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Systematic Studies on the Conducting Tissue of the Gametophyte in Musci

(9) On Regularity Among Anatomical Characteristics of Stems in Some Species of Dicranaceae

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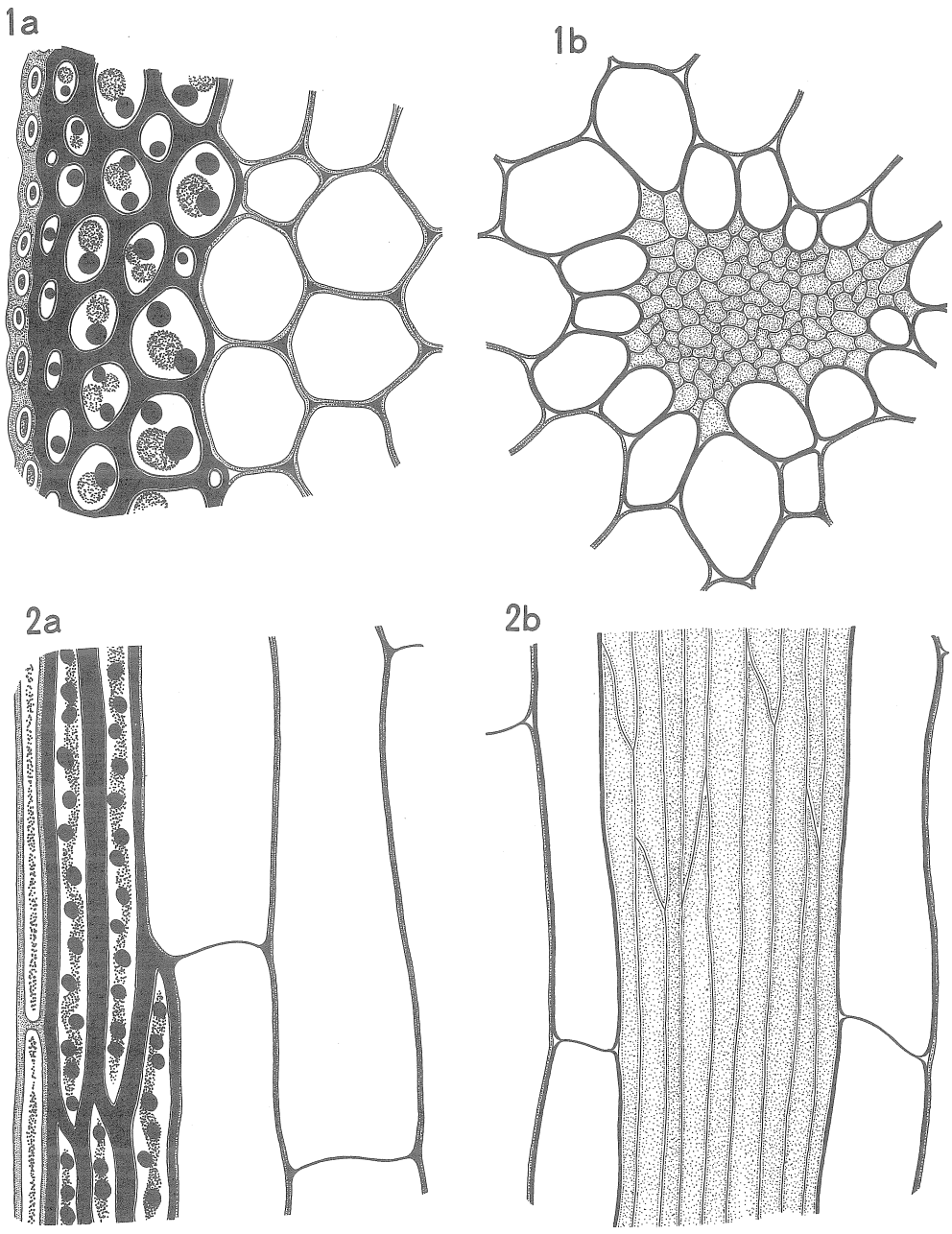
Abstract Many of the anatomical characteristics hitherto observed, which are closely connected with the cutting at the early-stage of the ontogeny, seem to show regularity, so the interior structure of the stem found in twenty-four species of Dicranaceae has been observed from this point of view.

The stems of Dicranaceae are classified into ten types through the observation of the cross section. A longitudinal section is observed in each one of the species with the stem belonging to each type, and as a result of observation of the various characteristics ten characteristics are considered.

On the stems of the ten species the affinity regarding the anatomical characteristics of the cross and longitudinal sections is considered. From these considerations, some regularity can be seen among some of the anatomical characteristics of the stem in cross and longitudinal sections. What is of developmental and taxonomical interest is that these characteristics are the type of inner differentiation of the stem (**III** and **IV** types), comparative length of cells (**H3a** and **H4a** types in the hadrom), thickness of cell walls (**R** and **S** types), comparative thickness of cell walls (**P** and **Q** types), thickness of the septum (**HTN** and **HAS** types in the hadrom), comparison of the size of cells (**M** and **N** types) and the shape of cells (**HRE**, **HRH** and **HSP** types in the hadrom), and that they are alomst exclusively the characteristics of the hadrom.

Introduction

When the inner structure of fresh stems in *Dicranum* are observed, chloroplast is found in the cells of the cortex, but is not in the leptom and hadrom (Fig. 1, 2). The stem of *Dicranum* seems to consist of an epidermis, cortex (an assimilation tissue), leptom, hydrom sheath and a hadrom (IV type). The initial of the epidermis and cortex originates from the two outer cells which are derived from segments through first and second divisions. The initial of the leptom and hadrom originates from the one inner



Cross sections (Fig. 1) and longitudinal sections (Fig. 2) of the fresh stem in *Dicranum nipponense* BESCH. a : Outer part of the stem, b : Central part of the stem

cell which comes from a segment.

Many of the anatomical characteristics hitherto observed, which are closely connected with the cutting at the early-stage of the ontogeny, seem to indicate a certain regularity, so the interior structure of the stem in twenty-four species of Dicranaceae is observed from this point of view.

Materials and Methods

The materials used for this research are composed of specimens of mosses collected in Japan. All the samples studied are deposited in the Moss Herbarium of kanazawa University.

Arctoa fulvella (DICKS.) B.S.G.: Gifu (39249), *Brothera leana* (SULL.) C. MUELL.: Mie (39382), Nara (39244), Shizuoka (32630), *Campylopodium euphorocladum* (C.MUELL.) BESCH.: Kagoshima (35923), *Campylopus japonicus* BROTH.: Kagoshima (39203), *Campylopus richardii* BRID.: Koochi (39252), Wakayama (39385), Kyooto (37401), Kumamoto (37555), Wakayama (32544), Kumamoto (34997), *Dichodontium pellucidum* (HEDW.) SCHIMP.: Shiga (37342), *Dicranella heteromalla* (HEDW.) SCHIMP.: Shiga (37341), Mie (39396), Miyagi (34907), Shizuoka (32631), *Dicranella palustris* (DICKS.) CRUNDW. ex WARB.: Niigata (37420), Ishikawa (36263), Hyoogo (37381), Niigata (37350), *Dicranella varia* (HEDW.) SCHIMP.: Mie (38549), *Dicranodontium denudatum* (BRID.) BRITT. ex WILL.: Gifu (11023), Shizuoka (32708), Ishikawa (36192), *Dicranum bonjeanii* D. NOT.: Hokkaidoo (37340), *Dicranum caesium* MITT.: Miyagi (34908), *Dicranum hamulosum* MITT.: Gifu (34920), Ishikawa (32501), *Dicranum japonicum* MITT.: Kumamoto (37496), Kagoshima (39254), Aichi (34910), Kumamoto (37532), Kumamoto (35065), *Dicranum majus* TURN.: Hokkaidoo, *Dicranum nipponense* BESCH.: Kyooto (37313), Tokushima (32609), *Dicranum scoparium* HEDW.: Kagoshima (34949), Nagano (37531), Shizuoka (32620), Ishikawa (32616), Shizuoka (32618), Gifu (11019), *Dicranum viride* v. *hakkodense* (CARD.) TAK.: Fukuoka (37314), *Dicranum setifolium* CARD.: Niigata (37366), *Leucoloma molle* (C.MUELL.) MITT.: Tokushima (39376), *Leucoloma okamurae* BROTH.: Wakayama (34058), Wakayama (39407), *Oncophorus crispifolius* (MITT.) LINBD.: Shizuoka (32611), Kumamoto (35150), Miyazaki (35025), *Oncophorus crispifolius* v. *brevipes* (CARD.) IHS.: Ooita (35199), *Trematodon longicollis* f. *atrovirens* (BROTH.) TAK.: Kumamoto (34992), Kumamoto (37553).

The hard mosses are boiled in water for about an hour in order to prevent the soft tissue from breaking. The inner structure of the stem is studied from transverse sections and longitudinal sections having a thickness of five microns. Gentian violet and acid fuchsin combination is used for staining anatomical preparations.

Observation and Discussion

I. Anatomical Characteristics in Stem Cross Sections

Tab. 1 Anatomical characteristics of the stems in twenty-four species of Dicranaceae

	Number of the cell layers of the leptom is 1-4 cell layers (A type) or 4-13 cell layers (B type)	Number of the cell layers of the cortex is 1-4 cell layers (C type) or 4-7 cell layers (D type)	Cells of the epidermal layer are larger (V type), as large (W type) or smaller (X type) than those of the cortex	Epidermal cell walls are thicker (G type), as thick (H type) or thinner (I type) than those of the cortex	Cells of the epidermal layer are parenchymatous (T type) or not (U type)	Cells of the hadrom are parenchymatous (R type) or not (S type)	Cells of the hadrom are larger (L type), as large (M type) or smaller (N type) than those of the leptom	Cell walls of the hadrom are thicker (O type), as thick (P type) or thinner (Q type) than those of the leptom	The stem differentiates into an epidermis, cortex, leptom and a hadrom (III type) or into an epidermis, cortex, leptom, hydrom sheath and a hadrom (IV type)	Number of the figures in the Plate
Leucoloma molle (C. MUELL.) MITT.	*	2(2-2)C	X	G	U	S	M	P	III	I-1
Leucoloma molle (C. MUELL.) MITT.	*	2(2-3)C	X	G	U	S	M	P	III	I-2
Leucoloma molle (C. MUELL.) MITT.	*	2(2-3)C	X	G	U	S	M	P	III	I-3
Leucoloma molle (C. MUELL.) MITT.	*	2(2-3)C	X	G	U	S	M	P	III	I-4
Leucoloma okamurae BROTH.	*	2(1-2)C	X	I	U	S	M	P	III	I-5
Leucoloma okamurae BROTH.	*	1(1-2)C	X	I	U	S	M	P	III	I-6

Leucoloma okamurae BROTH.	*	1(1-2)C	X	I	U	S	M	P	Ⅲ	I-7
Leucoloma okamurae BROTH.	*	1(1-2)C	X	I	U	S	M	P	Ⅲ	I-8
Arctoa fulvella (DICKS.) B.S.G.	3(2-3)A	1(1-2)C	X(W)	H(G)	U	R	N(M)	P(Q)	Ⅳ	I-9
Arctoa fulvella (DICKS.) B.S.G.	2(2-3)A	1(1-2)C	X	H(G)	U	R	N(M)	P(Q)	Ⅳ	I-10
Arctoa fulvella (DICKS.) B.S.G.	3(3-4)A	1(1-2)C	X	H	U	R	N(M)	P(Q)	Ⅳ	I-11
Arctoa fulvella (DICKS.) B.S.G.	3(2-4)A	1(1-1)C	X	H	U	R	N(M)	P(Q)	Ⅳ	I-12
Arctoa fulvella (DICKS.) B.S.G.	3(2-3)A	1(1-2)C	X	H	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-1
Brothera leana (SULL.) C.MUELL.	1(1-2)A	1(1-1)C	X(W)	G	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-2
Brothera leana (SULL.) C.MUELL.	1(1-2)A	1(1-1)C	X(W)	G	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-3
Brothera leana (SULL.) C.MUELL.	1(1-1)A	1(1-1)C	X(W)	G	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-4
Brothera leana (SULL.) C.MUELL.	1(1-1)A	1(1-1)C	X(W)	G	U	R	N	P(Q)	Ⅳ	Ⅱ-5
Brothera leana (SULL.) C.MUELL.	1(1-2)A	1(1-2)C	X(W)	G	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-6
Brothera leana (SULL.) C.MUELL.	1(1-2)A	1(1-2)C	X(W)	G	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-7
Brothera leana (SULL.) C.MUELL.	1(1-2)A	1(1-2)C	X(W)	G	U	R	N(M)	P(Q)	Ⅳ	Ⅱ-8
Trematodon longicollis f. *atrovirens* (BROTH.) TAK.	2(2-3)A	1(1-2)C	X(W)	G	U	S	N	P	Ⅳ	Ⅱ-9
Trematodon longicollis f. *atrovirens* (BROTH.) TAK.	1(1-3)A	1(1-1)C	X(W)	G	U	S	N	P	Ⅳ	Ⅱ-10
Trematodon longicollis f. *atrovirens* (BROTH.) TAK.	2(2-3)A	1(1-2)C	X(W)	G	U	S	N	P	Ⅳ	Ⅱ-11
Trematodon longicollis f. *atrovirens* (BROTH.) TAK.	2(1-3)A	1(1-2)C	X(W)	G	U	S	N	P	Ⅳ	Ⅱ-12
Campylopodium euphorocladum (C.MUELL.) BESCH.	3(2-4)A	1(1-2)C	X(W)	G	U	S	N(M)	Q	Ⅳ	Ⅲ-1
Campylopodium euphorocladum (C.MUELL.) BESCH.	3(3-4)A	1(1-2)C	X	G	U	S	N(M)	Q	Ⅳ	Ⅲ-2
Campylopodium euphorocladum (C.MUELL.) BESCH.	3(2-4)A	1(1-2)C	X(W)	G	U	S	N(M)	Q	Ⅳ	Ⅲ-3
Campylopodium euphorocladum (C.MUELL.) BESCH.	2(1-3)A	1(1-1)C	X	G	U	S	N(M)	Q	Ⅳ	Ⅲ-4
Dicranodontium denudatum (BRID.) BRITT.	2(1-3)A	2(2-3)C	X	I	U	S	N	Q	Ⅳ	Ⅲ-5
Dicranodontium denudatum (BRID.) BRITT.	2(1-3)A	2(2-3)C	X	I	U	S	N	Q	Ⅳ	Ⅲ-6
Dicranodontium denudatum (BRID.) BRITT.	1(1-2)A	2(2-3)C	X(W)	I	U	S	N	Q	Ⅳ	Ⅲ-7
Dicranodontium denudatum (BRID.) BRITT.	2(2-2)A	3(2-3)C	X(W)	I	U	S	N	Q	Ⅳ	Ⅲ-8
Dicranum bonjeanii DE NOT.	4(3-5)B	1(1-2)C	X	I	U	S	N	Q	Ⅳ	Ⅲ-9
Dicranum bonjeanii DE NOT.	4(4-5)B	2(2-3)C	X	I	U	S	N	Q	Ⅳ	Ⅲ-10
Dicranum bonjeanii DE NOT.	4(3-5)B	1(1-2)C	X	I	U	S	N	Q	Ⅳ	Ⅲ-11
Dicranum bonjeanii DE NOT.	4(4-5)B	1(1-2)C	X	I	U	S	N	Q	Ⅳ	Ⅲ-12
Dicranum hamulosum MITT.	3(2-3)A	2(2-3)C	V(W)	I	U	S	N	Q	Ⅳ	Ⅳ-1
Dicranum hamulosum MITT.	3(3-4)A	2(2-3)C	V	I	U	S	N	Q	Ⅳ	Ⅳ-2
Dicranum hamulosum MITT.	2(2-4)A	2(2-3)C	V(W)	I	U	S	N	Q	Ⅳ	Ⅳ-3
Dicranum hamulosuu MITT.	2(2-3)A	2(2-3)C	V	I	U	S	N	Q	Ⅳ	Ⅳ-4
Dicranum japonicum MITT.	3(3-4)A	1(1-2)C	X	I	U	S	N	Q	Ⅳ	Ⅳ-5
Dicranum japonicum MITT.	4(4-5)B	1(1-2)C	X	I	U	S	N	Q	Ⅳ	Ⅳ-6
Dicranum japonicum MITT.	5(5-6)B	2(1-2)C	X	I	U	S	N	Q	Ⅳ	Ⅳ-7
Dicrannm japonicum MITT.	5(3-5)B	2(2-3)C	X	I	U	S	N	Q	Ⅳ	Ⅳ-8
Dicranum majus TURN.	4(4-6)B	3(2-3)C	X	I	U	S	N	Q	Ⅳ	V-1
Dicranum majus TURN.	4(4-5)B	3(2-3)C	X	I	U	S	N	Q	Ⅳ	V-2
Dicranum majus TURN.	4(4-5)B	2(2-3)C	X	I	U	S	N	Q	Ⅳ	V-3

Dicranum nipponense BESCH.	3(3-4)A	1(1-2)C	X	I	U	S	N	Q(P)	IV	V-4
Dicranum nipponense BESCH.	3(2-4)A	1(1-2)C	X	I	U	S	N	Q(P)	IV	V-5
Dicranum nipponense BESCH.	3(3-4)A	1(1-1)C	X	I	U	S	N	Q(P)	IV	V-6
Dicranum nipponense BESCH.	4(3-5)B	2(2-3)C	X	I	U	S	N	Q(P)	IV	V-7
Dicranum scoparium HEDW.	4(3-5)B	1(1-1)C	X(W)	I	U	S	N	Q	IV	V-8
Dicranum scoparium HEDW.	4(3-4)A	1(1-2)C	X	I	U	S	N	Q	IV	V-9
Dicranum scoparium HEDW.	3(3-4)A	1(1-1)C	X	I	U	S	N	Q	IV	V-10
Dicranum scoparium HEDW.	4(3-5)B	1(1-2)C	X	I	U	S	N	Q	IV	VI-1
Dicranum scoparium HEDW.	4(3-5)B	1(1-2)C	X	I	U	S	N	Q	IV	VI-2
Dicranum setifolium CARD.	4(3-5)A	2(2-3)C	X(W)	I	U	S	N	Q	IV	VI-3
Dicranum setifolium CARD.	3(2-4)A	2(2-3)C	X	I	U	S	N	Q	IV	VI-4
Dicranum setifolium CARD.	4(3-5)A	3(2-3)C	X	I	U	S	N	Q	IV	VI-5
Dicranum setifolium CARD.	3(3-4)A	3(2-3)C	X(W)	I	U	S	N	Q	IV	VI-6
Dicranum caesium MITT.	5(4-6)B	2(2-3)C	X(W)	I	U	R	N	Q	IV	VI-7
Dicranum caesium MITT.	4(2-5)B	2(2-3)C	X	I	U	R	N	Q	IV	VI-8
Dicranum caesium MITT.	5(5-6)B	2(2-3)C	X(W)	I	U	R	N	Q	IV	VI-9
Dicranum viride v. *hakkodense* (CARD.) TAK.	3(1-3)A	3(2-4)C	W	I	U	R	N	Q	IV	VII-1
Dicranum viride v. *hakkodense* (CARD.) TAK.	3(3-4)A	3(3-4)C	W	I	U	R	N	Q	IV	VII-2
Dicrauum viride v. *hakkodense* (CARD.) TAK.	2(2-3)A	3(2-3)C	W(V)	I	U	R	N	Q	IV	VII-3
Dicranum viride v. *hakkodense* (CARD.) TAK.	2(1-2)A	2(2-3)C	W	I	U	R	N	Q	IV	VII-4
Dichodontium pellucidum (HEDW.) SCHIMP.	3(2-3)A	1(1-2)C	X(W)	G	U	R	N	Q	IV	VII-5
Dichodontium pellucidum (HEDW.) SCHIMP.	3(2-3)A	2(1-2)C	X(W)	G	U	R	N	Q	IV	VII-6
Dichodontium pellucidum (HEDW.) SCHIMP.	3(2-4)A	2(1-2)C	X	G	U	R	N	Q	IV	VII-7
Dichodontium pellucidum (HEDW.) SCHIMP.	2(2-3)A	2(1-3)C	X	G	U	R	N	Q	IV	VII-8
Dicranella heteromalla (HEDW.) SCHIMP.	2(1-3)A	1(1-2)C	X	G	U	R	N	Q	IV	VII-9
Dicranella heteromalla (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	X	G	U	R	N	Q	IV	VII-10
Dicranella heteromalla (HEDW.) SCHIMP.	1(1-1)A	1(1-1)C	X	G	U	R	N	Q	IV	VII-11
Dicranella heteromalla (HEDW.) SCHIMP.	1(1-2)A	1(1-2)C	X	G	U	R	N	Q	IV	VII-12
Dicranella palustris (DICKS.) CRUNDW.	2(2-3)A	1(1-1)C	X	G	U	R	N	Q	IV	VIII-1
Dicranella palustris (DICKS.) CRUNDW.	2(1-3)A	1(1-2)C	X	G	U	R	N	Q	IV	VIII-2
Dicranella palustris (DICKS.) CRUNDW.	2(1-3)A	1(1-2)C	X	G	U	R	N	Q	IV	VIII-3
Dicranella palustris (DICKS.) CRUNDW.	2(2-3)A	1(1-2)C	X	G	U	R	N	Q	IV	VIII-4
Dicranella varia (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	W(X)	H	U	R	N	Q	IV	VIII-5
Dicranella varia (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	W	H	U	R	N	Q	IV	VIII-6
Dicranella varia (HEDW.) SCHIMP.	2(2-3)A	1(1-1)C	W(X)	H	U	R	N	Q	IV	VIII-7
Dicranella varia (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	X	H	U	R	N	Q	IV	VIII-8
Dicranella varia (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	W(X)	H	U	R	N	Q	IV	IX-1
Dicranella varia (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	W	H	U	R	N	Q	IV	IX-2
Dicranella varia (HEDW.) SCHIMP.	1(1-2)A	1(1-1)C	W(X)	H	U	R	N	Q	IV	IX-3
Oncophorus crispifolius (MITT.) LINDB.	5(4-5)B	3(3-4)C	X	I	U	R	N	Q	IV	IX-4
Oncophorus crispifolius (MITT.) LINDB.	5(4-6)B	4(4-5)D	X(W)	I	U	R	N	Q	IV	IX-5
Oncophorus crispifolius (MITT.) LINDB.	6(5-7)B	5(4-5)D	X(W)	I	U	R	N	Q	IV	IX-6

Oncophorus crispifolius v. *brevipes* (CARD.) IHS.	2(1-3)A	3(2-4)C	W(X)	I	U	R	N	Q	IV	IX-7
Oncophorus crispifolius v. *brevipes* (CARD.) IHS.	3(2-3)A	3(3-4)C	W(X)	I	U	R	N	Q	IV	IX-8
Oncophorus crispifolius v. *brevipes* (CARD.) IHS.	3(2-3)A	3(2-4)C	W(X)	I	U	R	N	Q	IV	X-1
Oncophorus crispifolius v. *brevipes* (CARD.) IHS.	3(2-4)A	3(3-4)C	W(X)	I	U	R	N	Q	IV	X-2
Campylopus japonicus BROTH.	3(3-4)A	3(3-4)C	V	I	U	R	N(M)	Q	IV	X-3
Campylopus japonicus BROTH.	2(1-4)A	3(2-3)C	V	I	U	R	N	Q	IV	X-4
Campylopus japonicus BROTH.	4(3-4)A	3(3-4)C	V	I	U	R	N	Q	IV	X-5
Campylopus japonicus BROTH.	3(3-4)A	3(2-4)C	V	I	U	R	N	Q	IV	X-6
Campylopus richardii BRID.	3(3-4)A	3(2-4)C	V	I	T	R	N	Q	IV	X-7
Campylopus richardii BRID.	2(2-3)A	3(2-4)C	V	I	T	R	N	Q	IV	X-8
Campylopus richardii BRID.	2(2-3)A	2(2-3)C	V	I	T	R	N	Q	IV	X-9
Campylopus richardii BRID.	2(1-2)A	2(2-3)C	V	I	T	R	N	Q	IV	X-10

Tab. 2 Affinity regarding the anatomical characteristics in the cross section of the stem

Species	Leptom	Cortex	Epidermis			Hadrom			Types
Leucoloma molle (C. MUELL.) MITT.	*	C	X	G	U	S	M	P	III
Leucoloma okamurae BROTH.	*	C	X	I	U	S	M	P	III
Arctoa fulvella (DICKS.) B. S. G.	A	C	X	H	U	R	N(M)	P(Q)	IV
Brothera leana (SULL.) C. MUELL.	A	C	X(W)	G	U	R	N(M)	P(Q)	IV
Trematodon longicollis f. *atrovirens* (BROTH.) TAK.	A	C	X(W)	G	U	S	N	P	IV
Campylopodium euphorocladum (C. MUELL.) BESCH.	A	C	X	G	U	S	N(M)	Q	IV
Dicranodontium denudatum (BRID.) BRITT.	A	C	X	I	U	S	N	Q	IV
Dicranum bonjeanii D. NOT.	B	C	X	I	U	S	N	Q	IV
Dicranum hamulosum MITT.	A	C	V	I	U	S	N	Q	IV
Dicranum japonicum MITT.	B	C	X	I	U	S	N	Q	IV
Dicranum majus TURN.	B	C	X	I	U	S	N	Q	IV
Dicranum nipponense BESCH.	A	C	X	I	U	S	N	Q(P)	IV
Dicranum scoparium HEDW.	A	C	X	I	U	S	N	Q	IV
Dicranum setifolium CARD.	A	C	X	I	U	S	N	Q	IV
Dicranum caesium MITT.	B	C	X	I	U	R	N	Q	IV
Dicranum viride v. *hakkodense* (CARD.) TAK.	A	C	W	I	U	R	N	Q	IV
Dichodontium pellucidum (HEDW.) SCHIMP.	A	C	X	G	U	R	N	Q	IV
Dicranella heteromalla (HEDW.) SCHIMP.	A	C	X	G	U	R	N	Q	IV
Dicranella palustris (DICKS.) CRUNDW.	A	C	X	G	U	R	N	Q	IV
Dicranella varia (HEDW.) SCHIMP.	A	C	W	H	U	R	N	Q	IV
Oncophorus crispifolius (MITT.) LINDB.	B	D	X	I	U	R	N	Q	IV
Oncophorus crispifolius v. *brevipes* (CARD.) IHS.	A	C	W	I	U	R	N	Q	IV
Campylopus japonicus BROTH.	A	C	V	I	U	R	N	Q	IV
Campylopus richardii BRID.	A	C	V	I	T	R	N	Q	IV

Tab. 3 Relationship between the similarity regarding the anatomical characteristics and the classification

Subfamilies	Genera	Similarity in genus	Similarity in subfamily
Dicranoideae	*Leucoloma*	Ⅲ-P-M-S	Ⅳ(Ⅲ)-Q(P)-N(M)-R(S)
	Arctoa	Ⅳ-P-N-R	
	Oncophorus	Ⅳ-Q-N-R	
	Dichodontium	Ⅳ-Q-N-R	
	Dicranum	Ⅳ-Q-N-R(S)	
Paraleucobryoideae	*Brothera*	Ⅳ-P-N-R	Ⅳ-P-N-R
Campylopodioideae	*Dicranodontium*	Ⅳ-Q-N-S	Ⅳ-Q-N-R(S)
	Campylopodium	Ⅳ-Q-N-S	
	Campylopus	Ⅳ-Q-N-R	
	Dicranella	Ⅳ-Q-N-R	
Trematodontoideae	*Trematodon*	Ⅳ-P-N-S	Ⅳ--P-N-S

Tab. 4 Observation of the anatomical characteristics in the longitudinal section of the stem

Species	Length of cell (a: Length of cell in the epidermis)			Shape of cell				Thickness of the septum (Comparison with the longitudinal cell walls)		
	Cortex	Leptom	Hadrom	Epidermis	Cortex	Leptom	Hadrom	Cortex	Leptom	Hadrom
Leucoloma okamurae BROTH.	a	2a	2.5a	RH	RH	RH	RE	SI	SI	TN
Brothera leana (SULL.) C. MUELL.	1.5a	a	4a	RH	RE	RE	RH	SI	SI	SI
Campylopodium euphorocladum (C. MUELL.) BESCH.	1.5a	2a	4a	RE	RE	RE	RH	SI	TN	SI
Arctoa fulvella (DICKS.) B. S. G.	1.5a	a	4a	RH	RE	RE	SP	SI	TN	SI
Trematodon longicollis f. *atrovirens* (BROTH.) TAK.	1.5a	1.5a	4a	RH	RH	RE	SP	SI	TN	SI
Dicranella varia (HEDW.) SCHIMP.	a	2a	4a	RH	RH	RE	SP	SI	SI	SI
Dichodontium pellucidum (HEDW.) SCHIMP.	1.5a	3a	4a	RH	RE	RE	SP	SI	SI	SI
Campylopus richardii BRID.	a	2a	4a	RE	RH	RE	SP	SI	TN	SI
Dicranum caesium MITT.	a	a	4a	RE	RH	RH	SP	SI	TN	SI
Dicranum japonicum MITT.	2.5a	3a	4a	RH	RE	RE	SP	SI	TN	SI

RH: Rhombic, RE: Rectangular, SP: Spindle, SI: The septum is as thick as the longitudinal cell walls, TN: The septum is thinner than the longitudinal cell walls.

The inner structures of the stem in twenty-four species of Dicranaceae are observed (see Table 1 and 2). In all the genera dealt with in this paper, the stems of each genus, with the exception of *Leucoloma,* show the same type of interior differentiation. Namely, the stems of *Arctoa, Brothera, Trematodon, Campylopodium, Dicranodontium, Dicranum, Dichodontium, Dicranella, Oncophorus* and *Campylopus* show a differentiation of tissues into an epidermis, cortex, leptom, hydrom sheath and a hadrom (**IV** type). In the stems of *Leucoloma, Arctoa, Brothera* and *Trematodon,* the cell walls of the hadrom are as thick as those of the leptom: **P** or **P(Q)** types, but the stems of *Campylopodium, Dicranodontium, Dicranum, Dichodontium, Dicranella, Oncophorus* and *Campylopus* show a **Q** type (the cell walls of the hadrom are thinner than those of the leptom). Next, in *Arctoa, Brothera, Trematodon, Campylopodium, Dicranodontium, Dicranum, Dichodontium, Dicranella, Oncophorus* and *Campylopus,* the cells of the hadrom are smaller than those of the leptom; **N** or **N(M)** types. However, *Leucoloma* has an **M** type stem. The hadroms of *Leucoloma, Trematodon, Campylopodium, Dicranodontium* and *Dicranum* are not parenchymatous (**S** type), but in *Arctoa, Brothera, Dicranum, Dichodontium, Dicranella, Oncophorus* and *Campylopus,* the hadrom of the stem is parenchymatous (**R** type).

There is something in common among the characteristics of the interior structure of the stem in the species belonging to the identical genus (see Table 3). In *Leucoloma,* the stems of the species are of the identical type of **III-P-M-S**; in *Arctoa,* **IV-P-N-R**; in *Oncophorus,* **IV-Q-N-R**; in *Dichodontium,* **IV-Q-N-R**; in *Dicranum,* **IV-Q-N-R(S)**; in *Brothera,* **IV-P-N-R**; in *Dicranodontium,* **IV-Q-N-S**; in *Campylopodium,* **IV-Q-N-S**; in *Campylopus,* **IV-Q-N-R**; in *Dicranella,* **IV-Q-N-R**; and in *Trematodon,* **IV-P-N-S.**

As stated above, in all species belonging to the identical genus some regularity can be seen among the anatomical characteristics of the stems. From these facts, the anatomical characteristics mentioned above, that is, the type of inner differentiation of the stem (**III** and **IV** types); comparative thickness of the cell walls of the hadrom and of the leptom (**P** and **Q** types); comparison of the size of the cells of the hadrom and that of the cells of the leptom (**M** and **N** types); and the thickness of the cell walls of the hadrom (**R** and **S** types), appear to be very important in making an investigation of the essential characteristics.

II. Anatomical Characteristics in the Longitudinal Sections of the Stem

The stems of Dicranaceae are classified into ten types through an observation of the cross section. A longitudinal section is observed in each one of the species with the stem belonging to each type, that is, the stem of the following ten species is observed in the longitudinal section; *Leucoloma okamurae* as species with the stem of **III-P-M-S--U-I**-type, *Trematodon longicollis* f. *atrovirens* as that of **IV-P-N-S-U-G**-type, *Arctoa fulvella* as that of **IV-P-N-R-U-H**-type, *Brothera leana* as that of **IV-P-N-R-U-G--**type, *Campylopodium euphorocladum* as that of **IV-Q-N-S-U-G**-type, *Dicranum japonicum* as that of **IV-Q-N-S-U-I**-type, *Dicranum caesium* as that of **IV-Q-N-R-U-**

I-type, *Dichodontium pellucidum* as that of IV-Q-N-R-U-G-type, *Dicranella varia* as that of IV-Q-N-R-U-H-type, and *Campylopus richardii* as that of IV-Q-N-R-T-I--type. As a result of observing the various characteristics, the ten characteristics as in Table 4 are considered.

The cell-length of the epidermis is represented by the sign "a", and the cell-length of each tissue is shown as the ratio to that of the epidermis. The shape of the cell is itemized into three types, rectangular, rhombic and spindle. The thickness of the septum is shown as ratio to that of the cell walls. In *Dicranum caesium,* all the dimensions of cells making up an epidermis, cortex and a leptom are identical, but in *Arctoa fulvella, Brothera leana, Campylopodium euphorocladum, Dicranum japonicum* and *Dichodontium pellucidum,* each cell in an epidermis, cortex and a leptom has its own length of cell. In *Leucoloma okamurae, Trematodon longicollis* f. *atrovirens, Brothera leana, Campylopodium euphorocladum* and *Dichodontium pellucidum,* the shape of cells in an epidermis, cortex and a leptom are almost identical, and in many species with the exception of *Leucoloma okamurae, Brothera leana* and *Campylopodium euphorocladum,* the shape of the hadrom are spindle and slender. In *Brothera leana, Dichodontium pellucidum* and *Dicranella varia,* the septum in a cortex, leptom and a hadrom is as thick as the vertical cell walls. In the leptom of the other species the septum is thinner than the vertical cell walls, but the vertical cell walls of the hadrom are generally so thin that the septum and the vertical cell walls are identical.

III. Affinity Regarding the Anatomical Characteristics Seen in the Cross and Longitudinal Sections

Next, on the stems of ten species the affinity regarding the anatomical characteristics observed in the cross and longitudinal sections is considered (Table 5). In *Leucoloma okamurae,* the stem develops into an epidermis, cortex, leptom and a hadrom (III type), the cell-length of the hadrom is shorter than thrice the length of the epidermal cells (3a), the septum of the hadrom is thinner than the vertical cell walls of the hadrom (HTN type), and the cells of the hadrom are as large as those of the leptom (M type).

The stems of the nine species other than *Leucoloma okamurae,* develop into an epidermis, cortex, leptom, hydrom sheath and a hadrom (IV type), the cell-length of the hadrom is longer than four times the length of the epidermal cell (4a type), the septum of the hadrom is as thick as the vertical cells walls of the hadrom (HAS type), and the cells of the hadrom are smaller than those of the leptom (N type). Of these nine species *Brothera leana* and *Campylopodium euphorocladum* have stems with rhombic hadrom (HRH type), but in the other species hadroms are spindle shaped (HSP type). The stems with the hadrom of HRH type are classified into two types. The stem of *Brothera leana* is of the type that the cell walls of the parenchymatous hadrom (R type) are as thick as those of the leptom (P type), and the stems of *Campylopodium euphorocladum* are of another type in which the cell walls of the hadrom of S type (non parenchymatous) are

Tab. 5 Affinity regarding the anatomical characteristics in the cross and longitudinal sections of the stem

Ⅲ or Ⅳ	Hadrom						Leptom			Cortex	Species
	Length	Septum	Size	Shape	Thckness		Septum	Shape	Length	Length	
					P or Q	R or S					
Ⅲ	H3a	HTN	M	HRE	P	S	LSI	LRH	L2a	Ca	*Leucoloma okamurae* BROTH.
Ⅳ	H4a	HSI	N	HRH	P	R	LSI	LRE	L2a	Ca	*Brothera leana* (SULL.) C. MUELL.
					Q	S	LTN	LRE	L2a	Ca	*Campylopodium euphorocladum* (C. MUELL.) BESCH.
				HSP	P	R	LTN	LRE	L2a	Ca	*Arctoa fulvella* (DICKS.) B. S. G.
						S	LTN	LRH	L1.5a	Ca	*Trematodon longicollis* f. *atrovirens* (BROTH.) TAK.
					Q	R	LSI	LRE	L3a	Ca	*Dicranella varia* (HEDW.) SCHIMP.
										C1.5a	*Dichodontium pellucidum* (HEDW.) SCHIMP.
							LTN	LRE	L2a	Ca	*Campylopus richardii* BRID.
								LRH	La	Ca	*Dicranum caesium* MITT.
						S	LTN	LRE	L3a	C2a	*Dicranum japonicum* MITT.

H: Hadrom, L: Leptom, C: Cortex, a: Length of the epidermal cell, TN: Thinner, SI: Similar, RE: Rectangular, RH: Rhombic, SP: Spindle.

thinner than those of the leptom (**Q** type). The stems with the hadrom of **Hsp** type are classified into two types: the type that the cell walls of the hadrom are as thick as those of the leptom (**P** type), and one other type that cell walls of the hadrom are thinner than those of the leptom (**Q** type).

Among the stems of **Hsp-P**-type are included *Arctoa fulvella* whose stem has parenchymatous hadrom (**R** type), and *Trematodon longicollis* f. *atrovirens* whose stem has the hadrom which is non parenchymatous (**S** type). Of the hadroms with the **Hsp-Q**-type, the stems with parenchymatous hadrom (**R** type) are itemized in two types: the type that the septum of the leptom is as thick as the cell walls of the leptom (**Las** type), and one other type that the septum of the leptom is thinner than cell walls of the leptom (**Ltn** type). The stem with non parenchymatous hadrom (**S** type) has the leptom whose septum is thinner than cell walls of the leptom (**Ltn** type), and this type is found in the stem of *Dicranum japonicum.*

The stems with the leptom of **Las** type are classified into two types: the type of stem in which the cell-length of the cortex is as long as that of the epidermis (**Ca** type) as in *Dicranella varia* ; and one other type of the stem in which the cell-length of the cortex is longer than 1.5 times the length of the epidermal cell (**C1.5a** type) as in *Dichodontium pellucidum.*

The stems with the leptom of **Ltn** type are classified into two types: the type of the stem in which the cell-length of the rectangular leptom is longer than twice the length of the epidermal cells (**L2a** type) as in *Campylopus richardii,* and one other type of the stem in which the cell-length of the rhombic leptom is as long as that of the epidermal cell as in *Dicranum caesium.*

As stated above, some regularity can be seen among some of the anatomical characteristics of the stem in cross and longitudinal sections. They are the type of inner differentiation of the stem (**III** and **IV** types), comparative length of cells of the hadrom and the epidermis (**H3a** and **4a** types), comparative thickness of the cell walls and the septum of the hadrom (**Htn** and **Has** types), comparison of the size of the cells of the hadrom and that of the cells of the leptom (**M** and **N** types), shape of cells of the hadrom (**Hre**, **Hrh** and **Hsp** types), comparative thickness of the cell walls of the hadrom and of the leptom (**P** and **Q** types) and the thickness of the cell walls of the hadrom (**R** and **S** types). These characteristics which pertain almost exclusively to the hadrom, appear to be very important in making an investigation of the essential characteristics.

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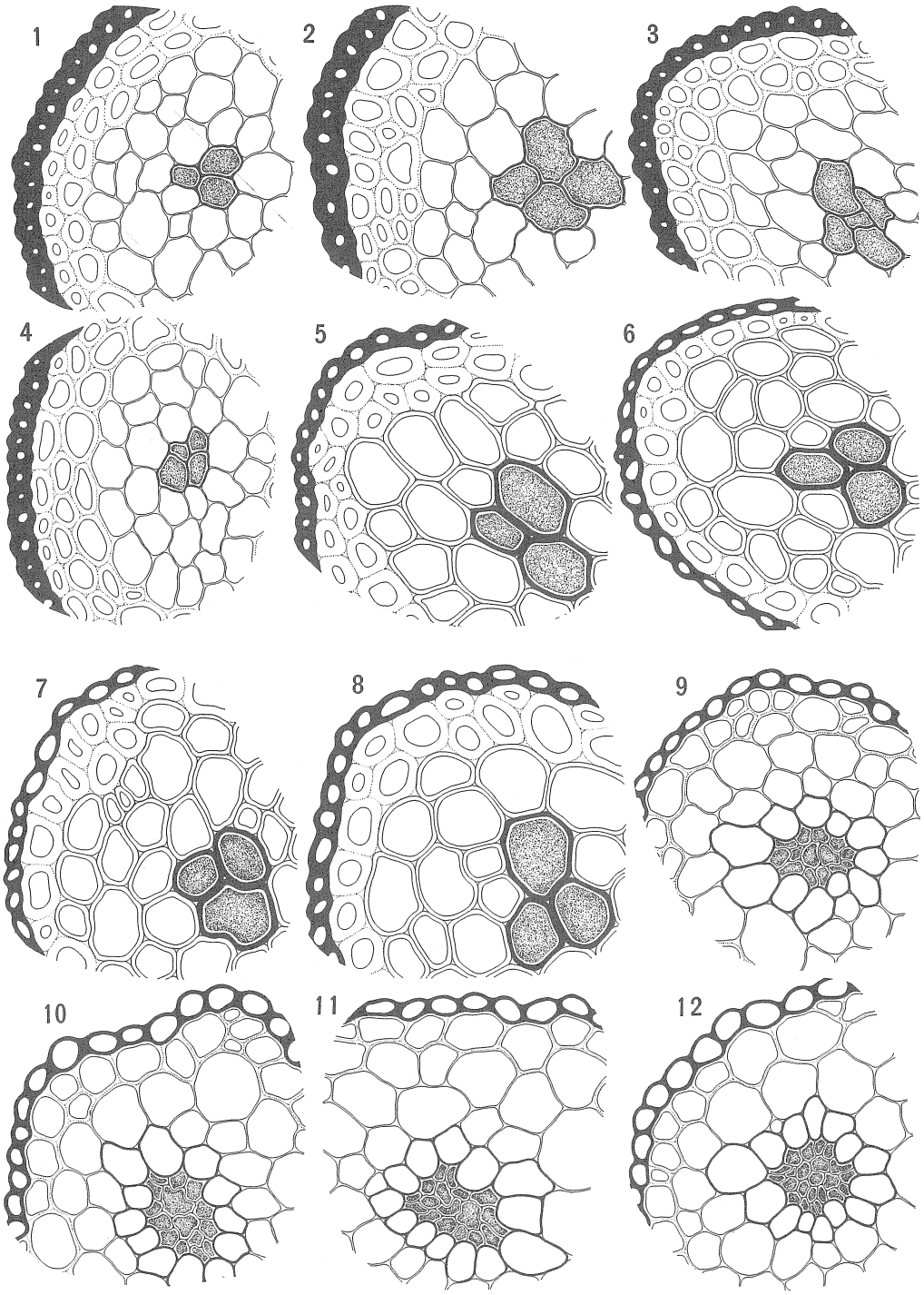

Plate I Cross sections of the stem
Fig. 1-4: *Leucoloma molle* (C. MUELL.) MITT. ×280 Fig. 5-8: *Leucoloma okamurae* BROTH. ×280 Fig. 9-12: *Arctoa fulvella* (DICKS.) B. S. G. ×280

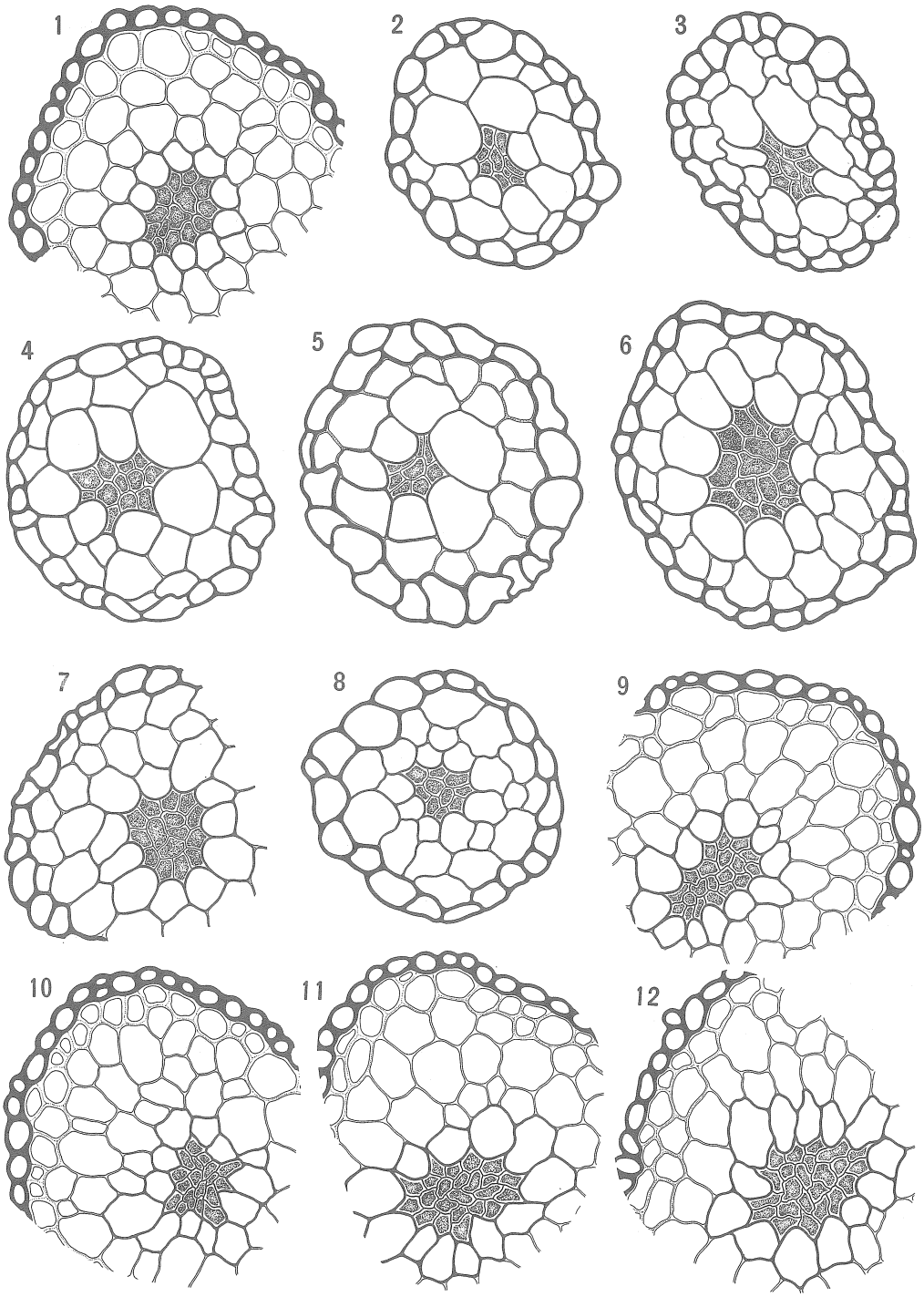

Plate II Cross sections of the stem
Fig. 1: *Arctoa fulvella* (DICKS.) B. S. G. ×280 Fig. 2-8: *Brothera leana* (SULL.) C. MUELL. ×280
Fig. 9-12: *Trematodon longicollis* f. *atrovirens* (BROTH.) TAK. ×220

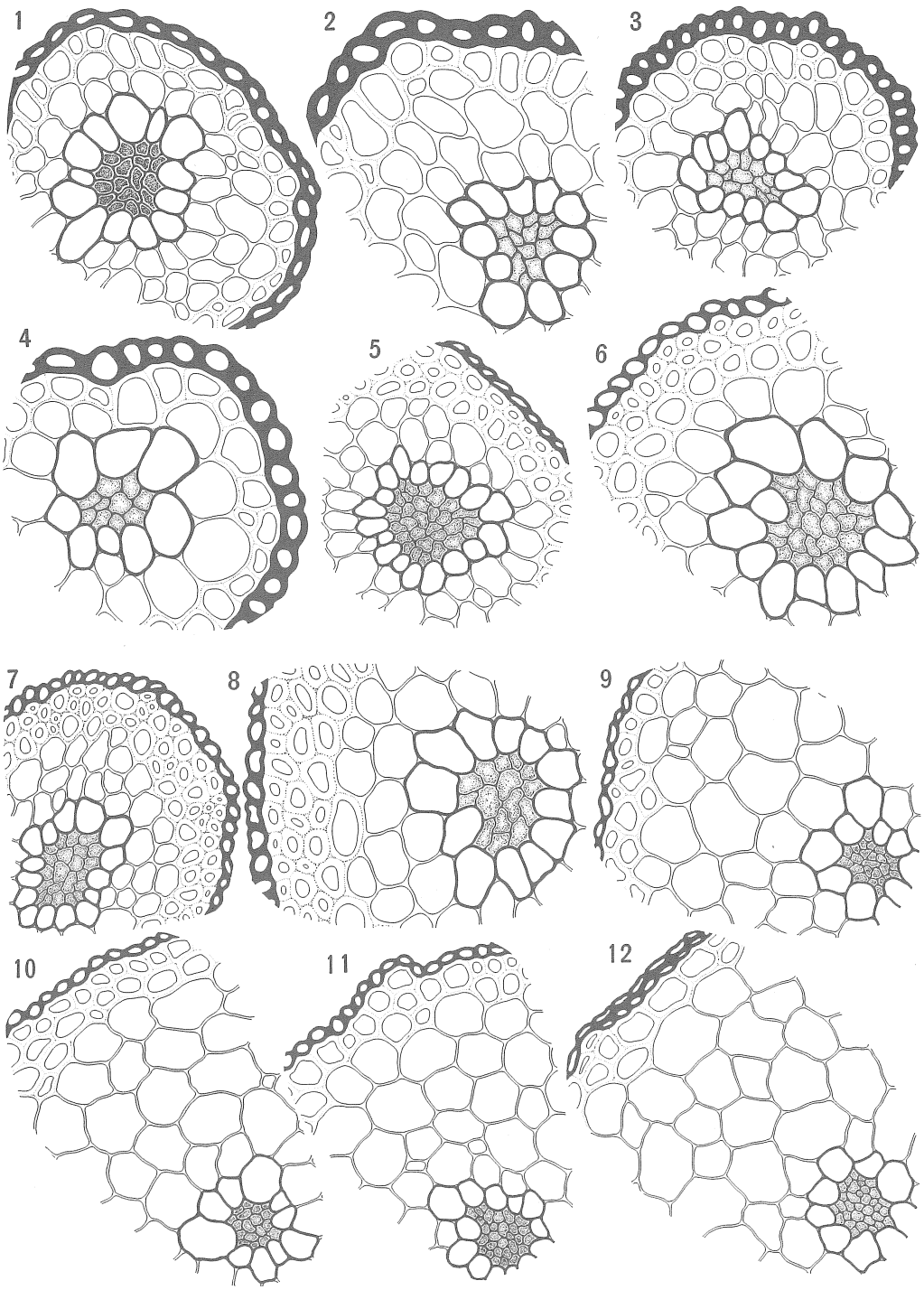

Plate III Cross sections of the stem
Fig. 1–4 : *Campylopodium euphorocladum* (C. MUELL.) BESCH. ×280 Fig. 5–8 : *Dicranodontium denudatum* (BRID.) BRITT. ex WILL. ×220 Fig. 9–12 : *Dicranum bonjeanii* DE NOT. ×220

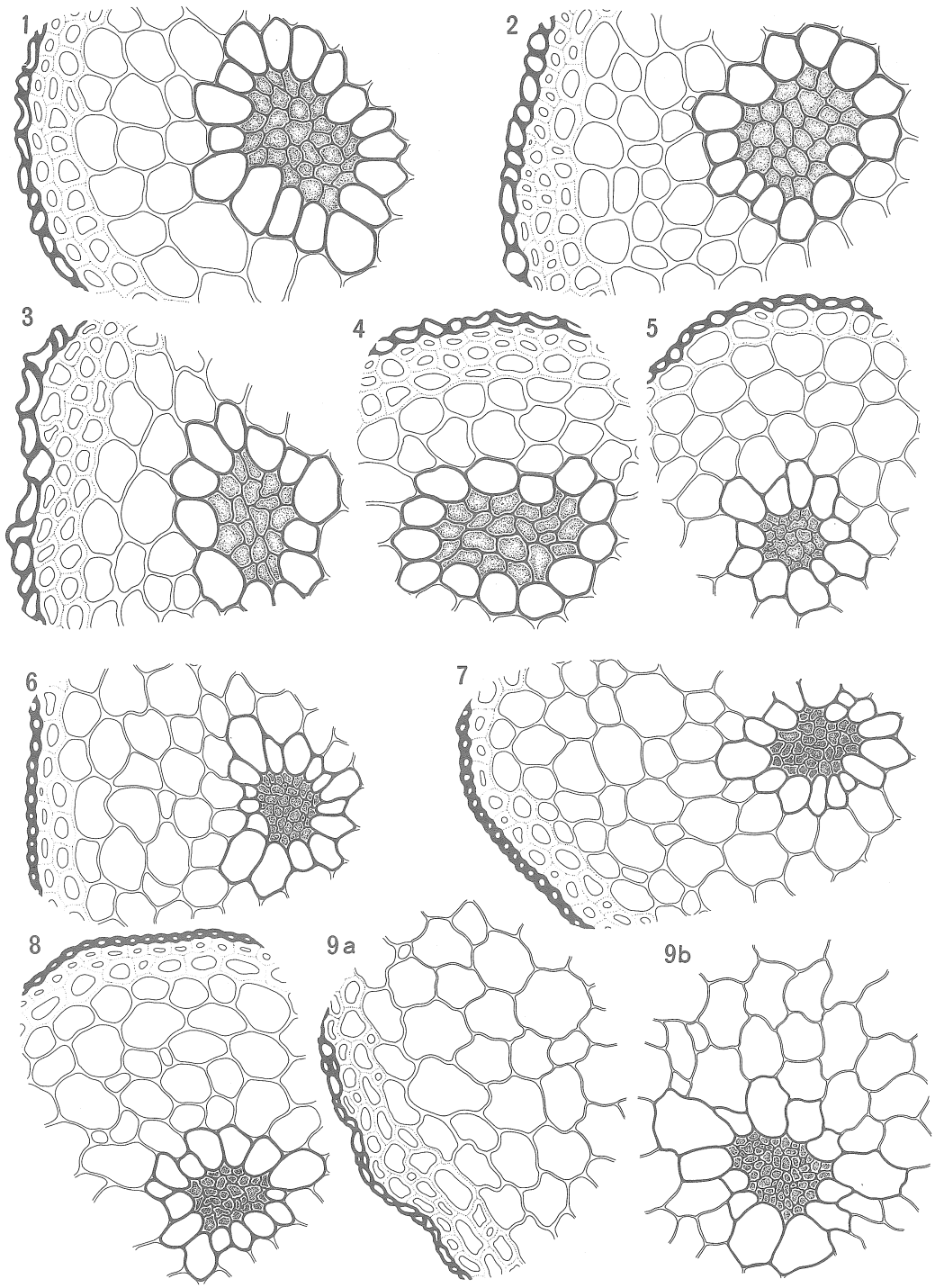

Plate IV Cross sections of the stem
Fig. 1–4 : *Dicranum hamulosum* MITT. ×280 Fig. 5–8 : *Dicranum japonicum* MITT. ×220 Fig. 9 : *Dicranum majus* TURN. ×220 a : Outer part of the stem, b : Central part of the stem

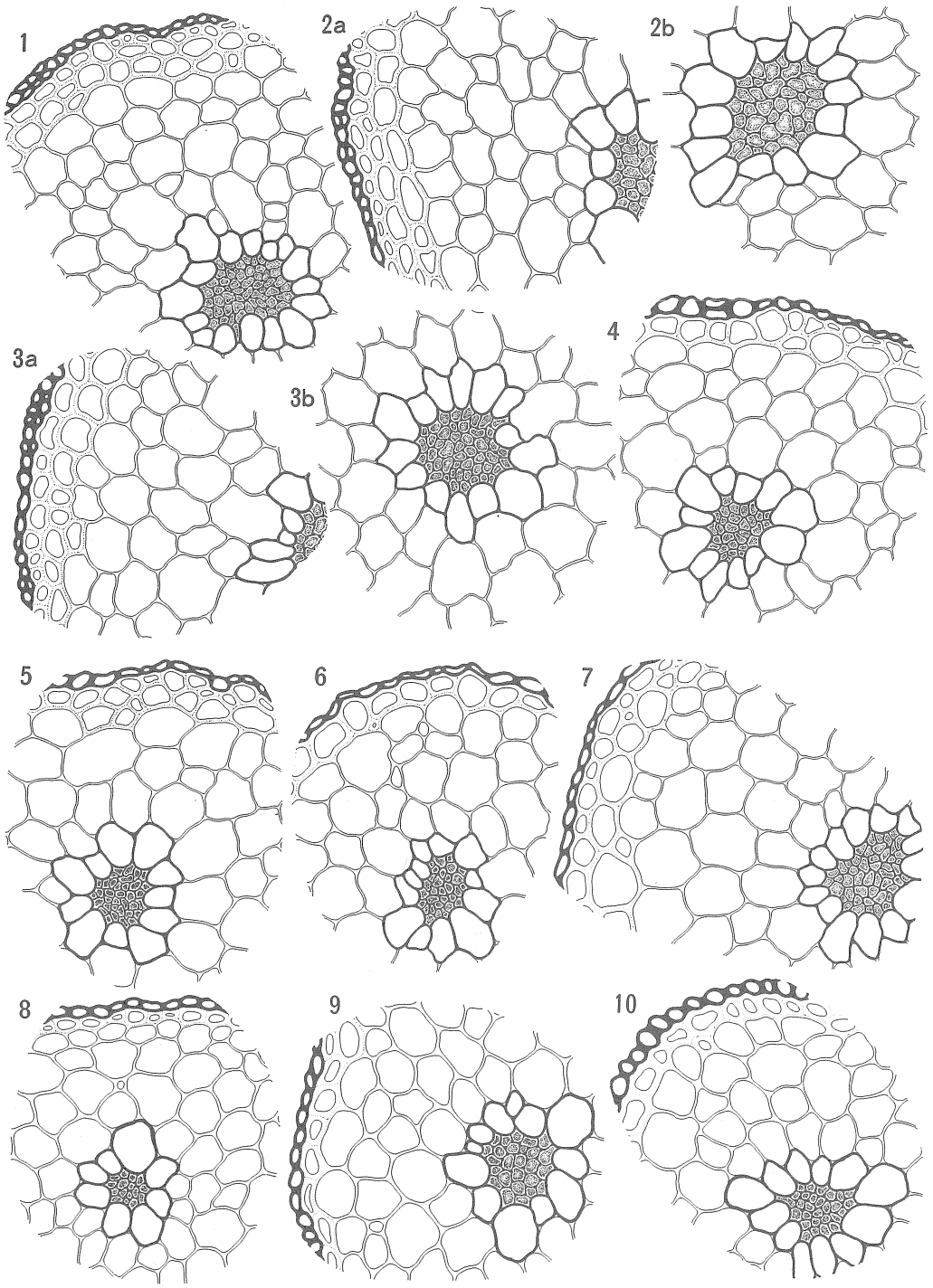

Plate V Cross sections of the stem
Fig. 1–3 : *Dicranum majus* TURN. ×220 Fig. 4–7 : *Dicranum nipponense* BESCH. ×220 Fig. 8–10 : *Dicranum scoparium* HEDW. ×220 a : Outer part of the stem b : Central part of the stem

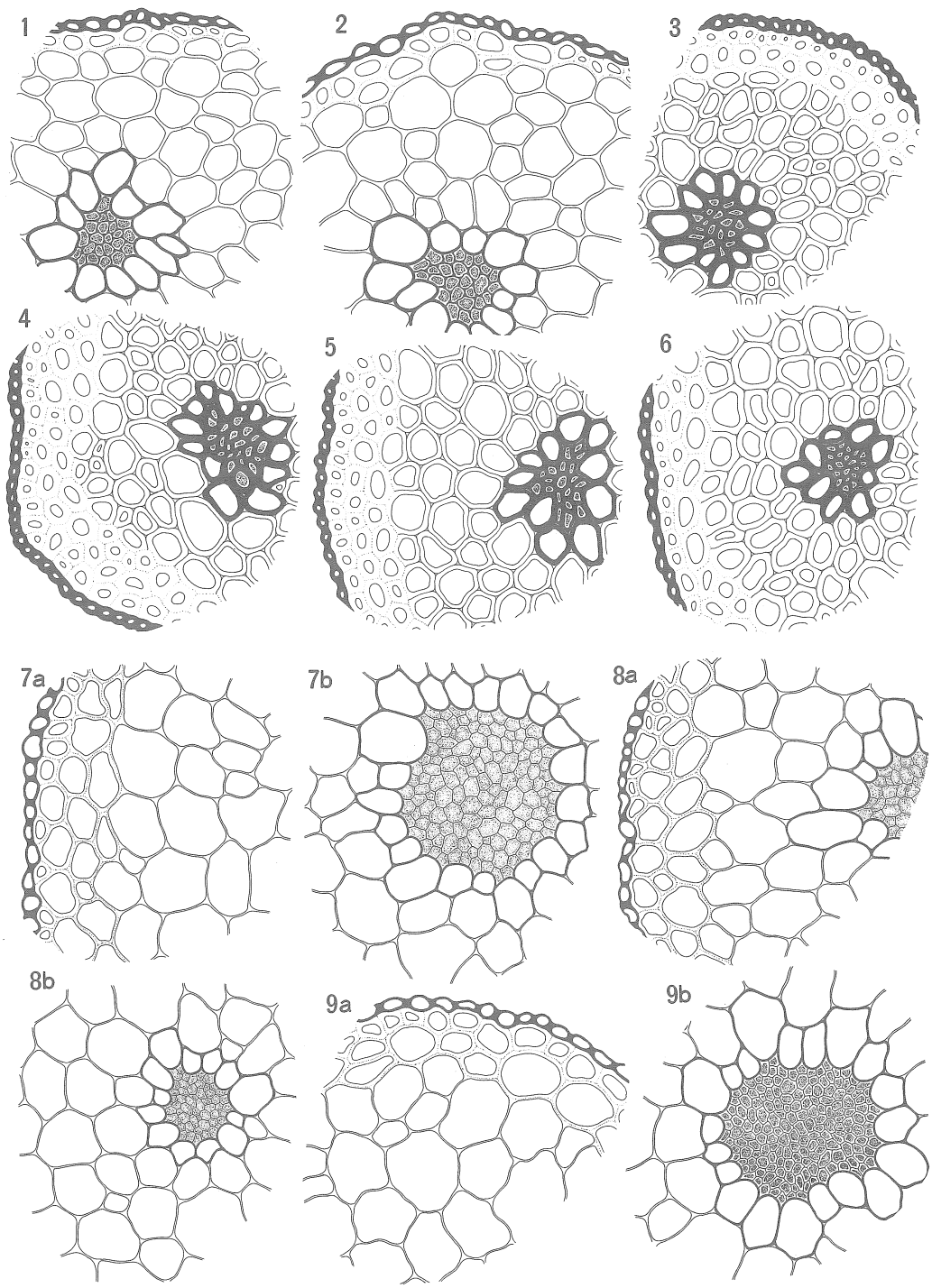

Plate VI Cross sections of the stem
Fig. 1–2 : *Dicranum scoparium* HEDW. ×220 Fig. 3–6 : *Dicranum setifolium* CARD. ×220 Fig. 7–9 : *Dicranum caesium* MITT. ×220 a : Outer part of the stem b : Central part of the stem

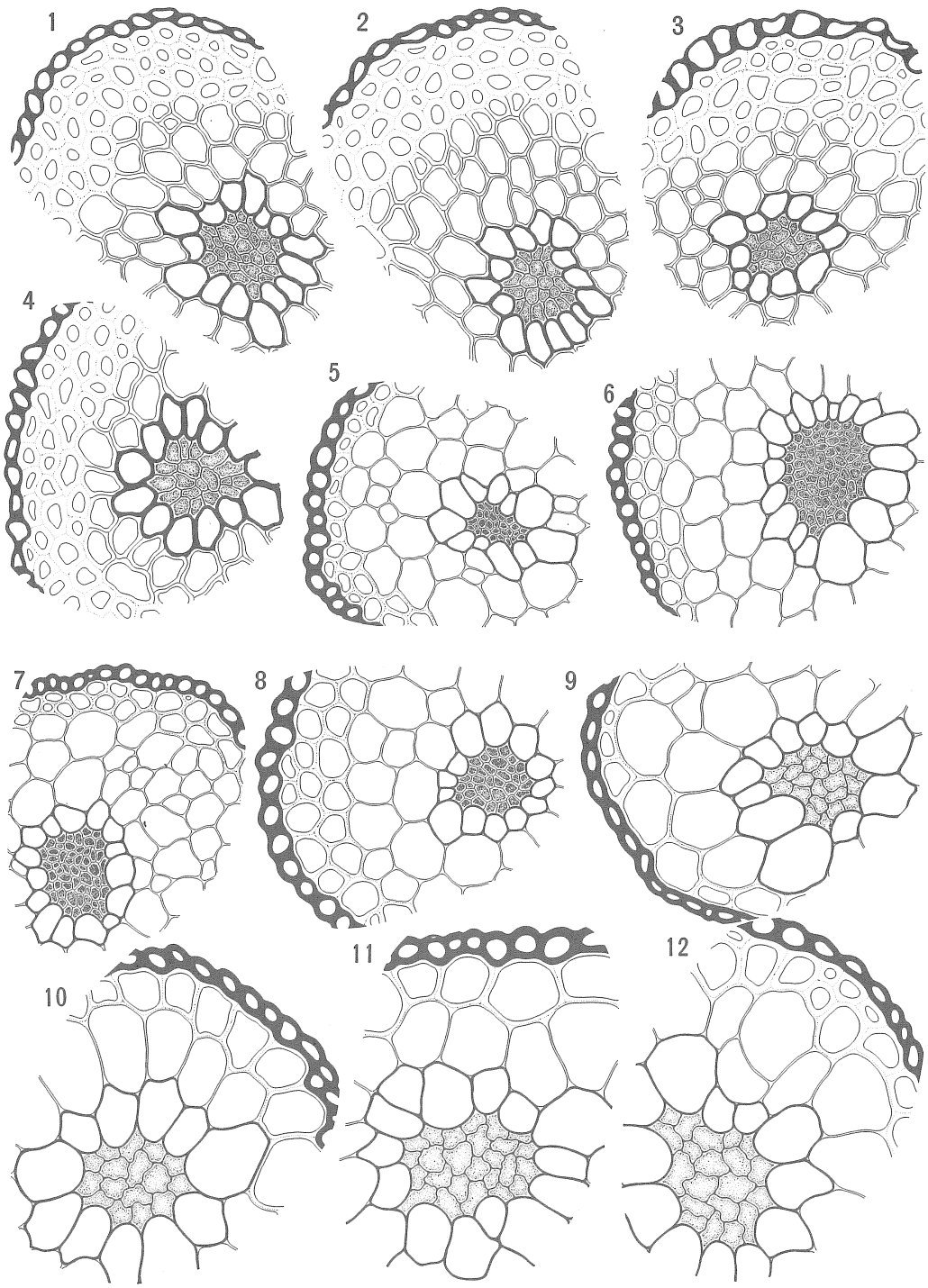

Plate VII Cross sections of the stem
Fig. 1–4 : *Dicranum viride* v. *hakkodense* (CARD.) TAK. ×280 Fig. 5–8 : *Dichodontium pellucidum* (HEDW.) SCHIMP. ×220 Fig. 9–12 : *Dicranella heteromalla* (HEDW.) SCHIMP. ×280

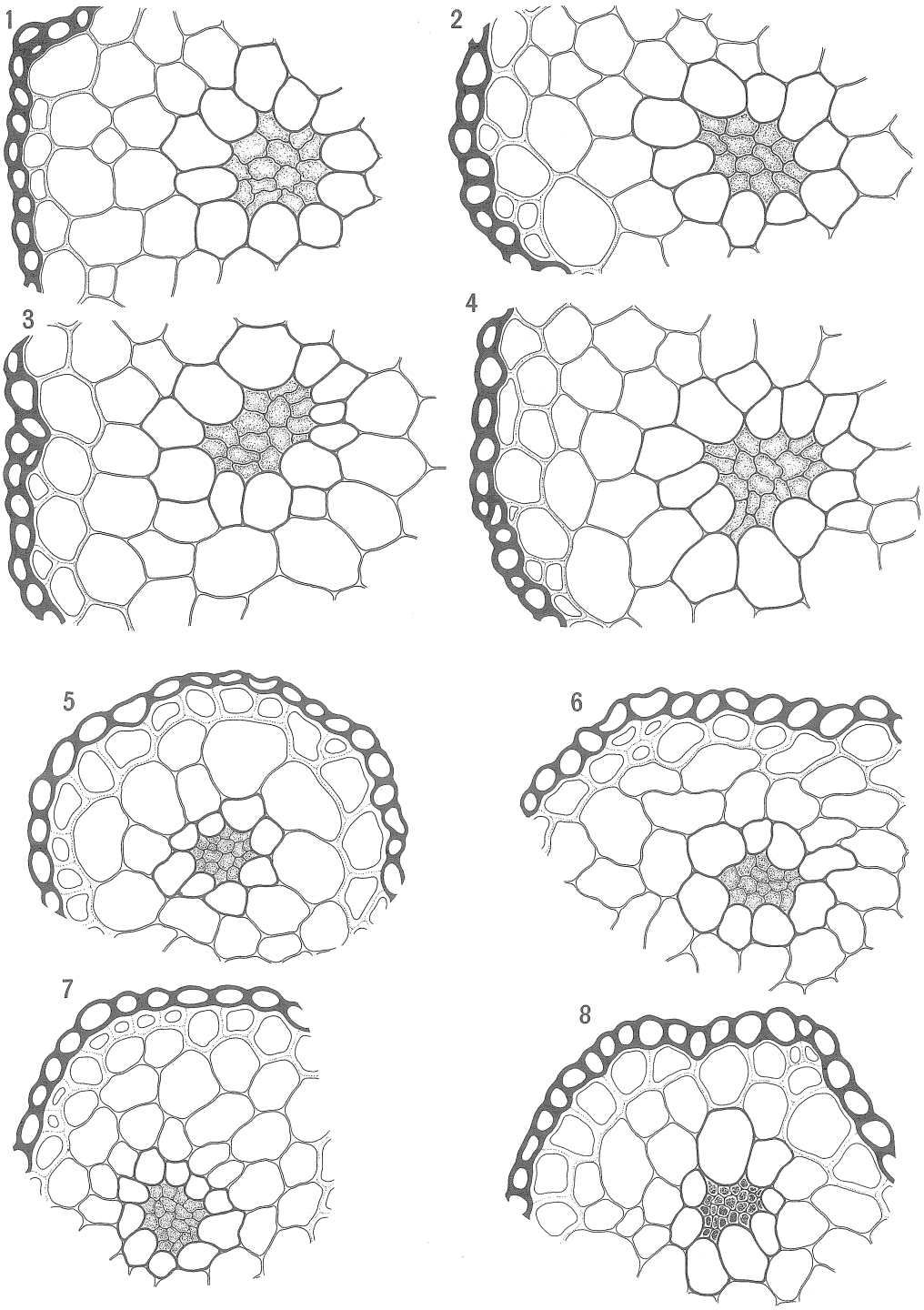

Plate VIII Cross sections of the stem
Fig. 1–4: *Dicranella palustris* (DICKS.) CRUNDW. ex WARB. ×220 Fig. 5–8: *Dicranella varia* (HEDW.) SCHIMP. ×280

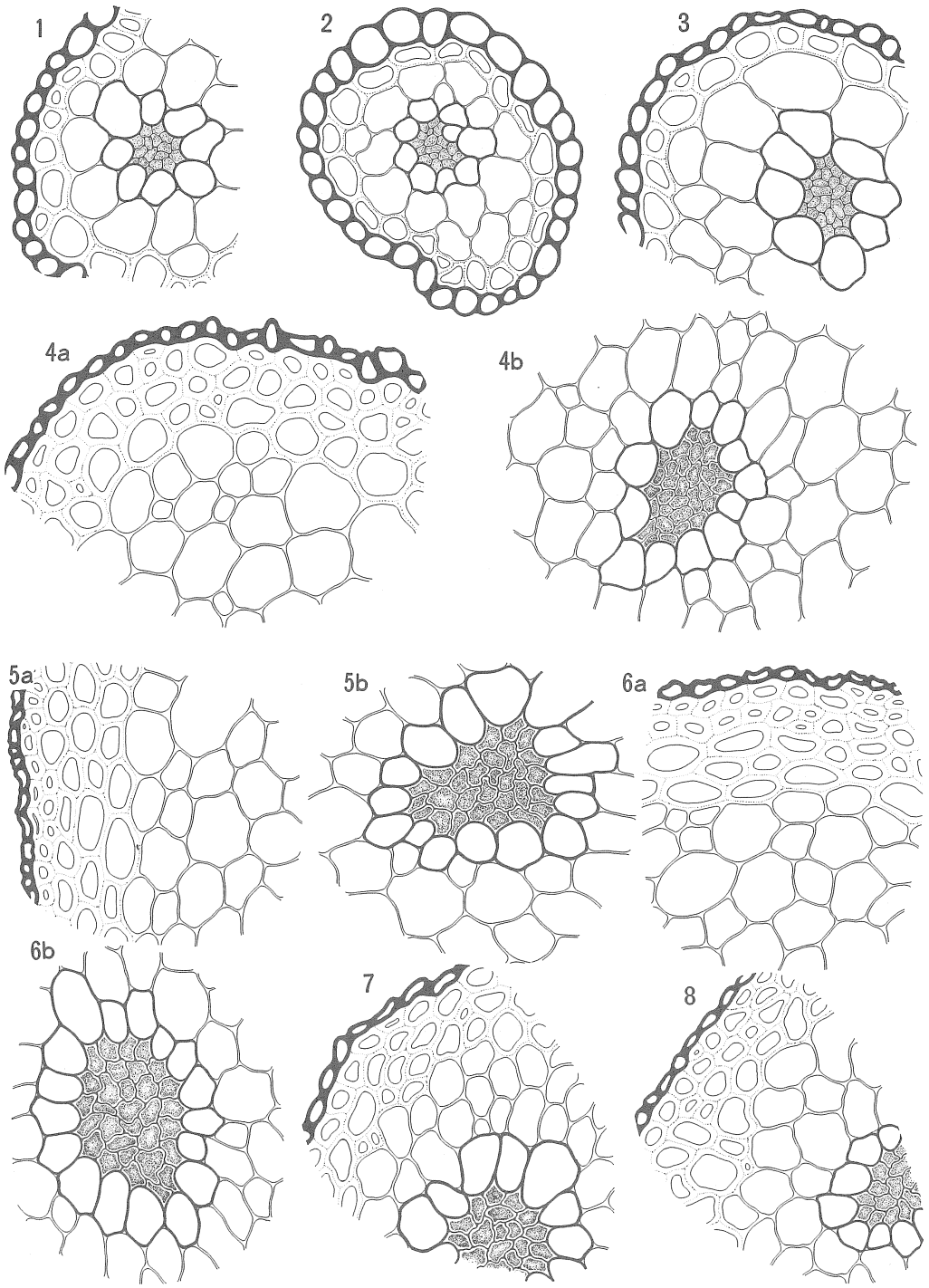

Plate IX Cross sections of the stem
Fig. 1–3 : *Dicranella varia* (HEDW.) SUHIMP. ×280 Fig. 4–6 : *Oncophorus crispifolius* (MITT.) LINDB. ×280 Fig. 7–8 : *Oncophorus crispifolius v. brevipes* (CARD.) IHS. ×280 a : Outer part of the stem b : Central part of the stem

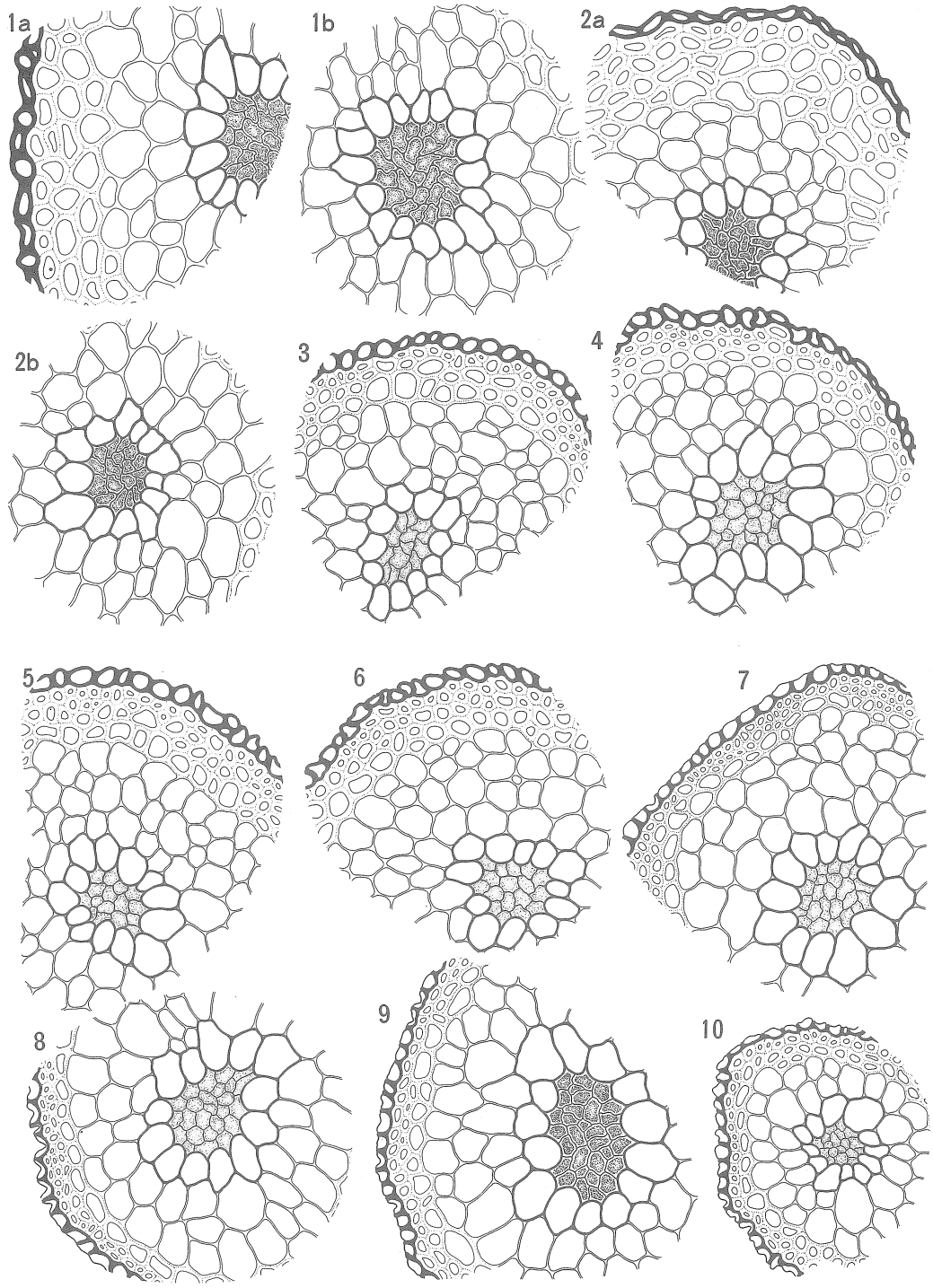

Plate X Cross sections of the stem
Fig. 1–2: *Oncophorus crispifolius* v. *brevipes* (CARD.) IHS. ×280 Fig. 3–6: *Campylopus japonicus* BROTH. ×220 Fig. 7–10: *Campylopus richardii* BRID. ×220 a: Outer part of the stem b: Central part of the stem

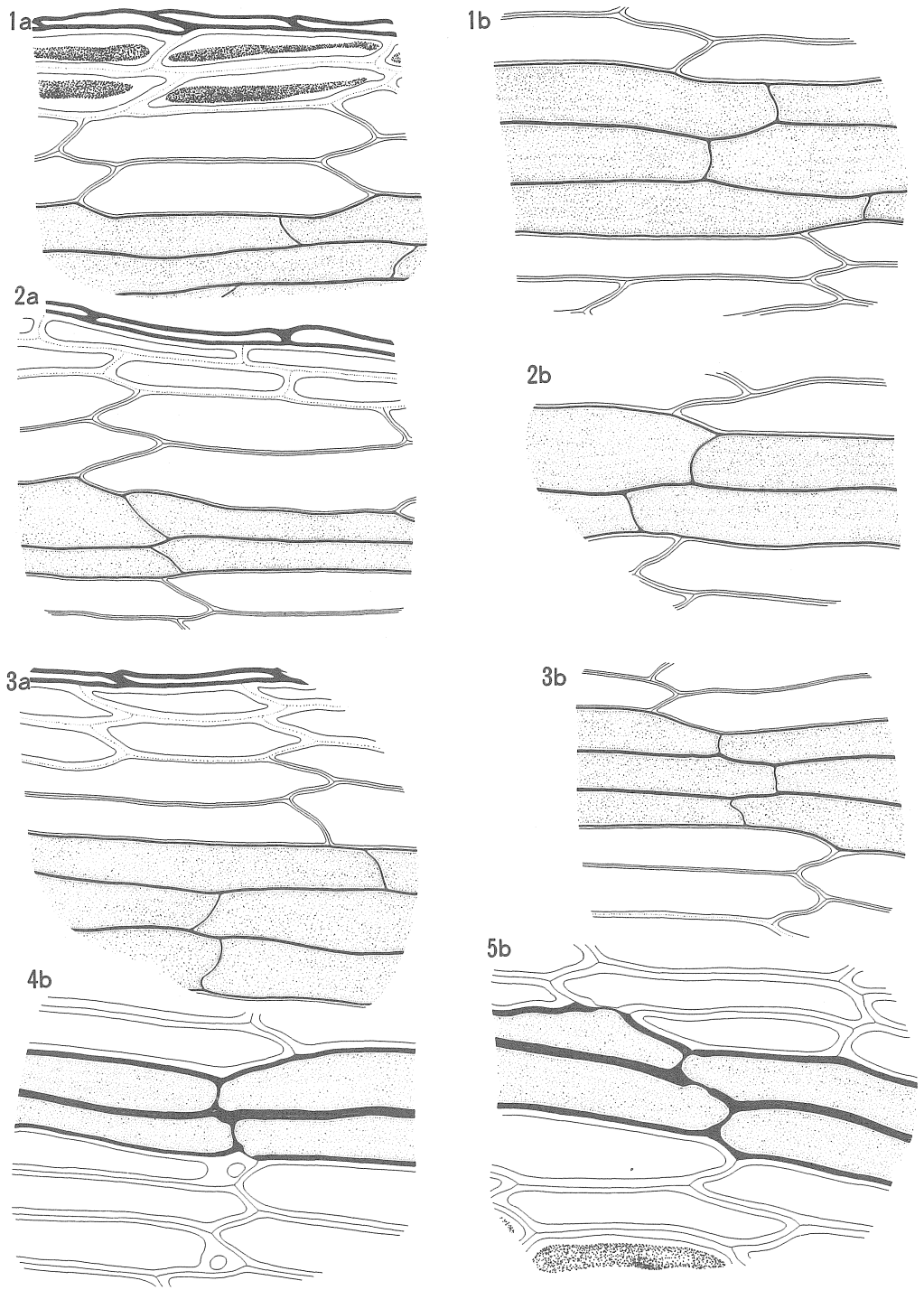

Plate XI Longitudinal sections of the stem
Fig. 1–5: *Leucoloma okamurae* BROTH. ×280 a: Outer part of the stem b: Central part of the stem

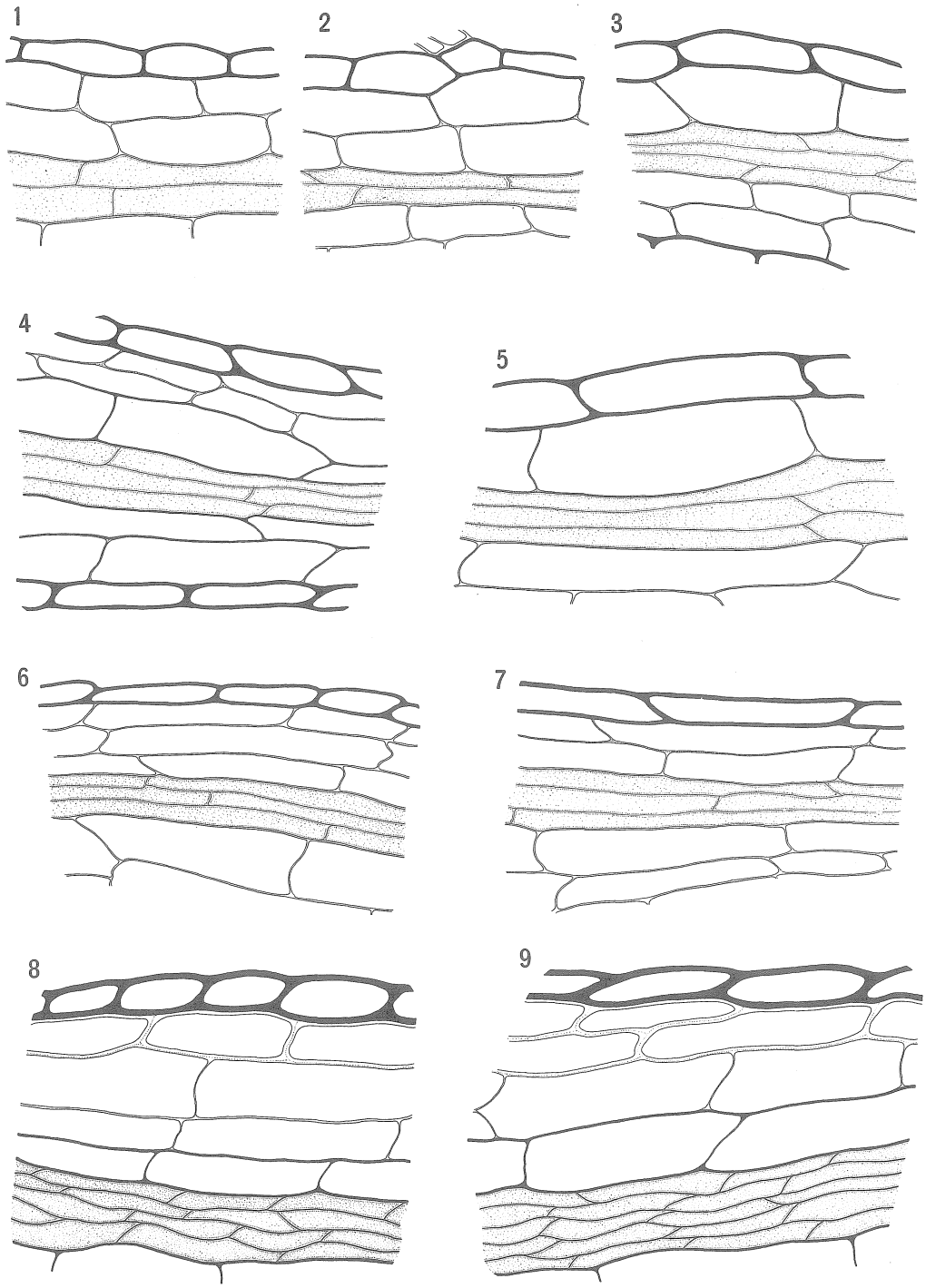

Plate XII Longitudinal sections of the stem
Fig. 1–7: *Brothera leana* (SULL.) C. MUELL. ×280 Fig. 8–9: *Campylopodium euphorocladum* (C. MELL.) BESCH. ×280

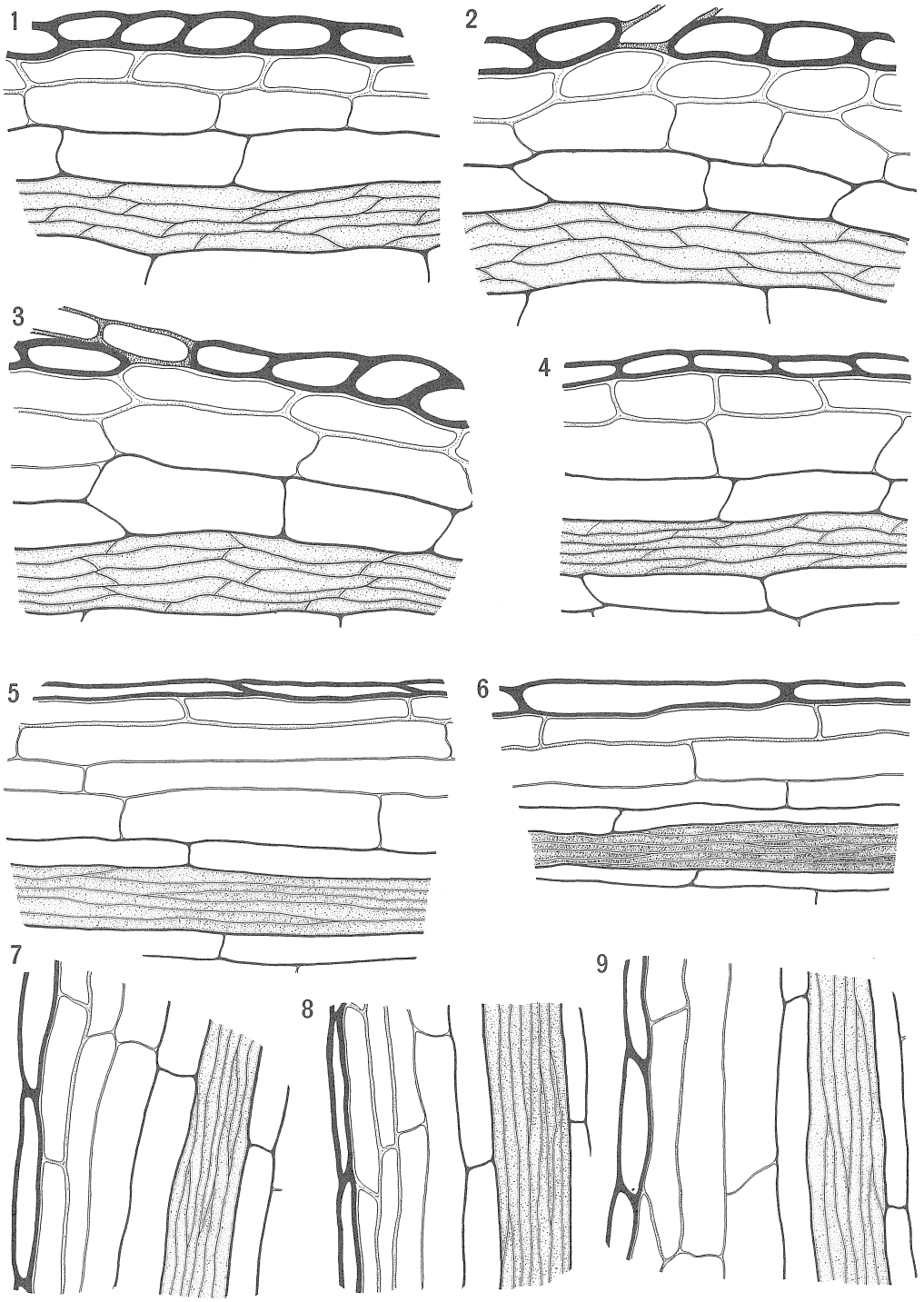

Plate XIII Longitudinal sections of the stem
Fig. 1–4: *Campylopodium euphorocladum* (C. MUELL.) BESCH. ×280 Fig. 5–9: *Arctoa fulvella* (DICKS.) B. S. G. ×280

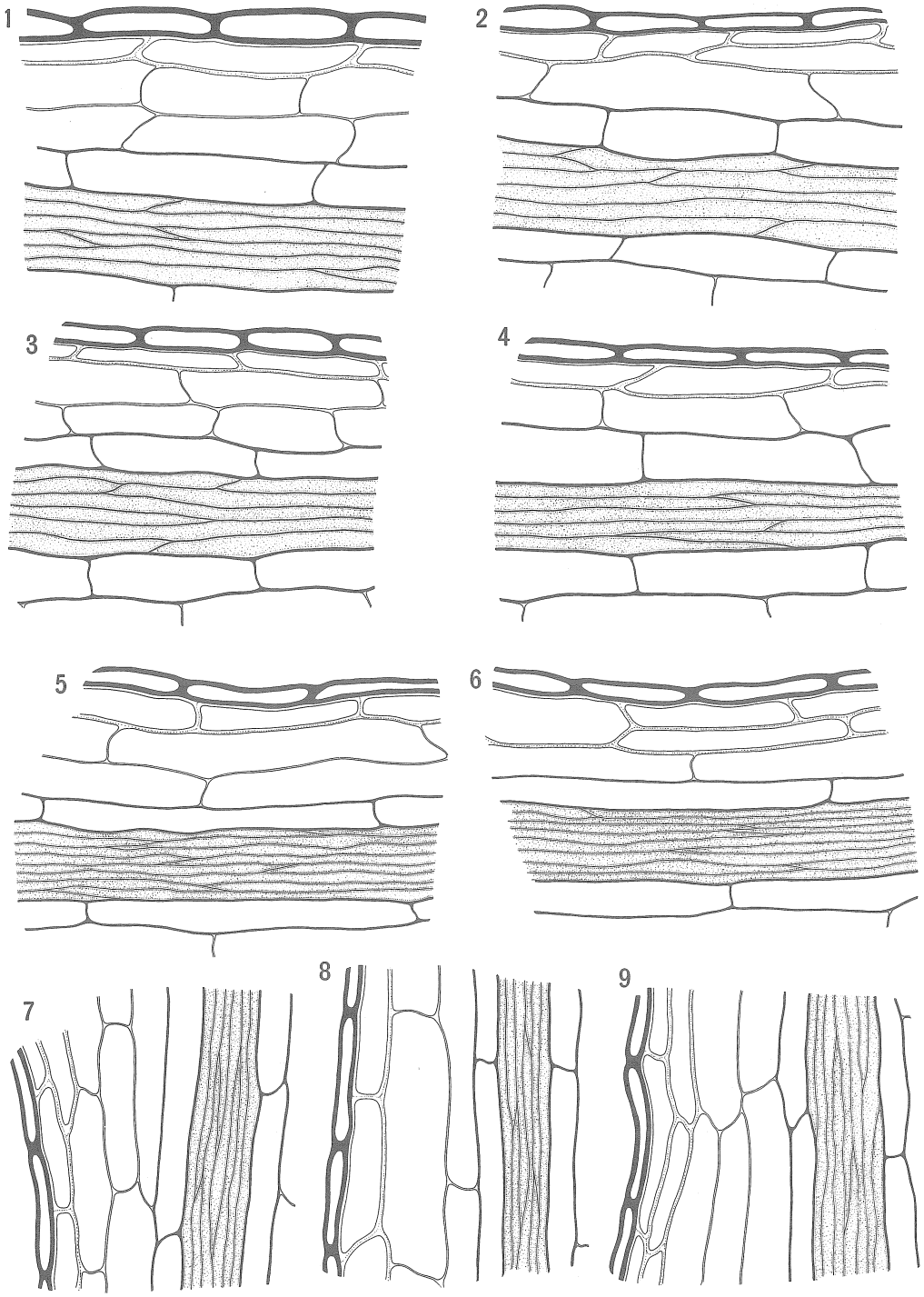

Plate XIV Longitudinal sections of the stem
Fig. 1-4: *Trematodon longicollis* f. *atrovirens* (BROTH.) TAK. ×280 Fig. 5-9: *Dichodontium pellucidum* (HEDW.) SCHIMP. ×220

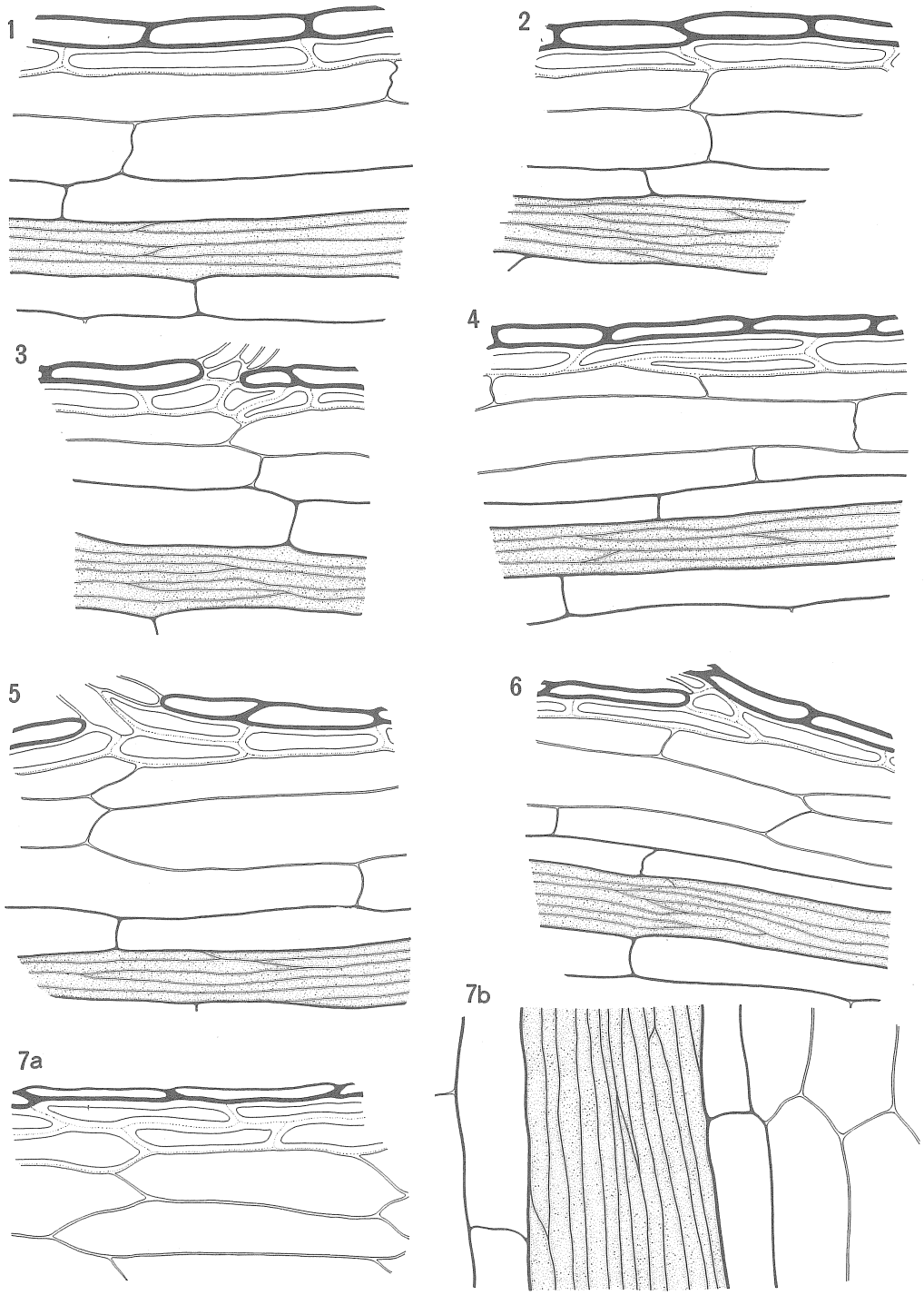

Plate XV Longitudinal sections of the stem
Fig. 1-6 : *Dicranella varia* (HEDW.) SCHIMP. ×280 Fig. 7 : *Campylopus richardii* BRID. ×280
a : Outer part of the stem b : Central part of the stem

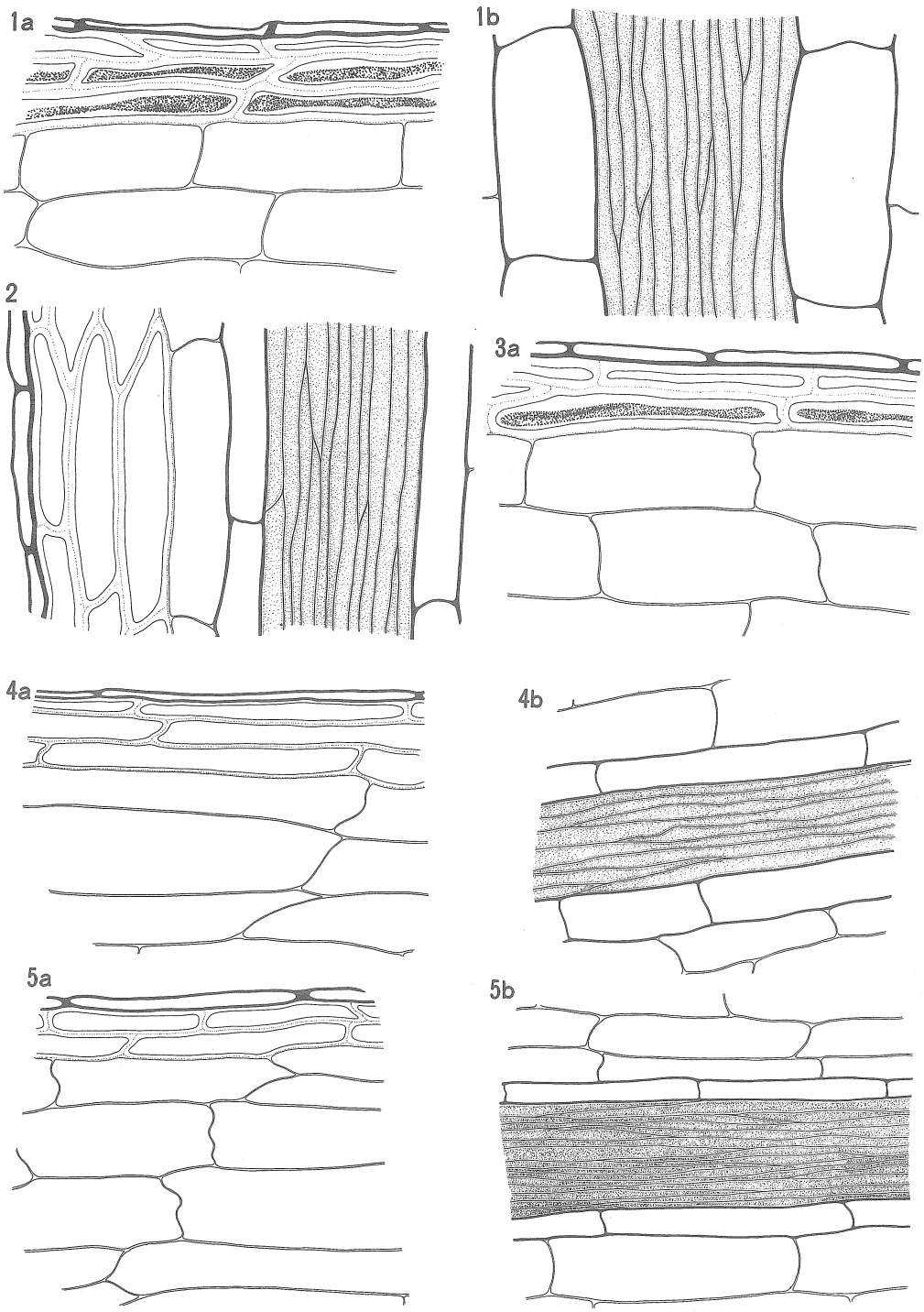

Plate XVI Longitudinal sections of the stem
Fig. 1-3: *Campylopus richardii* BRID. ×280 Fig. 4-5: *Dicranum caesium* MITT. ×220 a: Outer part of the stem b: Central part of the stem

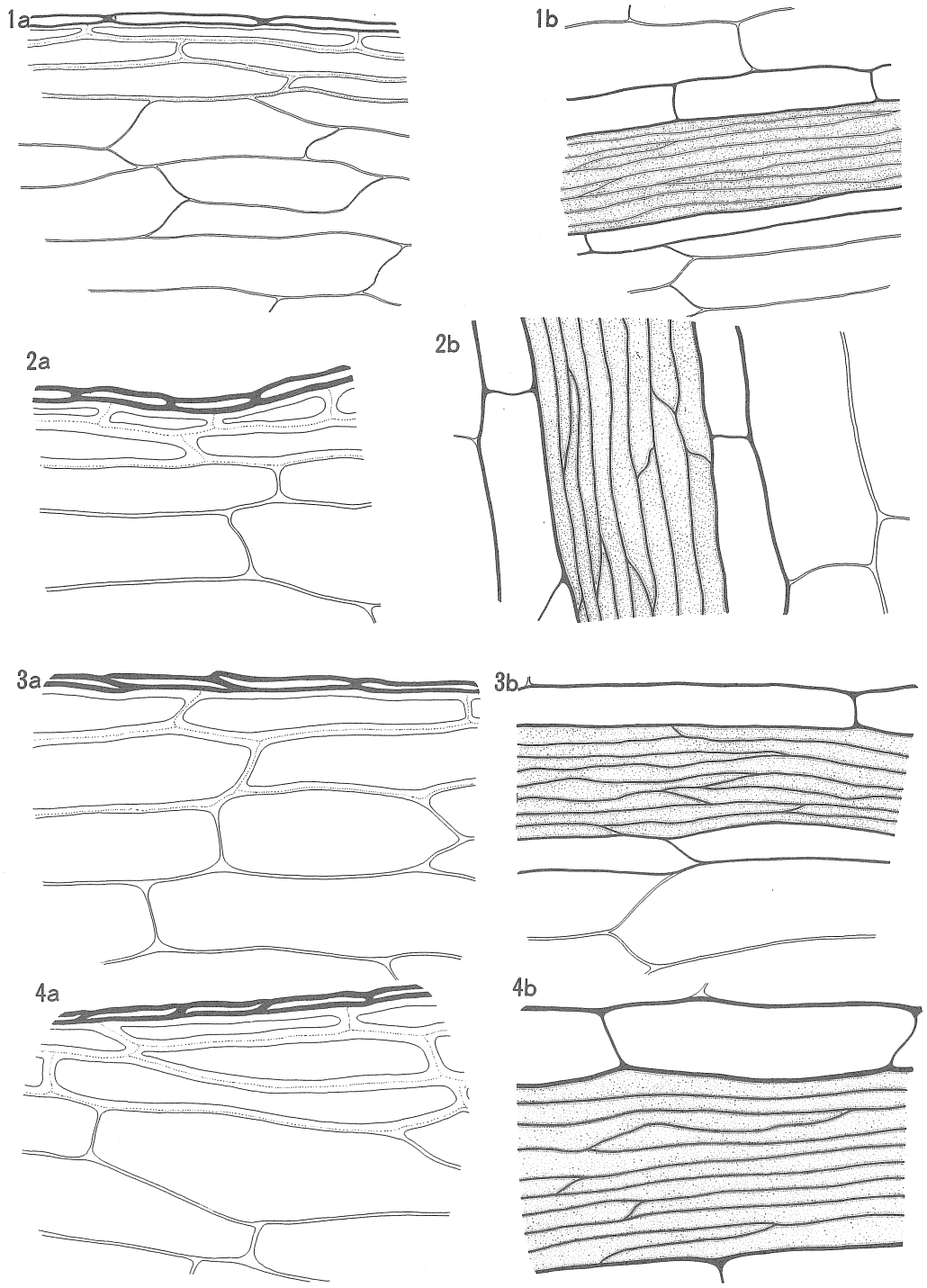

Plate XVII Longitudinal sections of the stem
Fig. 1: *Dicranum caesium* MITT. ×220 Fig. 2–4: *Dicranum japonicum* MITT. ×280 a: Outer part of the stem b: Central part of the stem