Systematic Studies on the Conducting Tissue of the Gametophyte in Musci

(2) On the Affinity Regarding the Inner Structure of the Stem in Some Species of *Dicranaceae*, *Bartamiaceae*, *Entodontaceae* and *Fissidentaceae*

Isawo KAWAI*

蘚類植物における配偶体の通導組織についての分類学的研究

(2) シッポゴケ科，タマゴケ科，ツヤゴケ科，ホウオウゴケ科の若干種における内部構造についての類縁性

Abstract

We suggest that on the basis of affinity shown in morphological differentiation we can classify the inner structures of the stem in Musci into six types we then consider to which type the inner structure of each stem in the endohydric mosses belongs. In some species of Dicranaceae: ***Campylopodium euphorocladum*** (C. MUELL.) BESCH., ***Dicranum japonicum*** MITT., ***Dicranum majus*** SMITH, ***Dicranum scoparium*** HEDW., ***Dicranum undulatum*** EHRH., ***Leucoloma okamurae*** BROTH., ***Oncophorus crispifolius*** (MITT.) LINDB., ***Thysanomitrium richardii*** SCHWGR., and in the species of Bartramiaceae: ***Philonotis falcata*** (HOOK.) MITT., ***Philonotis turneriana*** MITT., a cross section of the stem shows a differentiation of tissues into a epidermis, external cortex, internal cortex, endodermis and central strand (Type IV). The four species belonging to Entodontaceae: ***Entodon challengeri*** PAR., ***Entodon okamurae*** BROTH., ***Entodon ramulosus*** MITT., ***Entodon scabridens*** LINDB., and the species of Fissidentaceae: ***Fissidens cristatus*** WILS., ***Fissidens taxifolius*** (L.) HEDW. show differentiation into an epidermis, external cortex, internal cortex and central tissue (Type III).

With regard to the cell walls of the central strand, the stem of only the Dicranaceae is collenchymatous, but not so in the other families: Bartramiaceae, Entodontaceae and Fissidentacese. In ***Dicranum*** and ***Campylopodium*** of the Dicranaceae, cell walls of the central strand are slightly thick, but the central strand of ***Oncophorus***, ***Leucoloma***,

* *Department of Biology, Faculty of Science, Kanazawa University*

Thsanomitrium (Dicranaceae), *Philonotis* (Bartramiaceae), *Entodon* (Entodontaceae), and *Fissidens* (Fissidentaceae) consists of extremely thin-walled cell. The epidermal cell walls are thick in *Campylopodium, Dicranum, Oncophorus* and *Fissidens,* but are not in *Leucoloma, Thysanomitrium, Philcnotis* and *Entodon.* Furthermore, there is something in common among number of the cell layers of the internal cortex in the species belonging to the identical genus. In view of these facts, it is suggested that the characteristics of the conducting tissue of the stem are to a great extent peculiar to the genus, and that the characteristics of the stem-structure are vitally important in the classification of the genus and family.

Thus, in the studies of the inner structure, it is necessary for us to consider the origin of each tissue of the stem and interrelationship among the epidermis, external cortex, internal cortex, endodermis and central strand.

Introduction

In Musci, systematic studies on the conducting tissue and the stem of gametophyte have been made by many bryologists. They have different points of view; however, they agree in the opinion that the structural characteristics have to be given primary emphasis in taxonomical studies. Koponen (1968) pointed out that in Mniaceae the characters shown in the conducting tissue of the gametophyte, that is, the midrib of leaf and the stem, should be taken into consideration in the taxonomic discussion, and moreover, Ando (1957) made a great point of whether the central strand is or not; how much differentiated the epidermal cells are in the classification of the *Hypnum.* Kawai (1965) suggested that the inner structures of the stem and the midrib have to be given due emphasis in taxonomical studies of the *Grimmia,* and Kawai et Ikeda (1970) considerated on the inner structures of the stem in some species of the family Polytrichaceae and suggested that these characteristics have to be given due emphasis in taxonomical studies, and that on the basis of affinty shown in morphological differentiation we can classify the inner structures of the stem in Musci into six types; Type I (cortex-axial cylinder), Type II (epidermis-axial cylinder), Type III (epidermis-cortex-central tissue), Type IV (epidermis-cortex-endodermis-central strand), Type V (epidermis-cortex-endodermis-leptom-hadrom) and Type VI (epidermis-cortex-endodermis-leptom-hydrom-stereom). First, we will consider to which type the inner structure of each stem in the endohydric mosses belongs.

Materials and methods

The main source of material used for this research comprises specimens of mosses collected from Japan and Germany. All the samples studied are deposited in the Moss Herbarium of Kanazawa University. ***Campylopodium euphorocladum*** (C. Muell.) Besch.; Sakurajima Volcano, Kagoshima Pref. (35923), ***Dicranum japonicum*** Mitt. : Kuma, Isshoochi, Kumamoto Pref. (35015), Matsuye, Rakuzan, Shimane Pref. (35149), ***Dicranum majus*** Smith: Mt. Daisetsu, Hokkaido (35084), Harburg, Sieverser Sunder, Germany (30641), Harburg, Sieverser Sunder, Germany (30594), ***Dicranum scoparium*** Hedw.: Kitaazumi, Takasegawa, Nagano Pref. (35017), Ooshirakawa, Oonogun, Gifu Pref. (11022), Harburg nahe Neugraben, Fischbeker Heide, Germany (33222), Harburg, Sieverser Sunder, Germany (30640), Harburg, Wiedenthal, Germany (30573), Winsen Radbruch, Germany (30017), Holstein, Horneburg, Germany (30791), Metzendorf über Hittfeld, Germany (30794). ***Dicranum undulatum*** Ehrh.: Jesteburg, Bendestorf über Itzenbüttel, Germany (30672), Hamstedter Berge, Germany (33963), Holstein, Horneburg, Staatsforst Rüstje, Germany (30595), Winsen Radbruch, Germany (33647), Harburg, Sieverser Sunder, Germany (33666). ***Entodon challengeri*** Par.: Hitoyoshi, Kumamoto Pref. (35195), Isshoochi, Kumamoto Pref. (35083). ***Entodon okamurae*** Broth.: Kanakami, Mt. Sobo, Ooita Pref. (34952). ***Entodon ramulosus*** Mitt.: Mt. Jinkakuji, Ooita Pref. (35194). ***Entodon scabridens*** Lindb.: Kawakami, Misugi, Mie Pref. (34974). ***Fissidens cristatus*** Wils.: Mt. Hakusan, Ishikawa Pref. (34831). ***Fissidens japonicus*** Doz. et Molk.: Rokumanzan, Mt. Hakusan Ishikawa Pref. (39003). ***Fissidens taxifolius*** (L.) Hedw.: Aumühle nahe Hamburg, Germany (30734). ***Leucoloma okamurae*** Broth.: Nachi, Wakayama Pref. (34958). ***Oncophorus crispifolius*** (Mitt.) Lindb.: Sakatani, Miyazaki Pref. (35025). ***Philonotis falcata*** (Hook.) Mitt.: Saijo, Ehime Pref. (35081). ***Philonotis turneriana*** Mitt.: Ohwani, Aomori Pref. (35077). ***Thysanomitrium richardii*** Schwgr.: Kuma, Nishinomura, Kumamoto Pref. (34997).

For anatomical studies, microtome sections of the fresh moss are prepared by the ethylalcohol-buthylalcohol-paraffin method, following Bouin's fluid fixation. Before examination the dry moss is boiled in water for about half an hour. The inner structure of the stem of gametophyte is studied from serial transverse section having a thickness of 5-10μ. Acid fuchsin, fuchsin, fast green, methyl green are used for staining anatomical preparations.

Observation

The four families, eight genera, sixteen species were studied ints as to the conducting tissue of the stem. A cross section of the stem generally shows a differentiation of tissues into a epidermis, external cortex, internal cortex, endodermal layer and central strand (IV-type) in all species of Dicranaceae, *Campylopodium euphorocladum* (C. MUELL.) BESCH., *Dicranum japonicum* MITT., *Dicranum majus* SMITH, *Dicranum scoparium* HEDW., *Dicranum undulatum* EHRH., *Oncophorus crispifolium* (MITT.) LINDB., *Leucoloma okamurae* BROTH., and *Thysanomitrium richardii* SCHWGR. That is, on the outside of the stem there is a superficial layer of smaller cells with strongly thickened walls (except *Leucoloma* and *Thysanomitrium*). In the stem of *Leucoloma okamurae* BROTH. and *Thysanomitrium richardii* SCHWGR. the epidermis consists of a layer of large cells with thinner superficial walls and so the superficial cell walls are frequently concave. What I name external cortex is the band of sclerenchymatous cells containing a few chloroplasts. The external cortex, which has 1-6 layers with a strongly thickened cell walls and is considered to be a mechanical tissue, consists of smaller cells. What I name internal cortex is the thin-walled green parechyma which consists of 2-4 layers of large polygonal cell. The internal cortex containing a great number of chloroplasts may be a part of the assimilation tissue. At the inner limit of these cortical layers, which are a band of sclerenchymatous cells and a band of green parenchymatous cells, there is a layer of large cells. This layer, of which the cells are also thin-walled, parenchymatous green cells containing a great number of chloroplasts and bear a striking resemblance to the cells of the internal cortex, is here named endodermal layer. The central strand, of which the walls turn deep violet when treated with gentian violet solution, consists mainly a great number of extremely small, collenchymatous living cells (about 15-100 cells). The cell walls of the central strand are slightly thicker than those of the internal cortex and endodermal layer (except *Oncophorus, Leucoloma* and *Thysanomitrium*). In *Oncophorus crispifolius* (MITT.) LINDB., *Leucoloma okamurae* BROTH. and *Thysanomitrium richardii* SCHWGR. the cell walls of the central strand are extremely thin.

In *Philonotis falcata* (HOOK.) MITT. and *Philonotis turneriana* MITT. belonging to the family Bartramiaceae, a cross section of the stem shows as great a differentiation of tissues as in *Dicranum*. The epidermis, which is made up of one cell layer, has thinner cell walls than those of the external cortex, therefore, the superficial cell walls are frequently concave as in *Leucoloma okamurae* BROTH. and *Thysanomitrium richardii* SCHWGR. The cortical layers, which generally exist between the epidermis and the endodermal layer, differentiat into an external cortex, consisting of a sclerenchymatous cell layer with a few chloroplasts, and an internal cortex which contains about one to three parenchymatous cell layers with a great numbe of chloroplasts. The endodermal layer, which is inside the internal cortex, also ccntains many chloroplasts and resembles the internal cortex. The central strand has thinner cell walls than any other parts, and is not collenchymatous.

The four species belonging to the Entodontaceae, ***Entodon challengeri*** PAR., ***Entodon ramulosus*** MITT., ***Entodon scabridens*** LINDB. and ***Entodon okamurae*** BROTH., and the species of Fissidentaceae, ***Fissidens cristatus*** WILS., ***Fissidens taxifolius*** (L.) HEDW., show a differentiation into an epidermis, external cortex, internal cortex and a central tissue (Type III). The stem has generally one epidermal layer like that of ***Philonotis falcata*** (HOOK.) MITT., ***Philonotis turneriana*** MITT., ***Leucoloma okamurae*** BROTH. and ***Thysanomitrium richardii*** SCHWGR. The external cortex consists of two to six sclerenchymatous layers and the internal cortex consists of five to seven parenchymatous layers. Inside the internal cortex there is a central mass, which consists of slightly smaller cells with extremely thin cell walls.

In the two species of Fissidentaceae, ***Fissidens cristatus*** WILS. and ***Fissidens taxifolius*** (L.) HEDW., a cross section of the stem shows a differentiation of tissues into an epidermis, external cortex, internal cortex and central tissue (Type III). The epidermis consists of a layer of smaller cells with thicker walls; the external cortex, which has two layers with thickened cell walls, consists of slightly smaller cells; the internal cortex consists of 1-2 layers of large polygonal cells; the central tissue, of which the walls are slightly thinner than those of the internal cortex, consists of a mass of smaller cells.

Discussion

It is to be examined that whether these characteristics are peculiar to the species and whether there is something in common among the characteristics of the inner structures of the stem in the species belonging to the identical genus or family in Musci.

In the observation of the Polytrichaceae, the stem of ***Pogonatum, Polytrichum*** and ***Atrichum*** differentiates into the hadrom and the leptom, but it is not so in ***Bartramiopsis*** and ***Oligotrichum.*** This fact shows a certain correlation between the differentiation of the inner structure of the stem and the classification system of the Polytrichaceae (KAWAI et IKEDA 1970).

Also in other families also, such as Dicranaceae, Bartramiaceae, Entodontaceae and

Fissidetaceae, morphological differentiation of tissue in the stem shows some differences from species to species, and the stem of Dicranaceae and Bartramiaceae shows differentiation into the epidermis, the external cortex, the internal cortex, the endodermis and the central strand, which is Type IV, one of the six types classified on the basis of affinity shown in morphological differentiation. In Entodontaceae and Fissidentaceae, the stem of some species consists of an epidermis, the sclerenchymatous cortex, the parenchymatous cortex and the central conductive strand. The type is named Type III. As to the cell walls of the central strand, only the stem of the Dicranaceae is collenchymatous,

Tab. I Relationship among sixteen species as classified on the basis of affinity in characteristics of the inner structure of the stem

Family	Species	Numbers of Figure	Number of the cell layers of the external cortex (1–2 layers: A-type, 3–4 layers: B-type, 5–6 layers: C-type)		Number of the cell layers of the internal cortex (1–3 layers: A-type, 4–7 layers: B-type)		Epidermal cell walls are thick (A-type) or not (B-type)	Cell walls of the central strand are thick (A-type) or not (B-type)	Cells of the central strand are collenchymatous (A-type) or not (B-type)	Types of inner structure of the stem
Dicranaceae	*Campylopodium euphorocladum* (C. MUELL.) BESCH.	II-5	(1-2)1	A	(2-3)2	A	A	A	A	IV
Dicranaceae	*Dicranum japonicum* MITT.	I-2	(2-2)2	A	(4-5)5	B	A	A	A	IV
Dicranaceae	*Dicranum scoparium* HEDW.	II-4	(1-1)1	A	(5-6)6	B	A	A	A	IV
Dicranaceae	*Dicranum majus* SMITH.	II-6	(2-3)3	B	(5-6)6	B	A	A	A	IV
Dicranaceae	*Dicranum undulatum* EHRH.	I-3	(3-4)4	B	(4-5)4	B	A	A	A	IV
Dicranaceae	*Oncophorus crispifolius* (MITT.) LINDB.	I-1	(1-2)2	A	(2-5)4	B	A	B	A	IV
Dicranaceae	*Leucoloma okamurae* BROTH.	IV-13	(1-1)1	A	(1-2)1	A	B	B	A	IV
Dicranaceae	*Thysanomitrium richardii* SCHWGR.	III-7	(2-2)2	A	(5-6)5	B	B	B	A	IV
Bartramiaceae	*Philonotis falcata* (HOOK.) MITT.	III-8	(1-1)1	A	(1-2)1	A	B	B	B	IV
Bartramiaceae	*Philonotis turneriana* MITT.	III-9,10	(1-1)1	A	(3-4)3	A	B	B	B	IV
Entodontaceae	*Entodon challengeri* PAR.	V-15	(2-2)2	A	(4-5)5	B	B	B	B	III
Entodontaceae	*Entodon ramulosus* MITT.	V-16	(3-3)3	B	(6-7)7	B	B	B	B	III
Entodontaceae	*Entodon scabridens* LINDB.	V-14	(3-4)3	B	(4-5)5	B	B	B	B	III
Entodontaceae	*Entodon okamurae* BROTH.	V-17	(6-7)6	C	(4-6)6	B	B	B	B	III
Fissidentaceae	*Fissidens cristatus* WILS.	IV-11	(2-2)2	A	(1-3)2	A	A	B	B	III
Fissidentaceae	*Fissidens taxifolius* (L.) HEDW.	IV-12	(1-2)1	A	(1-2)2	A	A	B	B	III

but is not in the other families, Bartramiaceae, Entodontaceae and Fissidentaceae. In *Dicranum* and *Campylopodium* of the Dicranaceae, cell walls of the central strand are slightly thick, but the central strand of *Oncophorus, Leucoloma, Thysanomitrium* (Dicranaceae), *Philonotis* (Bartramiaceae), *Entodon* (Entodontaceae), and *Fissidens* (Fissidentaceae) consists of extremely thin-walled cells. The epidermal cell walls are thick in *Campylopodium, Dicranum, Oncophorus* and *Fissidens*, but are not in *Leucoloma, Thysanomitrium, Philonotis* and *Entodon.* Furthermore, there is something in common among the numbers of the cell layers of the internal cortex in the species belonging to the identical genus; in *Campylopodium* it consists of 2-3 cell layers, in *Dicranum* it consists of 4-6 cell layers, in *Oncophorus* it consists of 2-5 cell layers, in *Leucoloma* it consists of 1-2 cell layers, in *Thysanomitrium* it consists of 5-6 cell layers, in *Philonotis* it consists of 1-3 cell layers, in *Entodon* it consists of 4-7 cell layers, in *Fissidens* it consists of 1-3 cell layers. In view of these facts, it is suggested that the characteristics of the conducting tissue of the stem are to a great extent peculiar to the genus, so that the characteristics of the the stem-structure are vitally important in the classification of the genus and family (Tab. I).

In our future studies it has to be investigated whether, just as has generally been expected, these tissues of the stem, such as epidermis, external cortex, internal cortex, endodermis and central strand, have undergone distinctly different development of tissue specialized for the function. The first cell division in the young sgment cut off from the apex of stem, is periclinal and two cells the outer cell and the inner cell are produced. In the Type III, it is thought that (1) that the leaf is derived from the outer cell of the segment, that the epidermis, external cortex, internal cortex and central tissue are derived from the inner cell, (2) that the leaf and epidermis are derived from the outer cell, that the external cortex, internal coetex and central tissue are derived from the inner cell, (3) that the leaf, epidermis and cortex are derived from the outer cell and that the central tissue is derived from the inner cell (Fig. I, II, III)

In Type IV, it is thought that (1) the leaf originates in the outer cell, that the epidermis, external cortex, internal cortex, endodermis and central strand originate in the inner cell, (2) that the leaf and epidermis originate in the outer cell, and that the external cortex, internal cortex, endodermis and central strand originate in the inner cell, (3) that the leaf, epidermis, external cortex and internal cortex originate in the outer cell, that the endodermis and central strand originate in the inner cell, (4) that the leaf, epidermis, external cortex, internal cortex and endodermis originate in the outer cell, and that the central strand originates in the inner cell (Fig. IV, V, VI, VII)

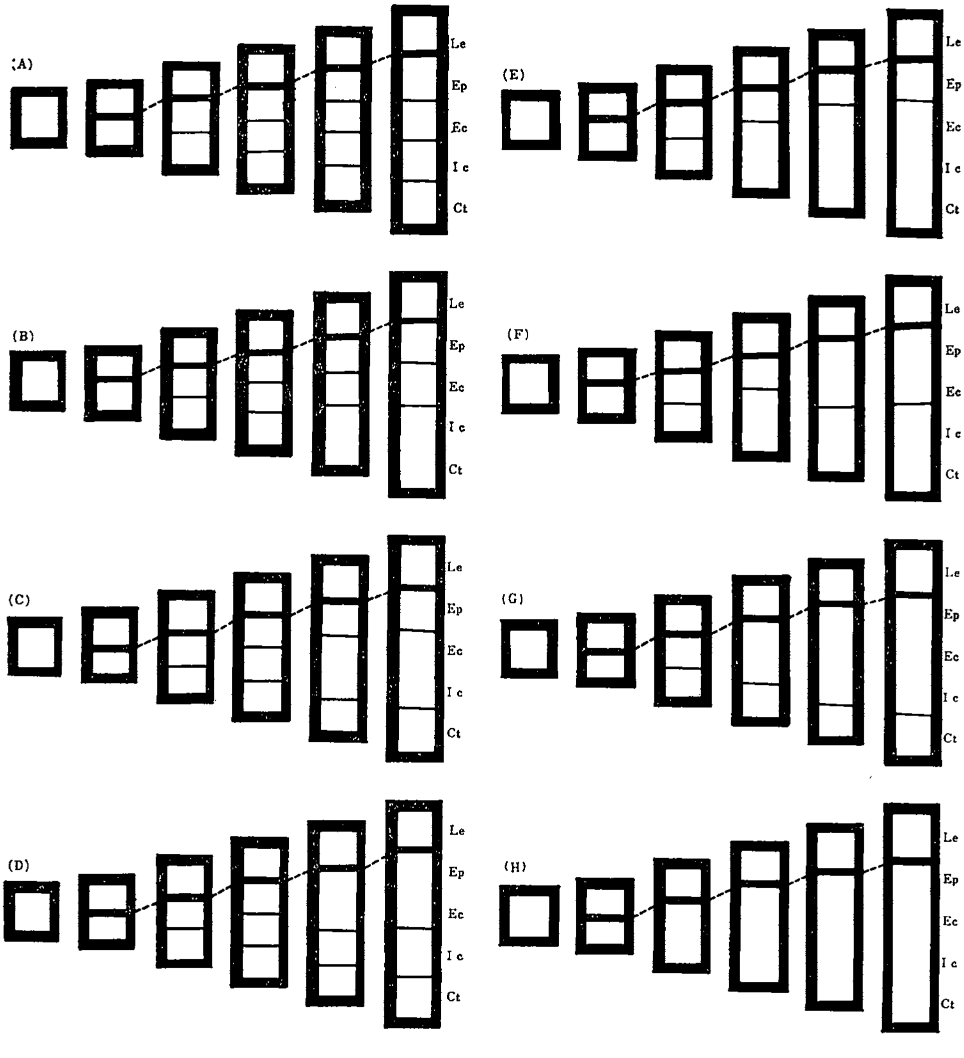

Fig. I Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), and central tissue (Ct).
The leaf is derived from the outer cell. The epidermis, external cortex, internal cortex and central tissue are derived from the inner cell.

For example, in a case (a in Fig. VII), it is found that the leaf is derived from the 0-1 cell, that the epidermis, external cortex, internal cortex and endodermis are derived from the 0-2 cell, and that the central strand is derived from the inner cell. These facts show that the distinction among the epidermis, the external cortex, the internal cortex and the endodermis is not clear, but that the distinction between those tissue and the central tissue is very clear. We propose a difinition that the tissue, which is derived from the 0-1 cell, is a leaf, and that the tissue, which is derived from the inner cell, is a central tissue. Thus, in studying on the inner structure, it is important to take in to consideration the origin of each tissue of the stem and interrelationship among the epidermis, external cortex, internal cortex, endodermis and central strand.

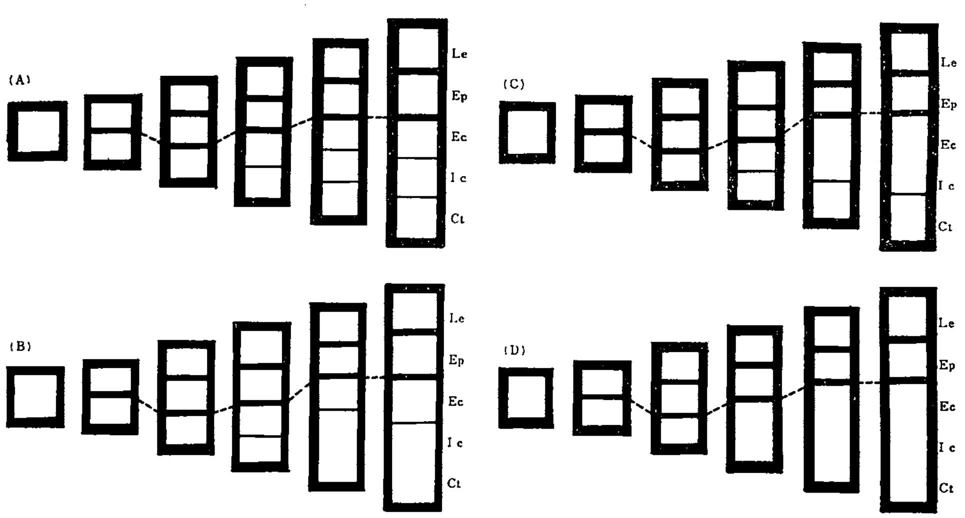

Fig. II Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), and central tissue (Ct).
The leaf and epidermis are derived from the outer cell. The external cortex, internal cortex and central tissue are derived from the inner cell.

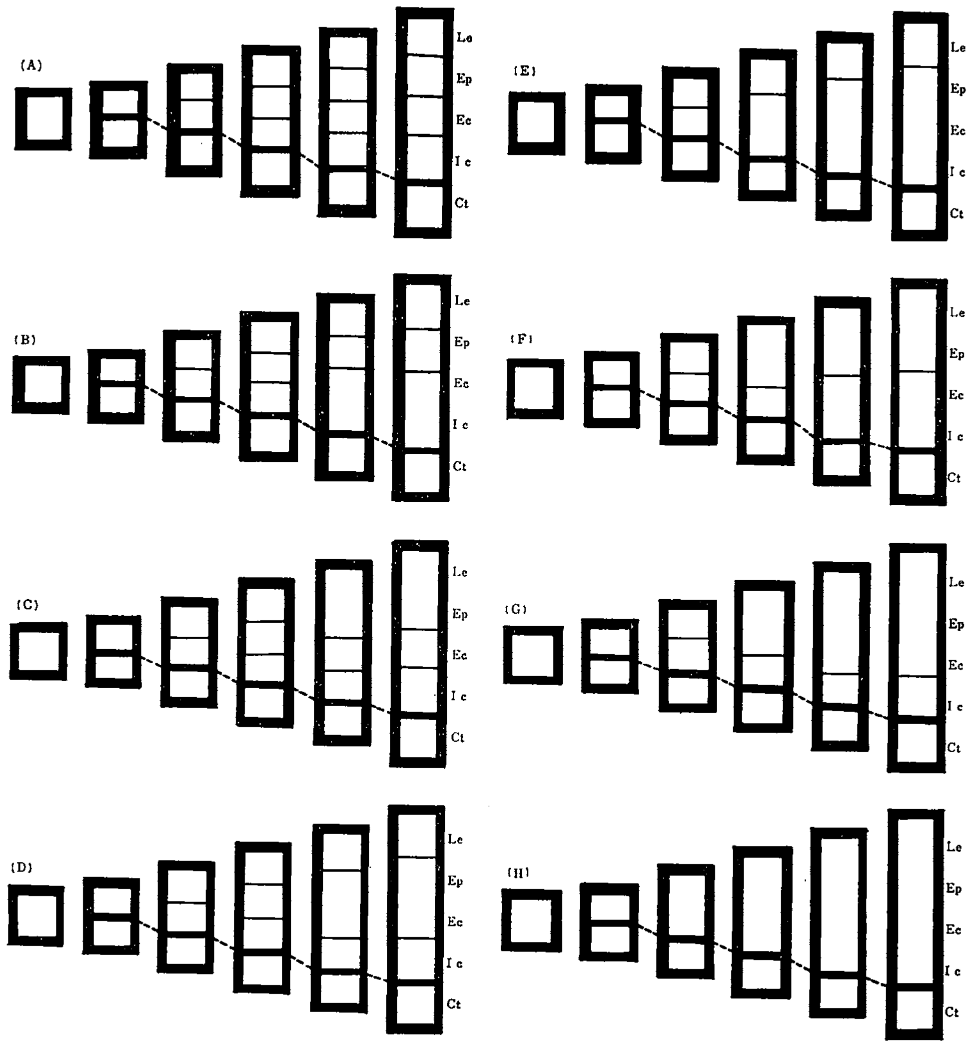

Fig. III Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), and central tissue (Ct).
The leaf, epidermis, external cortex, internal cortex are derived from the outer cell. The central tissue is derived from the inner cell.

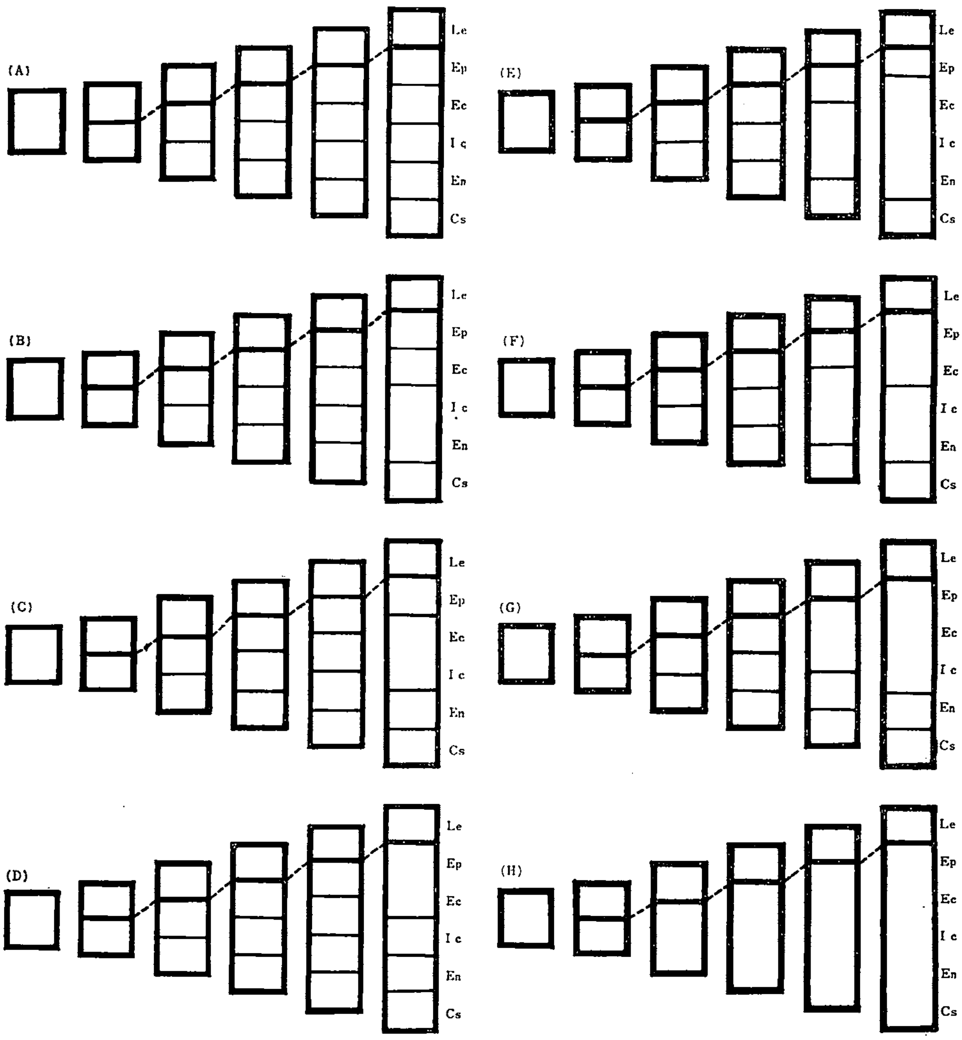

Fig. IV Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), endodermis (En) and central strand(Cs). The leaf is derived from the outer cell. The epidermis, external cortex, internal cortex, endodermis and central strand are derived from the inner cell.

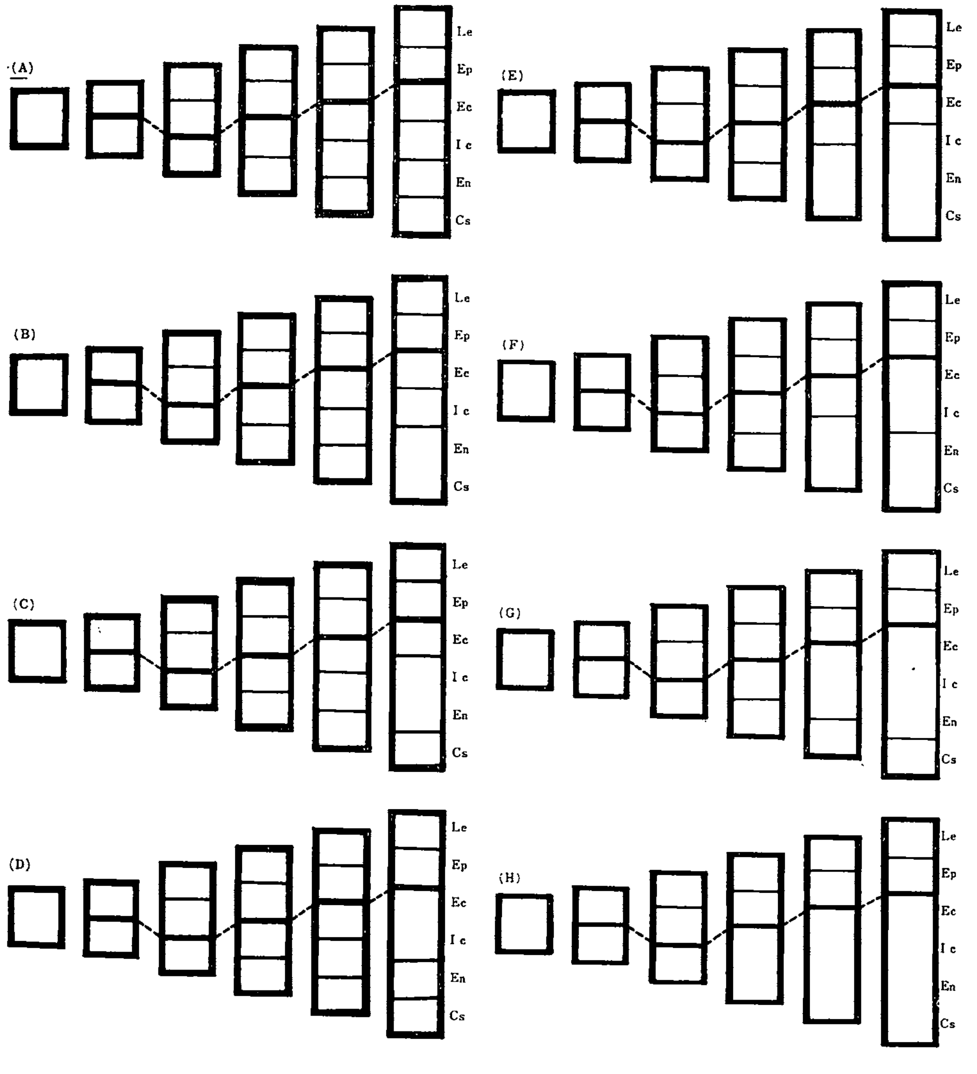

Fig. V Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), endodermis (En) and central strand (Cs). The leaf and epidermis are derived from the outer cell. The external cortex, internal cortex, endodermis and central strand are derived from the inner cell.

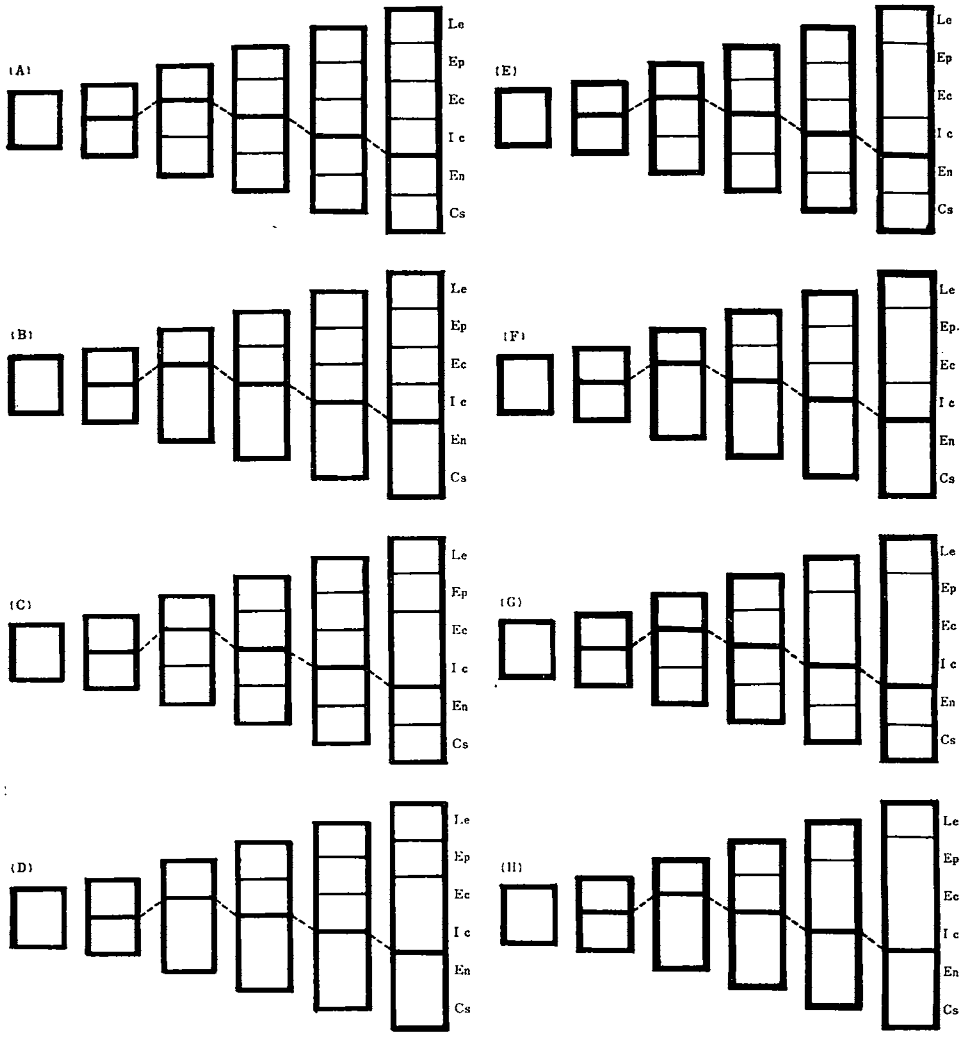

Fig. VI Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), endodermis (En) and central strand (Cs). The leaf, epidermis, external cortex and internal cortex are derived from the outer cell. The endodermis and central strand are derived from the inner cell.

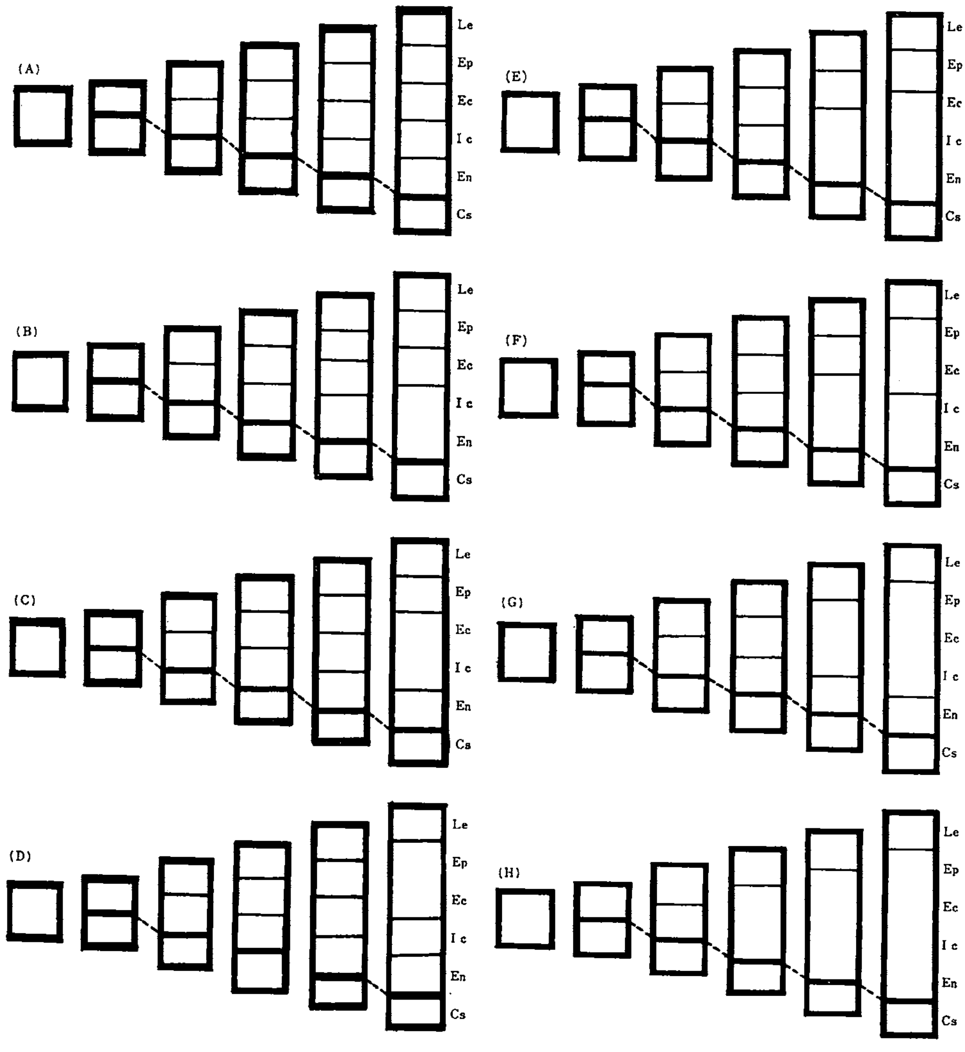

Fig. VII Imaginary pictures shown the origin of the leaf (Le), epidermis (Ep), external cortex (Ec), internal cortex (Ic), endodermis (En) and central strand (Cs). The leaf, epidermis, external cortex, internal cortex and endodermis are derived from the outer cell. The central strand is derived from the inner cell.

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要　　　約

蘚類植物は陸上植物の祖と一般にいわれていることは，その生活様式が水中生活様式と陸上生活様式の両方を示していることからも暗示される。陸上生活様式で最も重要な事は吸収組織，通導組織，更に機械組織などの発達であろうと思われる。若しも陸上生活への進化が起ったと考えるならば，そこには当然これらの陸上生活に適した組織分化への進化が起ったであろうと考えられる。而し又組織分化にはその環境に一時的に適応した形質もあり，それらのうち本質的なものを追究して行かねばならない。ここでは主に配偶体の茎におけるその内部構造をその横断面において分析し，本質的な特性を追究することに努めた。

この観察はまだ初期段階であり，更に多くの種についての観察をした上でなければ，充分な考

察は出来ないが，第一報におけるスギゴケ科の観察を参考にして，ここではシッポゴケ科，タマゴケ科，ツヤゴケ科，ホウオウゴケ科のそれぞれの茎に見られる普遍性と特異性について分類学的に考察した。

蘚類植物の茎の内部構造を組織分化の程度に基づいて6型に類型した。ここで観察された16種の茎の構造の中，ヘビゴケ属（*Campylopodium*），シッポゴケ属（*Dicranum*），コブゴケ属（*Oncophorus*），マツバゴケ属（*Leucoloma*），フデゴケ属（*Thysanomitrium*），サワゴケ属（*Philonotis*）の茎は表皮，外皮層，内皮層，内皮，中心束に分化し，第4型に属すると考えられる。ツヤゴケ属（*Entodon*），ホウオウゴケ属（*Fissidens*）の茎は表皮，外皮層，内皮層，中心組織に分化し，第3型に属すると考えられる。

中心束についてはシッポゴケ科のものは厚角細胞から成っているが，他のタマゴケ科，ツヤゴケ科，ホウオウゴケ科ではそうではない。又中心束を構成する細胞の膜の厚さは，シッポゴケ属（*Dicranum*）とヘビゴケ属（*Campylopodium*）ではやや厚いが，他の属，即ちコブゴケ属（*Oncophorus*），マツバゴケ属（*Leucoloma*），フデゴケ属（*Thysanomitrium*），サワゴケ属（*Philonotis*），ツヤゴケ属（*Entodon*），ホウオウゴケ属（*Fissidens*）では極めて薄い。表皮細胞の細胞膜はヘビゴケ属（*Campylopodium*），シッポゴケ属（*Dicranum*），ホウオウゴケ属（*Fissidens*）では厚いが，他の属，即ちコブゴケ属（*Oncophorus*），マツバゴケ属（*Leucoloma*），フデゴケ属（*Thysanomitrium*），サワゴケ属（*Philonotis*），ツヤゴケ属（*Entodon*）は薄膜であるために，屢々凹形を示すことがある。更に内皮層の細胞層数は同一属に所属する種の茎では或共通性が見られる。これらの事実から，茎の内部構造の特徴は属や科について固有性を示し，分類学上意義あるものであろうと推測される。而しながら内部構造の研究には横断面による分析だけでは全く不充分であり，特に組織分化の区分のはっきりしないものもあって，その類型化には不適当な面が多い。これを究明するには各組織，即ち表皮，外皮層，内皮層，内皮，中心束などのそれぞれの起源を追究し，それぞれの組織の定義づけを明確にしなければならない。ここで観察された2類型即ち，第3型と第4型についての起源を追究するために，その可能な形式の模式図をあげて今後の研究の参考にしたい。

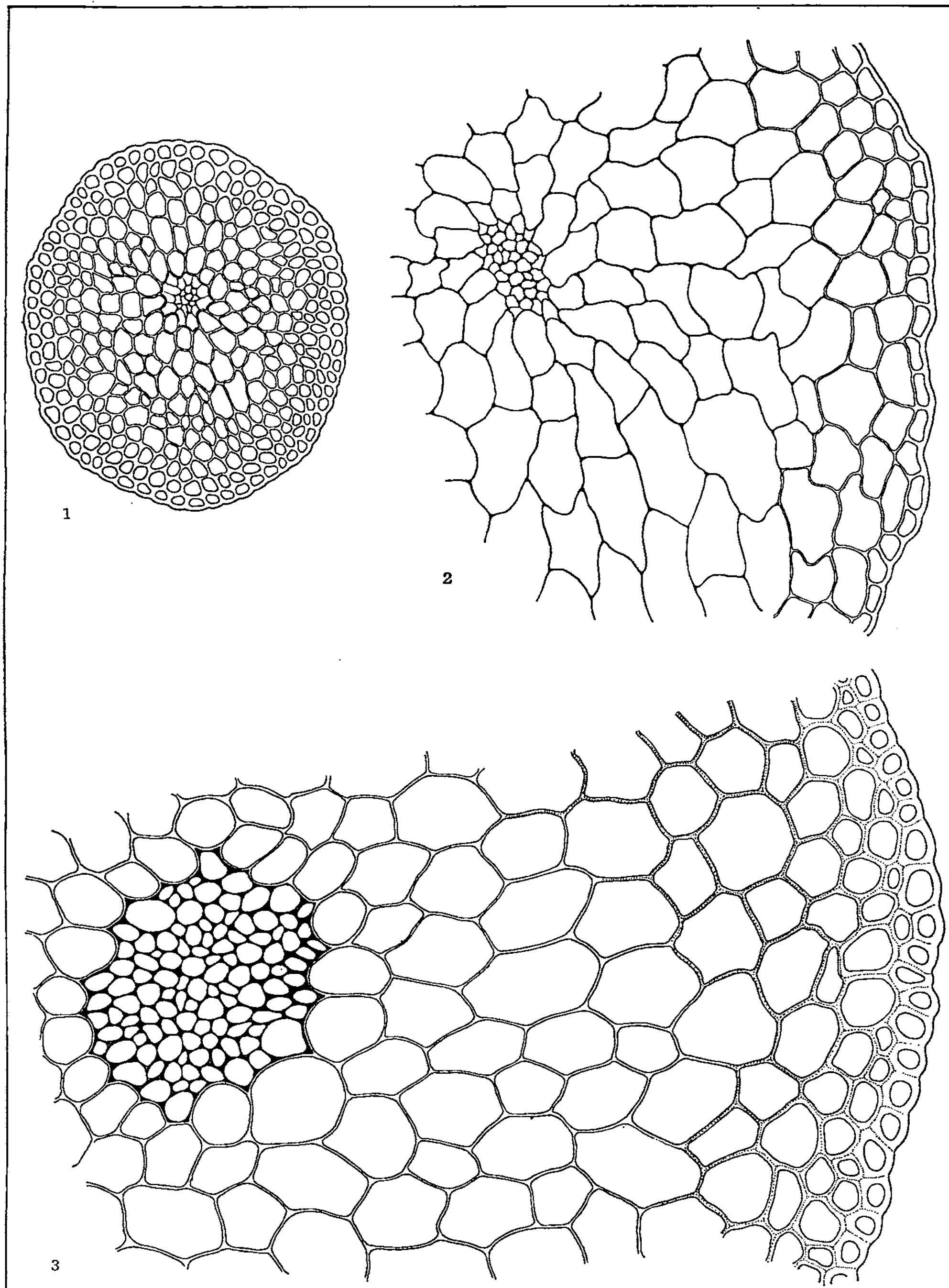

Plate I Cross section of stem

Fig. 1 : *Oncophorus crispifolius* (MITT)) LINDB. X200

Fig. 2 : *Dicranum japonicum* MITT. X200

Fig. 3 : *Dicranum undulatum* EHRH. X200

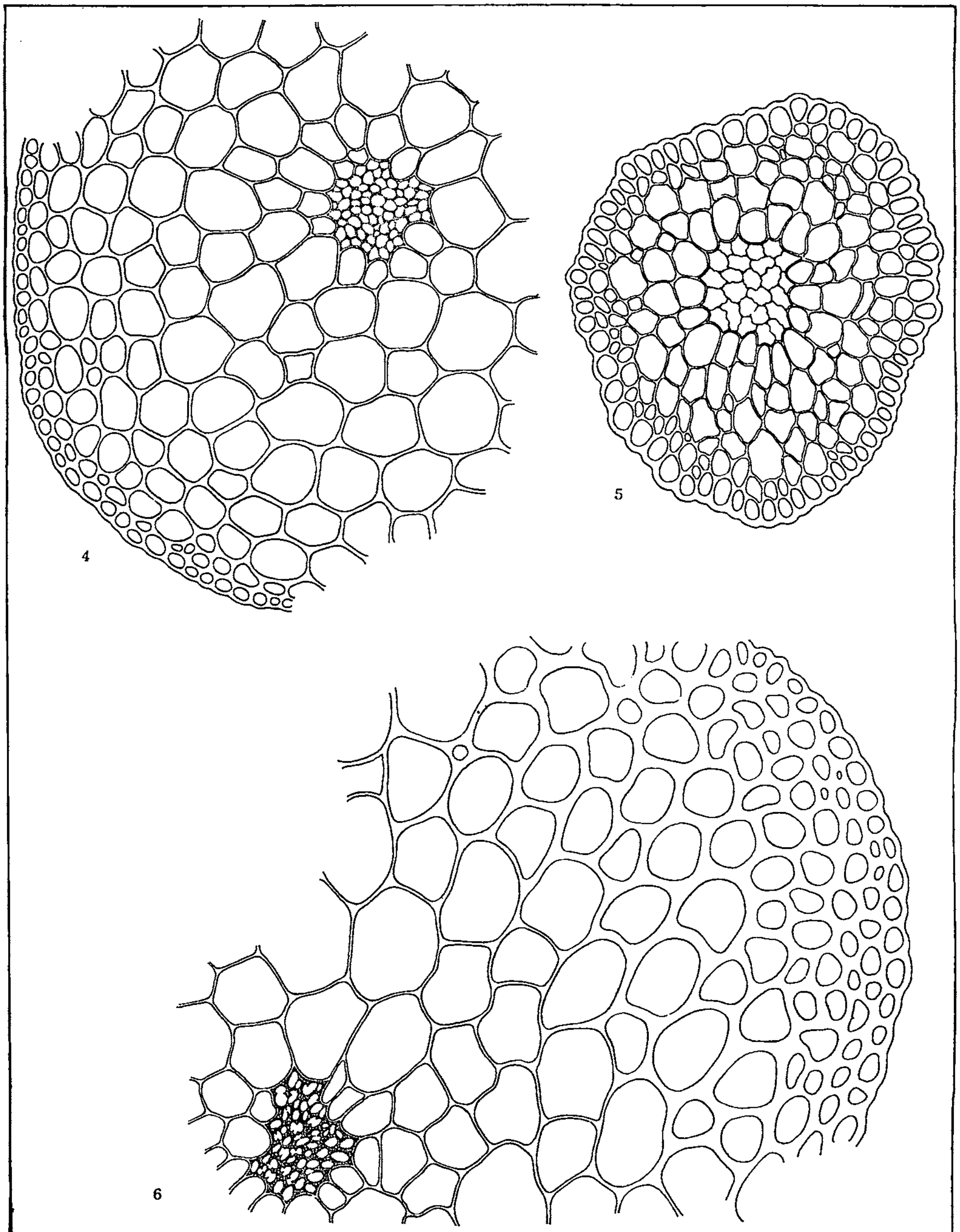

Plate II Cross section of stem

Fig. 4 : *Dicranum scoparium* Hedw. X200

Fig. 5 : *Campylopodium euphorocladum* (C. Mueii.) Besch. X200

Fig. 6 : *Dicranum majus* Smith X200

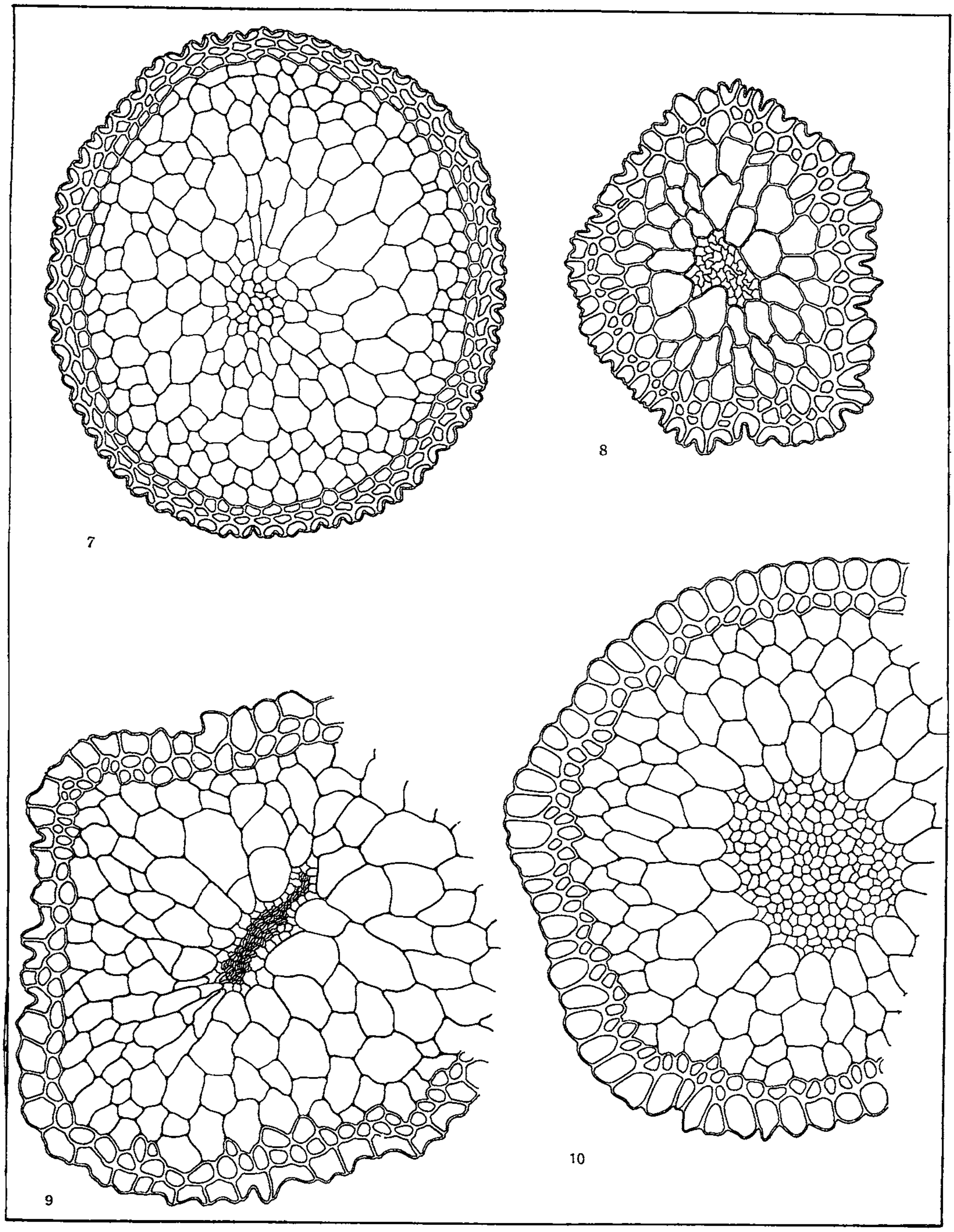

Plate III Cross section of stem

Fig. 7 : *Thysanomitrium richardii* SCHWGR. X200

Fig. 8 : *Philonotis falcata* (HOOK.) MITT. X200

Fig. 9 : *Philonotis turneriana* MITT. X200

Fig. 10 : *Philonotis turneriana* MITT. X200

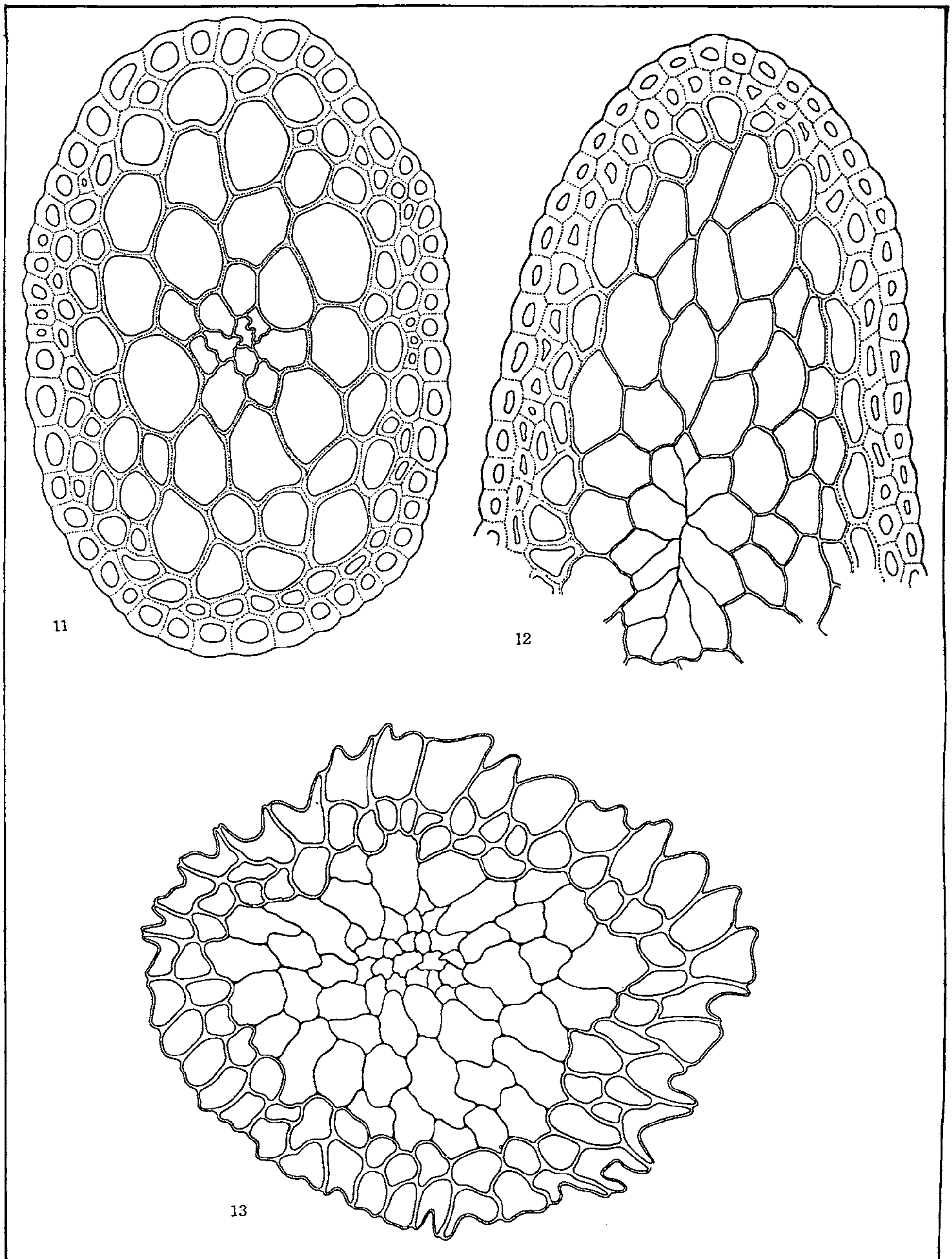

Plate IV Cross section of stem

Fig. 11 : *Fissidens taxifolius* (L.) HEDW. X300

Fig. 12 : *Fissidens cristatus* WILS. X300

Fig. 13 : *Leucoloma okamurac* BROTH. X300

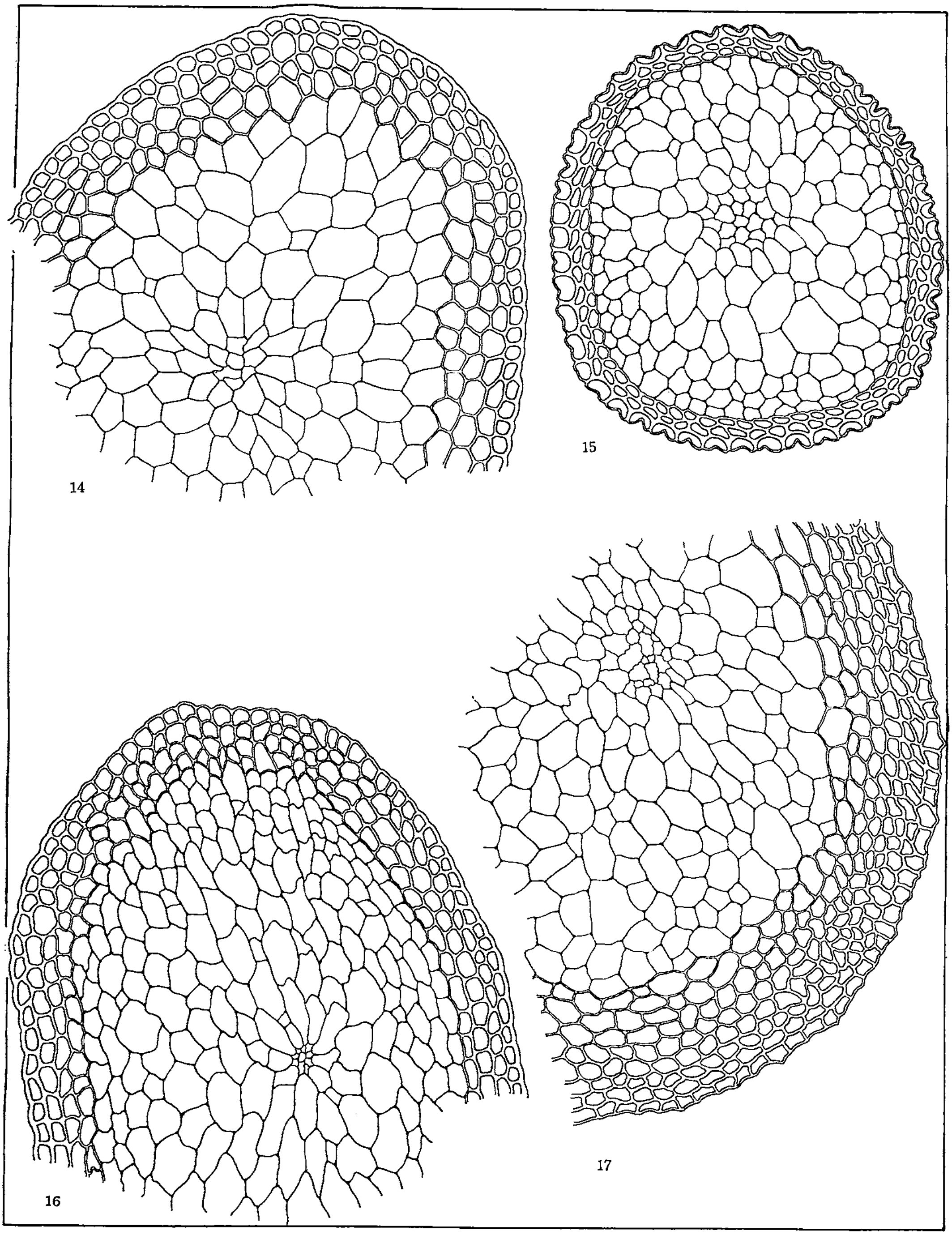

Plate V Cross section of stem

Fig. 14 : *Entodon scabridens* LINDB. X200

Fig. 15 : *Entodon challengeri* PAR. X200

Fig. 16 : *Entodon ramulosus* MITT. X200

Fig. 17 : *Entodon okamurae* BROTH. X200