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Systematic Studies on the Conducting Tissue of the Gametophyte in Musci

(4) On the Affinity Regarding the Inner Structure of the Stem in Some Species of Mniaceae

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Abstract Ever since 1967, we have primarily studied, the characteristics of the inner structure of the stem in some species of the Polytrichaceae, Entodontaceae, Fissidentaceae, Thuidiaceae, Dicranaceae, Mniaceae and Bartramiaceae. Thus we came to know that some of the characteristics of the stem may be less variable, distinctly specific and peculiar to the species and genus. Since then we have studied and taken great interest in whether we can place any emphasis upon the characteristics of the inner structure of the stem in Musci in general. We examined, therefore, whether those characteristics are peculiar to the genus and family, and whether there is something in common among the characteristics of the inner structure of the stem in the species belonging to the identical genus and family.

We also propose, as KOPONEN(1968) did, that the characteristics of the stem, such as thicking of the epidermal cell walls are to an extent peculiar to the genus, and that there is something in common among the characteristics in the species belonging to the identical genus and section. The characteristics of the epidermis are E-type in *Trachycystis,* F-type in *Pseudobryum* and G-type in *Orthomniopsis,* but in one section, *Eumnium,* it shows E-type or F-type.

An attempt has been made to distinguish in the stem "écorce externe, écorce interne, hydroïdes, cellule de parenchyme, leptoïdes" through an electron microscope(HÉBANT 1970). Of those tissues, "écorce externe" and "écorce interne" correspond respectively to our external cortex and internal cortex. As stated above, we believe that HÉBANT and we have examined the inner structure of the stem from similar points of view. Besides, HÉBANT is of the opinion that each tissue may have electron-microscopic features quite its own. We attach

great importance to this point, too.

Moreover, the stem is considered as to the eight characteristics of the inner structure of the stem in different families; types of the inner structure of the stem, whether cells of the central tissue are collenchymatous or not, whether the cell walls of the central tissue are thicker, as thick or thinner than those of the internal cortex, whether the cells of the central tissue are larger, as large or smaller than those of the internal cortex, whether distinction between the central tissue and the internal cortex is clear or not, whether the epidermal cell walls are thicker, as thick or thinner than those of the external cortex, whether the number of cell layers of the internal cortex is 1-4 cell layers or 4-12 cell layers, whether the number of cell layers of the external cortex is 1-3 cell layers or 4-7 cell layers. It is suggested that the stem with IV-P-L-H-type is peculiar to Dicranaceae, IV-Q-N-L-H-type to Bartramiaceae, IV-Q-O-L-H-type to Mniaceae, III-Q-N-K-H-E-type to Fissidentaceae, III-Q-N-L-H-F-type to Entodontaceae. In some genera there are characteristics of the stem which are peculiar to the genus but in the other genera there is no peculiarity to the genus. BOWERS(1968) grouped cytologically the species of *Mnium* in 3 groups: Group I, Group II (ex. *M. trichomanes, M. cuspidatum),* and Group III(ex. *M. punctatum).* We have to attach importance to this point, too.

In systematic studies of the inner structure of the stem it is necessary for us to consider what characters are important in genus in particular and in Musci in general. It is most difficult to determine which of these characteristics of the inner structure of the stem are the essential ones. However, we believe that in a systematic consideration the selection of essential characteristics is most important and that, therefore, we have first to investigate and give priority to extracting the essential ones.

Introduction

In a taxonomic study it is the most important to research over the entire life history. For the present study, we placed primary emphasis upon the characteristics of the conducting tissue in the gametophyte. Firstly because the traditional taxonomical study of Musci (fundamental) has been made mostly on the sporophyte and scarcely on the gametophyte. Secondly because the gametophyte is likely to keep the essential characteristics related the life history as well as the sporophyte and plays an important part in the life cycle. It is believed to be important that the observation of the gametophyte is made comparatively with the sporophyte. That is the third reason.

The characteristics of the inner structure of Musci-stem have been observed by many bryologists. The significance and relevancy of the stem for systematic study, however, have so far been little investigated. Some species of Polytrichaceae, Entodontaceae, Dicranaceae, Bartramiaceae, Fissidentaceae and Thuidiaceae were studied as to their

characteristics; ie., types of inner structure of the stem, whether the cell walls of the central tissue are thicker, as thick or thinner than those of the internal cortex, whether distinction between the central tissue and the internal cortex is clear or not, whether the cells of the central tissue are collenchymatous or not, whether the cell layers of the internal cortex are 1–4 or 4–12, whether the number of cell layers of the external cortex are 1–3 or 4–7, whether the epidermal cell walls are thicker, as thick or thinner than those of the external cortex, whether distinction between the hadrom and the leptom is clear or not (KAWAI et IKEDA 1970, KAWAI 1971a, 1971b). As a result, it was suggested that there should be something in common among the characteristics of the inner structures of the stem in the species belonging to the identical genus in the Polytrichaceae, Dicranaceae, Bartramiaceae, Entodontaceae, Fissidentaceae and Thuidiaceae. And in such genera as *Entodon, Herpetineurum, Thuidium, Campylopodium, Dicranum, Oncophorus, Leucoloma, Thysanomitrium, Philonotis, Oligotrichum* and *Bartramiopsis*, the characteristics of the stem show their own peculiarities. On the other hand, there are not any peculiarities in the stem any of the genera: *Fissidens, Boulaya, Miyabea, Haplohymenium, Pogonatum, Atrichum* and *Polytrichum*. This leads us to believe that not all the characteristics of the stem structure are important in the classifying of the genera. It is most difficult to determine whether certain characteristics of the inner structure of the stem are the essential ones. We believe, however, that, in systematic consideration, the selection of the essential characteristics is most important and that, therefore, we have first to investigate and give priority to selecting the essential ones. For this purpose, we believe it necessary to observe many other species, and consider the origin of each tissue of the stem.

Materials and methods

The materials used for this research comprise specimens of mosses collected from Japan. All the samples studied are deposited in the Moss Herbarium of Kanazawa University. *Mnium arcuatum* (BROTH.) P. BEAUV.: Mt. Fujisan, Yamanashi Pref.(36311), Higashi-Iyayama, Tokushima Pref.(36294), *Mnium cuspidatum* HEDW.: Mt. Hakusan, Ishikawa Pref.(36309), Omata, Shizuoka Pref.(36295), *Mnium flagellare* SULL. et LESQ.: Nishiiyayama, Tokushima Pref.(36310), *Mnium hornum* HEDW.: Mt. Hakusan, Ishikawa Pref.(36292), *Mnium laevinerve* GARD.: Mt. Iwatake, Shizuoka Pref.(36287), Hitoyoshi, Kumamoto Pref.(34902), *Mnium maximoviczii* LINDB: Mt. Kiyomizudera, Shimane Pref.(35218), Sendai, Miyagi Pref.(34980), Keta, Shizuoka Pref.(36296), *Mnium microphyllum* DOZ. et MOLK.: Kami-niikawa, Toyama Pref.(32706), Ishikiri, Shizuoka Pref.(36305), *Mnium punctatum* SCHREB. ex HEDW.: Hitoyoshi, Kumamoto Pref.(35156)., Mt. Iwatake, Shizuoka Pref.(36293), *Mnium rostratum* SCHRAD.: Hitoyoshi, Kumamoto Pref.(35157), Keta, Shizuoka Pref.(36307), *Mnium sapporense* BESCH.: Ishikiri, Shizuoka Pref.(36302), *Mnium*

speciosum MITT.: Kami-ina, Nagano Pref.(35219), *Mnium striatulum* MITT.: Miwa, Nagano Pref.(35052), Mt. Ontake, Gifu Pref.(34934), Mt. Kenzan, Tokushima Pref.(36303), Kyomaru, Shizuoka Pref.(36304), *Mnium trichomanes* MITT.: Omata, Shizuoka Pref.-(36299), Mt. Iwatake, Shizuoka Pref.(36300), Mt. Kenzan, Tokushima Pref.(36301), *Mnium vesicatum* BESCH.: Kuma, Kumamoto Pref.(35047), Sendai, Miyagi Pref.(34981), Misugi, Mie Pref.(34903), Omata, Shizuoka Pref.(36306), Ishikiri, Shizuoka Pref.(36297), Nishi--Iyayama, Tokushima Pref.(36298), *Orthomniopsis japonica* BROTH.: Shimokitayama, Nara Pref.(34986)

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 hard 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 12μ.

Observation

In this paper, fifteen species from two genera of Mniaceae are studied into as to the following characteristics of the stem; the type of the inner structures of the stem **(I-VI types)**, whether the cells of the central tissue are collenchymatous **(P-type)** or not **(Q-ype)**, whether the cell walls of the epidermis are thicker**(E-type)**, as thick**(F-type)** or thinner**(G-type)** than those of the external cortex, whether the cell walls of the central tissue are thicker **(M-type)**, as thick **(N-type)** or thinner **(O-type)** than those of the internal cortex, whether the cells of the central tissue are larger **(J-type)**, as large**(K-type)** or smaller **(L-type)** than those of the internal cortex, whether distinction between the central tissue and the internal cortex is clear **(H-type)** or not **(I-type)**, whether the number of cell layers of the internal cortex is 1-4 **(C-type)** or 4-12 **(D-type)** and whether the number of cell layers of the external cortex is 1-3 **(A-type)** or 4-7 **(B-type)**.

In Mniaceae a cross section of the stem generally shows a differentiation of tissues into an epidermis, external cortex, internal cortex, endodermal layer and central strand **(Type IV)**. Cells of the central tissue are not collenchymatous**(Q-type)**, cell walls of the central tissue are thinner than those of the internal cortex **(O-type)**, cells of the central tissue are smaller than those of the internal cortex **(L-type)**, and distinction between the central tissue and the internal cortex is clear**(H-type)**. However, distinction between the internal cortex and the endodermal layer is not very clear, so in this paper the endodermal layer is counted into the number of the cell layers of the internal cortex **(Tab. 1)**.

Of the stems of Mniaceae, there are some stems in which the epidermal cell walls are thicker than those of the external cortex〔E-type: *Mnium cuspidatum* HEDW., *Mnium microphyllum* DOZ. et MOLK., *Mnium rostratum* SCHRAD., *Mnium maximoviczii* LINDB.,

Tab. 1 Anatomical characteristics of the stem and those similar types in the species of Mniaceae

	Number of cell layers of the external cortex is 1-3 cell layers (**A-type**) or 4-7 cell layers (**B-type**)		Number of cell layers of the internal cortex is 1-4 cell layers (**C-type**) or 4-12 cell layers (**D-type**)		Epidermal cell walls are thicker (**E-type**), as thick (**F-type**) or thinner (**G-type**) than those of the external cortex	Distinction between the central tissue and the internal cortex is clear (**H-type**) or not (**I-type**)	Cells of the central tissue are larger (**J-type**), as large (**K-type**) or smaller (**L-type**) than those of the internal cortex	Cell walls of the central tissue are thicker (**M-type**), as thick (**N-type**) or thinner (**O-type**) than those of the internal cortex	Cells of the central tissue are collenchymatous (**P-type**) or not (**Q-type**)	Types of inner structure of the stem	Number of figures
	Layers	Types	Layers	Types							
Mnium cuspidatum HEDW.	(3-4)4	B	(6-7)6	D	E	H	L	O	Q	IV	II-5,6
Mnium cuspidatum HEDW.	(3-4)4	B	(6-8)6	D	E	H	L	O	Q	IV	II-7
Mnium cuspidatum HEDW.	(3-4)4	B	(6-7)6	D	E	H	L	O	Q	IV	II-8
Mnium microphyllum DOZ. et MOLK.	(3-4)4	B	(4-5)4	D	E	H	L	O	Q	IV	VII-25
Mnium microphyllum DOZ. et MOLK.	(4-5)5	B	(3-5)4	D	E	H	L	O	Q	IV	VII-26
Mnium microphyllum DOZ. et MOLK.	(4-5)5	B	(4-5)4	D	E	H	L	O	Q	IV	VII-27
Mnium rostratum SCHRAD.	(2-3)2	A	(4-5)4	D	E	H	L	O	Q	IV	VIII-31
Mnium rostratum SCHRAD.	(2-3)2	A	(5-6)5	D	E	H	L	O	Q	IV	VIII-32
Mnium rostratum SCHRAD.	(1-3)2	A	(5-6)5	D	E	H	L	O	Q	IV	IX-33
Mnium rostratum SCHRAD.	(2-3)2	A	(4-5)4	D	E	H	L	O	Q	IV	IX-34
Mnium rostratum SCHRAD.	(1-2)2	A	(6-7)6	D	E	H	L	O	Q	IV	IX-35
Mnium maximoviczii LINDB.	(1-2)2	A	(4-5)4	D	E	H	L	O	Q	IV	V-20
Mnium maximoviczii LINDB.	(2-3)2	A	(4-5)4	D	E	H	L	O	Q	IV	VI-21
Mnium maximoviczii LINDB.	(2-3)2	A	(4-5)4	D	E	H	L	O	Q	IV	VI-22
Mnium maximoviczii LINDB.	(2-3)2	A	(5-6)5	D	E	H	L	O	Q	IV	VI-23,24
Mnium arcuatum (BROTH.) P. BEAUV.	(1-2)1	A	(4-5)4	D	E	H	L	O	Q	IV	I-1
Mnium arcuatum (BROTH.) P. BEAUV.	(1-2)1	A	(5-6)5	D	E	H	L	O	Q	IV	I-2
Mnium arcuatum (BROTH.) P. BEAUV.	(1-2)1	A	(4-5)4	D	E	H	L	O	Q	IV	I-3
Mnium arcuatum (BROTH.) P. BEAUV.	(2-3)2	A	(4-6)5	D	E	H	L	O	Q	IV	I-4
Mnium flagellare SULL. et. LESQ.	(1-2)1	A	(3-4)4	C	E	H	L	O	Q	IV	III-9
Mnium flagellare SULL. et. LESQ.	(1-2)1	A	(3-4)4	C	E	H	L	O	Q	IV	III-10
Mnium flagellare SULL. et. LESQ.	(1-1)1	A	(3-5)4	C	E	H	L	O	Q	IV	III-11
Mnium flagellare SULL. et. LESQ.	(1-2)1	A	(4-5)4	C	E	H	L	O	Q	IV	III-12
Mnium hornum HEDW.	(1-2)1	A	(3-4)4	C	E	H	L	O	Q	IV	IV-13
Mnium hornum HEDW.	(1-2)1	A	(3-4)4	C	E	H	L	O	Q	IV	IV-14
Mnium hornum HEDW.	(1-2)1	A	(3-4)4	C	E	H	L	O	Q	IV	IV-15
Mnium hornum HEDW.	(1-2)1	A	(4-5)4	C	E	H	L	O	Q	IV	IV-16
Mnium laevinerve CARD.	(2-3)2	A	(3-4)4	C	E	H	L	O	Q	IV	V-17
Mnium laevinerve CARD.	(1-2)2	A	(3-4)4	C	E	H	L	O	Q	IV	V-18
Mnium laevinerve CARD.	(2-3)2	A	(4-5)4	C	E	H	L	O	Q	IV	V-19
Mnium punctatum SCHREB. ex HEDW.	(2-2)2	A	(3-4)3	C	E	H	L	O	Q	IV	VII-28
Mnium punctatum SCHREB. ex HEDW.	(2-3)2	A	(3-4)4	C	E	H	L	O	Q	IV	VIII-29
Mnium punctatum SCHREB. ex HEDW.	(2-3)2	A	(3-4)3	C	E	H	L	O	Q	IV	VIII-30
Mnium sapporense BESCH.	(1-2)1	A	(2-3)3	C	E	H	L	O	Q	IV	X-37
Mnium sapporense BESCH.	(1-2)1	A	(2-4)3	C	E	H	L	O	Q	IV	X-38
Mnium sapporense BESCH.	(1-2)1	A	(2-3)3	C	E	H	L	O	Q	IV	X-39
Mnium sapporense BESCH.	(1-2)1	A	(2-3)3	C	E	H	L	O	Q	IV	X-40
Mnium striatulum MITT.	(2-3)2	A	(2-3)3	C	E	H	L	O	Q	IV	IX-36
Mnium striatulum MITT.	(2-3)2	A	(4-5)4	D	E	H	L	O	Q	IV	XV-57
Mnium striatulum MITT.	(2-3)2	A	(3-5)4	C	F	H	L	O	Q	IV	XV-58
Mnium striatulum MITT.	(2-3)3	A	(3-4)3	C	E	H	L	O	Q	IV	XI-41
Mnium striatulum MITT.	(1-3)2	A	(3-4)4	C	E	H	L	O	Q	IV	XI-42
Mnium striatulum MITT.	(1-2)2	A	(3-4)4	C	E	H	L	O	Q	IV	XI-43
Mnium striatulum MITT.	(2-3)2	A	(3-4)4	C	E	H	L	O	Q	IV	XI-44
Mnium speciosum MITT.	(2-3)2	A	(10-11)10	D	F	H	L	O	Q	IV	XII-45
Mnium speciosum MITT.	(2-3)3	A	(6-8)7	D	F	H	L	O	Q	IV	XII-46
Mnium speciosum MITT.	(2-3)2	A	(5-7)6	D	F	H	L	O	Q	IV	XII-47
Mnium speciosum MITT.	(2-3)3	A	(6-7)7	D	F	H	L	O	Q	IV	XII-48
Mnium trichomanes MITT.	(3-4)4	B	(4-6)5	D	F	H	L	O	Q	IV	XIII-49
Mnium trichomanes MITT.	(2-4)3	B	(5-6)6	D	F	H	L	O	Q	IV	XIII-50
Mnium trichomanes MITT.	(2-4)3	B	(4-6)5	D	F	H	L	O	Q	IV	XIII-51
Mnium trichomanes MITT.	(3-4)4	B	(5-6)5	D	F	H	L	O	Q	IV	XIII-52
Mnium vesicatum BESCH.	(2-3)2	A	(3-4)3	C	F	H	L	O	Q	IV	XIV-53
Mnium vesicatum BESCH.	(2-3)2	A	(3-5)4	C	F	H	L	O	Q	IV	XIV-54
Mnium vesicatum BESCH.	(1-2)2	A	(3-4)3	C	F	H	L	O	Q	IV	XIV-55
Mnium vesicatum BESCH.	(1-2)2	A	(3-4)3	C	F	H	L	O	Q	IV	XIV-56
Mnium vesicatum BESCH.	(2-3)2	A	(2-4)3	C	F	H	L	O	Q	IV	XV-59
Orthomniopsis japonica BROTH.	(2-3)2	A	(3-3)3	C	G	H	L	O	Q	IV	XV-60
Orthomniopsis japonica BROTH.	(1-3)2	A	(3-3)3	C	G	H	L	O	Q	IV	XVI-61
Orthomniopsis japonica BROTH.	(2-3)2	A	(2-4)3	C	G	H	L	O	Q	IV	XVI-62
Orthomniopsis japonica BROTH.	(2-3)2	A	(3-4)3	C	G	H	L	O	Q	IV	XVI-63
Orthomniopsis japonica BROTH.	(2-3)2	A	(3-4)3	C	G	H	L	O	Q	IV	XVI-64

Mnium arcuatum (BROTH.) P.BEAUV., *Mnium flagellare* SULL. et LESQ., *Mnium hornum* HEDW., *Mnium laevinerve* CARD., *Mnium punctatum* SCHREB. ex HEDW., *Mnium sapporense* BESCH., *Mnium striatulum* MITT.〕. In the some epidermal cell walls are as thick as those of the external cortex(**F-type** : *Mnium speciosum* MITT., *Mnium trichomanes* MITT., *Mnium vesicatum* BESCH.) and there are still some others in which the epidermal cell walls are thinner than those of the external cortex (**G-type**: *Orthomniopsis japonica* BROTH.).

In the stems having an epidermis of the **E-type** , what we call internal cortex consists of 4-6 layers of large polygonal cells (**D-type**) or 3-4 layers (**C-type**). *Mnium cuspidatum* HEDW., *Mnium microphyllum* DOZ. et MOLK., *Mnium rostratum* SCHRAD., *Mnium maximoviczii* LINDB., *Mnium arcuatum* (BROTH.) P.BEAUV. have the internal cortex of the **D-type.** The **C-type** is found in *Mnium flagellare* SULL. et LESQ., *Mnium hornum* HEDW., *Mnium laevinerve* CARD., *Mnium punctatum* SCHREB. ex HEDW., *Mnium sapporense* BESCH., *Mnium striatulum* MITT. In the stems having the internal cortex of the **D-type,** the external cortex consists of 1-3 cell layers(**A-type**) or 4-5 cell layers(**B-type**). *Mnium rostratum* SCHRAD., *Mnium maximoviczii* LINDB. and *Mnium arcuatum* (BROTH.) P.BEAUV. have the external cortex of the **A-type**, and the **B-type** is found in *Mnium cuspidatum* HEDW. and *Mnium microphyllum* DOZ. et MOLK. In the stems having the internal cortex of the **C-type**, the external cortex consists of 1-3 cell layers (**A-type**).

In the stems having the epidermis of the **F-type,** the internal cortex consists of 5-10 layers (**D-type**) or 3-4 layers (**C-type**). *Mnium vesicatum* BESCH. has the internal cortex of the **C-type.** The **D-type** is found in *Mnium speciosum* MITT. and *Mnium trichomanes* MITT. In the stems having the internal cortex of the **D-type,** the external cortex consists of 2-3 cell layers (**A-type** : *Mnium speciosum* MITT.) or 3-4 cell layers (**B-type** : *Mnium vesicatum* BESCH.). The external cortex of the stems having the internal cortex of the **C-type** consists of 2 cell layers (**A-type**).

In the stems having the epidermis of the **G-type,** the internal cortex consists of 3 layers (**C-type**), and the external cortex consists of 2 layers (**A-type**).

Discussion

Ever since 1967, we have primarily studied, the characteristics of the inner structure of the stem in some species of the Polytrichaceae, Dicranaceae, Bartramiaceae, Entodontaceae, Fissidentaceae, Thuidiaceae and Mniaceae. Thus we came to know that such characteristics of the stem, as types of inner structures of the stem, whether cells of the central tissue are collenchymatous or not, whether the cell walls of the central tissue are thicker, as thick or thinner than those of the internal cortex, whether the cells of the central tissue are larger, as large or smaller than those of the internal cortex, whether distinction between the central tissue and the internal cortex is clear or not, whether epidermal cell walls are thicker, as thick or thinner than those of the external cortex, whether the number of cell layers of the internal cortex is 1-4 or 4-12, whether the

number of the cell layers of the external cortex is 1-3 or 4-7, are less variable, distinctly specific and peculiar to the species and genus. Since then we have studied and taken great interest in whether we can place our emphasis upon the characteristics of the inner structure of the stem in Musci in general. Thus we have examined, whether those characteristics are peculiar to the species and genus, and whether there is something in common among the characteristics of the inner structure of the stem in the species belonging to the identical genus in Musci.

Analysis of the inner structure of the stem T. KOPONEN(1968) described the epidermis of the stem in Mniaceae as follows: "The three different types of epidermis are called the *Bryum, Mnium* and *Pseudobryum* types. Each type seems to occur throughout a given genus and they can therefore be included among the generic characters. In the tribes *Mnieae* and *Cinclidieae* of the *Mnium* type the epidermis consists mainly of one cell layer with strongly thickened cell walls. In the mature stem parts the cell wall is thickened by an inner, often clearly defined, secondary layer, which nearly fills the lumen of the cell. In the stems of *Plagiomnium, Orthomnium* and *Orthomniopsis* of the *Bryum* type the epidermis is composed of two or more layers of cells. In typical cases the cell walls show no or only slight secondary thickening. Such thickening was seen in some mature stem parts, but in no case did it reach the degree observed, for instance, in *Mnium.* The same type of thickning was found to be present in *Bryum, Rhodobryum* and *Roellia.* In the stems of *Pseudobryum* cinclidioides and *P. speciosum* of the *Pseudobryum* type, the main thickening takes place in the tangential walls between the first and the second cell layers. In addition, the outermost wall of the epidermis is extremely thin, especially in P. *cinclidioides*".

We observed the epidermis, external cortex, internal cortex and the central tissue of the stem in Mniaceae, Thuidiaceae, Dicranaceae, Bartramiaceae, Entodontaceae, Fissidentaceae and Polytrichaceae. As shown in Tab.1, in the stems of all species of the Mniaceae: the type of the inner structure of the stem is **IV**; cells of the central tissue are not collenchymatous(**Q-type**); cell walls of the central tissue are thinner than those of the internal cortex(**O-type**); cells of the central tissue are smaller than those of the internal cortex(**L-type**); distinction between the central tissue and the internal cortex is clear(**H-type**). In the epidermal cell walls, however, all species do not show one identical type but three types, **E-**,**F-** and **G-types.** The internal cortex shows **C-type** or **D-type** and the external cortex shows **A-type** or **B-type.**

KOPONEN states that the stem epidermis shows some characteristics, such as the number of the cell layers and the thickening of the cell walls which may have taxonomical significance. We also propose that the characteristics of the stem such as thickening of the epidermal cell walls are to an extent peculiar to the genus, and that there is something in common among the characteristics in the species belonging to the identical genus and section(Tab. 2). Such unity can not be a mere accident. As shown in Tab. 2, the characteristics of the epidermis are E-type in *Trachycystis,* **F-type** in *Pseudobryum* and **G-type** in *Orthomniopsis.* In only one section, the *Eumnium,* it shows

Tab. 2 Peculiarities to each genus, section and species

Genera and sections	Species	Epidermal cell walls are thicker (**E-type**), as thick (**F-type**) or thinner (**G-type**) than those of the external cortex	Number of cell layers of the internal cortex is 1-4 cell layers (**C-type**) or 4-12 cell layers (**D-type**)	Number of cell layers of the external cortex is 1-3 cell layers (**A-type**) or 4-7 cell layers (**B-type**)
Trachycystis	*Mnium microphyllum* DOZ. et MOLK.	B	D	E
Trachycystis	*Mnium flagellare* SULL. et LESQ.	A	C	E
Mnium Sect. *Pseudoleucolepis*	*Mnium arcuatum* (BROTH.) P. BEAUV.	A	D	E
Mnium Sect. *Polla*	*Mnium hornum* HEDW.	A	C	E
Mnium Sect. *Polla*	*Mnium laevinerve* CARD.	A	C	E
Mnium Sect. *Polla*	*Mnium sapporense* BESCH.	A	C	E
Mnium Sect. *Rhizomnion*	*Mnium punctatum* SCHREB. ex HEDW.	A	C	E
Mnium Sect. *Rhizomnion*	*Mnium striatulum* MITT.	A	C	E
Mnium Sect. *Eumnium*	*Mnium cuspidatum* HEDW.	B	D	E
Mnium Sect. *Eumnium*	*Mnium rostratum* SCHRAD.	A	D	E
Mnium Sect. *Eumnium*	*Mnium maximoviczii* LINDB.	A	D	E
Mnium Sect. *Eumnium*	*Mnium trichomanes* MITT.	B	D	F
Mnium Sect. *Eumnium*	*Mnium vesicatum* BESCH.	A	C	F
Pseudobryum	*Mnium speciosum* MITT.	A	D	F
Orthomniopsis	*Orthomniopsis japonica* BROTH.	A	C	G

E-type or **F-type.** KOPONEN'S observation of the epidermis and ours differ only in one genus *Orthomniopsis;* in *Orthomniopsis dilatata* (MITT.)NOG. the epidermis is composed of two or more layers of cells(KOPONEN 1968), however, in *Orthomniopsis japonica* BROTH. it is composed of one cell layer. We have also observed the epidermis of the stem in Polytrichaceae. The stems of *Pogonatum grandifolium* (LINDB.) JAEG. and *Polytrichum formosum* HEDW. are found with the epidermis of two cell layers and all the other species in Polytrichaceae used for our study are found with the epidermis of one cell layer. In Entodontaceae, Dicranaceae, Fissidentaceae, Bartramiaceae, Thuidiaceae and Mniaceae, all of the species used for our study are found with the same type of the stem with the epidermis of one cell layer. The epidermis seems to show different types in different species. This is one of the important problem for us to investigate.

HÉBANT(1964) made a memoir that in *Funaria hygrometrica* HEDW., a cross section of

Tab. 3 Anatomical characteristics of the stem in the species of Entodontaceae, Fissidentaceae, Thuidiaceae, Mniaceae, Bartramiaceae, Dicranaceae and Polytrichaceae

Families	Genera	Nuwber of cell layers of the external cortex *is* 1-3 cell layers (**A-type**) or 4-7 cell layers (**B-type**)	Number of cell layers of the internal cortex is 1-4 cell layers (**C-type**) or 4-12 cell layers (**D-type**)	Epidermal cell walls are thicker (**E-type**), as thick (**F-type**) or thinner (**G-type**) than those of the external cortex	Distinction between the central tissue and the internal cortex is clear (**H-type**) or not (**I-type**)	Cells of the central tissue are larger (**J-type**), as large (**K-type**) or smaller (**L-type**) than those of the internal cortex	Cell walls of the central tissue are thicker (**M-type**), as thick (**N-type**) or thinner (**O-type**) than those of the internal cortex	Cells of the central tissue are collenchymatous (**P-type**) or not (**Q-type**)	Types of inner structures of the stem
Entodontaceae	*Entodon*	B	D	F	H	L	N	Q	III
Entodontaceae	*Entodon*	A	D	F	H	L	N	Q	III
Fissidentaceae	*Fissidens*	A	C	E	H	K	N	Q	III
Thuidiaceae	*Claopodium*	A	C	E	H	K	N	Q	III
Thuidiaceae	*Haplocladium*	A	C	E	H	K	N	Q	III
Thuidiaceae	*Anomodon*	A	C	E	H	K	N	Q	III
Thuidiaceae	*Anomodon*	B	D	E	I	K	N	Q	III
Thuidiaceae	*Anomodon*	A	D	E	I	K	N	Q	III
Thuidiaceae	*Hylocomiopsis*	A	D	E	I	K	N	Q	III
Thuidiaceae	*Boulaya*	A	D	E	I	K	N	Q	III
Thuidiaceae	*Miyabea*	A	C	E	I	K	N	Q	III
Thuidiaceae	*Haplohymenium*	A	C	E	I	K	N	Q	III
Thuidiaceae	*Thuidium*	B	C	E	H	L	M	Q	IV
Thuidiaceae	*Thuidium*	B	D	E	H	L	M	Q	IV
Thuidiaceae	*Thuidium*	A	D	E	H	L	M	Q	IV
Thuidiaceae	*Herpetineurum*	A	D	E	H	L	O	Q	IV
Mniaceae	*Mnium*	B	D	E	H	L	O	Q	IV
Mniaceae	*Mnium*	A	D	E	H	L	O	Q	IV
Mniaceae	*Mnium*	A	C	E	H	L	O	Q	IV
Mniaceae	*Mnium*	A	D	F	H	L	O	Q	IV
Mniaceae	*Mnium*	B	D	F	H	L	O	Q	IV
Mniaceae	*Mnium*	A	C	F	H	L	O	Q	IV
Mniaceae	*Orthomniopsis*	A	C	G	H	L	O	Q	IV
Bartramiaceae	*Philonotis*	A	C	G	H	L	N	Q	IV
Dicranaceae	*Campylopodium*	A	C	F	H	L	M	P	IV
Dicranaceae	*Dicranum*	A	D	F	H	L	M	P	IV
Dicranaceae	*Dicranum*	B	D	F	H	L	M	P	IV
Dicranaceae	*Oncophorus*	A	D	F	H	L	N	P	IV
Dicranaceae	*Leucoloma*	A	C	G	H	L	N	P	IV
Dicranaceae	*Thysanomitrium*	A	D	G	H	L	N	P	IV
Polytrichaceae	*Oligotrichum*	A	C	E	H	*	*	*	V
Polytrichaceae	*Bartramiopsis*	B	D	E	H	*	*	*	V
Polytrichaceae	*Pogonatum*	A	D	E	H	*	*	*	VI
Polytrichaceae	*Pogonatum*	B	D	E	H	*	*	*	VI
Polytrichaceae	*Pogonatum*	B	C	E	H	*	*	*	VI
Polytrichaceae	*Atrichuu*	B	C	E	H	*	*	*	VI
Polytrichaceae	*Polytrichum*	B	D	E	H	*	*	*	VI
Polytrichaceae	*Polytrichum*	A	D	E	H	*	*	*	VI
Polytriehaceae	*Polytrichum*	A	C	E	H	*	*	*	VI

the stem shows differentiation of tissues into an epidermis, stereid, cortex and hydroid. Each of those tissues corresponds to each of those we named epidermis, external cortex, internal cortex and central tissue, that is, "stereïdes" of HÉBANT for our external cortex, "écorce" for our internal cortex and "hydroïdes" for our central tissue. Thus we make our analysis of the inner structure of the stem from the same points of view, whether the names are HÉBANT's or not. Moreover, HÉBANT(1969, 1970) examined through an electron microscope the transverse and longitudinal sections of the apical and mature parts of the stem in Polytrichaceae and attempted to distinguish as follows: "écorce externe, écorce interne, hydroïdes, cellule de parenchyme, leptoïdes". Of those tissues, "écorce externe" and "écorce interne" correspond to our external cortex and internal cortex. As stated above, it seems that HÉBANT and the present writer examine the inner structure of the stem from similar points of view. Besides, HÉBANT has a new idea that each tissue may have electron-microscopic features quite its own. We should perhaps attach great importance to this points, too.

Summaring up the characteristics of the inner structure in the stems of Entodontaceae, Fissidentaceae, Thuidiaceae, Mniaceae, Bartramiaceae, Dicranaceae and Polytrichaceae. From Tab. 3, we infer that the type of the inner structure of the stem(III-VI) is the most important of the eight characteristics we considered, for the type of the inner structure of the stem is most consistent in the species belonging to the identical genus and family. The stem with **III-type** is found in Entodontaceae, Fissidentaceae and Thuidiaceae. The stem showing **IV-type** is found in Thuidiaceae, Mniaceae, Bartramiaceae and Dicranaceae. The stem with **V- and VI-types** is found in Polytrichaceae. Thuidiaceae and Polytrichaceae have two types. In Entodontaceae, Fissidentaceae, Mniaceae, Bartramiaceae and Dicranaceae, however, there is the same type of inner structure of the stem in the species belonging to the identical family. When we consider the eight characteristics of the inner structure in the stem of some families, there is a peculiarity in each of these families, that is, the stem with **IV-, P-, L-, H-types** is peculiar to Dicranaceae. Peculiarities to Bartramiaceae are that the stem shows **IV-, Q-, N-, L-** and **H-types.** What is peculiar to Mniaceae is that the stem of the species shows **IV-, Q-, O-, L-** and **H-types.** The stem with **III-, Q-, N-, K-, H-** and **E-types** is

Tab. 4 Peculiarities to each family

Families	Peculiarities
Entodontaceae	Ⅲ-Q-N-L-H-F-D
Fissidentaceae	Ⅲ-Q-N-K-H-E-C-A
Mniaceae	Ⅳ-Q-O-L-H
Bartramiaceae	Ⅳ-Q-N-L-H-G-C-A
Dicranaceae	Ⅳ-P-L-H

peculiar to Fissidentaceae. The stem showing **III-, Q-, N-, L-, H-** and **F-types** is peculiar to Entodontaceae(Tab. 4). In view of these facts, it is suggested that the characteristics of the inner structure of the stem, especially types of inner structure of the stem, whether the cells of the central tissue are collenchymatous or not, whether the cell walls of the central tissue are thicker, as thick or thinner than those of the internal cortex, whether the cells of the central tissue are larger, as large or smaller than those of the internal cortex, whether distinction between the central tissue and the internal cortex is clear or not, are to a great extent peculiar to the families(except Thuidiaceae and Polytrichaceae), and the genus(*Entodon, Philonotis, Campylopodium, Dicranum, Oncophorus,*

Tab. 5 Similarities in each genus

Genera	Similarities
Entodon	III-Q-N-L-H-F-D
Fissidens	III-Q-N-K-H-E-C-A
Claopodium	III-Q-N-K-H-E-C-A
Haplocladium	III-Q-N-K-H-E-C-A
Anomodon	III-Q-N-K
Hylocomiopsis	III-Q-N-K-I-E-D-A
Boulaya	III-Q-N-K-I-E-D-A
Miyabea	III-Q-N-K-I-E-C-A
Haplohymenium	III-Q-N-K-I-E-C-A
Thuidium	IV-Q-M-L-H-E
Herpetineurum	IV-Q-O-L-H-E-D-A
Mnium	IV-Q-O-L-H
Orthomniopsis	IV-Q-O-L-H-G-C-A
Philonotis	IV-Q-N-L-H-G-C-A
Campylopodium	IV-P-M-L-H-F-C-A
Dicranum	IV-P-M-L-H-F-D
Oncophorus	IV-P-N-L-H-F-D-A
Leucoloma	IV-P-N-L-H-G-C-A
Thysanomitrium	IV-P-N-L-H-G-D-A
Oligotrichum	V-H-E-C-A
Bartramiopsis	V-H-E-D-B
Pogonatum	VI-H-E
Polytrichum	VI-H-E

Leucoloma, Thysanomitrium, Oligotrichum and *Bartramiopsis*).

In all genera, there is something in common among the characteristics of the inner structure of the stem in the species belonging to the identical genus(Tab. 5). In *Entodon* the stem of the species is of the identical type of **III-Q-N-L-H-F-D, III-Q-N-K-H-E-C-A** in Fissidentaceae, **III-Q-N-K-H-E-C-A** in *Claopodium,* **III-Q-N-K-H-E-C-A** in *Haplocladium,* **III-Q-N-K** in *Anomodon,* **III-Q-N-K-I-E-D-A** in *Hylocomiopsis,* **III-Q-N-K-I-E-D-A** in *Boulaya,* **III-Q-N-K-I-E-C-A** in *Miyabea,* **III-Q-N-K-I-E-C-A** in *Haplohymenium,* **IV-Q-M-L-H-E** in *Thuidium,* **IV-Q-O-L-H-E-D-A** in *Herpetineurum,* **IV-Q-O-L-H** in *Mnium,* **IV-Q-O-L-H-G-C-A** in *Orthomniopsis,* **IV-Q-N-L-H-G-C-A** in *Philonotis,* **IV-P-M-L-H-F-C-A** in *Campylopodium,* **IV-P-M-L-H-F-D** in *Dicranum,* **IV-P-N-L-H-F-D-A** in *Oncophorus,* **IV-P-N-L-H-G-C-A** in *Leucoloma,* **IV-P-N-L-H-G-D-A** in *Thysanomitrium,* **V-H-E-C-A** in *Oligotrichum,* **V-H-E-D-B** in *Bartramiopsis,* **VI-H-E** in *Pogonatum,* **VI H-E** in *Polytrichum.*

On the other hand there are some other facts which are not peculiar to the genus as seen in *Fissidens, Claopodium, Haplocladium* and *Anomodon.* Such things are considered to be indicative of the fact that not all the characteristics of the stem-structure are important in classification of all genera. Therefore, in systematic studies of the inner structure of the stem it is necessary for us to consider what characters are important in given genus and in Musci in general.

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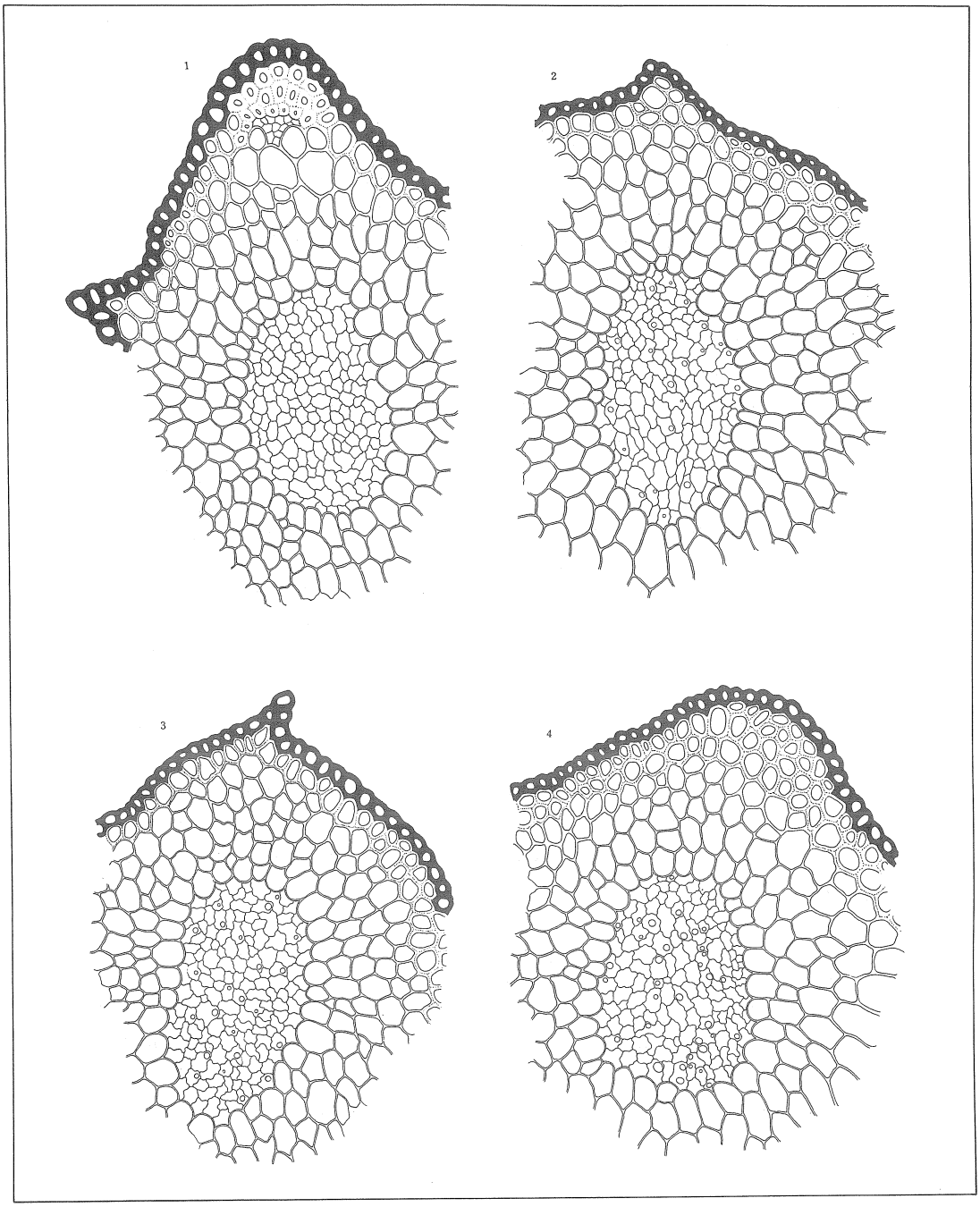

Plate I Cross sections of stem
Fig. 1 : *Mnium arcuatum* (BROTH.) P. BEAUV. ×160
Fig. 2 : *Mnium arcuatum* (BROTH.) P. BEAUV. ×160
Fig. 3 : *Mnium arcuatum* (BROTH.) P. BEAUV. ×160
Fig. 4 : *Mnium arcuatum* (BROTH.) P. BEAUV. ×160

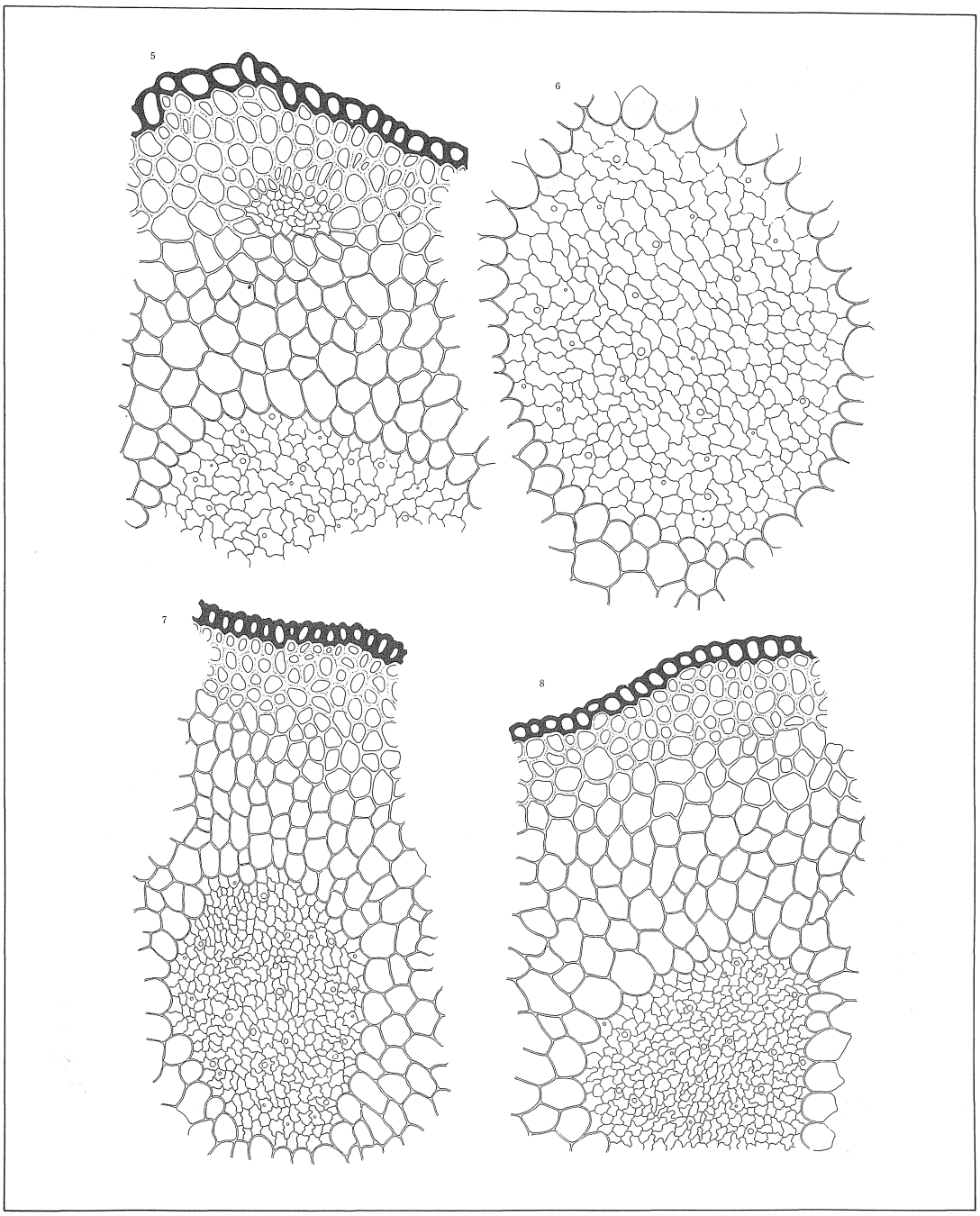

Plate II Cross sections of stem

Fig. 5 : *Mnium cuspidatum* HEDW. ×160

Fig. 6 : *Mnium cuspidatum* HEDW. ×160 (central part of the stem in Fig. 5)

Fig. 7 : *Mnium cuspidatum* HEDW. ×160

Fig. 8 : *Mnium cuspidatum* HEDW. ×160

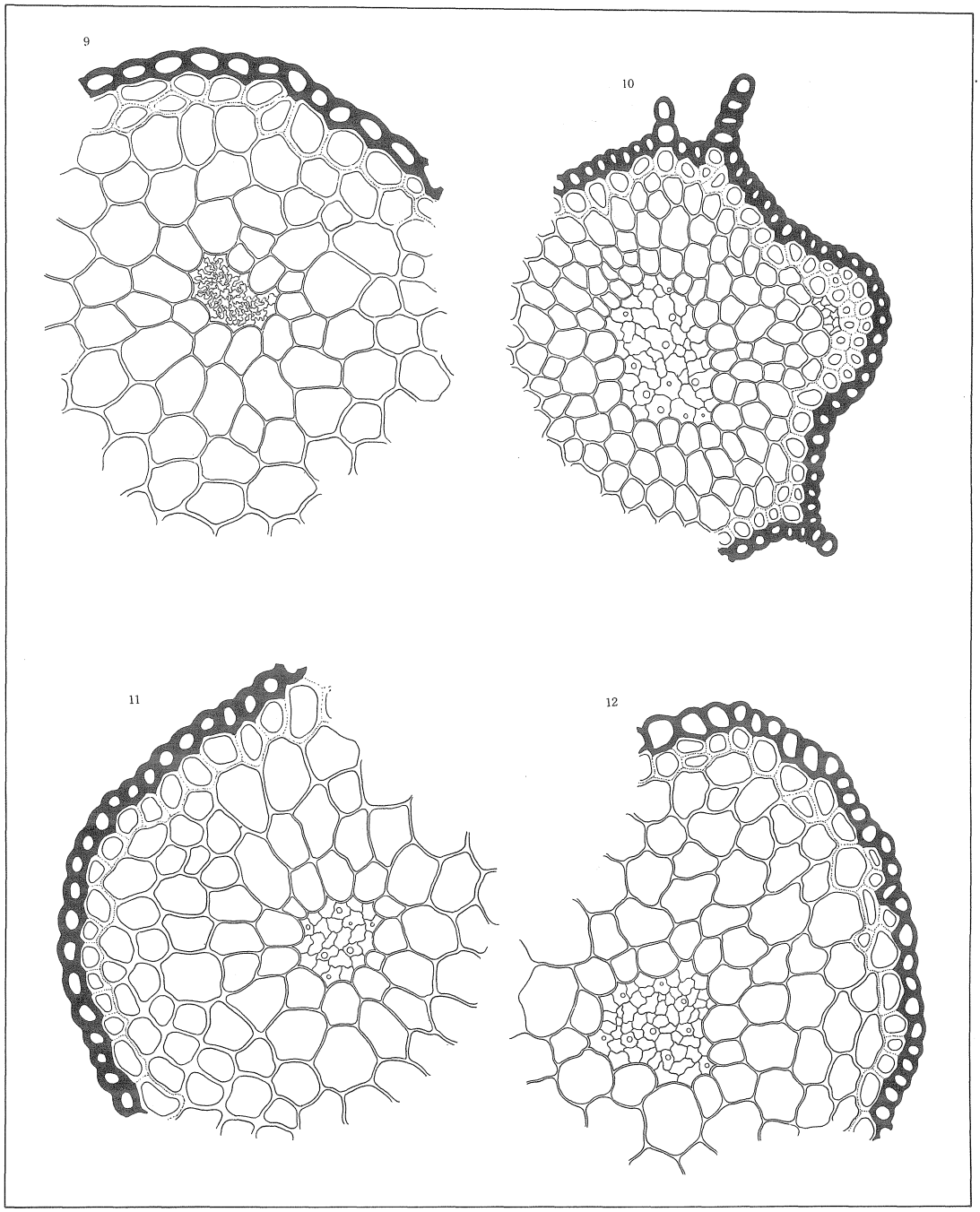

Plate III Cross sections of stem
Fig. 9 : *Mnium flagellare* SULL. et LESQ. ×160
Fig. 10 : *Mnium flagellare* SULL. et LESQ. ×160
Fig. 11 : *Mnium flagellare* SULL. et LESQ. ×160
Fig. 12 : *Mnium flagellare* SULL. et LESQ. ×160

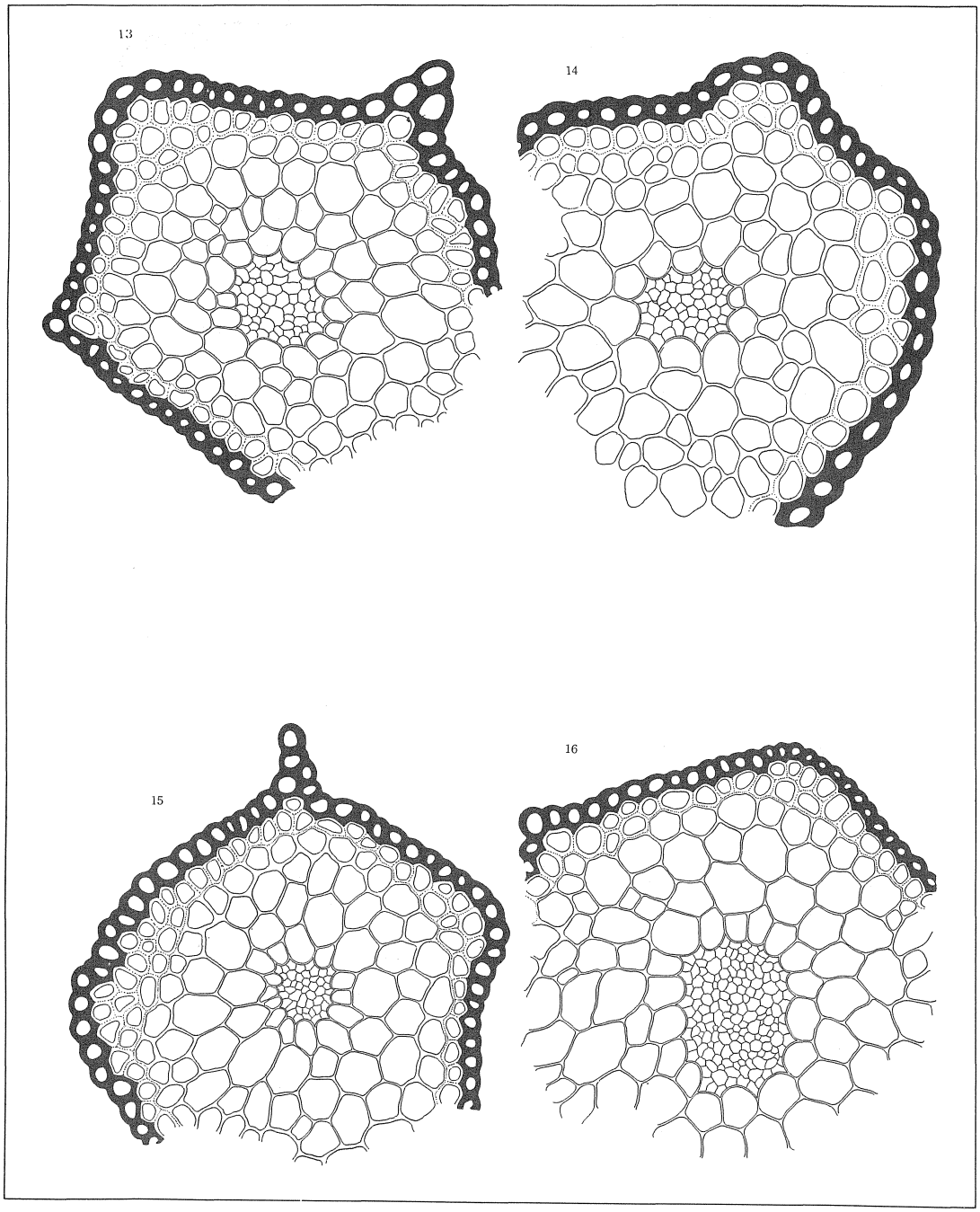

Plate IV Cross sections of stem
Fig. 13 : *Mnium hornum* HEDW. ×160
Fig. 14 : *Mnium hornum* HEDW. ×160
Fig. 15 : *Mnium hornum* HEDW. ×160
Fig. 16 : *Mnium hornum* HEDW. ×160

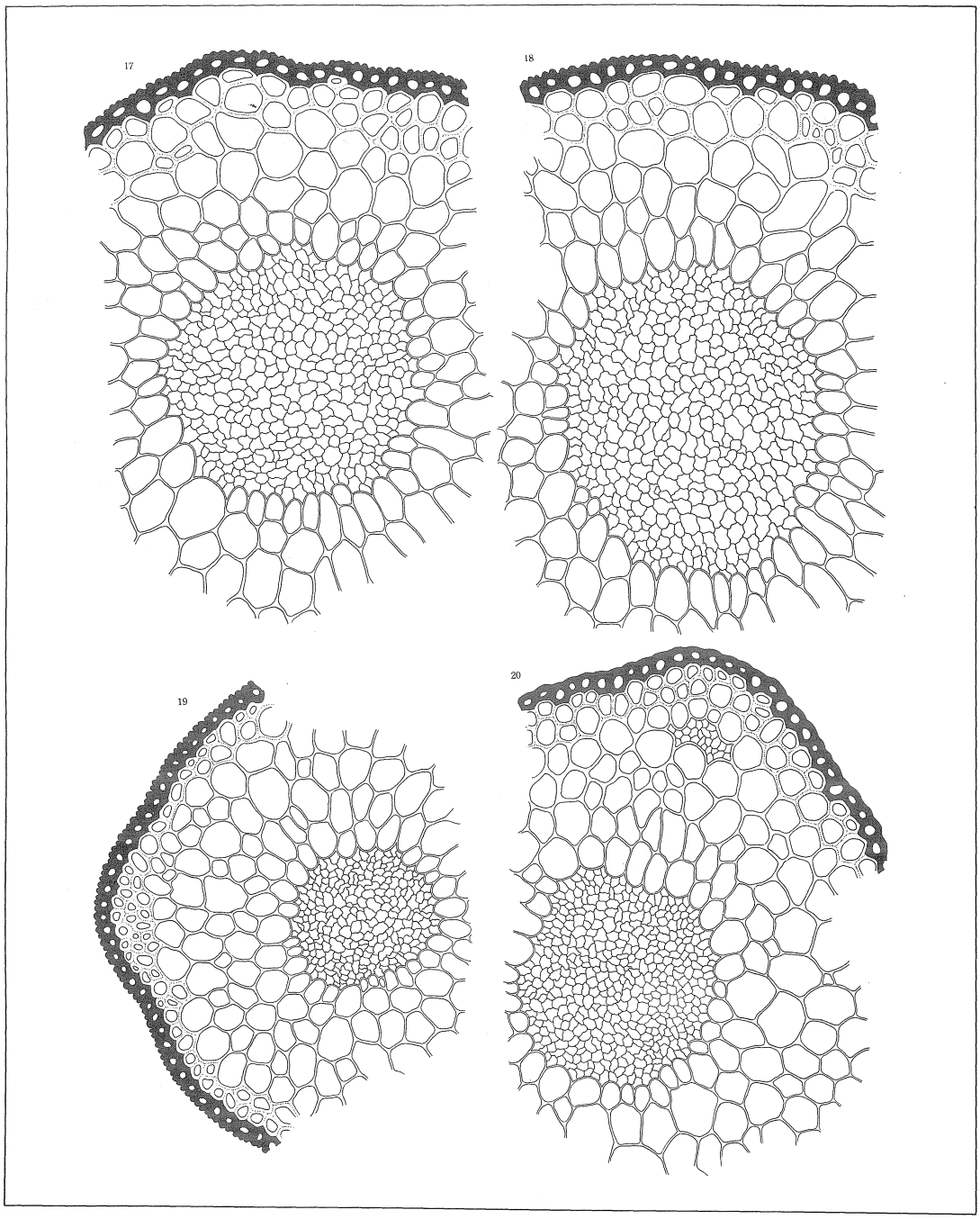

Plate V Cross sections of stem
Fig. 17 : *Mnium laevinerve* CARD. ×160
Fig. 18 : *Mnium laevinerve* CARD. ×160
Fig. 19 : *Mnium laevinerve* CARD. ×160
Fig. 20 : *Mnium maximoviczii* LINDB. ×160

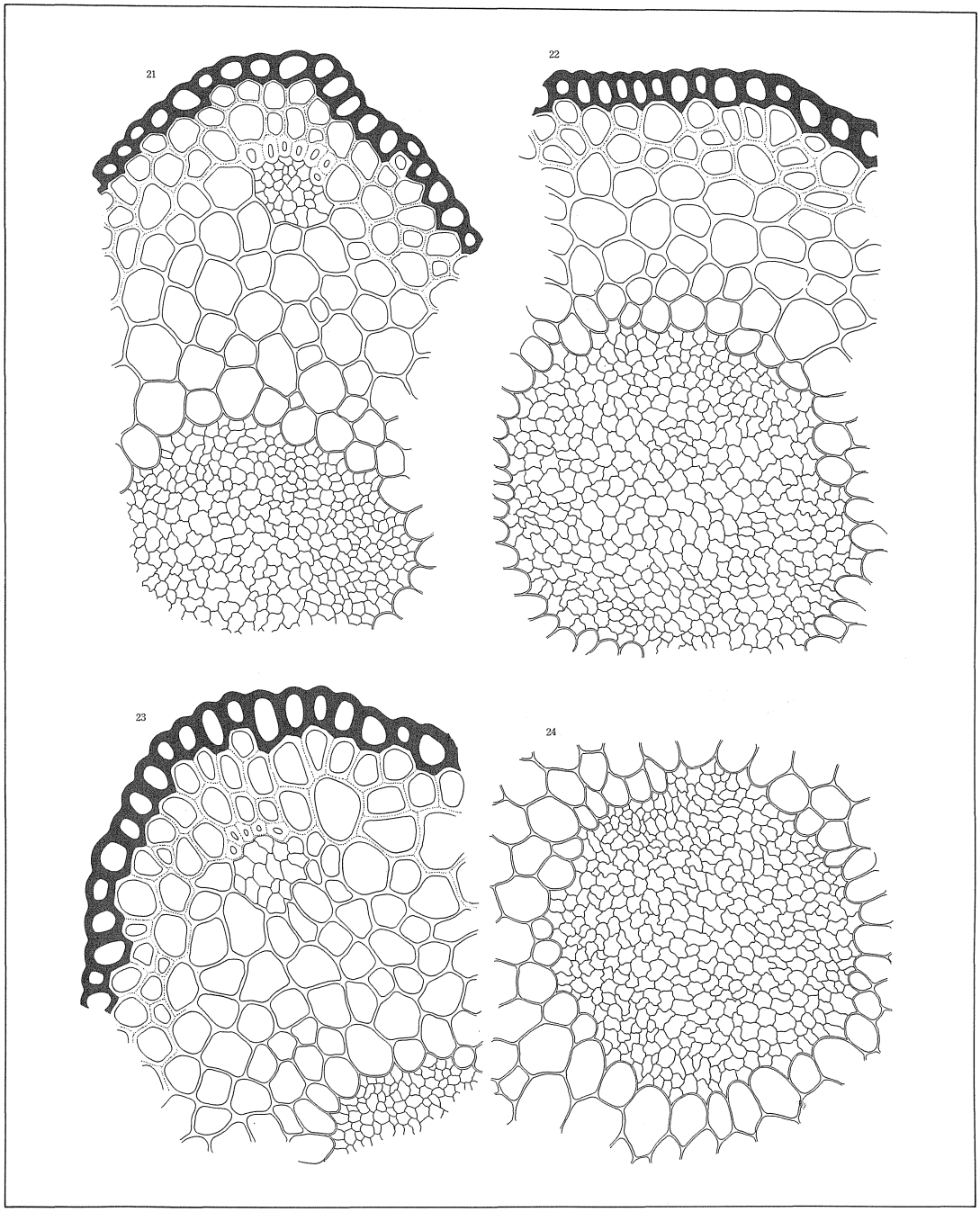

Plate VI Cross sections of stem

Fig. 21 : *Mnium maximoviczii* LINDB. ×160

Fig. 22 : *Mnium maximoviczii* LINDB. ×160

Fig. 23 : *Mnium maximoviczii* LINDB. ×160

Fig. 24 : *Mnium maximoviczii* LINDB. ×160 (central part of the stem in Fig. 23)

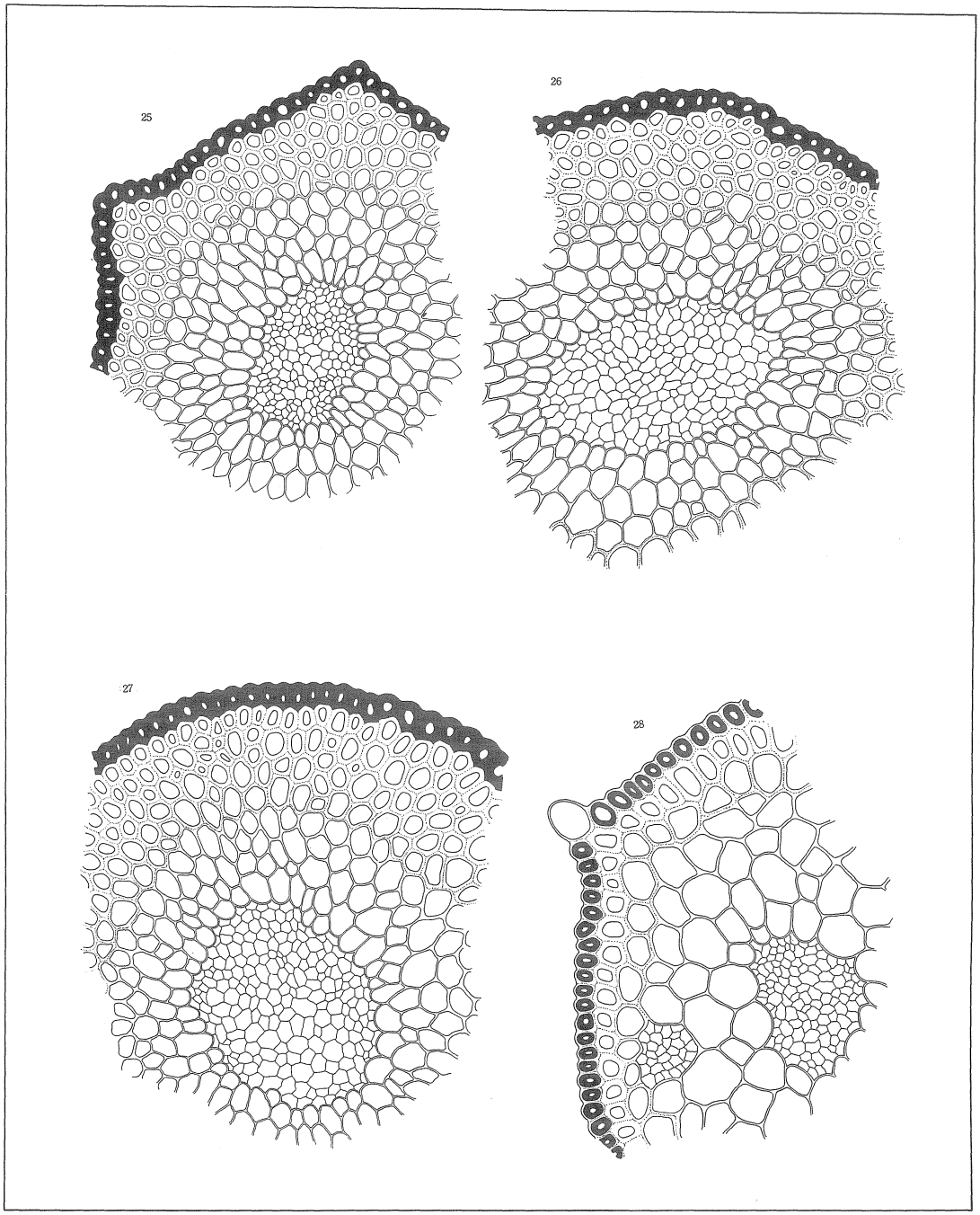

Plate VII Cross sections of stem

Fig. 25 : *Mnium microphyllum* DOZ. et MOLK. ×160
Fig. 26 : *Mnium microphyllum* DOZ. et MOLK. ×160
Fig. 27 : *Mnium microphyllum* DOZ. et MOLK. ×160
Fig. 28 : *Mnium punctatum* SCHREB. ex HEDW. ×160

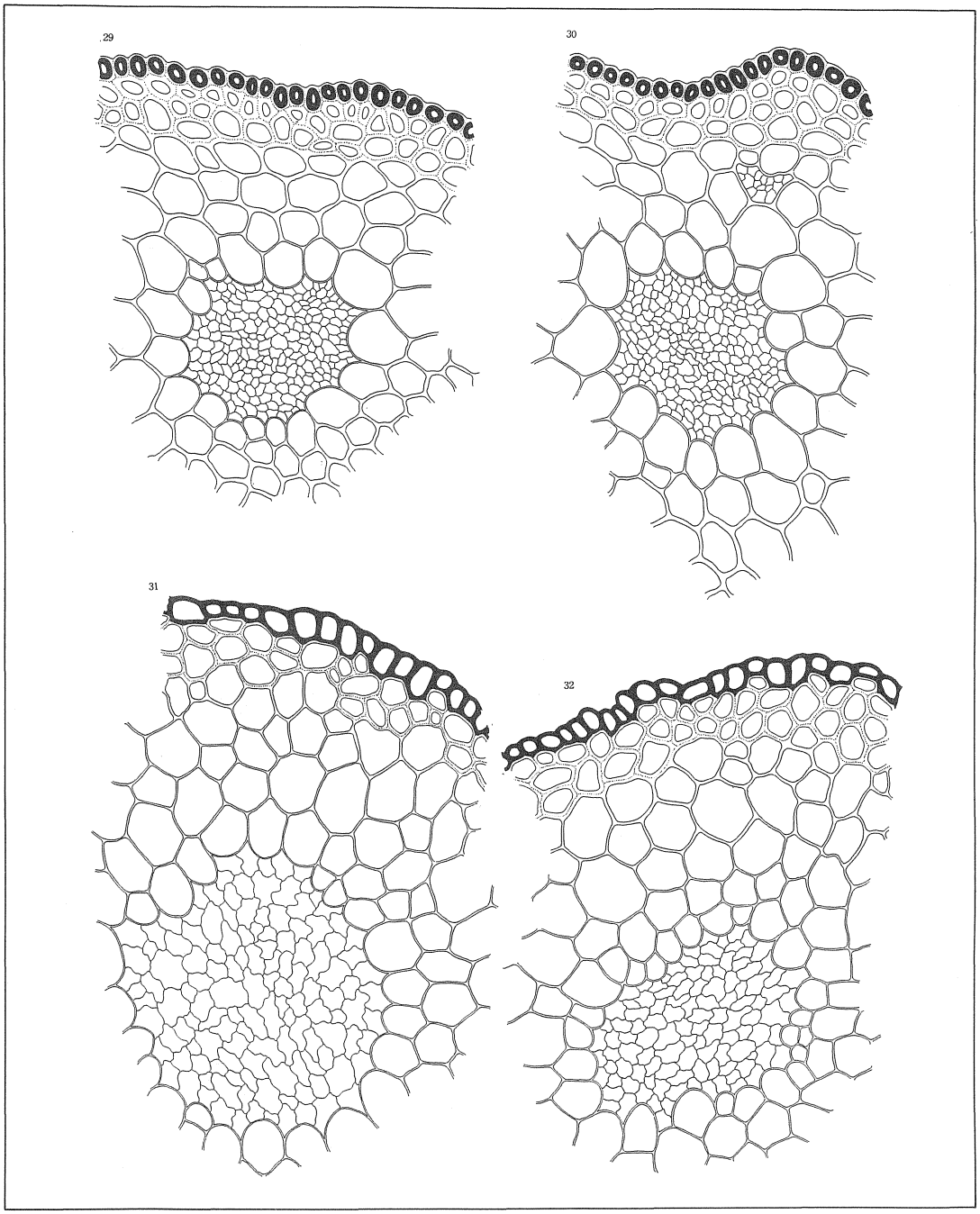

Plate VIII Cross sections of stem
Fig. 29 : *Mnium punctatum* SCHREB. ex HEDW. ×160
Fig. 30 : *Mnium punctatum* SCHREB. ex HEDW. ×160
Fig. 31 : *Mnium rostratum* SCHRAD. ×160
Fig. 32 : *Mnium rostratum* SCHRAD. ×160

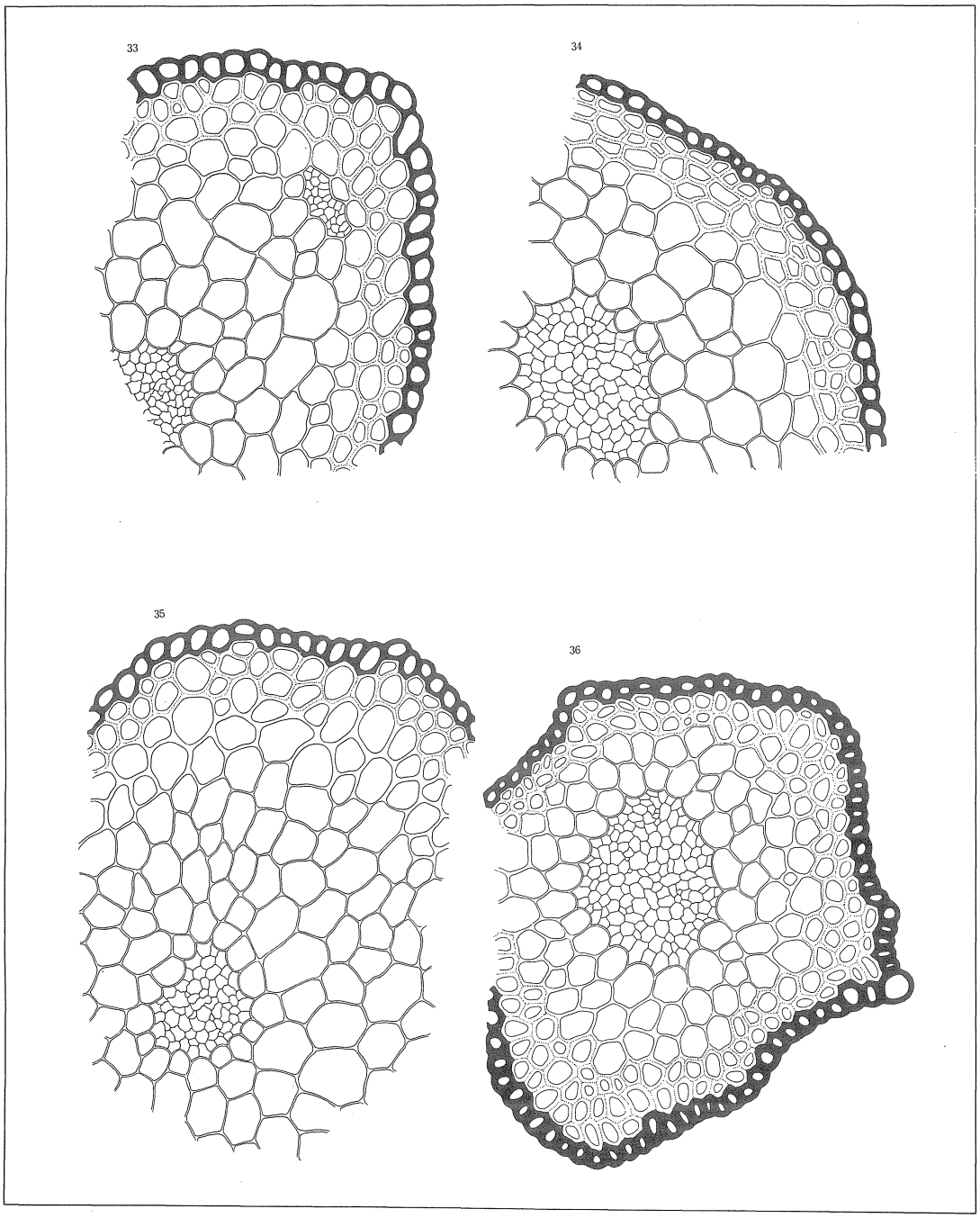

Plate IX Cross sections of stem

Fig. 33 : *Mnium rostratum* SCHRAD. ×160

Fig. 34 : *Mnium rostratum* SCHRAD. ×160

Fig. 35 : *Mnium rostratum* SCHRAD. ×160

Fig. 36 : *Mnium striatulum* MITT. ×160

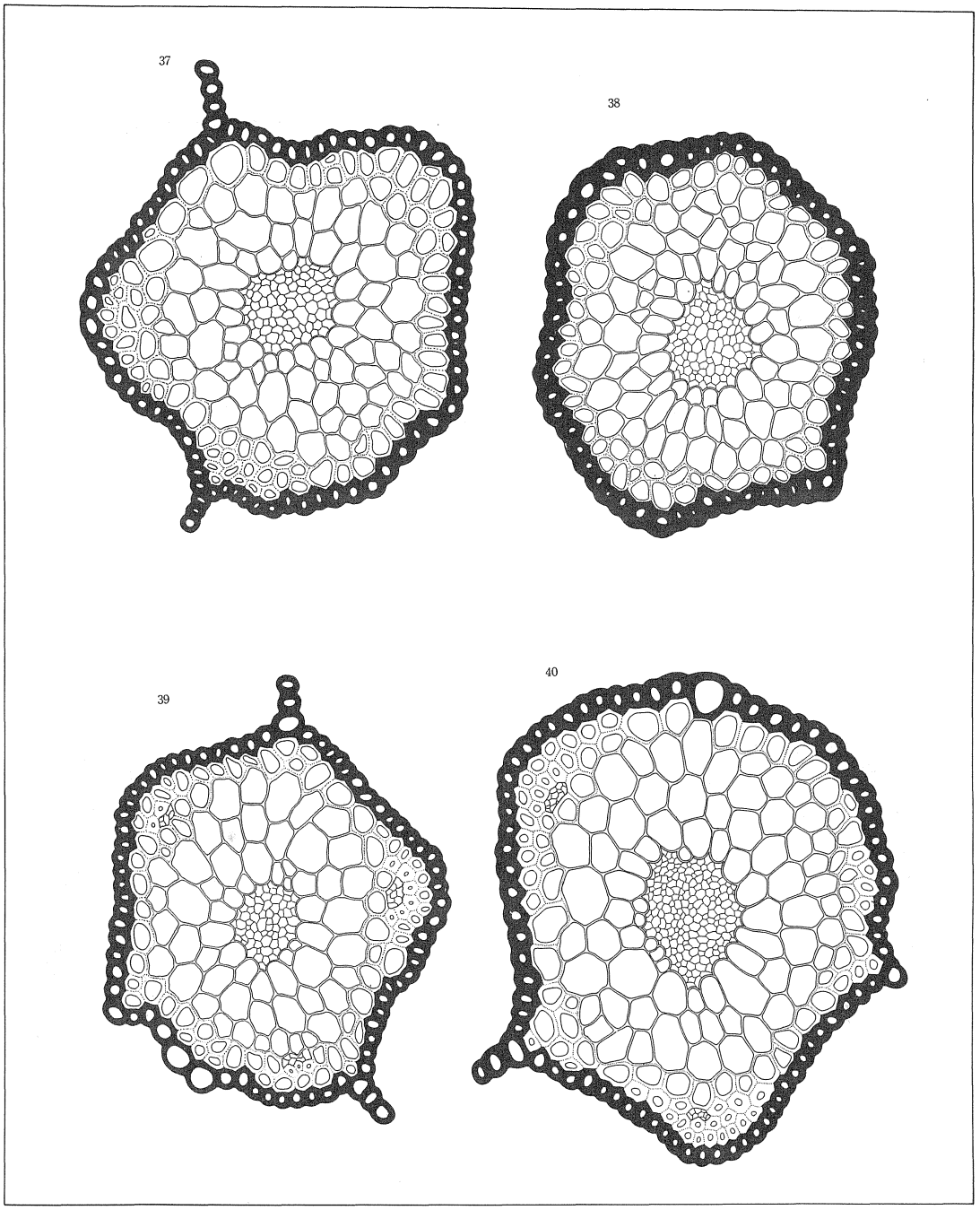

Plate X Cross sections of stem

Fig. 37 : *Mnium sapporense* BESCH. ×160
Fig. 38 : *Mnium sapporense* BESCH. ×160
Fig. 39 : *Mnium sapporense* BESCH. ×160
Fig. 40 : *Mnium sapporense* BESCH. ×160

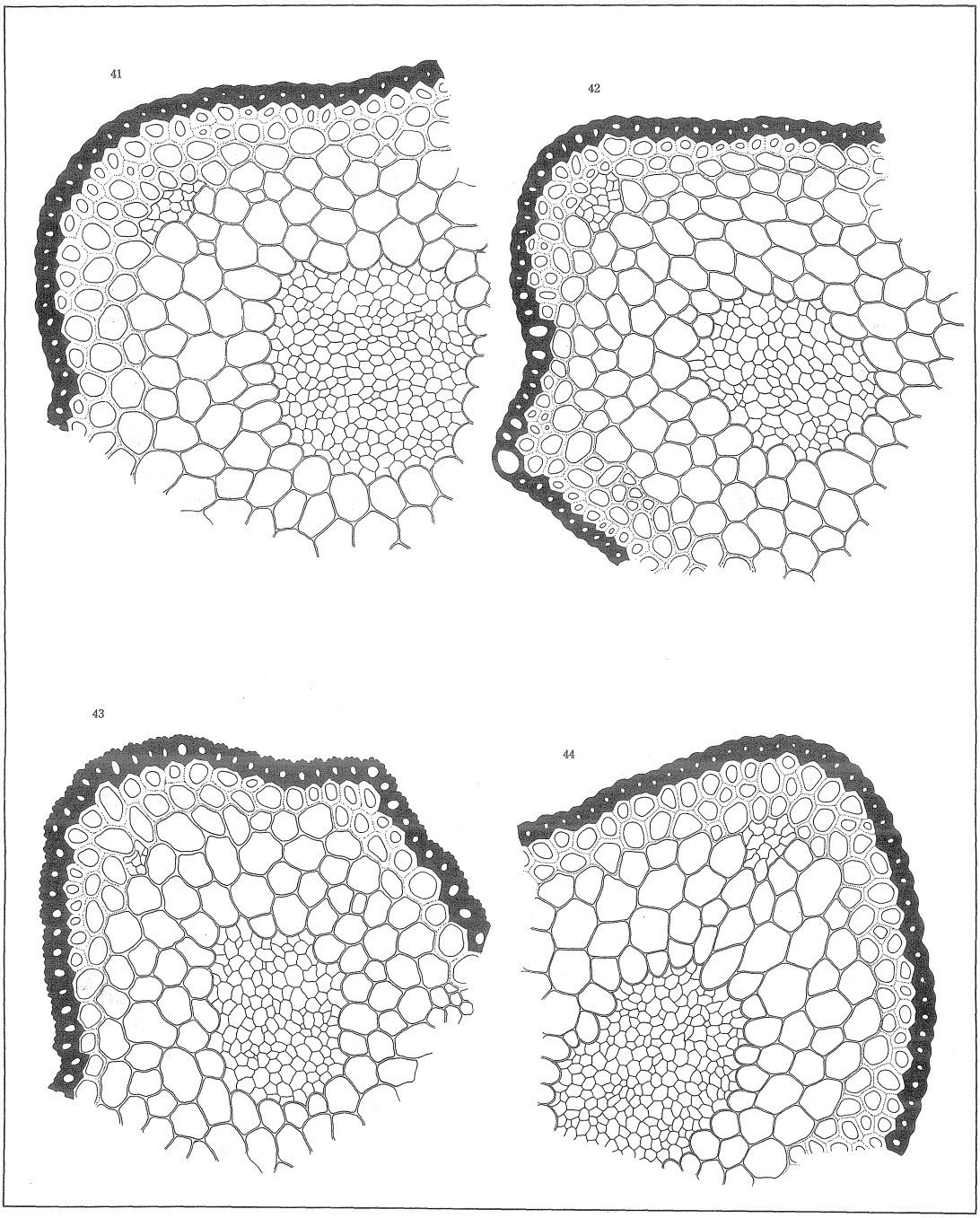

Plate XI Cross sections of stem
Fig. 41 : *Mnium striatulum* MITT. ×160
Fig. 42 : *Mnium striatulum* MITT. ×160
Fig. 43 : *Mnium striatulum* MITT. ×160
Fig. 44 : *Mnium striatulum* MITT. ×160

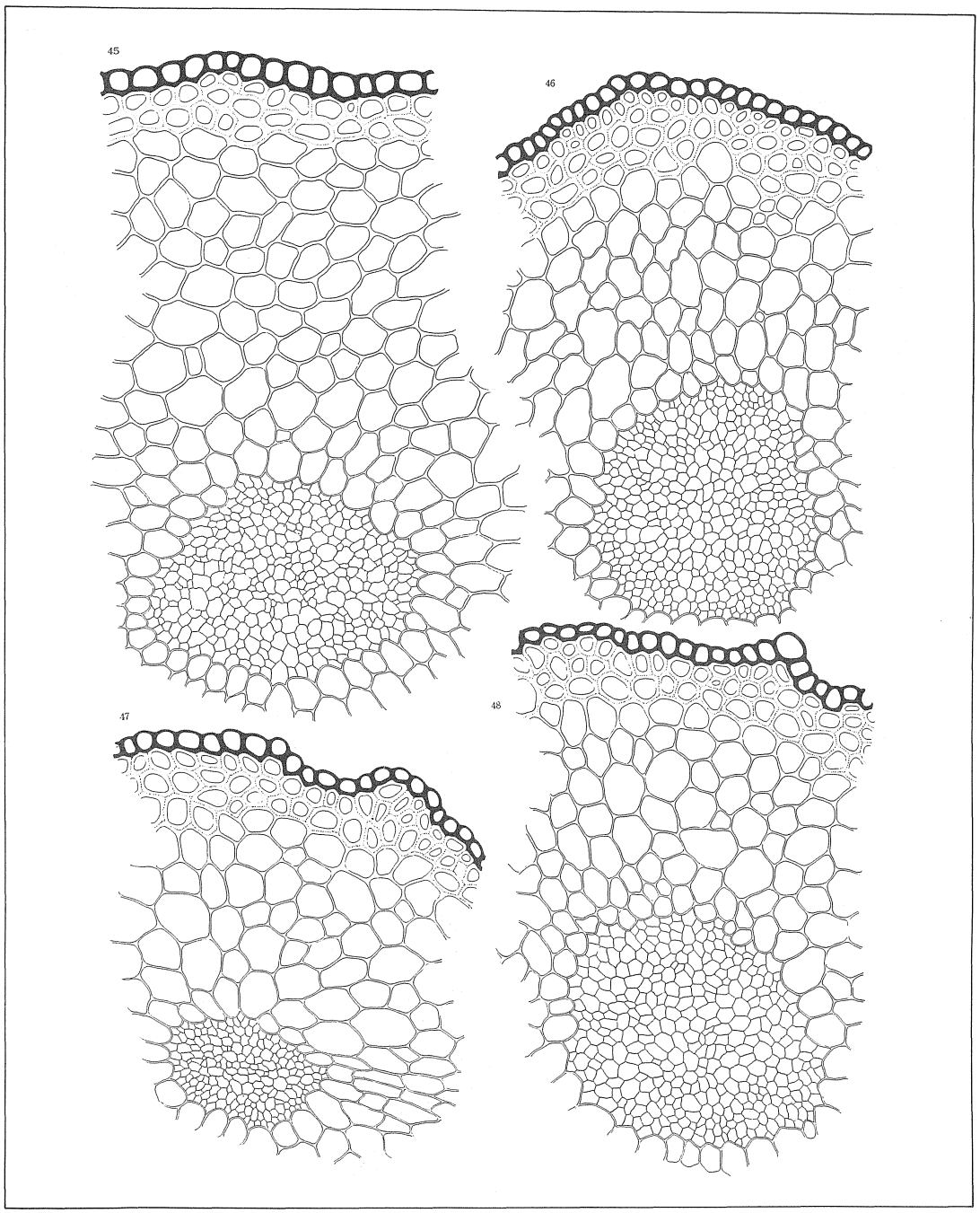

Plate XII Cross sections of stem

Fig. 45 : *Mnium speciosum* MITT. ×160

Fig. 46 : *Mnium speciosum* MITT. ×160

Fig. 47 : *Mnium speciosum* MITT. ×160

Fig. 48 : *Mnium speciosum* MITT. ×160

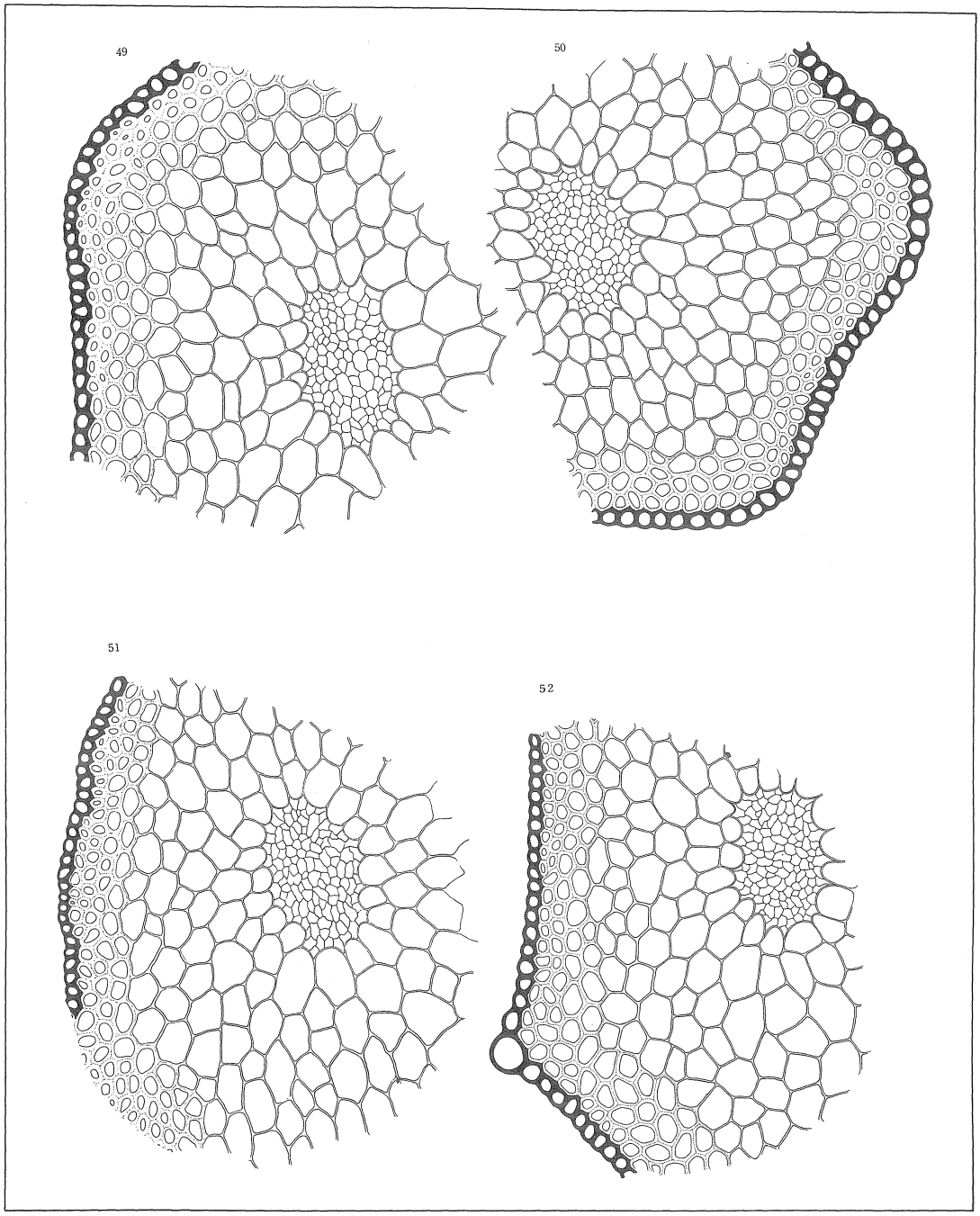

Plate XIII Cross sections of stem

Fig. 49 : *Mnium trichomanes* MITT. ×160
Fig. 50 : *Mnium trichomanes* MITT. ×160
Fig. 51 : *Mnium trichomanes* MITT. ×160
Fig. 52 : *Mnium trichomanes* MITT. ×160

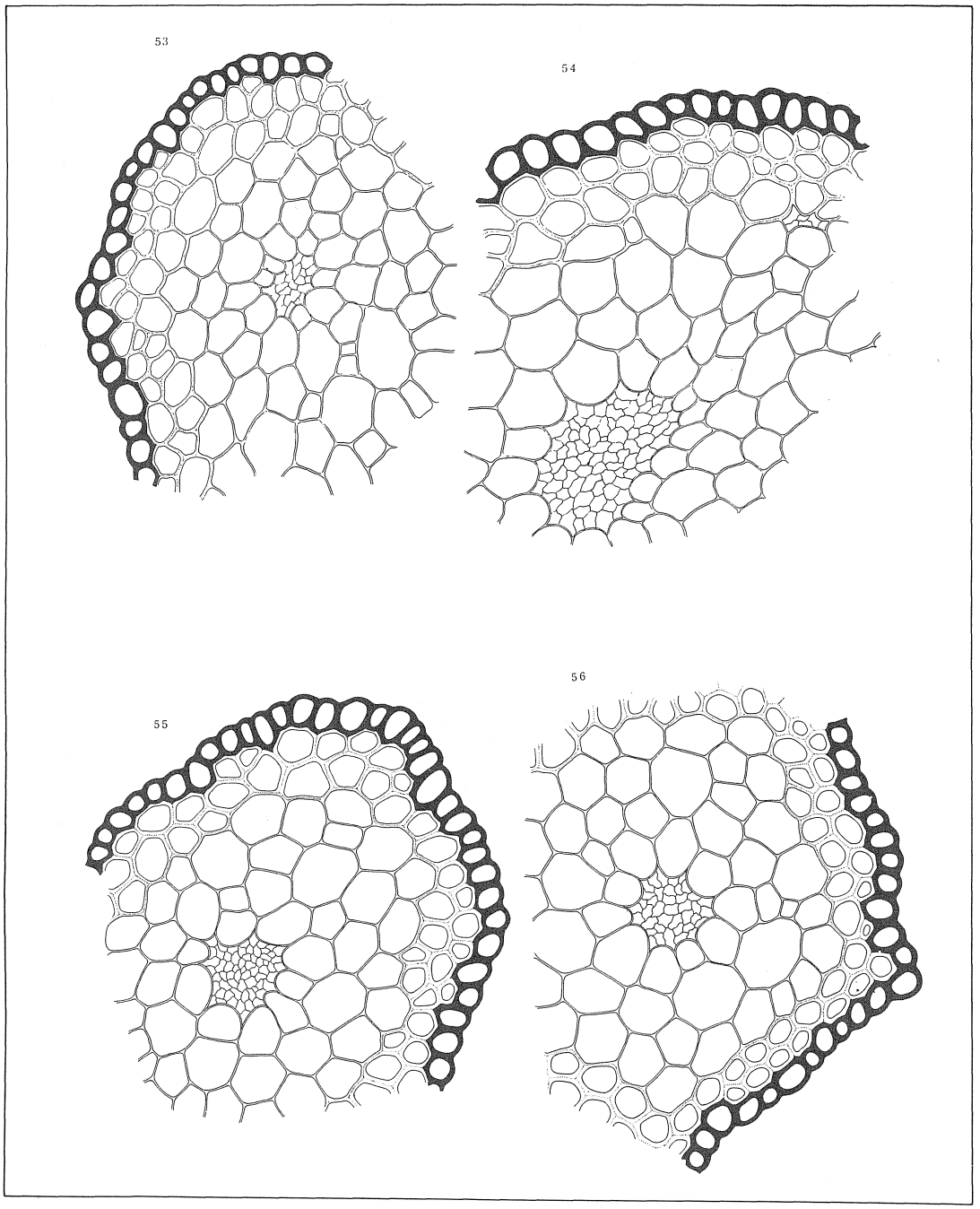

Plate XIV Cross sections of stem

Fig. 53 : *Mnium vesicatum* BESCH. ×160
Fig. 54 : *Mnium vesicatum* BESCH. ×160
Fig. 55 : *Mnium vesicatum* BESCH. ×160
Fig. 56 : *Mnium vesicatum* BESCH. ×160

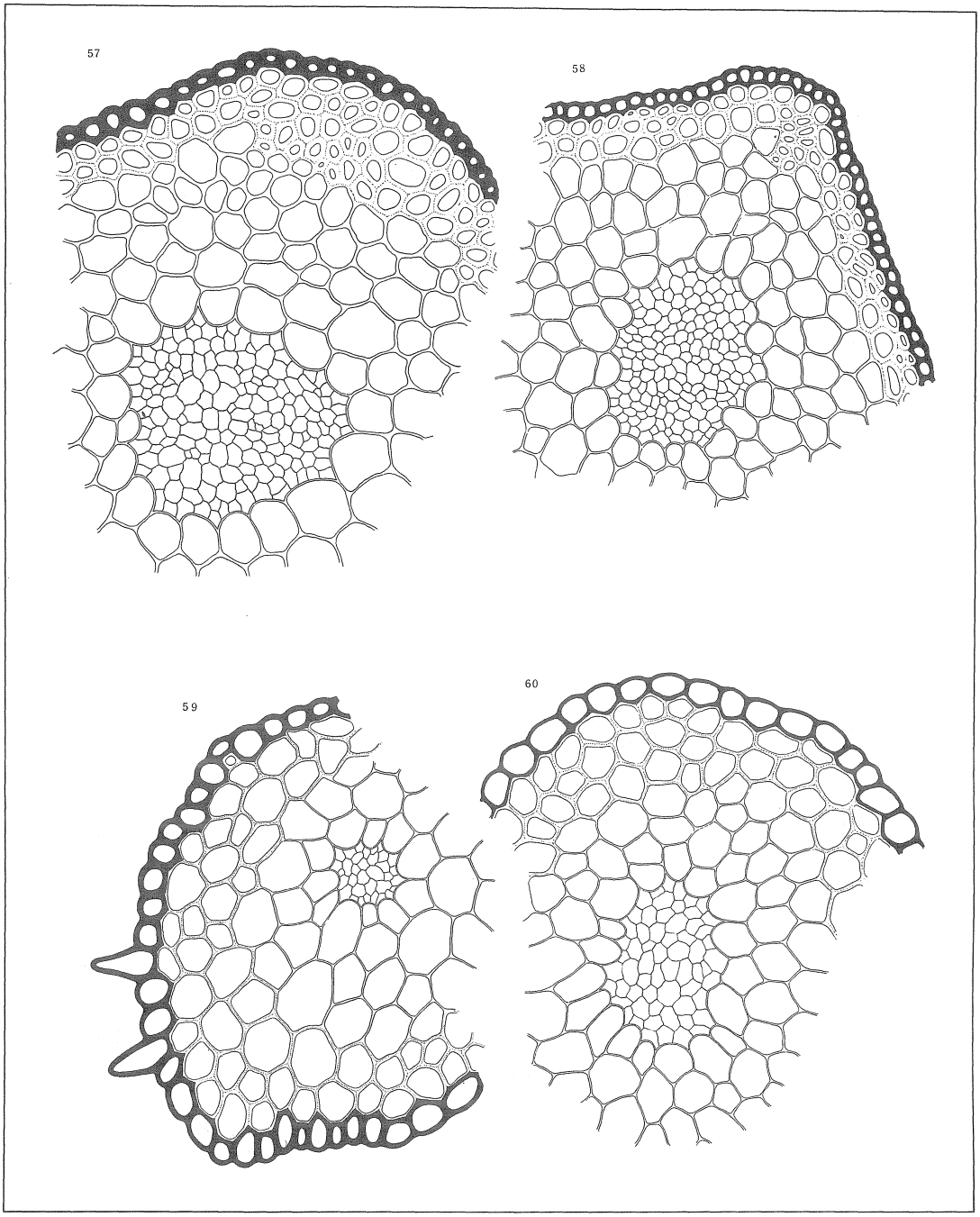

Plate XV Cross sections of stem

Fig. 57 : *Mnium striatulum* MITT. ×160

Fig. 58 : *Mnium striatulum* MITT. ×160

Fig. 59 : *Mnium vesicatum* BESCH. ×160

Fig. 60 : *Orthomniopsis japonica* BROTH. ×160

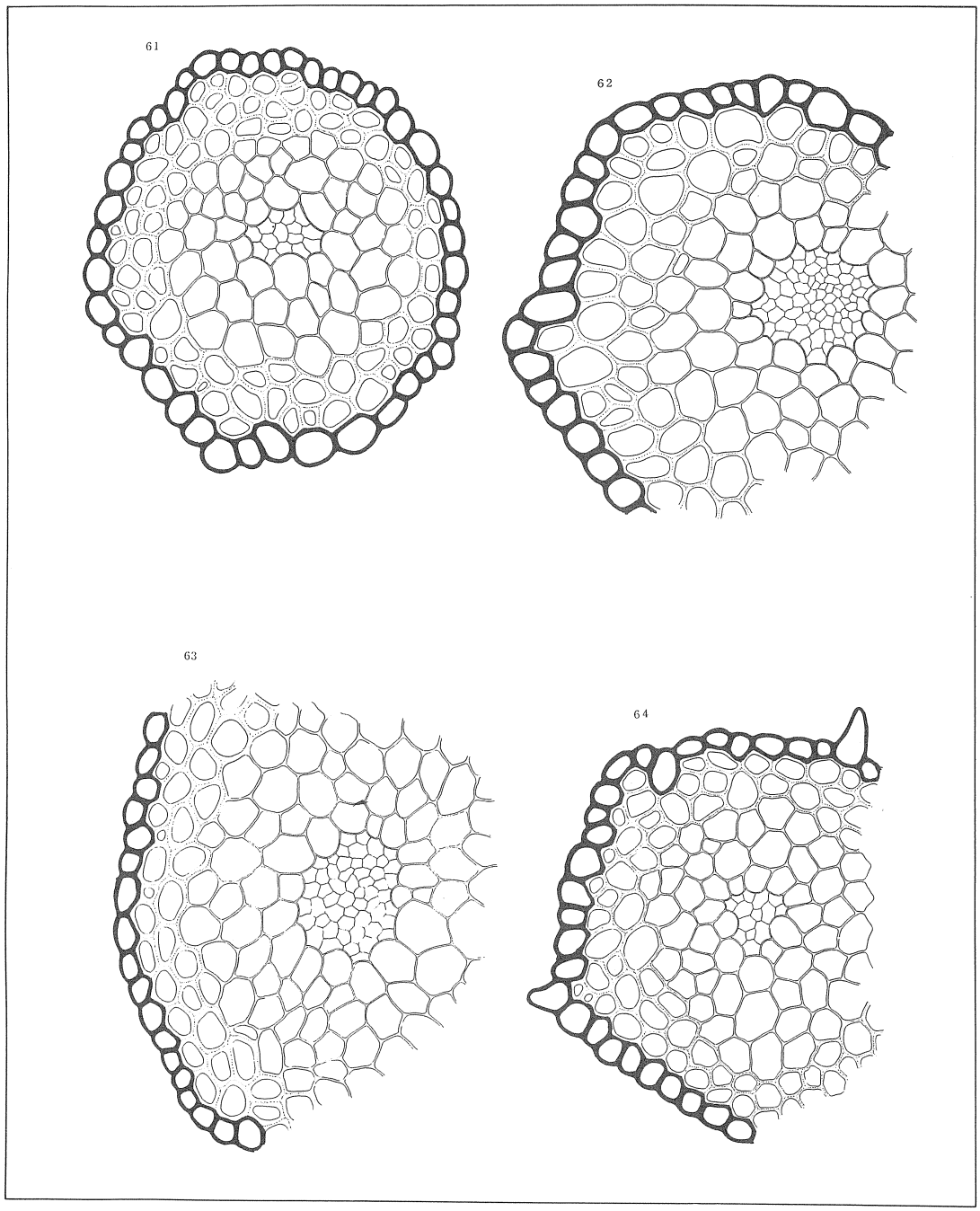

Plate XVI Cross sections of stem
Fig. 61 : *Orthomniopsis japonica* BROTH. ×160
Fig. 62 : *Orthomniopsis japonica* BROTH. ×160
Fig. 63 : *Orthomniopsis japonica* BROTH. ×160
Fig. 64 : *Orthomniopsis japonica* BROTH. ×160