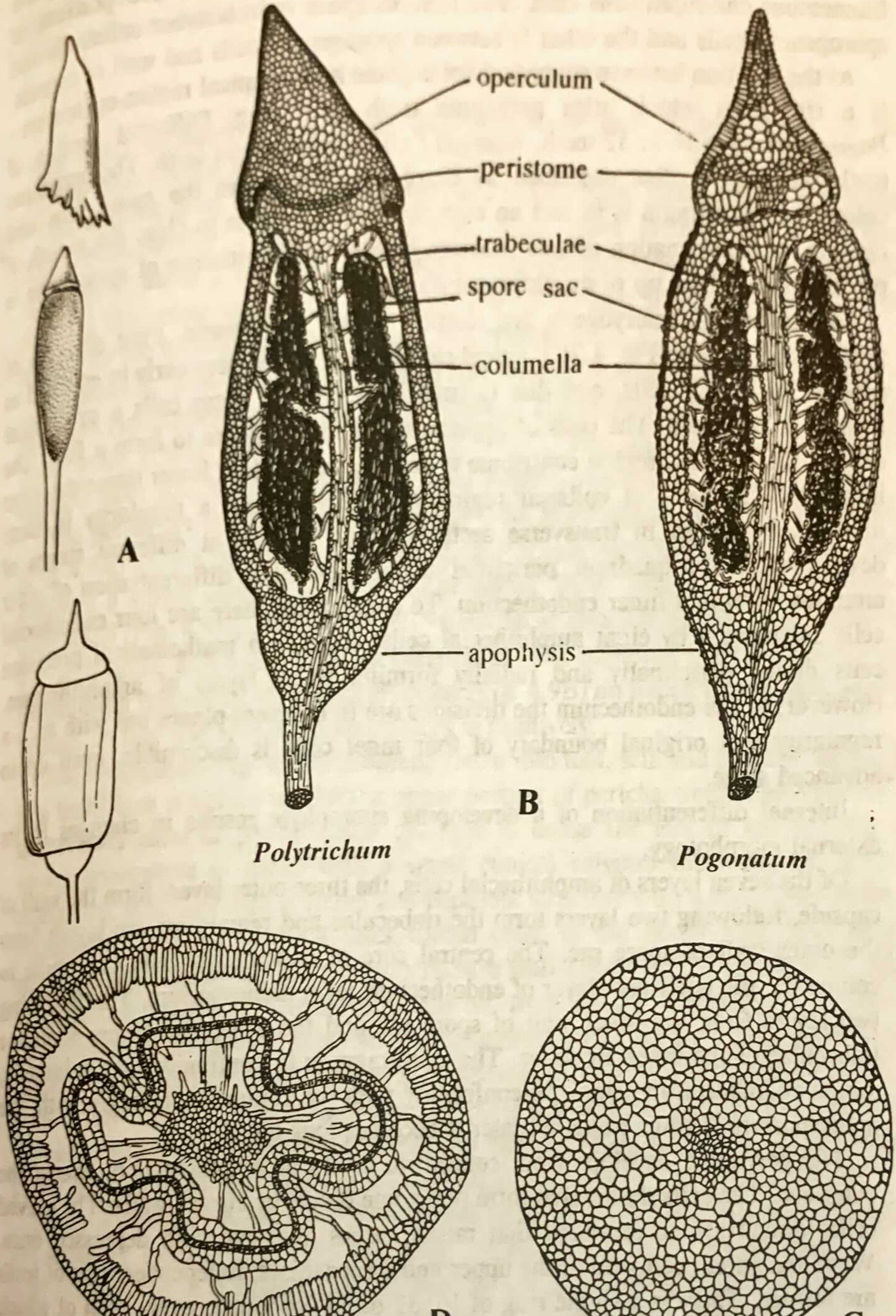


**Fig. 4.8.** *Pogonatum* and *Polytrichum*, sporophytes
A, capsules of *Pogonatum* and *Polytrichum*, respectively. B, l.s. capsule of *Polytrichum* and *Pogonatum*. C, t.s. through seta of *Pogonatum*. D, t.s. through capsule of *Pogonatum* at the region of sporogenous tissue.

sporogenous region or spore sac lies in between columella and wall of capsule surrounded by two zones of air spaces, traversed by supportive portions of filamentous chlorophyllous cells. The first air space is in between columella and sporogenous cells and the other is between sporogenous cells and wall of capsule.

At the junction between main body of capsule and its apical region-operculum is a rim from which arise peristome teeth in a ring. Different species of *Pogonatum* have 16 or 32 teeth, whereas *Polytrichum* has 64 teeth. The peristome teeth roll over a disc described as diaphragm, it covers the spore sacs and columella. Epiphragm is in fact an expansion of columella to close the mouth of capsule. An appreciation of this intricate cellular differentiation of sporophyte is possible in a follow up of developmental details.

The details of embryogeny are similar to that of *Funaria.* First division of zygote is transverse (Fig. 4.7C), apical cells are organized very early in epibasal as well as hypobasal cells, and due to orderly activity of these cells a cylindrical embryo is produced. The cells of hypobasal half differentiate to form a foot. The cells in the terminal region contribute to capsule and bulk of lower tissue develops into seta. The cells of epibasal region of embryo reveal a regularity in their division, best seen in transverse sections of an embryo at different stages of development. In a quadrant, periclinal divisions result in differentiation of outer amphithecium and inner endothecium. To begin with, there are four endothecial cells surrounded by eight amphithecial cells. Later in a mathematical precision cells divide periclinally and radially forming seven layers of amphithecium. However, in the endothecium the divisions are in different planes but with such a regularity that original boundary of four inner cells is discernible, even up to advanced stage.

Internal differentiation of a developing sporophyte results in changes in its external morphology.

Of the seven layers of amphithecial cells, the three outer layers form the wall of capsule, following two layers form the trabeculae and remaining two layers form the outer wall of spore sac. The central core of endothecial cells contribute to columella, the outermost layer of endothecium form archesporium. The following two layers form the inner wall of spore sac and the inner two layers form the trabeculae of the inner air space. The epiphragm is in continuity with columella, and is endothecial in origin. In conformity with the columella, to begin with, the archesporium is square-like but later it becomes four-lobed.

The peristome develops from concentric layers of amphithecium, except the outer one. The cells destined to form peristome divide by curved walls. The curved cells formed are so arranged that raised areas alternate with depressed ones. When the parent cell wall at the upper end disorganises, independent tips of teeth are formed. There is a single ring of 16, 32 or 64 concentric teeth, each of which is a blunt multicellular structure - of four concentric layers having straight cells in its central zone and U-shaped cells towards the periphery.

Dehiscence of a mature capsule is triggered due to shrivelling in dry weather; the operculum falls off and pressure on air cavities around sporogenous layer can result in ejection of spores through the spaces between peristome teeth. However, peristome teeth twist about each other, to close the mouth and prevent rapid

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shedding of spores. Instead, the jarring of capsule wall results in puffing out of spores through the gaps between the peristome teeth. In this manner, for an extended period occurs the dispersal of spores.