SPHAGNALES (bog-moss)

The Sphagnobrya - the bog moss - with a single genus *Sphagnum* has characters common with Hepaticeae, Anthocerotaceae and Musci.

It differs from other mosses in having :

(a) Thallose protonema, that produces one gametophyte.

(b) Leaves are without midrib, made up of two types of cells.

(c) Axillary antheridia, that are with a distinctive differentiation of fertile portion.

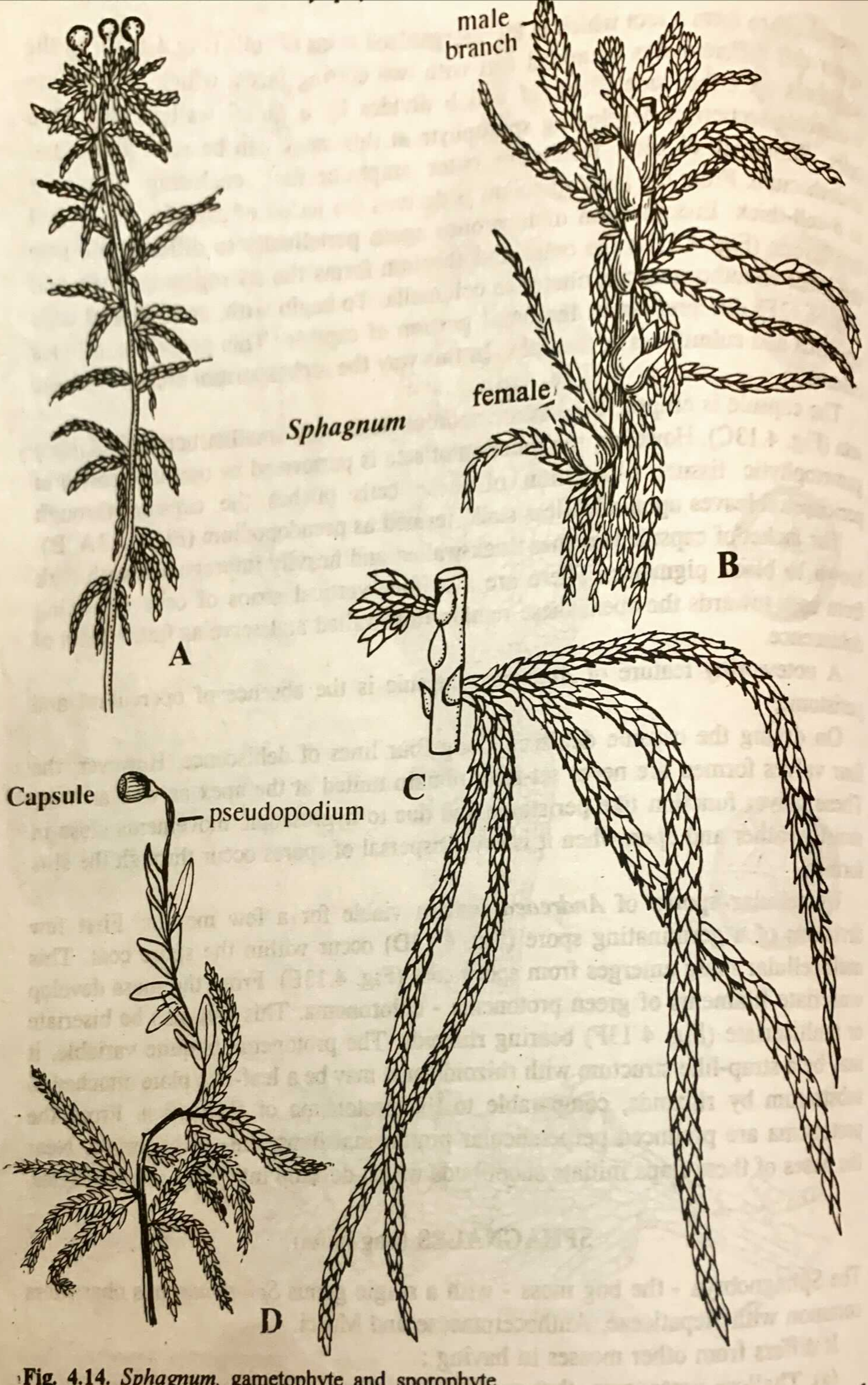

Fig. 4.14. *Sphagnum*, gametophyte and sporophyte.
A, portion of a plant of *S. palustre* bearing terminal cluster of sporogonia. B, the same, of *S. acutifolium*, bearing antheridial and archegonial branches. C, the same, showing divergent and pendent branches. D, the same, showing a mature sporogonium borne on an elongate pseudopodium.

(d) Archegonia are acrogynous.
(e) Sporogenous tissue of sporophyte is derived from amphithecium.
(f) In common with *Andreaea* the sporophyte has a pseudopodium.

SPHAGNUM

Sphagnum is a cosmopolitan genus that grows abundantly as dense masses in ponds, lakes or sites where due to seepage soft-water is available and there is but little lime. It reaches its greatest abundance in cooler temperate regions of northern Hemisphere where it dominates the vegetation of wetlands. The plant is perennial, the stem continues to grow year after year. Around the plants the water is so acidic that there is but little decay of dead basal portions. The older parts die and the dead organic remains of these plants along with remains of the other plants form a compact mass, known as peat. Accordingly it is known as peat moss, also it is typical of bogs, hence, also described as bog-moss. As a peat-former, it is commercially the most valuable of bryophytes.

In India *Sphagnum* is represented by about 20 species (Gangulee, 1969) in Himalayas, east as well as west, *S. ceylonicum* has also been reported from south India. However, in India the growth of this moss is not so luxuriant to result into a peat or a bog.

The plants are branched leafy gametophytes (Fig. 4.14A, B) differentiated into stem and leaves. The leaves are spirally arranged and widely spaced, with little or no chlorophyll. There are no rhizoids. On the stem, at a position where the fourth leaf is expected to arise, there is a fascicle of 3-8 lateral branches (Fig. 4.14C), these branches are also spirally arranged. Each fascicle has two or more divergent branches and two or more slender pendent branches, which drop downwards along the stem. The stem is only a few inches in length and close aggregation of short and stumpy branches towards the apex (Fig. 4.14A) make it look like a head or capitulum. The branches also have spirally arranged leaves. With the growth of axis in length the branches towards the apex elongate and the main stem in turn forms new short branches. Occasionally, one of the branches becomes robust and grows upwards, like the main axis, produces a tuft of branches and apical cluster of branches. This dominant branch is known as innovation. The plant is capable of effective vegetative propagation; the branches on separation form new individuals.

The stem grows by means of an apical cell with three cutting faces. Each segment cut off by the apical cell contributes towards a leaf and subtending portion of stem. To begin with leaves are arranged in 3 vertical rows, corresponding to three cutting faces of apical cell, but due to growth of stem this arrangement is displaced.

The leaves are distinctive in lacking a midrib and an orderly disposition of two types (Fig. 4.15A) of cells : (a) narrow and elongate chlorophyllous cells, and (b) polygonal large hyaline cells which are devoid of cell contents. These cells have thickening bands and pores. The leaves on the main stem are different in size, shape and structure than those on branches. The stem leaves have little or no chlorophyll, their hyaline cells lack pores and thickenings. The leaves present on branches are made up of a network of elongate chlorophyllous cells, 5 or 6 of which surround one hyaline swollen porose dead cell.

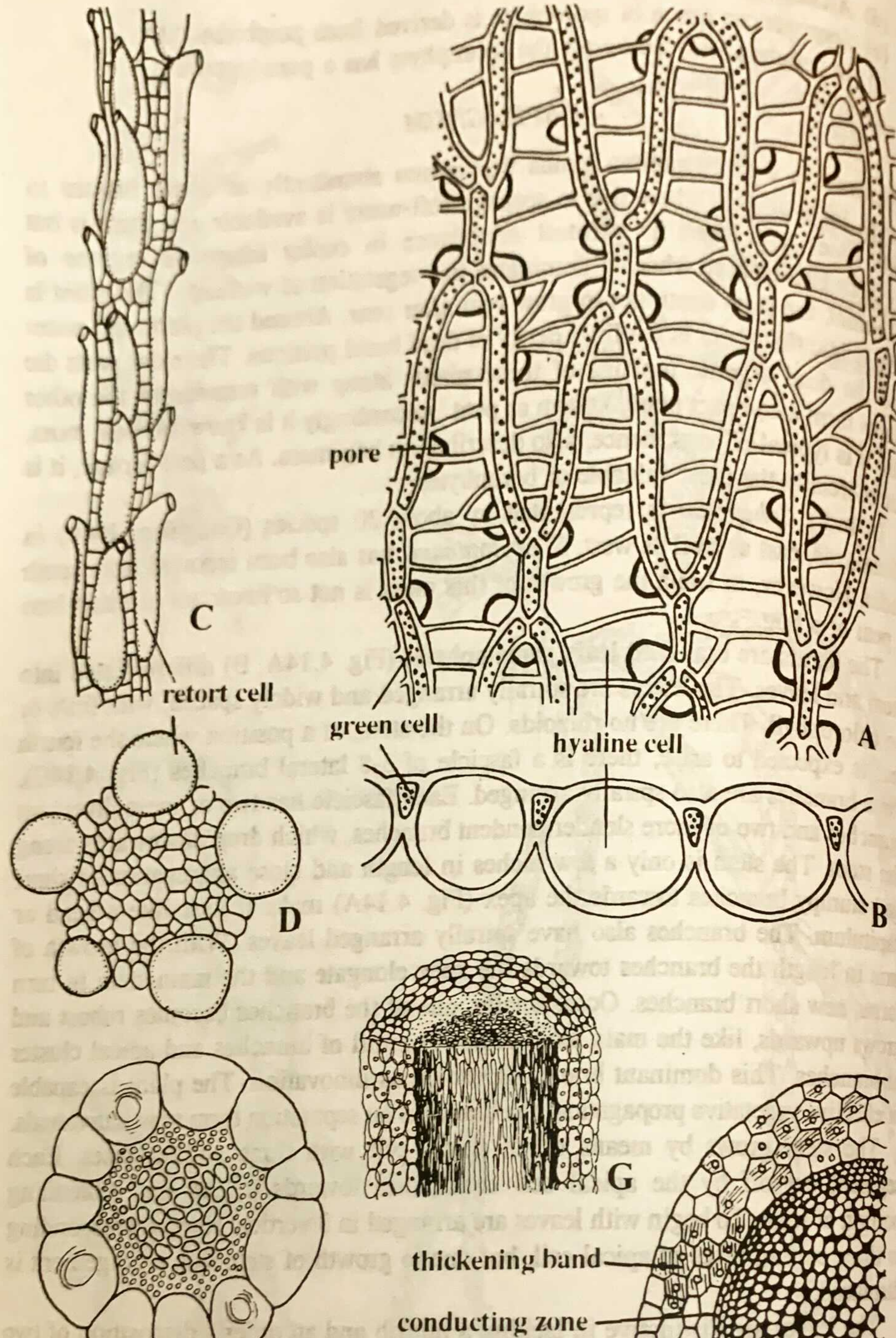

Fig. 4.15. *Sphagnum,* structure of leaf and stem.
A, portion of mature leaf. B, section of a leaf. C, portion of stem, showing retort cells. D, the same, in t.s. E, old stem in t.s. F, t.s. of stem (divergent branch) showing cortical cells with fibrillar thickenings and pores. G, 3-D representation showing multistratose cortex with pores and fibrils.

In a cross section of mature leaf (Fig. 4.15B) there is an alternation of large and dead hyaline cell and wedge-shaped chlorophyllous cell.

This characteristic pattern of leaf cells, described above, is possible due to activity of an apical cell with two cutting faces, forming right and left segments in a regular manner. To begin with, in a young leaf all cells are alike. However, later each cell of a young leaf divides asymmetrically to form a smaller cell towards the margin of leaf and a larger cell. This larger cell divides asymmetrically to form a large cell and a small cell which lies towards the apex of leaf. In this process of division the chloroplasts go to narrow cells and larger cells become non-chlorophyllous, lose their contents and become hyaline. These cells, also develop thickening bands.

Internally the main stem is differentiated into three distinct zones (Fig. 4.15E, G). The cortical cells are hyaline and often have thickening bands and pores, as in hyaline cells of leaf, for absorption and retention of water. In species with submerged stems the cortical cells are unmodified normal cells. The axial cylinder is made up of outer layer of small pigmented thick-walled cells and a central mass of somewhat enlarged cells. The pigmented cells have various shades. Bright colours of *Sphagnum* plants are due to colour of these pigmented cells and light passing through colourless cortical cells.

The branches are characterised by one-layered cortex (Fig. 4.15F). The axial cylinder is similar to main stem. In some species the cortical cells are of two types. There is conspicuous elongation of some of the cortical cells into a long narrow structure with a curved neck and an opening. These modified cells resemble a retort; hence, the name retort cells (Fig. 4.15C, D). In species having cortical cells with thickenings and pores, the retort cells are missing.

Reproduction

Sphagnum can be dioecious as well as monoecious; but antheridia occur on different branches. Initially, the sexual branches are in the capitulum but due to elongation of main stem they are isolated.

The antheridial branches (Fig. 4.14B) are specialized divergent branches in which the upper region bears stalked axillary antheridia (Fig. 4.16A). The leaves of antheridial branches are similar to that of vegetative leaves but these branches have a characteristic shade - deep red to brown, dark green to yellow. A plant bears many antheridial branches. After the formation of antheridia a branch can resume its vegetative function.

The archegonial branches are stumpy bud-like (Fig. 4.14B), the perichaetial leaves are large and bright green. The apical cell of this branch is used up in the formation of first archegonium - primary archegonium. Secondary archegonia may arise from segments cut off by the apical cell. Usually there are three archegonia (Fig. 4.16B) without paraphyses. There are several archegonial branches on a shoot.

An antheridial initial is the superficial cell of stem. This cell divides transversely to form a filament (Fig. 4.16C). On the terminal cell of the filament is organized an apical cell with two cutting faces. This apical cell cuts off 12-15 segments, of

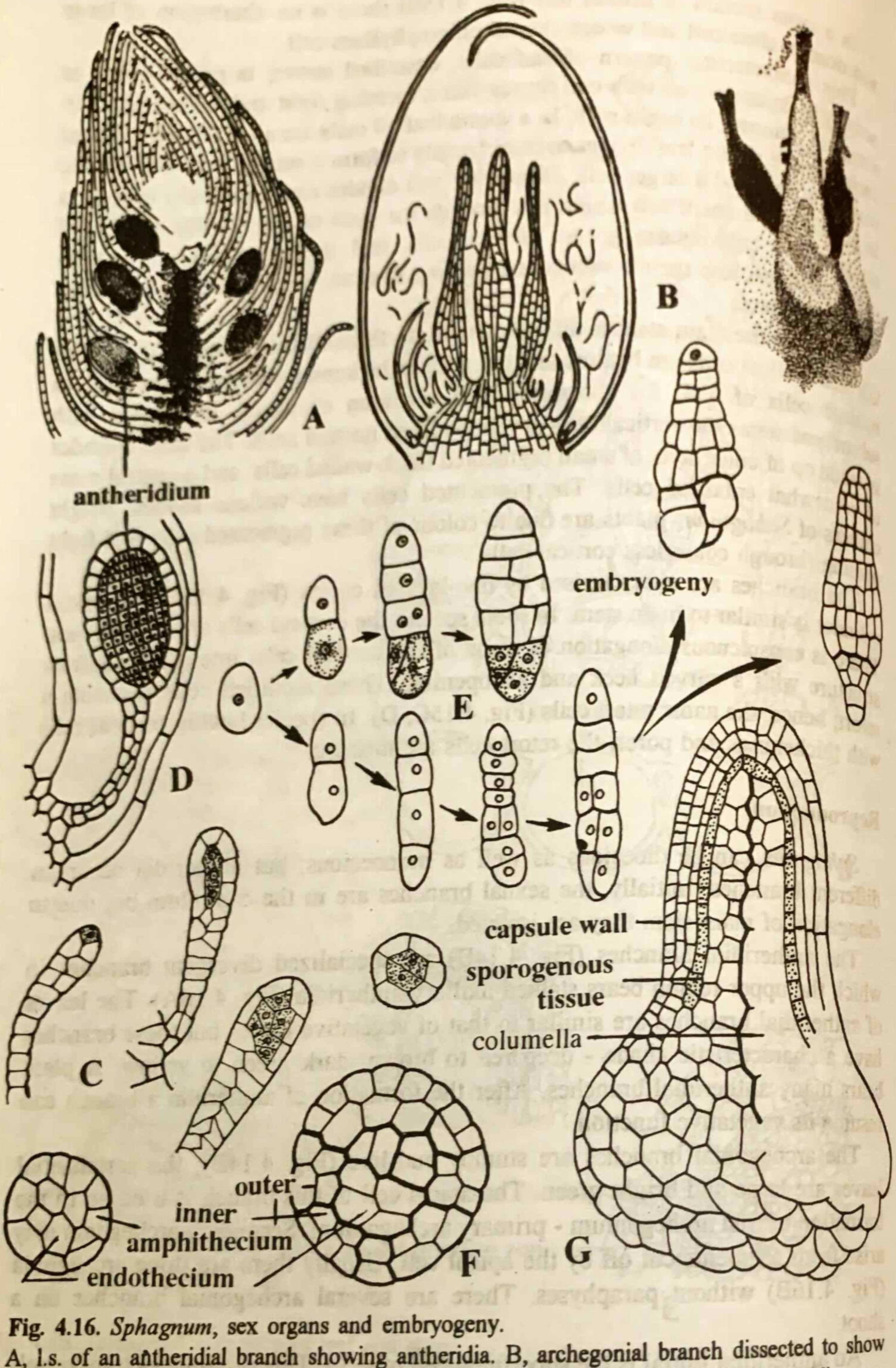

Fig. 4.16. *Sphagnum*, sex organs and embryogeny.
A, l.s. of an antheridial branch showing antheridia. B, archegonial branch dissected to show archegonia. C, stages in development of an antheridium. D, an axillary antheridium on maturity. E-G, stages of embryogeny.
(C, after Smith; D, after Parihar, E-G, after Waldner and after Bryan)

which last formed 2-5 segments contribute to the body of antheridium and the remaining cells contribute to the long stalk (Fig. 4.16D) of an antheridium.

For the development of an antheridium each of the upper 2-5 segments divides by an oblique vertical wall followed by another oblique wall which touches the first wall. In this way two jacket cells and one spermatogenous cell are formed. Due to similar divisions in neighbouring cells two spermatogenous cells are surrounded by four jacket cells. The jacket cells divide anticlinally to produce one-cell-thick jacket of an antheridium. Spermatogenous cells divide repeatedly to form a mass of androgonial cells, each androgonial cell forms two spermatogenous cells which metamorphose into biflagellate spermatozoids.

Sphagnum, in its mode of development of antheridium is similar to mosses *Funaria, Pogonatum* etc. However, its antheridia are similar to hepatics, as against clavate in mosses. This is because apical cell discontinues its activity rather early.

An antheridium dehisces, splitting at its apex to form several revolute lobes, which allow an easy escape of antherozoids.

The initial for the primary archegonium is the short apical cell. This may produce several segments from its two cutting faces or may divide transversely to produce a filament of cells. The secondary archegonia may arise from superficial cells on the stem apex. The mode of archegonial development is more in line with that seen in liverworts than in mosses. The terminal cell divides by three oblique walls forming three jacket initials and an axial cell. The jacket initials divide to form jacket of the neck and venter. The axial cell divides transversely to form upper cover initial and lower central cell. The cover initial forms a group of cover cells, it is unlike mosses. The central cell by transverse division produces primary neck canal cell and the venter cell. Primary neck canal cell divides to form a row of neck canal cells. The venter cell divides to form a venter canal cell and an egg. The venter and lower part of an archegonium are multilayered. A mature archegonium lacks a marked differentiation into neck and venter. The terminal portion of archegonium is derived from cover cell. However, this portion is not sharply differentiated, as in archegonia of liverworts.

Thus *Sphagnum* is intermediate between mosses and liverworts in structure and development of its sex organs.

During embryogeny (Fig. 4.16E) the zygote enlarges in size, secretes a wall and divides to form two equal cells. Hypobasal cell divides to form a haustorium which tends to be obliterated with the growth of sporophyte. Whereas epibasal cell divides to form a filament of five cells. The upper half of the filament contributes towards the capsule, median portion forms the foot of sporophyte and the lowermost cell adds to the haustorium. Each cell of the capsular region of embryo undergoes two successive vertical divisions. Periclinal divisions in each tier of four cells results in differentiation of outer amphithecium and inner endothecium (Fig. 4.16F). Division and redivision of endothecium results in differentiation of central columella of capsule. Whereas, periclinal division of amphithecium results in outer sterile layer and inner fertile layer - the archesporium (Fig. 4.16G). Both these layers overarch the columella. The archesporium divides to produce a sporogenous layer 2-4 cells in thickness, whereas outer sterile layer by becoming 3

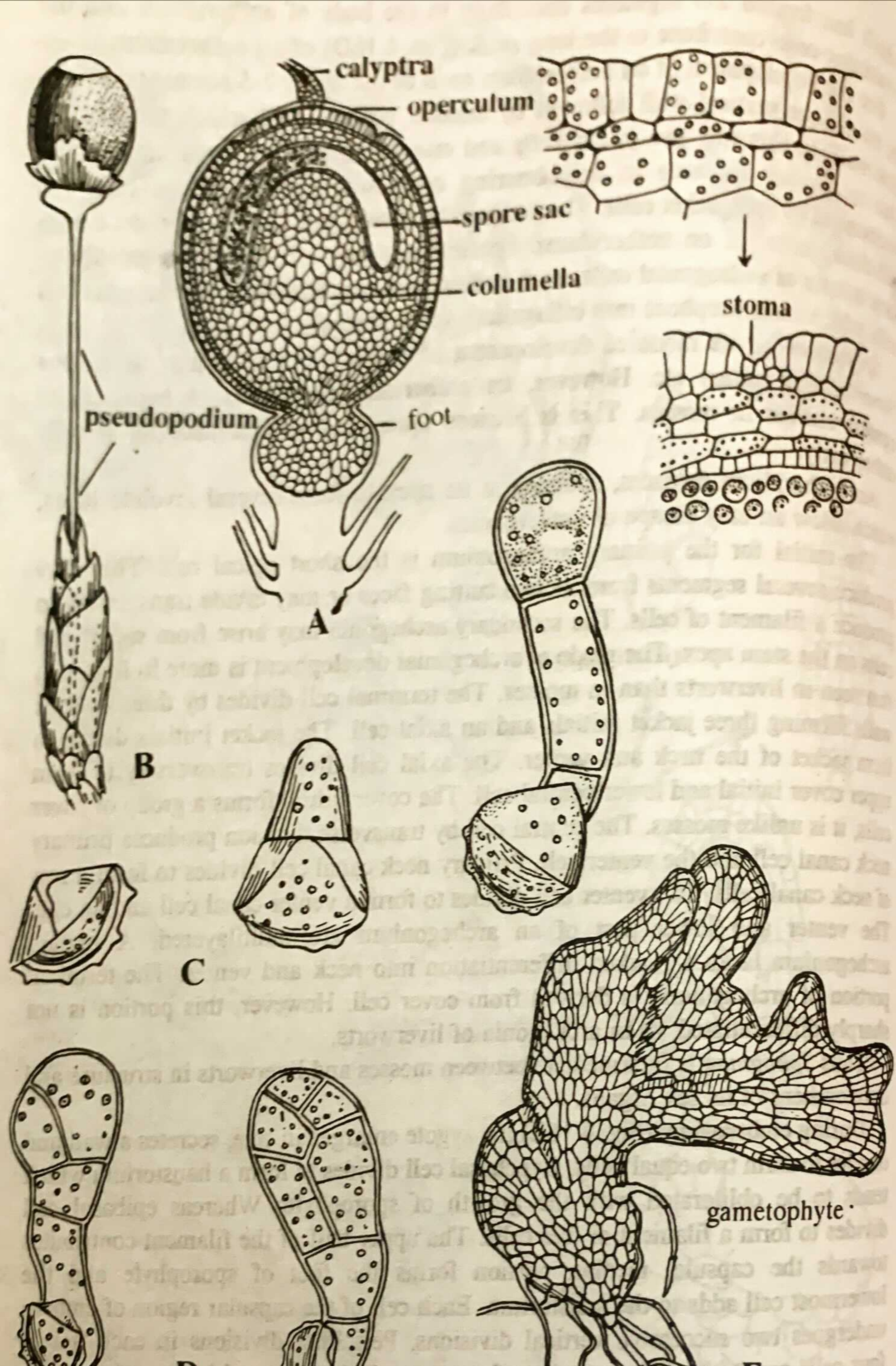

Fig. 4.17. *Sphagnum*, sporogonium and spores.
A, l.s. of mature sporogonium, also shown is wall of capsule bearing two stomata. B, mature sporogonium on an elongate pseudopodium. C-E, stages in germination of spores and formation of thalloid protonema.

to 4 cell-thick-layer becomes the jacket of capsule. The cells of jacket are homogenous, save for some cells differentiating into pairs of guard cells (Fig. 4.17A) which lack an opening. At a later stage in the development there is differentiation of a transverse ring of smaller cells (Fig. 4.17A) -annulus- in the upper portion of jacket which delimits the lid of capsule, the operculum. This is also accompanied by thickenings of walls of superficial cells of jacket. The archesporial cells differentiate into spore-mother-cells which divide to form spore tetrads.

Up to a late stage, the sporophyte is enclosed by calyptra; produced as a result of division of venter cells of archegonium. The neck of archegonium also remains as an appendage on the sporophyte (Fig. 4.17A).

The sporophyte has a massive foot and a bulbous capsule. The seta is represented by a constriction between capsule and foot. The function of seta is performed by elongation of female shoot termed as pseudopodium, which remains short till the sporophyte is mature. In a mature sporophyte the pseudopodium is an elongate structure (Fig. 4.17B).

Dehiscence of capsule is due to dual effect of hot weather and rapid growth of pseudopodium. On drying, the cells of columella shrivell and the space is replaced by air. The capsule tends to be cylindrical and due to the compression of enclosed air the operculum flicks away and brings about a rupture of spore sac, dispersing the spore, as yellow powder. In the entire process of dehiscence of capsule and dispersal of spores, an audible sound is produced.

In species growing submerged the capsule ruptures, allowing an escape for spores.

The spores remain viable for a few months and germinate (Fig. 4.17C) readily in favourable conditions to produce a germ tube which forms a filament of cells. Terminal cell of this filament differentiates into an apical cell of two cutting faces. Due to activity of this apical cell a flat plate of cells - protonema (Fig. 4.17D) - is formed. Later due to loss of control by the apical cell, on this plate appear localised areas of growth towards the margin, and rhizoids (Fig. 4.17E) appear at the posterior end. Any marginal cell can also regenerate into a filament which ends up into a thallose protonema. In this way is possible vegetative multiplication of thallose protonema. The marginal cells of this protonema give rise to a shoot-bud. One plant is produced by an individual protonema. The first-formed leaves are of uniform hexagonal chlorophyllous cells. Leaves formed later differentiate into a network of hyaline and green cells.