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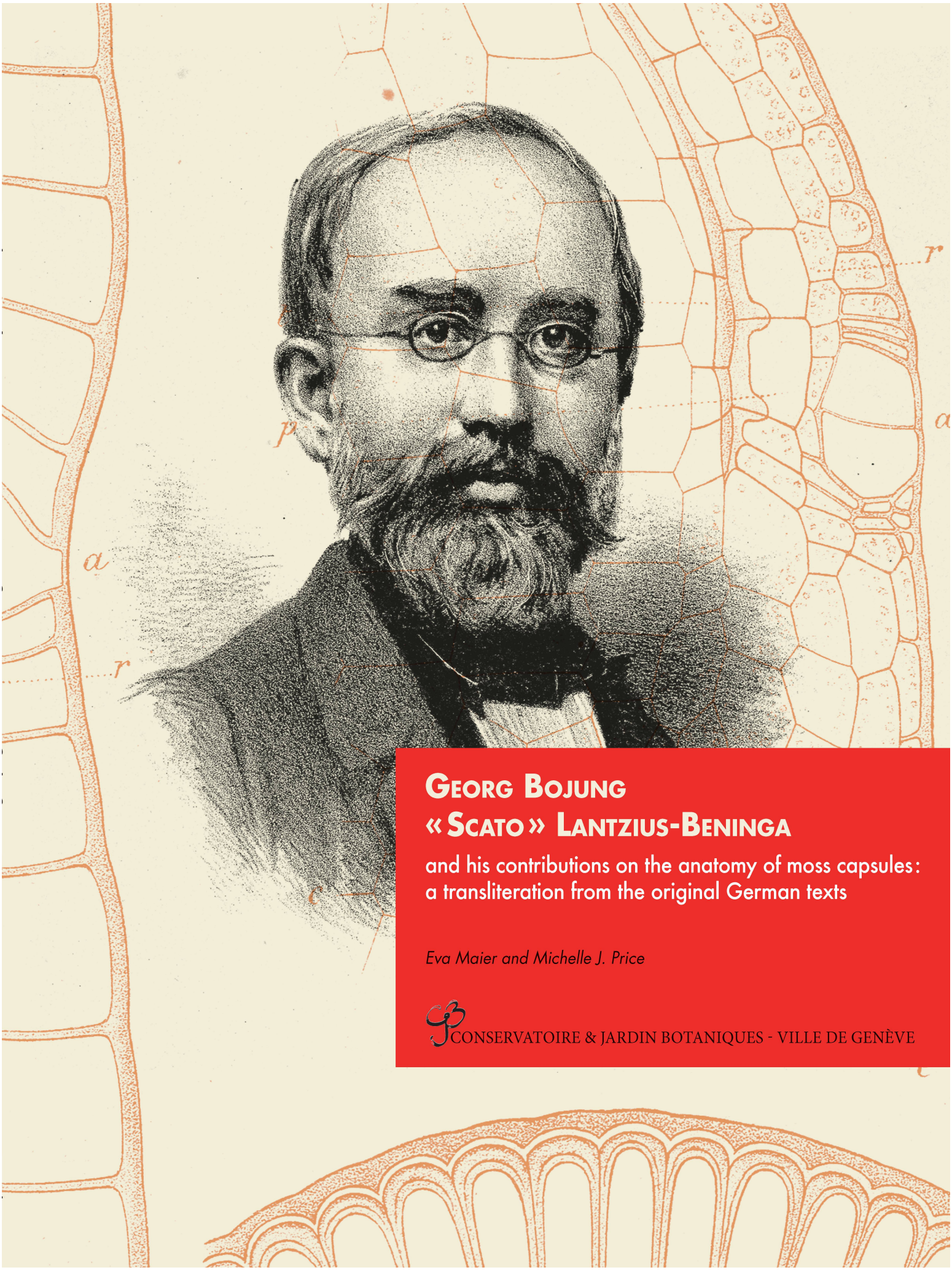

Georg Bojung «Scato» Lantzius-Beninga

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Eva Maier and Michelle J. Price

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Toute correspondance doit être adressée à:
All correspondence should be addressed to:
Rédaction «Candollea-Boissiera»
Conservatoire et Jardin botaniques de la Ville de Genève
Case postale 60
CH-1292 Chambésy
candollea.cjb@ville-ge.ch

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Georg Bojung "Scato" Lantzius-Beninga and his contributions on the anatomy of moss capsules:

a transliteration from the original German texts

Eva Maier & Michelle J. Price

Addresses of the authors:

Eva Maier: chemin des Cottenets 8, 1233 Bernex-Sézenove, Switzerland.

Michelle J. Price: Conservatoire et Jardin botaniques de la Ville de Genève, case postale 60, 1292 Chambésy, Switzerland. Email: **michelle.price@ville-ge.ch**.

Contents

Abstract

The two works of Georg Bojung "Scato" Lantzius-Beninga on the anatomy of moss capsules, entitled *"Beiträge zur Kenntniss des innern Baues der ausgewachsenen Mooskapsel, insbesondere des Peristomes",* of 1847 and 1850 have been largely forgotten within the body of bryological literature. These works contain fundamental information on the structure and anatomical composition of moss capsules, supported by detailed illustrations. Lantzius-Beninga examined species from *Sphagnum* L., the nematodontous mosses (*Polytrichum* Hedw. and *Tetraphis* Hedw.) and the arthrodontous mosses (*Aulacomnium* Schwägr., *Barbula* Hedw., *Bartramia* Hedw., *Ceratodon* Brid., *Dicranum* Hedw., *Fissidens* Hedw., *Funaria* Hedw., *Grimmia* Hedw., *Gymnostomum* Nees & Hornsch., *Hypnum* Hedw., *Orthotrichum* Hedw., *Phascum* Hedw., *Splachnum* Hedw., *Trichostomum* Bruch and *Weissia* Hedw.), as recognised at that time. In modern terms Lantzius-Beninga studied a total of 48 species from 38 genera, and illustrated 24 of them. He focused his observations on mature capsules and, in particular, the internal structure of the capsule and the capsule wall – peristome tooth junction in these mosses. His theory was that this particular region could hold important traits for use in species distinction in mosses. Lantzius-Beninga's findings, and their potential contribution to interpretation of the evolution of peristomes, has yet to be widely tested across this group of plants. Herein his two works, and a later biography, all published in German, are translite-rated with the aim of maintaining the spirit and charm of the original works while recounting as accurately as possible the wealth of information held within.

Key-words: Sporophytes – mosses – capsules – peristomes – Lantzius-Beninga

Introduction

Georg Bojung "Scato" Lantzius-Beninga (1815-1871) published his Latin dissertation in 1844, entitled *"De evolutione sporidiorum in capsulis muscorum"*, on the formation and development of spores within the capsules of mosses. He went on to study the anatomy of moss capsules in more detail, with the aim of investigating the composition and origins of the different tissues as well as the various structures that constitute this organ. He published two principal works, both entitled *"Beiträge zur Kenntniss des inneren Baues der ausgewachsenen Mooskapsel, insbesondere des Peristomes"*, in 1847 and 1850. The former work presented a summary of his findings and the later work was a more complete treatise of his observations, accompanied by 11 lithographs. Strongly influenced by the earlier findings of HEDWIG (1782, 1798, 1801), and a number of plant anatomy and key bryological works of the time (see Table 1), Lantzius-Beninga microscopically examined capsules in species of *Aulacomnium* Schwägr., *Barbula* Hedw., *Bartramia* Hedw., *Ceratodon* Brid., *Dicranum* Hedw., *Fissidens* Hedw., *Funaria* Hedw., *Grimmia* Hedw., *Gymnostomum* Nees & Hornsch., *Hypnum* Hedw., *Orthotrichum* Hedw., *Phascum* Hedw., *Polytrichum* Hedw., *Sphagnum* L., *Splachnum* Hedw., *Tetraphis* Hedw., *Trichostomum* Bruch and *Weissia* Hedw., as recognised at that time (see Table 2 for a list of the species studied by Lantzius-Beninga), providing descriptions of his observations and comparisons between the different entities that he had studied. Lantzius-Beninga studied a total of 48 species from 38 genera, and illustrated 24 of them in his works. Unfortunately, LANTZIUS-BENINGA (1847, 1850) did not give any details on the methods that he employed to prepare and examine the capsules.

LANTZIUS-BENINGA (1847, 1850) principally based his observations on mature moss capsules and, in particular, on the internal structure of the capsule and the junction of the peristome teeth with the capsule wall in the peristomate mosses he studied. He proved for the first time that the peristome of arthrodontous mosses is made up of cell wall remnants and demonstrated that the three innermost cell-layers of the amphithecium gives rise to the peristome (see in SCHWARTZ, 1991). He also deduced that the single rank of teeth in the haplolepidous mosses that he studied (in *Dicranum*) corresponded to the inner rank of teeth in the mosses that he has observed with a double rank of teeth *(Hypnum, Orthortichum)* (see in EDWARDS, 1984). Based on his detailed examinations and observations Lantzius-Beninga proposed that the capsule wall – peristome tooth junction region in mosses could hold important traits for use in species distinction: *"Bei allen guten Arten fand ich im Bau wesenliche Unterschiede von andern verwandten, ebenfalls sichern Arten, wogegen ich bei einigen schwankenden Species keine Abweichungen wahrnehmen konnte"* (LANTZIUS-BENINGA, 1850: 600), interpreted as: "In all good species I found, in the construction, essential differences to other related, clearly defined species, on the other hand in some varying species I could not recognize differences".

Lantzius-Beninga's works contain fundamental details on the structure and anatomical composition of moss capsules in the studied species as well as detailed illustrations of his associated observations. Despite the long history of the study of moss capsules and the use of sporophyte characteristics, particularly the peristomes, in their classification (see review of the

developmental studies in mosses of SCHWARTZ, 1991) Lantzius-Beninga's theory has yet to be widely tested within and across the mosses. Apart from some scattered mentions within the bryological literature (see SCHWARTZ, 1991 and MAIER & PRICE, 2005) and the application of his method of examining sections of capsules and peristomes by a few early bryologists (KIENITZ-GERLOFF, 1878a,1878b; LIMPRICHT, 1888-1889), his findings have been largely forgotten within the body of bryological work. EDWARDS (1979, 1984) evoked the discoveries of Lantzius-Beninga, indicating his contribution to the understanding of the homologies of the structures in haplolepidous and diplolepidous mosses, later re-formulated by PHILIBERT (1902; see also the translated and abridged version of Philibert's series of peristome articles in TAYLOR, 1962). MAIER & PRICE (2005, based on MAIER, 1999) discuss the context of Lantzius-Beninga's work and highlight some examples of species specific characteristics of the capsule wall – peristome tooth junction region within *Grimmia*.

LANTZIUS-BENINGA (1844, 1850) appears to have had ready access to the historical and current bryological literature of his time. He consulted the works of his predecessors (for example, HEDWIG, 1798, 1801; BROWN, 1811, 1819) and contemporaries (especially *Bryologia europaea*, BRUCH & al., 1836-1847), comparing his findings with these published works (see Table 1). His ability to interpret the structures that he saw and to compare them to previous observations demonstrates the depth of his studies. However, LANTZIUS-BENINGA (1850) was not always complementary about the authors of *Bryologia europaea* or of their illustrations and interpretations of structures in moss capsules given therein. His rather critical approach to the research of his contemporaries may have been one of the reasons why his works were not widely appreciated at the time.

Herein the two works of LANTZIUS-BENINGA (1847, 1850), and a later biography on him (BIELEFELD, 1897), all published in German, have been transliterated and the original lithographs have been reproduced (see Table 3 for a list of the species that he illustrated in his works). The rich information held within LANTZIUS-BENINGA (1847, 1850) on the construction and development of the capsules in the mosses he studied can be interpreted using his text and illustrations. Rather than undertaking a strict translation of his works in a more modern style, the spirit and charm of the original German text has been maintained. BIELEFELD's (1897) biography of Lantzius-Beninga gives some insights into his privileged background and his professional career as well as his behaviour, character and philosophy.

Note: The images are reproduced in the original format.

Acknowledgments

This work was supported by the Conservatoire et Jardin botaniques de la Ville de Genève (CJBG). We would like to thank the library staff of the CJBG, especially Paola Emery and Pierre Boillat, for their help in locating the references for this work. We are grateful to Bernard Renaud (CJBG) for the reproduction of the plates.

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Table 1. List of botanical and bryological works cited in LANTZIUS-BENINGA's works, entitled *Beiträge zur Kenntniss des innern Baues der ausgewaschsenen Mooskapsel, insbesondere des Peristomes*, of 1847 and 1850.

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WILSON, W. (1841). Notes and notices in reference to British Muscology. *Journal of Botany* 3: 374-386.

Table 2. Modern names for the species studied by LANTZIUS-BENINGA (1847, 1850). Authors names have been added to the names that were used in the original texts. The modern equivalent of the names are given, using TROPICOS (2014) as a reference, in bold. After each name, reference is made to its first use by citation of the year and page in the publication.

Anacalypta rubella* Huebener = ***Erythrobarbula rubella* Boros (1847: 19; 1850: 570)

Aulacomnium palustre (Hedw.) Schwägr. (1850: 574), as *"Aulacomnion"* but later as *" Aulacomnium"*

Barbula fallax Hedw. ≡ ***Didymodon fallax*** (Hedw.) R. H. Zander (1847: 19; 1850: 572)

Barbula muralis (Hedw.) Crome ≡ ***Tortula muralis*** Hedw. (1850: 573)

Barbula reflexa (Brid.) Brid. = ***Didymodon ferrugineus*** (Besch.) M. O. Hill (1847: 21)

Barbula tortuosa (Hedw.) F. Weber & D. Mohr ≡ ***Tortella tortuosa*** (Hedw.) Limpr. (1847: 21; 1850: 571)

Bartramia fontana (Hedw.) Turner ≡ ***Philonotis fontana*** (Hedw.) Brid. (1850: 584)

Bryum capillare Hedw. ≡ ***Rosulabryum capillare*** (Hedw.) J. R. Spence (1850: 581)

Bryum crudum (Hedw.) Turner ≡ ***Pohlia cruda*** (Hedw.) Lindb. (1850: 581)

Bryum cuspidatum (Hedw.) Crome ≡ ***Plagiomnium cuspidatum*** (Hedw.) T. J. Kop. (1850: 581)

Bryum turbinatum (Hedw.) Turner (1850: 581)

Catharinea undulata (Hedw.) F. Weber & D. Mohr ≡ ***Atrichum undulatum*** (Hedw.) P. Beauv. (1850: 586)

Ceratodon purpureus (Hedw.) Brid. (1850: 574)

Dicranum glaucum Hedw. ≡ ***Leucobryum glaucum*** (Hedw.) Ångstr. (1850: 576)

Dicranum rufescens (With.) Turner ≡ ***Dicranella rufescens*** (With.) Schimp. (1850: 576)

Dicranum schreberianum Hedw. (1850: 576) ≡ ***Dicranella schreberiana*** (Hedw.) H. A. Crum & L. E. Anderson

Dicranum scoparium Hedw. (1850: 575)

Dicranum varium Hedw. ≡ ***Dicranella varia*** (Hedw.) Schimp. (1850: 576)

Fissidens adianthoides Hedw. (1850: 576), as *"adiantoides"*

Funaria hygrometrica Hedw. (1850: 568)

Grimmia apocarpa Hedw. (1850: 575) ≡ ***Schistidium apocarpum*** (Hedw.) Bruch & Schimp.

Gymnostomum pyriforme Hedw. ≡ ***Physcomitrium pyriforme*** (Hedw.) Hampe (1850: 568)

Gymnostomum tenue Hedw. ≡ ***Gyroweisia tenuis*** (Hedw.) Schimp. (1850: 569)

Hypnum commutatum Hedw. ≡ ***Palustriella commutata*** (Hedw.) Ochyra (1850: 585)

Hypnum cuspidatum Hedw. ≡ ***Calliergonella cuspidata*** (Hedw.) Loeske (1850: 585)

Hypnum stramineum Brid. ≡ ***Straminergon stramineum*** (Brid.) Hedenäs (1850: 585)

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* In LANTZIUS-BENINGA (1847 & 1850) the name of *Anacalypta rubella* Huebener (now *Erythrobarbula rubella* Boros) was treated as being close to *Weissia recurvirostris* (written as "*Weissia recurvirostra*").

Hypnum sylvaticum Brid. ≡ ***Plagiothecium sylvaticum*** (Brid.) Schimp. (1847: 22; 1850: 585)

Orthotrichum anomalum Hedw. (1850: 593)

Orthotrichum affine Brid. (1850: 579), as *"Orthotrichum affine (pumilum)"*

Orthotrichum striatum Hedw. (1850: 580)

Phascum cuspidatum Hedw. (1850: 566)

Phascum patens Hedw. ≡ ***Physcomitrella patens*** (Hedw.) Bruch & Schimp. (1850: 567)

Pohlia elongata Hedw. (1850: 581)

Polytrichum commune Hedw. (1850: 566)

Polytrichum nanum Hedw. ≡ ***Pogonatum nanum*** (Hedw.) P. Beauv. (1850: 586)

Polytrichum piliferum Hedw. (1850: 586)

Polytrichum urnigerum Hedw. ≡ ***Pogonatum urnigerum*** (Hedw.) P. Beauv. (1850: 586)

Racomitrium ericoides (Brid.) Brid. (1850: 574), as *"Rhacomitrium"*

Sphagnum acutifolium Schrad. = ***Sphagnum capillifolium*** (Ehrh.) Hedw. (1850: 565)

Sphagnum obtusifolium Ehrh. = ***Sphagnum palustre*** L. (1850: 565)

Splachnum ampullaceum Hedw. (1850: 577)

Splachnum sphaericum Hedw. (1850: 577)

Syntrichia subulata (Hedw.) F. Weber & D. Mohr ≡ ***Tortula subulata*** Hedw. (1850: 573)

Tetraphis pellucida Hedw. (1850: 569)

Trichostomum tortile Schrad. (1850: 574) = ***Ditrichum pusillum*** (Hedw.) Hampe

Weissia controversa Hedw. (1850: 571)

Weissia fugax Hedw. ≡ ***Rhabdoweisia fugax*** (Hedw.) Bruch & Schimp. (1850: 571)

Weissia recurvirostris Hedw. ≡ ***Bryoerythrophyllum recurvirostrum*** (Hedw.) P. C. Chen (1847: 21; 1850: 570)

Table 3. Index of species that were illustrated in LANTZIUS-BENINGA's works of 1847 and 1850. The modern equivalent of the names are given in Table 2.

LANTZIUS-BENINGA, G. B. S. (1847). Beiträge zur Kenntniss des inneren Baues der ausgewachsenen Mooskapsel, insbesondere des Peristomes. *Botanische Zeitung* 5(2): 17-22, Tab. 1.

[original page 17]

Contributions to the knowledge of the inner structure of the mature moss capsule, especially of the peristome

S. Lantzius-Beninga,
Dr. of Philosophy and Privat-Docent at the University of Göttingen.

Table I.

The results of a series of examinations of the structure of the mature, not yet disintegrated moss capsule, especially in relation to the structure of the peristome which I had the occasion to execute this summer are presented here as a provisional excerpt; I hope to be able to present a more detailed description soon.

On the construction of the capsule in general I found not much remarkable. Hedwig at first distinguished the columella, and the inner and the outer capsule membrane; between the inner capsule membrane and the columella should be located the spores.

In my dissertation in the year 1844 (*De evolutione sporidiorum in capsulis muscorum*. Göttingae 1844. 4.) I said already, that I cannot take as natural such a separation and the designation of the inner parts of the moss capsule. At that time I made the suggestion that the inner capsule membrane and the two outer cell layers of the columella which, not only enclose the spore space and seem to be important for the support of the mother cells and for the forming of the spores, but also because the cells by their shape and content differ from all the other capsule cells, may be considered as a peculiar inner organ of the moss capsule. I have drawn the attention to the fact that in several species of *Polytrichum* this organ, along its entire length, **[original page 18]** is separated from the outer capsule membrane as well as of the columella and is connected with it only in the upper and lower parts of the capsule. At present, having examined many more moss capsules, I cannot but repeat this suggestion, in which I will use provisionally the name spore sac, however in a different sense to that of Bruch and Schimper. (The authors Bruch and Schimper inappropriately designate by the name spore sac Hedwig's membrana capsulae interior.)

All the mosses which I could examine agree essentially, so far, in that which concerns the construction of the lower and median parts of the capsule. More interesting is the upper part, beginning at the upper border of the spore sac, which after the operculum has detached, reveals the orifice of the capsule with the peristome.

Mosses without peristomes have in this part an absolutely uniform cell tissue showing nothing unusually remarkable. Worthy of mention is *Sphagnum* with the peculiarity that it has no separation of the spore sac from the outer capsule membrane and that the columella (at least from all the examinations I made) does not reach to the point of the operculum but is standing freely in the middle of the capsule like a pillar, being completely surrounded with spores at the sides and above.

Of the mosses with a single peristome the genus *Tetraphis* is already correctly described and depicted by Bruch and Schimper. In this case the outermost cell layer of the epidermis detaches as the operculum, the cell tissue remaining splits into four parts, and thus forms the four peristome teeth. **[original page 19]** Totally different are the other mosses with a single peristome. The base of it appears, in the upper part of the capsule, at about the same height as the annulus or at the place where the operculum detaches (somewhat below the middle), more or less in the centre of the capsule (one, two, or three cell layers of the epidermis), a circle or a real wall of sixteen or, sometimes by a further cell building, thirty-two relatively big cells, the membranes of them possessing a more or less strong partial thickening (see the given drawings at pp.). In the lower part of the peristome this thickening is from time to time nearly regular, normally, however, already here at the capsule wall, on the inner-side of the capsule, these cells are stronger (see Fig. 3, x); in the cells of the same layer, situated nearer to the capsule point, the thickening is usually already partial and also on the wall facing to the centre of the capsule (see Fig. 3, y. The drawing is made from a section somewhat oblique from below to above). It forms the peristome. On the thickened spots of the lower cells the next layer of upper cells are always arranged so that they form a cord, a pillar of thickenings (see Fig.1 pp.); if a cell has only one thickened cord then the peristome has sixteen teeth, if each big cell has two thickened cords then the peristome has thirty-two teeth (see Fig. 2. *Anacalypta rubella* with sixteen, Fig. 3, and 4, *Barbula fallax* with thirty-two teeth). In *Dicranum,* at the base of the peristome about half way up, in not yet dehisced capsules, a broad thickened stripe is seen which separates into two cords higher up (the reason for the division of the peristome teeth), thus the transverse section of the uppermost part of the capsule has the same appearance as the section of the point of a capsule of a *Barbula-* or a *Trichostomum*-species.

At the detachment of the operculum its inner cell tissue and also the membranes of the sixteen big cells tear, only the thickened cords remain upright as free pillars, as peristome teeth. **[original page 20]** I have especially noticed that at the same time as the membranes of the sixteen big cells (I will name them peristome cells), the neighbouring cells (t. t. Fig. 2, 3, 4) bordering the inner-side are thickened at the same place, thus each thickened cord or each peristome tooth consists of two halves, one orientated towards the inner-side, the other one to the outer-side, resulting in the interpretation that the teeth e.g. of *Barbula* would consist of a double layer of cells (in this case the thickened cords would be taken as being complete cells).

The indication of Bruch and Schimper that *Trichostomum* is distinguished from *Barbula* by the fact that the peristome of *Trichostomum* consists of one cell layer only and that of *Barbula* of two layers, is incorrect. The peristome teeth of *Trichostomum* are built as those of *Barbula* but they are more delicate and the both halves separate more easily.

Very similar is the construction of the capsule with a double peristome. It differs from that described above only by the fact that the membrane of the sixteen or thirty-two peristome cells, orientated to the outer side of the capsule, is very strongly thickened (mostly stronger than the wall orientated towards the inner side); the membranes of the outer-side of the cells, as in *Hypnum*, *Bryum* and other mosses with a similar peristome, participate in the thickening process. At the disintegration of the capsule the cell tissue as well as the horizontal and the

lateral membranes of the peristome cells are torn, and therefore the outer and the inner thickened cords remain as the outer and the inner peristome. The longitudinal and horizontal lines are the remains of the separating walls of the neighbouring cells, and the fine lines and spots are the remains of a granular, rough, thickened layer which covers the surface of most of the peristomes. In general these spots are spread out fairly regularly so that they appear as stripy or even as spirals by a weak magnification.

Noticeable is the position of the layer of the peristome cells in relation to the spore sac and the outer capsule wall (inner and outer capsule membrane), namely immediately above the gap, the air space, which is between these two organs. It follows clearly that it is once and for all out of the question whether the peristome arises from **[original page 21]** "the inner or the outer capsule membrane" (see Fig.1 and 5, v.p.p.).

Isolated is *Polytrichum*, the peristome teeth of it consist of bundles of horseshoe-like thick-walled fibre cells bent upwards, a structure correctly described also by Bruch and Schimper. In mosses of this section appear a "epiphragma", constructed at the place where the operculum detaches. Immediately at the peristome cells, and partly grown together with them, a layer of cells runs to the centre of the capsule, their lower membranes thickened and roughly granular. After the detaching of the operculum besides the peristome teeth, these thickened membranes remain as a connected skin (epiphragm) whilst the other tissue totally or partly tears off and disappears.

Explanation of the illustrations

Fig. 1. Depiction of a part of a longitudinal section of a mature capsule of *Anacalypta rubella* Hübn. *(Weissia recurvirostra)* ee. epidermis, a. annulus, v. empty space between outer capsule membrane and spore sac, s. inner space of the spore sac, rr. cell layer bordering the layer of the peristome cells to the outer side, pp. peristome cells, tt. cell layer close to the centre of the capsule, cc. centre of the capsule. The peristome is built here by the partial thickening of the connecting membranes of the cell layers pp. and tt. Magnification approximately 250x.

Fig. 2. Part of a transverse section of a capsule of the same moss. Meaning of the letters and magnifiction as for the previous figure.

Fig. 3. Part of a transverse section of a capsule of *Barbula tortuosa* not yet completely grown, cut slightly obliquely from below to above. Part x the lower one, part y. the upper one. Here is to be seen, that the thickening of the membranes of the cell layers pp. and tt. becomes entirely partial above. Meaning of the other letters and magnification as above.

Fig. 4. Part of a transverse section of a completely grown capsule of *Barbula reflexa.* In the thickening cords of the membranes situated between pp. and tt., the peristome teeth, which are here relatively very strong, are visible the separating lines of the different thickened layers. Meaning of the letters as above, magnification approximately 500x.

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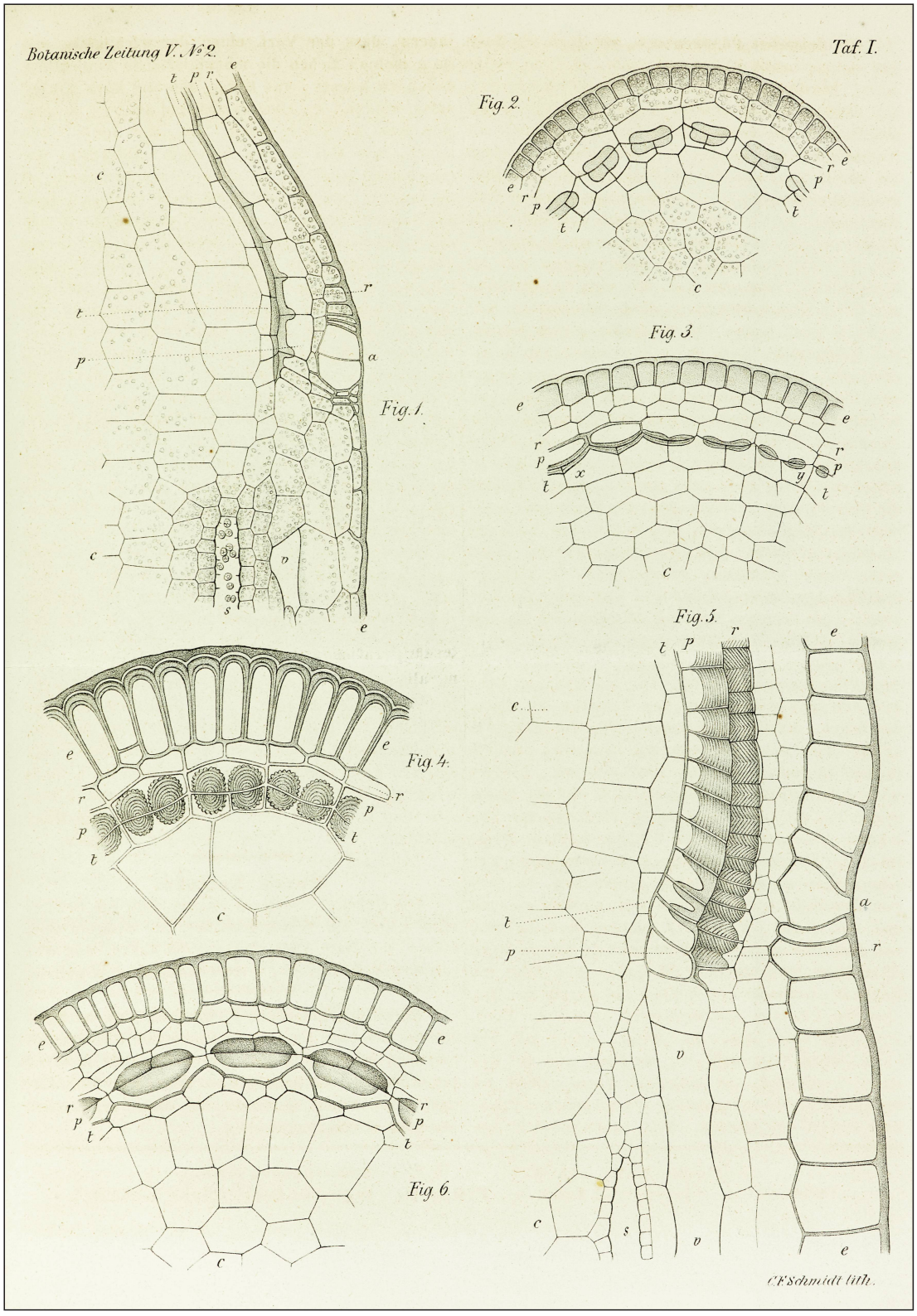
Fig. 5. Part of a longitudinal section of a capsule of *Hypnum sylvaticum.* At the place where in the previous figures a strong thickening between the cell layers pp. and tt. is visible, is here a weak one, the inner peristome; on the other hand relatively very strong is the thickening of the membranes between pp. and rr., forming the outer peristome. Meaning of the letters as above, magnification 250x.

Fig. 6. Part of a transverse section of a similar capsule; here the reason for the pleats of the inner peristome is visible (between pp. and tt.). Meaning of the letters and magnification as above.

The examinations are executed with an instrument von Schiek with a magnification 700x.


Botanische Zeitung V. № 2.
Taf. I.
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
C.F.Schmidt lith.

LANTZIUS-BENINGA, G. B. S. (1850). Beiträge zur Kenntniss des innern Baues der ausgewachsenen Mooskapsel, insbesondere des Peristomes. *Novorum Actorum Academiae Caesareae Leopoldino-Carolinae Naturae Curiosorum* 22(2): 559-604, Figs. 1-41.

[original page 559]

Contributions to the knowledge of the inner structure of the mature moss capsule, especially of the peristome

With 41 figures

by

S. Lantzius-Beninga,
Dr. of Philosophy, Privat-Docent in Göttingen,
M. d. A. d. N.

with 11 lithographic printed tables

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As often as the family of the mosses, in relation to their habitus and therefore to the systematic arrangement of the plants, was the subject of the research of botanists, as little has been done for the knowledge of their inner structure.

The most striking is, however, that especially the structure of the organ which, even by the systematists, has always been considered to be particularly important, namely the structure of the capsule or urn *(capsula, theca),* has remained unnoticed. Even the peristome, on which Hedwig established the sole, so far, useful system*) to arrange the mosses, has not essentially been examined. The knowledge of the structure and the morphological importance, is up till now, rather based on assumptions and superficial observations than on thorough examinations, and the cilia or the teeth that so often can be seen, seem to be enigmatic phenomena regarding their habitus as well as in what concerns their striking numerical correlations, without analogy in the plant kingdom.

*) Recent attempts to arrange mosses in natural subfamilies and genera are, in fact, only arbitrary and often very unnatural listings based on the habitus, and therefore are far from deserving the name of a natural system, even of a system at all.

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This uncertainty and the limited knowledge attracted my attention as I was on the point of using Hedwig's system as the basis for a systematic work.

The series of investigations, the results of which I will present in the following pages, were undertaken, essentially, with the aim of understanding the remarks of authors who have published on this family. A lack of leisure forces me to break off temporarily and, therefore, I beg pardon that the desired degree of completeness could not be achieved.

Historical preface

Essentially to Hedwig, the founder of the Scientific Bryology, is due what we know on the structure of the moss capsule. His publications are so well-known that it is not necessary to cite them here.

He divided the capsule into a lower and an upper part; the lower part represents the true sporangium, the upper one the operculum, the peristome, and so on. In the lower part of the capsule Hedwig, it seems, presumed the outer and the inner capsule membrane *(membrana capsulae exterior et interior),* the space where the spores are formed, and the columella, to be different organs. He thought that they were derived from the outer and inner cell layers of the seta *(pedunculus, seta).*

Hedwig divided the upper part into the true operculum, the peristome teeth, when present, and the point of the columella. He says that the operculum is the continuation of the outer capsule membrane, and the peristome – at least of the inner of the double ones, and of the simple ones in most of the cases – the continuation of the inner capsule membrane. He is not very explicit on that which concerns the structure of the peristome and he essentially says that

[original page 563] there are horizontal stripes or horizontal and longitudinal stripes, and so on.

Of Hedwig's successors, meaning those authors that recently specifically wrote about mosses or mentioned them, I cite as particularly important the following names:

Robert Brown in:

Some considerations on the fructification parts of the mosses together with the characters and descriptions of two new genera of this family. Presented the 20th June 1809 (Transactions of the Linnean Society of London. Vol. X).

Furthermore in: Character and description of the new Moss genus *Lyellia* with remarks on the section of the family to which it belongs and with some additions to *Leptostomum* and *Buxbaumia.* Presented the 6th April 1819 (Transactions of the Linnean Society of London. Vol. XII. P. 2).

See R. Brown's 'Vermischte Schriften,' edited by C. G. Nees v. Esenbeck. Vol 2. Leipz. 1826. 8. p. 683-744.

H. F. Link in:

Icones selectae anatomico-botanicae. Fasc. IV. Berlin 1842. Fol. Tab. VI-VII.

Hugo v. Mohl:

Einige Bemerkungen über die Entwickelung und den Bau der Sporen der cryptogamischen Gewächse. Flora 1833. Bd. 1. – Vermischte Schriften botanischen Inhalts. Tübingen 1845. 4. p. 67-83.

M. J. Schleiden:

Grundzüge der wissenschaftlichen Botanik etc. Part II. Leipzig 1846. 8. p. 64-82.

Bruch et W. P. Schimper:

Bryologia Europaea etc. Fasc. I-XI. Stuttgart. 1837-1847. 4.

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W. Wilson:

Notes and Notices in reference to British Muscology; in the Journal of Botany etc., by W. J. Hooker. Vol. III. London 1841. 8. p. 374-386.

In the cited work, Link commissioned some figures of transverse sections of moss capsules; but it seems that, unhappily, the capsules from which the sections have been made, partly, were too old, at least those, which are, relative to the excellent presentation of the upper part of the capsule, not instructive, and do not show a sufficiently clear view of the relative arrangement of the components.

H. v. Mohl shows transverse sections of not yet disintegrated (young) capsules of the mosses *Polytrichum aloides* and *Splachnum gracile* but the figures seem to be too schematic because the author did not take into particular consideration what especially concerns the peristome (see the cited paper: Vermischte Schriften botanischen Inhalts, Tab. II. Fig. 8. Tab. III. Fig. 1-3).

In what concerns the results and opinions of the other cited authors, I will come back to the special descriptions and observations of the individual mosses below.

Representation of the observations themselves

For the representation of the observations I follow the order presented by the construction of the examined mosses by gradually progressing from those showing a relatively simple structure of the capsule to those in which the structure is more complicated.

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SPHAGNUM.

I examined capsules of *Sphagnum obtusifolium* and *acutifolium.* They show a very simple structure: in their centre is an obtuse, conical columella that does not reach the culminating point (Tab. LVI. Fig. 1. *cc*) and around it is the space in which the spores develop (Fig. 1. *ss*). This space is present in all other mosses which I have had the opportunity to examine: initially at the beginning of the spore development, it is surrounded by a layer formed of relatively small cells, densely filled with chlorophyll (Fig. 1 *sc*); to this layer, outwardly below the superficial membrane, only three more cell layers are added, of which the nearest to the superficial membrane consists of cells filled with chlorophyll. The superficial cells themselves are empty of granulose contents and the membrane, mainly orientated towards the outer side of the capsule, is thickened.

A distinction between outer and inner membranes of the capsule, therefore, cannot be perceived.

At the place where, at the maturity of the spores, the operculum detaches, a slight depression is visible (Fig. 1. *a*), and the superficial cells are markedly smaller than elsewhere in the capsule; otherwise nothing indicates a special development of an annulus.

Against the lower part of the capsule, especially in the inner of the apophysis-like swelling, the cells are somewhat elongate.

Note. In the month of May this year (1846) I was lucky to collect young capsules of the cited mosses where I could observe the spore development, and immediately I was convinced that it happens in the same way as I saw it in the past in other mosses (see my dissertation: De evolutione sporidiorum in capsulis muscorum. Gott. 1844. 4.). In the younger capsules I **[original page 566]** found a dense tissue of mother cells containing thick nuclei, in the older ones, at the same place, the mother cells had four already completely developed spores. As it is said, at the end of the filiforme cells should be formed, by constriction, the four spores, but I could not see anything. (Meyen: Neues System der Pflanzenphysiologie, Bd. III. p. 389). *)

PHASCUM.

The lower and the central part of the capsule of *Phascum* show a construction that is found in all mosses, with exception of the previously described *Sphagnum.*

During the growth the cell tissue of the capsule separates into two components, an outer and an inner one, in the way that the three or four inner cell layers are torn off from the other inner layers, but remain connected at the apex of the capsule and below at its base, and also partly by confervoid filaments, thus forming the structure of the so-called "outer capsule membrane" (Tab. LVI. Fig. 2. *me*).

*) Even if I had the opportunity to convince myself of the formation of spores in a dense tissue of mother cells, and consequently to recognize the cited statement of Meyen as erroneous, I cannot avoid mentioning here a phenomenon that is perhaps the reason for this error: in several capsules of such cited mosses which were enclosed in a specimen box [Botanisierbüchse] for some days during warm weather, and appeared to be in a normal state externally, I found in their inner part, especially in the cavities with the mother cells, densely filled with a mold, composed of large, branched cells. This mold has not only displaced most of the mother cells, which already contained the young spores, but had partly grown on them, so that it seemed that the mother cells with the spores had grown on the mold. – Later on I found the same phenomenon in *Polytrichum commune.*

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In the column-shaped part, situated on the inside, again two different groups of cells are observable: the outer four cells, the mother cells followed by the spore surrounding layer – the spore sac (Fig. 2. *sc*)*) – and the inner, mostly composed of tissue of big cells – the columella (Fig. 2. *cc*). Between the latter named groups of cells appears here, as in most of the mosses, no special gap; as we will see later on, as this is the case in some species of *Polytrichum* only.

In the upper and lower parts of the capsule where the columella passes through the capsule point and the seta, the tissue becomes denser and the cells smaller (Fig. 2. *csp* and *cin*), and in this region the membrane of the mature capsule is brown.

The structure of the point itself shows nothing exceptional, no trace of the development of an annulus or a peristome.

The capsule of *Phascum patens,* as well as that of *Phascum cuspidatum*, is of the same structure.

*) In my above cited inaugural dissertation in 1844 I draw attention, for the first time, to the development of spores in mosses, the particularity of the cell layers surrounding the spore mother cells and their form and contents; in the Botanische Zeitung von Mohl und Schlechtendahl 1847. 2. I published a more detailed preliminary comment on some results of the current investigations. It seems to me that the anthers of phanerogam plants show a similar structure inasmuch as the mother cells that produce the spores are surrounded by a cell layer of which the construction and content of the cells is typical; see the figures of Nägeli in: Zur Entwickelungsgeschichte des Pollens u.s.w. 1842. Also: Meyen: Physiologie Vol. III, und Schleiden: Grundzüge, Vol. II, at the cited places.

I consider that the rather important discovery of remarkable groups of cells that appear to fulfil particular functions is progress in the knowledge of the inner construction of a plant.

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Note. In *Phascum* also I could observe the development of the spores; it is the same process as in *Gymnostomum (pyriforme)* and *Funaria (hygrometrica):* from only one layer of mother cells develop two other mother cells from which the spores originate.

There are few other mosses, their cell tissue being so clearly transparent as in *Phascum,* that make easier the observation of the cell development, and the cutting of the very small capsules into sufficiently thin sections. I saw most clearly in a mother cell with a completely preserved membrane, two younger cells, likewise with distinct membranes, enclosing each of the four separated small cells: the young spores.

GYMNOSTOMUM.

Gymnostomum (Physcomitrium) pyriforme.

As in *Funaria hygrometrica* the columella is connected with the seta by a loose tissue composed of conferve-like, many times branched filaments, the cells of which are densely filled with chlorophyll (Tab. LVII. Fig. 3. *y*.). Somewhat below, at the place where the seta is enlarged into the capsule are visible, between the cells, numerous air holes (Fig. 3. *x*), which are connected with the atmosphere to the outer side by stomata, and in the inner part of the capsule directly with a big hole (Fig. 3. *v*) situated between the outer capsule wall and the spore sac.*

*) This construction can be found in nearly all mosses. The stomata itself are indistinct from that of the higher plants, and the epidermis of the moss capsule which covers the leaves of the so-called complete plants is essentially the same; see also Schleiden: Grundzüge, Ed. 2, part 2, p. 81.

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In the upper part of the capsule is no trace of the development of teeth; the inside of this upper part consists of a tissue of large, regular cells; at that place only, where it separates at the moment of spore maturity, a slight depression is visible (compare *Sphagnum*) Fig. 3. *a;* the cells of the epidermis there are smaller, the form differs somewhat from that of the other parts of the capsule.

In *Gymnostomum tenue,* that I could examine, the formation of the annulus was somewhat different to that of *Gymnostomum pyriforme;* furthermore the columella is connected to the seta by a solid cell tissue. Otherwise the structure is congruent with the above described mosses.

TETRAPHIS.

Tetraphis pellucida.

The capsule as such shows no special features, but very curious is the development of the peristome teeth.

In the part above the spore sac, below the membrane (Tab. LVII. Fig. 4. and 5. *ee*), nearly parallel to the longitudinal section, are two layers of relatively small, elongate, fairly thick-walled cells (Fig. 4 and 5. *nn*); within is a delicate tissue of large cells. At the moment of the complete maturity of the spores only the membrane detaches as the operculum (Tab. LVII. Fig. 5. *ee*) and all the inner cell tissue divides into four equal parts, presenting the peristome teeth.

Already in the not yet deteriorated capsule the separating lines are indicated mostly by a strong development of inter-cellular substances between the cells (Tab. LVII. Fig. 4. *xc*, *yc*, *zc*).

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WEISSIA.

Weissia recurvirostris (*Anacalypta rubella* Hübner).

With *Weissia,* I begin a sequence of mosses which are very similar relative to the structure of their capsules, but essentially with respect to the development of the peristome

Whilst the lower and the median part of a capsule of nearly all mosses has the same construction as seen in *Phascum, Gymnostomum* and so on, in the upper part appears a layer of sixteen or thirty-two cells approximately at the same place as the annulus, at a distance of two, three, four or more widths of cells from the membrane. These relatively big cells are the base of the formation of the peristome. The cells are also remarkable for the more or less cord-like thickenings of their membranes which, after the deterioration of the capsule, remain as cilia and teeth at the orifice. In *Anacalypta rubella* these cells have strong thickenings on the walls pointing towards the centre of the capsule. I name these cells *peristome cells*, the thickenings of which form a cord in the central and the upper part of the peristome (Tab. LVII. Fig. 6. *pp*). In the development of the cord the membranes of the nearby cells participate, Fig. 6. *tt*, the thickened cords of the higher and lower cells together form a column. See the figures of the longitudinal section of the upper part of the capsule, Tab. LVII. Fig. 7. *pp*.

The layer of the peristome cells *pp* is immediately above the air hole placed between the outer capsule membrane and the spore sac, Fig. 7. *v*, and is connected on both sides by a relatively dense, strong tissue, the cells of which are rather small and the membranes thickened.

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When at the time of the complete formation of the spores, or the so-called maturation of the capsule, the operculum detaches by the partial deterioration of the cell tissue, then only the thickened cords of the peristome cells remain (the un-thickened parts of the membrane deteriorate and disappear also) as free columns at the base of the layer, with the spore sac and the tissue of the outer capsule wall. The columns representing the peristome teeth are, following the number of cells participating in their development, and seen in the transverse section, composed of two, three or more parts (here of three each) (Tab. LVII. Fig. 6. *pp*), leading to the opinion that they were composed of several cell layers. The visible traits are the separating lines of the contributing cells. The construction of the capsule and especially the peristome of *Weissia controversa* and *fugax* do not differ essentially from *Anacalypta rubella*.

BARBULA.

Barbula tortuosa and *fallax.*

There are also sixteen peristome cells, which in the lower part of the peristome are regularly strongly thickened, forming a longer or shorter ring-like connected “membrane”. Somewhat higher, the membrane on the inner side of the capsule remains thickened. Higher

up the thickening is divided into two lines or two cords for each cell; see the figure of the transverse section of the capsule of *Barbula tortuosa*, cut slightly obliquely, *m* the lower, *n* the upper part, Tab. LVIII. Fig. 8.

In some cases instead of two, three thickened cords per cell can be seen, often they are so strong that the lumen is completely filled.

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Sometimes one can see the separating lines of the different layers (see Tab. LVIII. Fig. 9. of *Barbula fallax*, *pp*). The outermost layer consists of regularly deposited wart-like knobs, giving it a rough aspect, particularly at a low magnification.

The description makes it evident that after the release of the operculum the thickened cords form the peristome teeth, and, as in each of the sixteen peristome cells two cords appear, the number of the teeth is thirty-two. Occasionally two thickenings unite into one cord, sometimes a cord divides in two so that from one big cell three cords come out (see *Barbula fallax* Tab. LVIII. Fig. 9. *x* and *y*), in the first case the number of the teeth is reduced, in the second one, augmented. Both cases must be considered as exceptions.

The figures make it clear that in *Barbula* the membranes of the connecting smaller cells also participate in the formation of the cord, therefore the transverse section of each tooth has two halves, an outer and an inner one*); often the outer half is darker in colour than the inner one.

*) Bruch and Schimper in the thirteenth to fifteenth parts of the already cited *Bryologia Europaea* explained the structure of the peristome teeth of *Barbula* as if they were built of two cell rows, *arranged side by side.* After a remark of *Wilson* they changed this explanation in the sense that the teeth are formed by two *radially* arranged cell rows, and corrected the figures in this sense (l.l. Fasc. XXXI. Suppl. I. *Barbula* Tab. Suppl. I). – Of a difference between the membrane and the lumen of a cell of course nothing is to be seen in a transverse section of such a tooth; what one may see is a homogeneous mass and at least the fine separation lines of the thickening layers. See the text above.

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The cells of the annulus (in this paper once and for all I will thus name those cells which are placed at the mentioned part of the capsule ignoring if the annulus is *detaching* or not) in *Barbula fallax* are flat and small, and, as well as the above situated epidermis cells, show very clearly the separating lines of the thickened layers of the exterior membrane (Tab. LVIII. Fig. 9. *ee*).

Barbula muralis.

I investigated the apex of young capules of this moss; in this state the peristome entirely presented the structure described in *Barbula fallax.* Some specimens had between normally thickened cords noticeable weak or thin ones.

Note. I feel obliged to mention here an extremely interesting abnormality which I could observe in the course of investigations of the spore formation in *Syntrichia subulata.* In a capsule of the cited moss, in the centre of the columella besides the normally arranged mother cells in the spore sac, I saw a group of cells which were revealed to be spore mother cells by the formation of cells inside, Tab. LVIII. Fig. 9*, *x*. Other sections made from below and above in the same capsule demonstrated that a continuous cord of them, originating in the spore sac, ran through the inner of the capsule up to the upper part as shown by the schematic figure of a longitudinal section of the capsule, Fig. 9**, *xx*. This observation, made but once, may be interesting in relation to a controversy, settled long ago, between

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Robert Brown and Palisot de Beauvois on the appearance of spores in the columella of mosses (compare Palisot de Beauvois in Mém. de la Société Linnéenne de Paris. Tom. I. p. 388, and Rob. Brown in its Vermischte Schriften by Nees v. Esenbeck p. 685).

TRICHOSTOMUM.

Agrees entirely in structure and peristome with *Barbula*. Only, the peristome teeth are weaker and more frail than in *Barbula* and the inner, more tender half may separate easier from the outer one than in that genus *).

Trichostomum tortile, which I could examine more exactly, has an immensely delicate construction of the annulus similar to that I will describe under *Aulacomnion palustre.*

Only briefly could I examine *Rhacomitrium ericoides.* In this moss too the teeth are constructed as in *Barbula.*

CERATODON.

Ceratodon purpureus.

The structure of the capsule reveals an affinity with *Trichostomum*, also the annulus and the peristome. Differences to note are that in the central and the upper parts of the peristome the outer half of the teeth are weaker and terete, whilst the inner ones are stronger and appearing flattened, that means

*) The separation of the genera *Trichostomum* and *Barbula* based on the difference of the structure of the peristome (Bruch and Schimper l. l. Fasc. XIII-XV *Barbula* p. 6 and Fasc. XVIII *Trichostomum* p. 3) is inadmissible because such a difference is non-existent. Both genera, together with *Didymodon* may be seen as a subunit of *one* genus not yet defined, because the turning of the peristome teeth is very variable.

[original page 575] that the membrane thickening of the peristome cells itself is not so strong as that of the neighbouring cells (compare Tab. LXVI. Fig. 40. *pp* and *tt*).

GRIMMIA.

Grimmia apocarpa Hedw.

There are sixteen peristome cells, the membranes of which have two or more thickened cords on the inner side of the capsule, and they anastomose, explaining the cribrose aspect of the peristome teeth.

In *Grimmia apocarpa* a separation of the outer capsule membrane and the spore sac was not visible, at least in the state of age that I examined the capsule; see also the figure in Schleiden's Grundzüge, 2. Ed. Vol. I. p. 73.

DICRANUM.

Dicranum scoparium (Tab. LVIII. Fig. 10-13. Tab. LIX. 14).

At about the same place as the annulus is visible, instead of sixteen, thirty-two large peristome cells, two of them together are built as one big cell seen in the mosses examined until now; see Fig. 11. *pp;* a little bit nearer to the apex of the capsule where the peristome disappears totally only *sixteen* of them may be seen; compare Fig. 12 and 13.

The base of the peristome itself is formed from a coarse tissue composed by considerably thickened cells constituting a strong connection with the outer capsule membrane; see the transverse section Fig. 10. *pp*, the longitudinal section Fig. 14. *x* and *y*. Somewhat higher above, the thickening of the membranes is concentrated on the side of the peristome cells that turn towards the inner side of the capsule, Fig. 11. *pp*, then the thickening becomes smaller and smaller and divides into two cords at half the height of the peristome, **[original page 576]** Fig. 12. *pp*, to finally finish somewhat below the apex of the capsule, Fig. 13. *pp*. The structure of the capsule above the separation of the teeth is essentially comparable with that described for *Barbula* (Fig. 12). *)

The annulus is formed by considerably small, flattened cells (Tab. LIX. Fig. 14. *a*).

Dicranum glaucum.

The structure of the capsule is slightly different from the preceding by the formation of the annulus cells.

Dicranum varium and *Schreberianum.*

Both mosses are completely congruent with each other. The base of their peristome stands out due to the strong thickening of five horizontal walls of the peristome cells arranged on top of each other; see Tab. LX. Fig. 15. *bc*.

Dicranum rufescens.

Dicranum rufescens has the ten to eleven lowest horizontal walls of the peristome cells thickened, Tab. LX. Fig. 16. *bc*.

FISSIDENS.

Fissidens adiantoides.

Especially in the longitudinal section, the capsule shows an exceptional regularly formed tissue, its structure is very similar to *Dicranum*.

*) The Messrs. Bruch and Schimper in the cited puplication, Fasc. XXXVII-XL *Dicranum* p. 6 state: "The dorsal side of the teeth is covered by a fine striated cell membrane, the commissures of them are scarcely visible because they have been overlooked till now. This membrane is a typical peculiarity of all real Dicranaceae". No wonder that this membrane has been overlooked till now, because it does not exist at all.

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The partial thickening of the sixteen peristome cells (here also on the walls orientated towards the inner-side of the capsule), at about half the height of the structure, the peristome divides into two cords for each cell.

It must be noticed that, at its base, the peristome gradually becomes smaller, Fig. 17. *p*, and does not stand out abruptly as a tissue of thickened cells as in *Dicranum;* furthermore that the horizontal separating walls of the cell layer neighbouring the peristome cells on the inner side are partly strongly thickened, therefore the peristome seems to be carved at the inner side, Fig. 17. *tt*, which in this extent is not the case in mosses with simple peristomes that I could see. At the place of the annulus are small thick-walled cells (Tab. LX. Fig. 17 *a*).

SPLACHNUM.

Splachnum sphaericum (Tab. LXI. Fig. 18-20).

The genus *Splachnum* is not only characterized by the form of the species, but also by the inner construction of the capsules that is comparatively delicate.

The apophysis, in the lower part, is constituted from an unusually strong development of parenchyma, particularly in the inner part of the seta; already here some layers of cells separate and create the outer capsule membrane; see in *Splachnum ampullaceum* Link l. l. Hft. 4. Tab. 6. Fig. 10. *dd*. Hedwig Musci frondosi, Vol. II. Tab. XIV. Fig. 12. The middle part of the capsule resembles most of the other mosses, but the upper one deviates in many respects. Above the gap between the outer capsule wall and the spore sac a layer of thickened coloured cells appear that, initially, do not show a regularity in number seen the transverse section, **[original page 578]** Fig. 18. *pp*, but afterwards augmenting to thirty-two bigger cells as in *Dicranum scoparium,* Fig. 19. *pp*, and further up moves on to sixteen peristome cells. These peristome cells have all their membranes thickened as well as the horizontal separating walls; chiefly thickened, however, are the covering membranes of the cells bordering the outer side, Fig. 18, 19 and 20. *rr*.

By the way (at least in *Splachnum sphaericum*) the layer of the peristome cells reaches to the outermost apex of the capsule to a degree that I have not seen in any other genus of mosses. At that place appear cells with red coloured membranes, so to speak as in the keystone of a vault. *)

Instead of a ring appear relatively small epidermis cells, Fig. 20. *a*, with strongly thickened membranes; higher up they become gradually larger and finally at the apex of the capsule form an extremely delicate crown, Fig. 20. *ap;* see this also in Hedwig Musci frondosi. Vol. 2. Tab. XIV. Fig. 14.

When the operculum has fallen off, the peristome of *Splachnum* consists of "eight relatively broad teeth, by a longitudinal fissure finally disintegrating in two teeth" **), it means that below, each tooth is formed by two couples, above by each two peristome cells bordering on one another. – In the sequence of *Weissia*, therefore in the sequence of mosses with sixteen or thirty-two peristome cells,

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*) The section, being at the base of the figure of a capsule of *Splachnum ampulaceum* (I. I. Tab. 6, Fig. 9) by Link is not executed exactly through the centre but somewhat to the side.

**) Compare Hübener: *Muscologia Germanica* etc. *Splachnum*, Gattungscharakter.- I cannot understand the comments of the Messrs. Bruch and Schimper, *Bryol. Europ.* Fasc. 23-24, *Splachnum* p.1: *Peristomii dentes sedecim e duplici cellularum serie compositi – dorso membrana cellulosa tenuissima, epidermidem sistente, obtecti etc.*

[original page 579] *Splachnum* is the only genus in which the peristome teeth consist of real cells and not only of parts of cells.

ORTHOTRICHUM.

Orthotrichum affine (pumilum).

Immediately below the exterior membrane, or separated by a simple cell layer, is a layer of sixteen peristome cells each. Their walls orientated towards the outside are partly strongly thickened, the thickenings occupied by nearly cilium-like cylindrical projections. The inner walls have thickening cords only in the corners where two peristome cells come together, the corners are mostly alternatively thickened or not. The thickening of the outer walls forms only *one* cord; only exceptionally is it formed by two separated cords, see Tab. LXII. Fig. 21, in which case two neighbouring corners of the peristome cells are thickened, which is an exception in this species. – The cells of the layer *tt* bordering the peristome cells on the inner side have membranes that are occupied by cylindrical-warty bumps as well as the thickened outer walls of the peristome cells (but not so dense).

When the capsule deteriorates or the operculum detaches, as it is known, eight teeth of the "outer" peristome and eight cilia as the "inner" peristome, arranged alternatively, appear; the eight teeth of the outer peristome are formed by the thickenings of the outer walls of two neighbouring peristome cells, the cilia by the alternatively thickened inner corners of the peristome cells, all the remaining membrane parts (as well as the horizontal separating walls) disintergrate and disappear.

[original page 580]

The inner peristome of species of *Orthotrichum* is composed of sixteen cilia, *all the inner* thickened corners result from the adjoining peristome cells; in those that have a complete inner peristome of sixteen teeth *(Orthotrichum striatum)* the *inner membranes* of the peristome cells are more or less *evenly* thickened.

It must be noted that in most of the species of this genus the stomata are distributed across the whole surface of the outer capsule wall below the operculum, and the surrounding cells have a tassel-like prolongation that partly close the stomata.

AULACOMNIUM.

Aulacomnium palustre.

A wall with sixteen very large peristome cells each situated above the gap between the outer capsule wall and the spore sac appears here as well. The membranes, orientated towards the outer side of the capsule, show a partly, very strongly thickened cord, which is, as it is visible in the transverse section Tab. LXII. Fig. 23, built of the thickening of the outer membrane of the peristome cells themselves and at the same time of the thickenings of the outer neighbouring cells, thus consisting (in transverse section) of three parts. The wall of the peristome cells orientated towards the inside is delicately plicate and quite regular and not strongly thickened.

The thickening of the outer membrane follows, partly, the horizontal separating walls of the peristome cells thus creating a saw-like notched aspect on the inner side of the outer thickening cords.

[original page 581]

Towards the apex of the capsule the peristome cells and, moreover, the cells of the inner tissue become smaller and their thickenings become weaker.

Extremely delicate is the formation of the annulus of *Aulacomnium palustre* consisting of relatively big, horizontally flattened and inwardly thin-walled cells, that are mostly empty of a granulose content, thus differing from other cells of the exterior membrane, see Tab. LXII. Fig. 22. *a.*

After the deterioration of the capsule the outer peristome are maintained as sixteen outer strong thickening cords, the thickened spots of the plicate inner membrane as the inner peristome, whilst all other un-thickened parts of the peristome cells as well as the neighbouring cells deteriorate and mostly entirely disappear. By the destruction of the thin delicate horizontal separating walls of the peristome cells, the circle of the outer thickening cords, or the outer peristome, will be separated from the inner, plicate, partly thickened membrane –the inner peristome; this membrane remains mostly completely joined together in the lower part up to about the median height (at least it is in the corners or the plicae that it separates); above the median height and further up the thickenings become weaker and appear in places, more or less distinct, to be formed from small delicate cords, the reason why the disintegration in inner teeth and cilia takes place here.

The same is the structure of the capsule and the peristome in all species of *Bryum* and in closely related genera which I could examine. I name as more exactly examined: *Bryum turbinatum, capillare, crudum, cuspidatum, Pohlia elongata* and so on.*)

*) The unclear and unsteady mode of expression and the insufficiency of the illustrations in the cited work of the Messrs. Bruch and Schimper make it a considerably difficult task to get a clear view about the opinion of the authors on the structure of the peristome as it is found in *Bryum* and, in this regard, related moss genera. It is sure that, generally speaking, they took for cells the thickened parts which build the teeth. Focusing on the information concerning statements on particular cases it is said, for instance, on the details of the characters of the genus *Mnium* (*Bryologia* Fasc. V. p.1): *"Peristomium duplex; exterius dentes 16 valde hygroscopici, lanceolati, truncato-lanceolati, pallidi, e serie unica cellularum in articulationibus intus lamellas, extus trabeculas efficientium conformati, dorso membrana tenerrima, laxe areolata obtecti".* Furthermore, on page 9 it is said: "They (these teeth) namely consist of a series of flat cylindrical cells which are curving on the inside and strongly protruding (?) against the upper horizontal wall, thus the inner-side of the teeth get a strongly lamellate structure. The dorsal side of the teeth is flat, the horizontal walls of the cells appear only weakly. Before the operculum detaches, all teeth are held together by an outermost delicate (?), weakly dotted, pale membrane which, later on, forms on the dorsal side of each tooth a tegument with a wavy longitudinal line and many horizontal lines. The longitudinal line of the tegument, for a long time, has erroneously been taken for the longitudinal line of two teeth grown together." – Firstly, the teeth should be formed of *one* row of cells, these cells should be curved against the upper horizontal separating wall; supposing that the individual thickening parts forming the tooth are cells, so they would be curved not only *against the upper horizontal separating wall* as it is said here and how the illustrations erroneously show it (see e.g. ibid. Tab. IX, Fig. 14, 17, 18), but also against the lower, because lamellae are formed only when the horizontal separating walls of peristome cells also partly participate in the thickening of the outer walls (as it is known to be the case in a lot of thickened outer membranes, as in some species of *Aloe* and so on), and therefore the separating line of the cells divides each lamella into two halves; it seems to me that the expression in the Latin description of the genus character: "***in articulationibus*** *intus lamellas, extus trabeculas efficientium"* is by no means congruent with the here cited extended German description, although the illustrations allow no doubt as to the real opinion of the authors.

The cells on the dorsal side, thus, should hold together by an outermost delicate(!), pale(!) weakly dotted membrane that forms, later on, the dorsal side of the tooth and so on, and the wavy longitudinal line. What concerns this membrane, indeed it exists and namely as membrane, but not as "outermost delicate, weakly dotted, pale" but mostly – at least for the width of the tooth – as *the outermost thick, very dark-coloured and dotted membrane* which often gives the tooth its strongest and darkest colour, and which the Messrs. Bruch and Schimper, if they had been consistent, should have explained that the tooth is built of two cells and consequently each tooth would consist of *two* layers of cells.

The illustrations in the cited work contradict themselves many times; mostly the teeth are shown as if they are composed of one cell layer only, but now and then they show clearly two layers as in *Meesia*, Fasc. X. Tab. II. Fig. 17. and so on. Amongst the big peristome cells they present an enigmatic "middle body" that I have never seen in nature (see l. l. Fasc. V. *Mnium.* Tab. I. Fig. 15. 16).

[original page 582]

FUNARIA.

Funaria hygrometrica.

The formation of the capsule of this interesting moss deviates only a little in not very important factors from the foregoing described.

[original page 583]

As is known, in the lower part of the capsule is as a connection between the columella and the seta formed of a delicate tissue that consists of conferve-like, branched filaments, as I described and drew above under *Gymnostomum pyriforme*. In the upper part appear also sixteen peristome cells, their outer membranes, however, are not as strongly thickened as in *Aulacomnium*, but their horizontal separating walls show, by a relatively strong and elongate thickening on the inner side, broad lamellae or projections (Tab. LXII. Fig. 24). The inner wall of the peristome cells below show a fairly regular thickening, above they constrict to a nearly cylindrical, terete cord, in juxtaposition to the cord on the outer wall (Tab. LXIII. Fig. 25, 26, 27. *tt*.).

The cells of the annulus are very large and are similar to that of *Aulacomnium palustre*.

[original page 584]

Particularly remarkable is a ring-like structure consisting of two layers of cells each composed of horizontally somewhat flattened cells, and connecting the base of the peristome with the outer capsule wall; the cells are dotted, rough, and at the maturity of the capsule coloured brownish-yellow; the wart-like knobs are arranged in regular rows thus, at a low magnification, appearing as spiral thickenings, see Tab. LXII. Fig. 24. *y*.

BARTRAMIA.

Bartramia (Philonotis) fontana Tab. LXIII. Fig. 28.

The capsule resembles in some aspects of the inner and the outer structure that of *Funaria*, but agrees nearly completely with *Aulacomnium* in that which concerns the upper part. The outer side of the peristome cells is, relatively, not so strongly thickened as in *Funaria*, but the outer wall is nearly completely regularly thickened, the cells of the ring-like structure are horizontally flattened and relatively small (Fig. 28. *a*); the gap between the outer capsule wall and the spore sac is very large and interwoven by numerous dainty filaments. Peculiar is a strong layer of small coarse cells as a connection between the layer of peristome cells and the ring-like structure or of the outer capsule wall, Fig. 28. *y*, and besides this, connections between lamellae, built by the partly thickening of the horizontal separating walls of the peristome cells, and rounded deposits of thickening substance in the upper parts of the peristomes, see Fig. 28. *z*.

HYPNUM.

The lower and the median part of the capsules of *Hypnum* and its closer relatives resemble the moss species described since *Phascum* so much that nothing special must be noted. The upper part of the capsule agrees with the inner structure, the **[original page 585]** peristome with the outer one of *Aulacomnium, Bryum* and so on, and differs more or less at the most in the structure of the annulus cells.

I examined the young capsules of *Hypnum commutatum, cuspidatum, stramineum, sylvaticum* and so on, and I add as representative for the construction of this large group of mosses the figures of parts of a longitudinal and a transverse section of a capsule of *Hypnum sylvaticum* in Fig. 29 and 30 on Tab. LXIII.*).

POLYTRICHUM.

The genus *Polytrichum* with its relatives in the family of mosses seems to be isolated what concerns the construction of the upper part of the capsule. The presentation, the structure of the peristome teeth, the appearance of a strange membrane, the epiphragm, connecting the teeth and closing the apex of the capsule are phenomena, which, by a superficially observation cannot be related with those known up to now. Before I describe these particularities I will portray the construction of the lower and median parts of the capsule.

As it is known, in the lower part of nearly all species of *Polytrichum* is a more or less strong thickening which may be taken as an expansion of the seta, the so-called apophysis, see Tab. LXIV. Fig. 31. *ap*. It is built by simple parenchyma cells, of interest only in relation to their arrangement or their position;

*) The author Schleiden also, by the way in his excellent presentation of a transverse section of a young capule of *Hypnum alretinum* has not correctly understood the structure of the outer peristome teeth by presenting them (see Grundzüge and so on Aufl. 2. Thl. 2. S. 74. Fig. 118. *b*) as were they built of complete cells with a strongly thickened membrane.

[original page 586] from the centre, Fig. 31. *ap*, they seem to spread to all sides by moving onto both sides of the epidermis, below towards the seta, and above towards the real base of the capsule. In the centre of this base (Tab. LXIV. Fig. 31. *b*) a column-like structure rises, c, the columella, which upwards widens to a plate-like disc (Fig. 31. *d*); around the columella is the spore sac formed as a hollow, quadrilaterally plicate cylinder, consistent of four cell layers each and the enclosed mother cells or spores (see the schematic presentation of the transverse section Fig. 31*. *sc*). In our presentation (of *Polytrichum piliferum*) the spore sac is separated of the columella by a clearly portrayed hollow space (Fig. 31. *va*) and connected to it only by confervoid-like filaments, but below it rises at the capsule base and is connected above with the disc-like widening of the columella. Again by a considerable gap (Fig. 31 and 31*. *v*), filled with confervoid-like filaments, separated from the spore sac, the outermost point of the outer capsule wall *(me)* can be found, passing above into the annulus and the operculum.

Not in all species of *Polytrichum* is the structure as described herein for *Polytrichum piliferum.* Some of them: *Polytrichum nanum, Catharinea undulata* and so on e.g. deviate in the respect that the spore sac is placed towards the inner side directly at the columella, which means that there is no special gap between the two parts; in all other parts there is no essential difference.

At first, in the upper part of the capsule on the sides of the disc-like widening of the columella a connection to it and the outer capsule membrane or the lower part of the operculum appears, and then the row of the peristome teeth (Tab. LXIV. Fig. 31, 32. **[original page 587]** Tab. LXVI. Fig. 33. Tab. LXV. Fig. 34, 35, 36. Tab LXVI. Fig. 39 *pp* and so on) by two or more cell layers separated from the epidermis. The peristome teeth consist of more or less strong bundles of horseshoe-like thick-walled fibre cells, and their upward pointing ends, growing together with the bundles, form a peristome tooth (compare Bruch and Schimper l. l. *Polytrichum*, describing the construction absolutely correctly) see the longitudinal section Tab. LXIV. Fig. 38. *da*, *eb*, *fc*, the transverse section Tab. LXVI. Fig. 33. Tab. LXV. Fig. 34, 35, 36. Tab. LXVI. Fig. 39. *pp*. Between the teeth, when the capsule is not yet deteriorated, appear considerably delicate, also somewhat bent, cells, see Fig. 34, 35, 36, *ip*.

Above the disc-like widening of the columella or between this structure and the loose parenchyma of the operculum extend, connecting the points of the peristome teeth, a layer of cells, that are relatively small, horizontally flattened, and their lower membrane is granular and roughly thickened. At the moment of the spore maturation, these cells form, when the operculum detaches, the epiphragm, by destruction of the thickened cell parts arranged immediately above and below it. The disc-like widening of the columella below shrinks and dries out, and the loose parenchyma above detaches with the operculum.*)

*) In the paper of Robert Brown's Abhandlung 1[sic, should be Volume 2, eds.]. 1. p. 715 is said the following: "most of the author's would have found very small connecting pores in the tympanum of *Polytrichum.* I never could discover the pores, but in some cases I noted a formation which perhaps induced the belief in their existence, namely a delicate network at the outer side of the membrane which visibly originally belonged to the cells of the inner surface of the operculum." It is clear that here is meant the separating lines of the cells and the wart-like knobs on the lower wall of the cells forming the epiphragm (Fig. 32 and 36. *ep*), which have been overlooked by the otherwise so perspicacious researcher. – In Bruch and Schimper in *Bryologia Europaea* I could find nothing about this.

[original page 588]

A partly granular thickening, shown by the cells constituting the epiphragm, is found also in the cells that delimit the peristome teeth on the outer and inner sides as well at those cells connecting the base of the peristome teeth with the annulus, see Tab. LXIV. Fig. 32. *xp*, and finally on some cells appearing between the upper part of the disc-like widening of the columella and the outer capsule membrane immediately below the peristome teeth, Fig. 32. *yp*.

When the spores are mature the membranes of the above described thickened cells decay into pieces, beginning at the annulus Fig. 32. *a,* at both sides of the peristome teeth p, and then below and above of the epiphragm *ep.* The complete upper part of the operculum detaches whilst the columella shrinks and the delicate tissue between the peristome teeth disappears, giving the spores that pour out of the destroyed spore sac a way out of the closed inner space of the capsule.

Comparative compilation of the above described facts besides some notes on them

A superficial view of the observations described above already shows, besides some minor differences, a great congruence in the main traits of the construction of the examined moss capsules. Apart from the fact of its **[original page 589]** morphological significance which may be established, probably only by a thorough investigation of the developmental history, the moss capsule appears as a simple structure of cells, in which minor modifications in construction are the result of insignificant, partly interior separations of individual groups of cells from others, and also by the lack or presence of more or less stronger thickenings of membranes in certain cell layers.

If at first sight *Polytrichum* seems to deviate essentially from the other genera, so a closer examination will show that this difference is, in fact, rather more an artefact than real.

The lower and the median part of the capsule, so important it is, namely for the spore formation, is so uniformly constructed that only minor differences in the different genera may be observed. Only somewhat deviating but obviously also the most simple is that of *Sphagnum.* In a spherical or egg-shaped cell body is a layer of mother cells running nearly from the base along the circumference to the point where the spores are produced by repeated cell formation; at first it is surrounded by a layer of small, densely filled cells with chlorophyll and other contents, the spore sac, whilst the other tissue consists of regularly formed, large and thin-walled cells that become smaller only near circumference and traverse the outer membrane cells with considerably thickened outer walls. Not far below the apex of the capsule, before the complete development of the spores, a slender ring-like constriction is formed where the cells of the outer membrane cells are smaller and die off earlier than in the other parts.

By the repeated formation of new cells in the mother cells for the production of spores inside the spore sac, in a period where the growth of other parts of the capsule **[original page 590]** has mostly ceased, the spore sac becomes strongly widened and as it presses the surrounding tissue the capsule gets caught in a state of tension, under which the small, already dead cells of the outer membrane located in the ring-like constriction (the outer membrane seems to procure to the moss capsule the greatest stability), as well as the delicate tissue located below it, has no sufficient resistance, so that the part of the capsule above the constriction can be detached as operculum and the mass of the spores comes out freely.

In other moss genera the layer of the mother cells in the spore sac does not completely reach the apex of the capsule but it remains, running from the base up to the outermost apex of the capsule, as a column composed of loose tissue, which surrounds it closely in form of a hollow cylinder. Outside of the spore sac, normally consisting of two layers of cells, is mostly (but not always) a more or less large air hole, and then follow some layers of parenchyma with the outer membrane.

Some species of *Polytrichum* deviate from this structure in so far as a gap is formed between the columella and the spore sac, thus it is free on both sides and connected only below and above with the other tissue.

The air hole between spore sac and the outer membrane of the capsule is connected with the atmosphere by more or less numerous stomata, normally distributed at the base of the capsule but sometimes also over the outer membrane below the annulus (e.g. *Orthotrichum*).

Some mosses show a swelling at the lower part of the capsule or the upper part of the seta, the apophysis. Its construction is very simple and its importance seems to be very insignificant, so I will not discuss it further.

[original page 591]

The only exception is *Phascum*, the capsules of this species deteriorate irregularly, but even its upper part is essentially similar to the other mosses, as in *Sphagnum*, a part from relatively unimportant differences in the structure (which I will discuss explicitly below). This upper part as well is marked by the ring-like cell layer of the epidermis which detach under the pressure on the capsule caused by spore formation.

That the formation of the spores causes a really important tension in the moss capsule, resulting in its destruction becomes clear by the following considerations. The examination of a completely grown capsule of *Gymnostomum pyriforme* with spores that were not yet totally formed shows, in the lower part of the columella, a loose confervoid-like tissue that appears to be tightened at that stage; at the same time a conspicuous large gap between the outer capsule wall and the spore sac is visible. Later on the spore sac is enlarged, the lower tissue is already considerably compressed, the gaps become less clear and also the big air hole is smaller and finally, when all spores are formed, the lower loose tissue is mostly totally compressed, and because all gaps in it have disappeared, it is at first sight like a closed parenchyma, and the big air-hole partly or totally disappears or becomes considerably smaller.

In other mosses also, which, in a completely grown but still young capsule show a considerable gap between spore sac and the outer capsule wall, and in an older state, when all spores are formed, **[original page 592]** the gap disappears as well as the loose cell filaments.

Given the diversity of the construction of the elementary organs, the upper part of the capsule above the spore sac, as simple as its function may be when compared to the lower part, surpasses the lower part considerably. A closer examination of the differences and particularities of the individually examined moss genera is not only important for the systematic organization, but also provides interesting contributions to the teaching of the life and shape of the cell of a plant in general.

Let us take a fleeting glance at the main points once again. In *Phascum* it was noted that the apex of the capsule consists of a simple, regular cell tissue, that on its outer membrane cells no formation of an annulus is to be perceived, and that the point therefore does not detach as an operculum.

Gymnostomum has a more or less clearly developed annulus construction; the apex of the capsule detaches at the moment of the spore maturation as the operculum, and in addition it contains a regular parenchyma.

Tetraphis detaches via the outer membrane above the annulus as an [Oberhaut] operculum, the cell tissue located in the inner capsule, the two outer layers of which consist of significantly smaller, considerably thickened cells, divides into four parts.

The complete series from *Weissia* to *Hypnum* offers so many interesting phenomena, that a more precise study would allow us to see in a favourable light the nature of the construction of the moss capsule, and this study will take quite some time.

All mosses presented here agree by the following main factors: At first appears immediately above the gap between the outer capsule wall and the spore sac a circular wall of **[original page 593]** sixteen or thirty two relatively large cells, which, as we have seen above, build the peristome teeth by partly thickened membranes and by forming thickened cords. Partially thickened only are the inner membranes (orientated towards the inner side of the capsule), partly only the outer ones (species of *Orthotrichum* which have no inner peristome, such as *Orthotrichum anomalum* and so on), and also partly more or less the inner and the outer ones, and in these cases every time the neighbouring cells participate.

This cell layer, located near the centre of the capsule, is limited by a layer of relatively small cells *(tt)* followed by a layer of mostly very big, somewhat transversally elongated cells *(qq),* and followed at least, in the middle part, by a delicate, regular tissue *(cc).* On the outer side as well a layer of mostly relatively small cells is added, the membranes of them very often or mostly have a granular and roughly thickened surface; this is followed on the outer side either immediately by the outer membrane or by two or more layers of considerably small, sometimes somewhat thickened cells.

Below, about at the height of the annulus, the layer of the peristome cells is connected by a considerably stronger tissue than the spore sac and the outer capsule wall as well. Already above we have seen that by the deterioration of the capsule, the cords are preserved in the layer of the peristome cells; I will not repeat the listing of the minor structural differences, but I will add some comments on the structures generally speaking:

The position of the peristome cell layer already makes it clear that neither for the single nor for the double **[original page 594]** peristomes can it be said that they originate from the *"inner or outer capsule membrane",* if in the moss capsule such organs could ever be supposed. The appearance of the layer of the peristome cells above the gap between the outer capsule membrane and the spore sac renders superfluous all further discussion about it; the peristome or the thickening cords after the deterioration of the capsule are connected to that part, with which they are joined the most intimately, such as, for instance, the peristome of *Dicranum* to the outer capsule wall, and although, following its position comparable with that of *Orthotrichum anomalum,* it may be considered as an inner one.

Supposing it really exists in the moss capsule, "inner and outer capsule walls" as special organs, a glance to the given figures is sufficient to see that at the same height as the annulus cells, these walls become completely undifferentiated, caused by the interposed layer of peristome cells. Their place will be occupied by a very simple tissue showing no morphological differentiation. *).

Especially noticeable in the group of mosses treated here is the regularity of the numerical correlation of the peristome teeth that appears in *Tetraphis* as well as in *Polytrichum* and has always been regarded as important and interesting, even as enigmatic. The repetition of the number four and its multiples provoked various considerations and persuaded R. Brown to accept the number thirty-two as the cardinal number. Later on his opinion has been rejected, and since the question has remained totally unsolved.

The following considerations may indicate how to clarify these interesting phenomena.

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*) Compare Schleiden: Grundzüge, Aufl. Th. 2. at the cited place.

[original page 595]

On regarding meticulously the figure of the transverse section of *Anacalypta rubella* (Tab. LVII. Fig. 6) it becomes clear that above each of the large peristome cells *(pp)* are arranged two cells of the layer pointing outwards *(rr)* and above it once again two cells (therefore there are four cells above each peristome cell) of the outer cell membrane. The same may be stated very regularly in *Barbula fallax* (Tab. LVIII. Fig. 9).

A transverse section of *Weissia fugax* shows, above each peristome cell, two of the following layers and four of the epidermis, another section shows two epidermis cells.

The upper part of the capsule of *Ceratodon purpureus* (see the figure of the fourth part of it, Tab. LXVI. Fig. 40) has regularly, in the centre, four big cells, therefore one cell for the fourth part (Fig. 40. *c*), followed by two cells *(d),* and then by four *(ff),* and then alternatively by four cells *(tt),* and then once again, four peristome cells *(pp);* the following outer cell layers for each peristome cell have two, then four cells, and finally four cells for the epidermis.

Dicranum, in Tab. LVIII. Fig. 11., has two peristome cells each, united in pairs, outside of them once again is a subsequent layer, then a layer of four cells and finally considerably regularly eight epidermis cells. A similar regularity, with other numbers, are visible in the figures of *Dicranum* in Tab. LVIII. Fig. 12. and 13. and as well in transverse sections of *Splachnum, Aulacomnium, Hypnum, Funaria* and so on.

The complete upper part of the cell tissue of the capsule of *Tetraphis* regularly divides into four parts; seen by meticulous observation, these parts are regularly structured; on the outer side of each part are to be seen, see Fig. 5. Tab. LVII. sixteen, in Fig. 4. eight cells of the outer cell membrane.

[original page 596]

The outermost cell layer of the teeth itself consists in Fig. 5. of mostly sixteen, in Fig. 4. of mostly eight cells.*).

In a transverse section of the uppermost part in the centre of the capsule of *Weissia fugax* four cells are frequently visible; in many mosses I stated the same structure in the apex of the operculum.

Even by its different structure, by the relatively great number of its inner organs, e.g. of the peristome teeth, *Polytrichum* has the same regularity in the numerical correlation.

The totality of these phenomena speaks, in my opinion, for an immensely regular process, originating in a centre and progressing, by a repeated development of two to four cells each, to the construction of the mother cells: this is why the only sure way to find an explanation is a conscientious study of the history of the evolution.

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*) Robert Brown, the perspicacious researcher, noted for the support of his opinion that the cardinal number in the numerical correlations of the peristome teeth is thirty-two (see above) l.l. p. 738: "Even *Tetraphis pellucida* may be taken of proof for the predominance of this number at the orifice. Each of the four teeth namely shows seven longitudinal strips and the result would be the real number of thirty-two and so on." On the other hand the authors of *Bryologia Europaea*, Bruch and Schimper, fasc. XXII, *Tetraphis*, p.4, say: "The longitudinal ribs on the dorsal side of the teeth change in number from 8 to 14 and therefore cannot be considered as dividing lines. And besides, the structure of the teeth is such, that their layout for the number thirty-two is absolutely not expressed, just as in the peristome of *Buxbaumia aphylla*, the structure of which is somewhat similar to the teeth of *Tetraphis.*" (??) – And later for *Tetrodontium:* "There is no trace of an indication that each tooth consists of eight teeth because the number of the longitudinal ribs is not fixed, sometimes there are six, nine and more." – In the cases where the number of the small cells is not exactly eight or sixteen and so on, it is at least the place and the relative size of the cells that indicate the extraordinary regularity of their building, and it is difficult to decide what should be more admired, the perspicacity of R. Brown or the superficiality of the observations of the Messrs. Bruch and Schimper, where these clearly visible characteristics were, once again, overlooked.

[original page 597]

The relative size and the low number of the peristome cells may be the reason that these cells, whilst building the capsule, cease to produce cells in themselves at the moment when the thickenings of the membranes begin to develop.

In my opinion as interesting for the complete evolution of the peristome construction in this group, the following should be noted.

Even when the capsules of one and the same moss species show in their inner construction the same type, they differ in small points from each other that sections of one capsule are never exactly the same as that from another capsule, and often one side of a cutting differs from the other side. Regarding e.g. the figure of the longitudinal section of *Dicranum scoparium,* then we see the left side (Tab. LIX. Fig. 14) differs in some points from the right one. Particularly important, however, is the following: on the right side of the same figure are visible on the left below the peristome cells some cells with thickened coloured membranes and even that some cells of the layer neighbouring the peristome cells inner-sides have their membranes partly thickened *(tt);* if this thickening would have been somewhat stronger or more connected, *Dicranum scoparium,* in this case, would have an inner peristome (although the capsule seen in the transverse section immediately by the differing position of the cells would have been recognized as differing from others with a double peristome). It is easy to recognize that the presence or the absence of a delicate inner or outer peristome depends on the external circumstances influencing the growth of a moss, as well as in one and the same moss species growing in sunny, dry habitats which have developed a stronger thickening **[original page 598]** of the leaf cells as those in a humid and shaded place.

The species of the genus *Eucalypta (sic),* that unhappily I could not thoroughly examine, in this respect, seem to me to be immensely interesting; their normal peristome, as I could see but in a few examinations, is in its construction and position analogous to the peristomes of *Weissia* and *Barbula* and so on, meaning that it consists of thickened cords of the inner peristome cell wall; but in the cases were an inner peristome is still present, it will consist of the thickening of the opposite wall of the small cells neighbouring the peristome cells on the inner side, therefore analogous to the above described formation of *Dicranum*.

Given the above stated considerations, it appears, at first sight, that the peristome of *Tetraphis,* following its construction and morphological significance, does not have any analogy with the mosses of the above described group. The two outer layers, consisting of small cells, seem at best to be analogous to those, located between the peristome cell layer and the epidermis.*).

What about *Polytrichum* with its numerous teeth, built of bent bundles of fibre cells and the epiphragm? Is its construction unique or may it be attached to the form of constructions as they appear in other mosses?

I dare to voice the following suppositions, which I have to name suppositions because they are based on fragmentary, unsure observations.

*) All the more wonderful is the assertion of the Messrs. Bruch and Schimper that they "begin considerably far below the capsule mouth from the loose layer of cells of the inner capsule wall."

[original page 599]

The peristome teeth of *Polytrichum* consists of horseshoe-like, upwardly bent bundles of thickened fibre cells; the middle part of these bundles therefore is horizontally arranged whilst the both ends are bent upwards (see Tab. LXIV. Fig. 38). The cells which are between these bundles, it means in the space created by the curvature above the horizontal parts, take part, more or less, in the curvature. This put the idea in my head that the curvature may be the effect of a relatively strong extension in the length of the cells forming the bundles after their development (as the comparably similarly built fibre cells in phanerogams and higher cryptogams are characterized by a rapid and strong extension mainly in one dimension), and that perhaps the original position is completely horizontal. Because, however, at least the middle part of them is always horizontal, I would take them, even when initially they had been bent, for analogous with those strong layers of cells located at the base of peristomes of other mosses, e.g. the striate-granulously thickened cells of *Funaria*, the thickened cells of *Philonotis*, of *Dicranum*, in addition the dense tissue which in all mosses is more or less clearly visible, located at the base of the peristome, about at the same height as the annulus.

The epiphragm seems to me to be an analogous phenomenon, by the often more or less clear presence of horizontally expanded cells at this height of the capsule in several other mosses (see e.g. *Dicranum Schreberianum*, *Fissidens* and so on). Even *Phascum* (Tab. LVI. Fig. 2.) shows, at the appropriate place, a relatively dense tissue. A brighter light could perhaps be shed on this by a more precise examination of some species of *Gymnostomum,* and particularly of *Hymenostomum*, which unhappily I could not conduct.

[original page 600]

The peristome of *Polytrichum* should not be placed together with the peristomes of mosses that have large peristome cells, not even with that of *Tetraphis;* in a strongly artificial system based on the structure of the capsule, *Polytrichum* rather would find its place in the sequence of species with *Gymnostomum* and *Hymenostomum.*

I draw attention to the granular thickening of the cell membrane, that appears often in a moss capsule. Not alone in the group of mosses with sixteen and thirty-two peristome cells, all peristome teeth are thickened on the exterior side in the same way, but the neighbouring cells have this thickening mostly in the later, older stages. In *Polytrichum* it is located in a cell layer – running from the annulus on both sides of the peristome – and also in those cells forming the epiphragm.

It seems that it appears very late in the development; it seems that the formation of this layer is the last sign of life of the cells, afterwards they die off, become brittle and tear easily. Cells thickened in such a way are the first to disintegrate when the operculum detaches.

I think it is not necessary to emphasize once more the influence that the results of the currently described examinations may have on the systematic arrangement of the mosses; I stressed sufficiently the resulting artificial groups as well as the characters that revealed to be important for the individual genera, and therefore I will only add the note that it seems to me that the inner structure of a capsule is an important element for the identification of a species. In all good species I found in the construction essential differences to other related, clearly defined species, on the other hand in some varying species I could not recognize differences. As an interesting example I cite here *Dicranum*. In the spring of 1846 I found in the proximity of **[original page 601]** Göttingen a large quantity of a moss which is exactly halfway between *Dicranum varium* and *Dicranum Schreberianum;* a subsequent anatomical examination of the capsules of the two supposed species confirmed completely the identity of them, the capsules were absolutely of the same construction, the related *Dicranum rufescens*, however, differed noticeably by its inner structure (compare the figures of *Dicranum varium* and *Dicranum Schreberianum* on Tab. LX. Fig. 15, and of *Dicranum rufescens* in Fig. 16).

Explanation of the figures

Table LVI.

Fig. 1. Half of a longitudinal section of a young capsule of *Sphagnum acutifolium,* magnification ~x 135. The signification of the letters is given in the text above. The capsule was still hidden between the perichaetial leaves.

Fig. 2. Half of a longitudinal section of a mature capsule of *Phascum cuspidatum,* magnification ~x 300. Signification of the letters in the text.

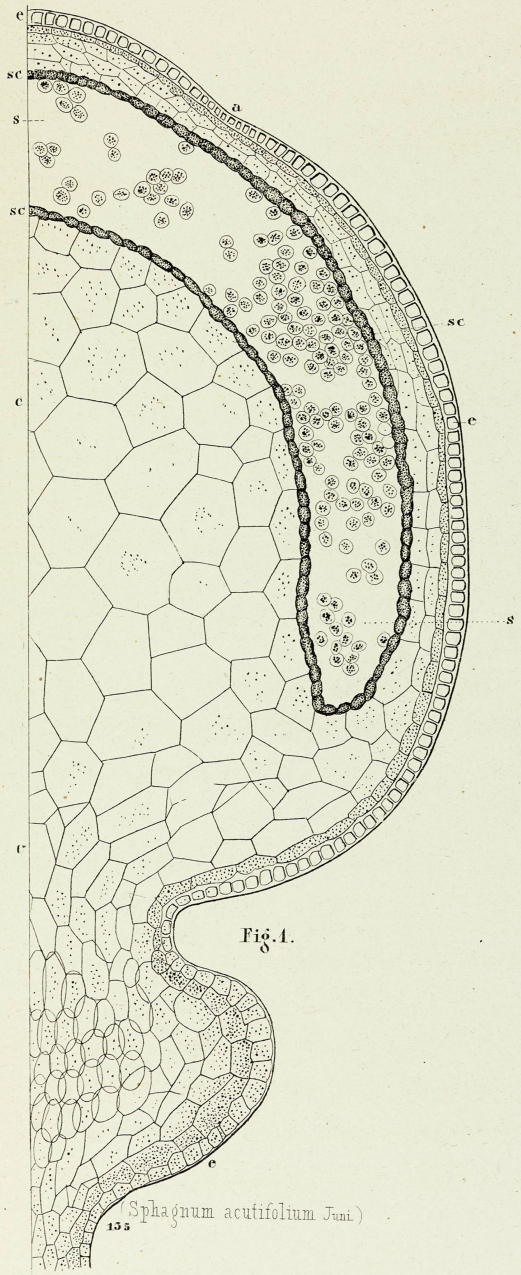


Fig. 1.

(Sphagnum acutifolium Juni.)

(Phascum curpidatum Aug.)

Fig. 2.

Table LVII.

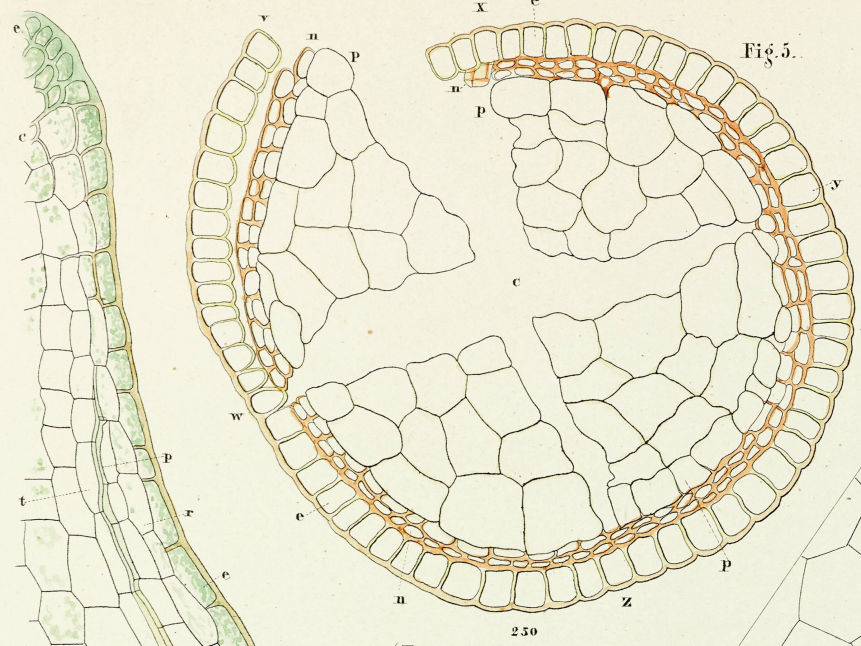
Fig. 3. Half of a longitudinal section of a mature capsule of *Gymnostomum pyriforme;* it is to note that the loose tissue at *y* is the lower part of the columella, which is, in a younger state, strongly tightened, slackens more, as presented, when the spore sac is more expanded, and is totally compressed by the complete development of the spores. See the additional remarks in the text. Magnification x 135.

Fig. 4. Half of a transverse section of the upper part of a not yet decomposed capsule of *Tetraphis pellucida,* magnification x 250.

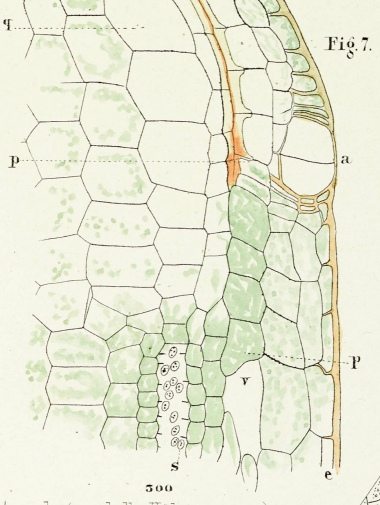
[original page 602]

Fig. 5. Transverse section of a somewhat older, already partly decomposed capsule of the same moss, not far above the annulus and executed lower as in the previous figure. Magnification x 250. See the text.

Fig. 6 and 7. Parts of a transverse and a longitudinal section of a fully grown but yet young capsule of *Weissia curvirostra* Hedw. (*Anacalypta rubella* Hübener). Magnification ~x 250 of the transverse section, ~x 300 of the longitudinal section.



(Tetraphis pellucida Juli.)



(Anacalypta rubella Hübener Juli.)

(Gymnostomum pyriforme Juni.)

(Anacalypta rubella Hübener Juli.)

(Tetraphis pellucida Juli.)

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Tab. LVIII.

Fig. 8. Part of a transverse section of a young capsule of *Barbula tortuosa,* magnification x 250, and

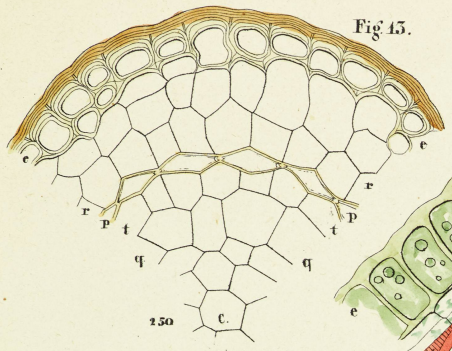
Fig. 9. of a mature capsule of *Barbula fallax,* magnification x 500. Further explanations are in the text.

Fig. 9*. Part of a transverse section of a young capsule of *Syntrichia subulata. ee* epidermis, *me* outer capsule wall, *v* gap between outer capsule wall and spore sac, *sc* spore sac, *cc* columella, *s* mother cells with nuclei, *x* row of mother cells, exceptionally found in the tissue of the columella.

Fig. 9**. Schematic longitudinal section of the same capsule.

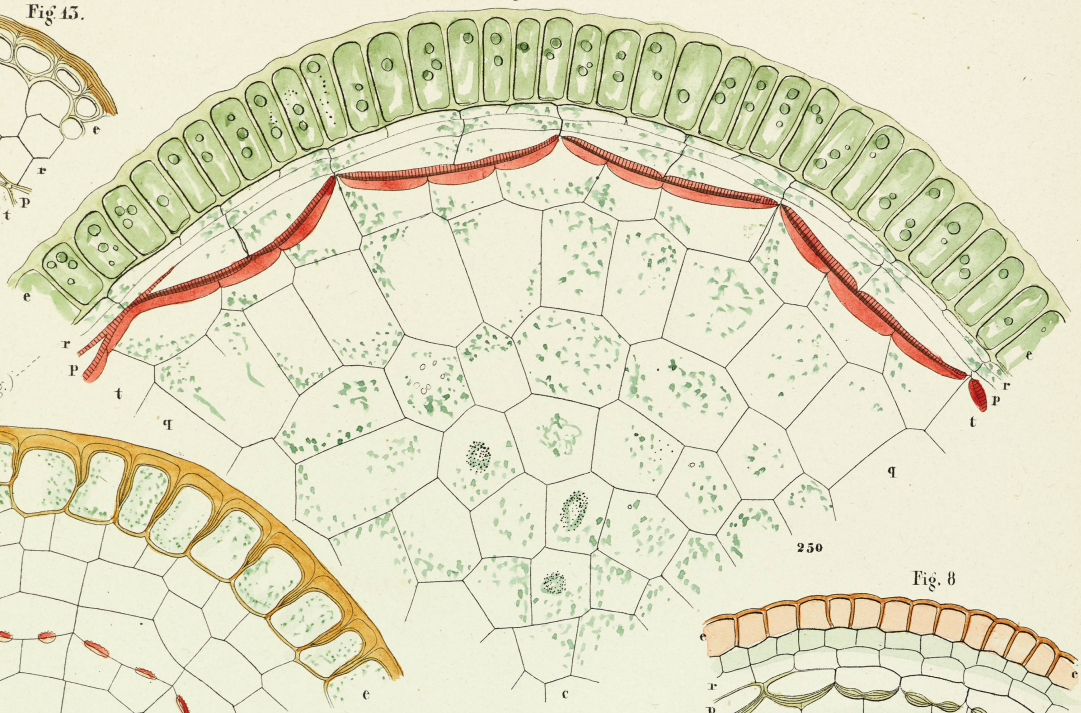
Fig. 10-13. Sections of mature capsules of *Dicranum scoparium.* Fig. 10. Part of a transverse section of the same capsule at the base of the peristome. Fig. 11. The same, somewhat above the annulus, Fig. 12. Part of a transverse section above the separation of the peristome teeth, and Fig. 13. At the place where the peristome teeth disappear.

Fig. 13.



(Ditranum scoparium Aug.)

Fig. 11.



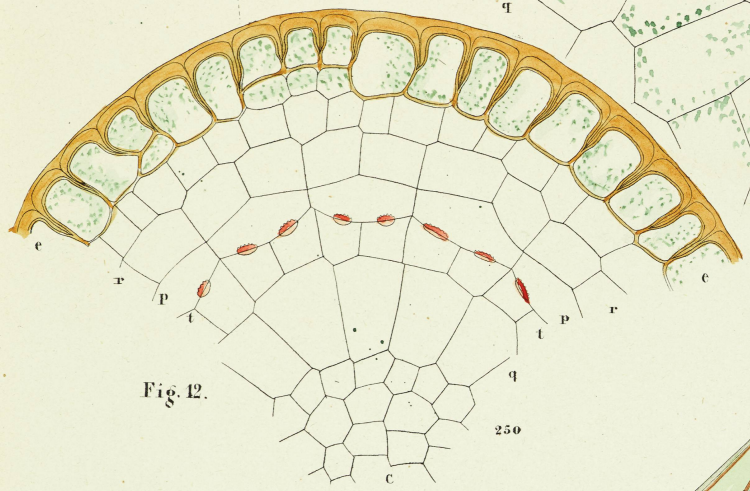
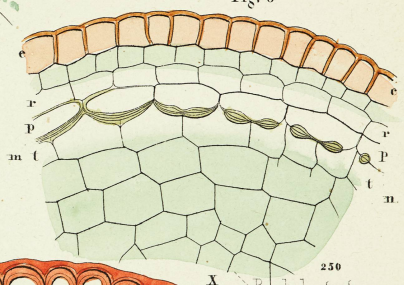
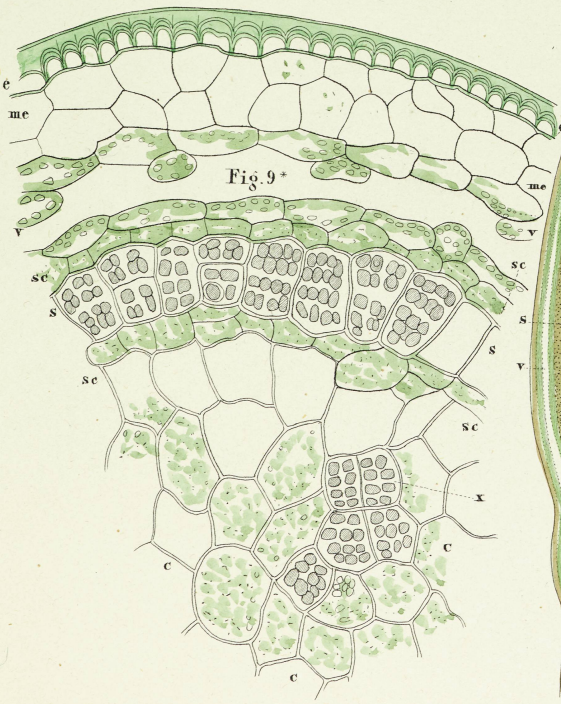


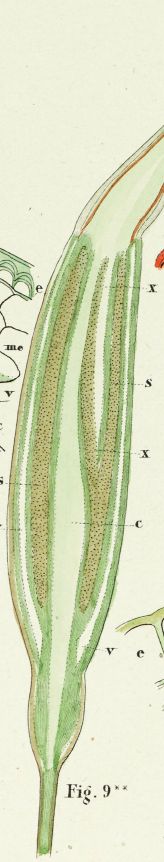
Fig. 12.

Fig. 8



Barbula tortuosa.





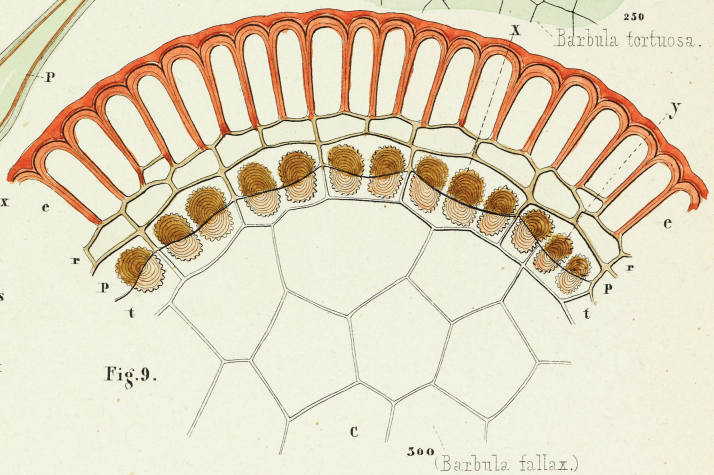


Fig. 9.

(Barbula fallax.)

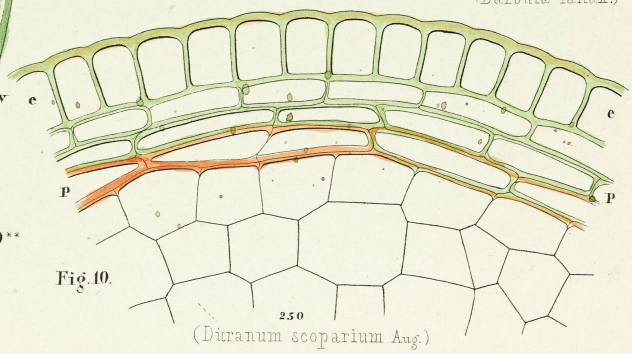


Fig. 10.

(Ditranum scoparium Aug.)

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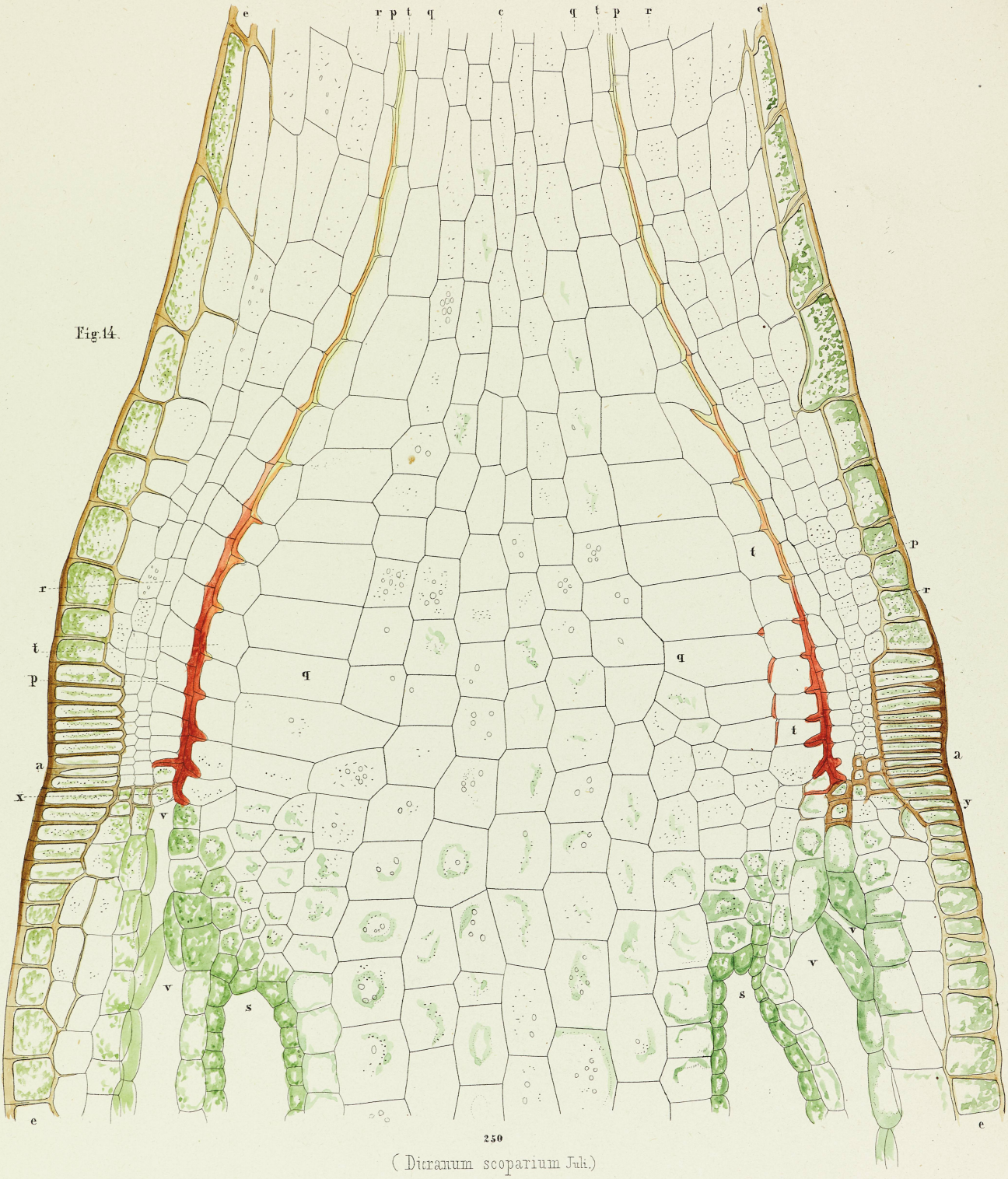
Table LIX.

Fig. 14. Part of a longitudinal section of such a capsule above and below the annulus. All figures by a magnification x 250.

Fig. 14.



(Dicranum scoparium Juk.)

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Table LX.

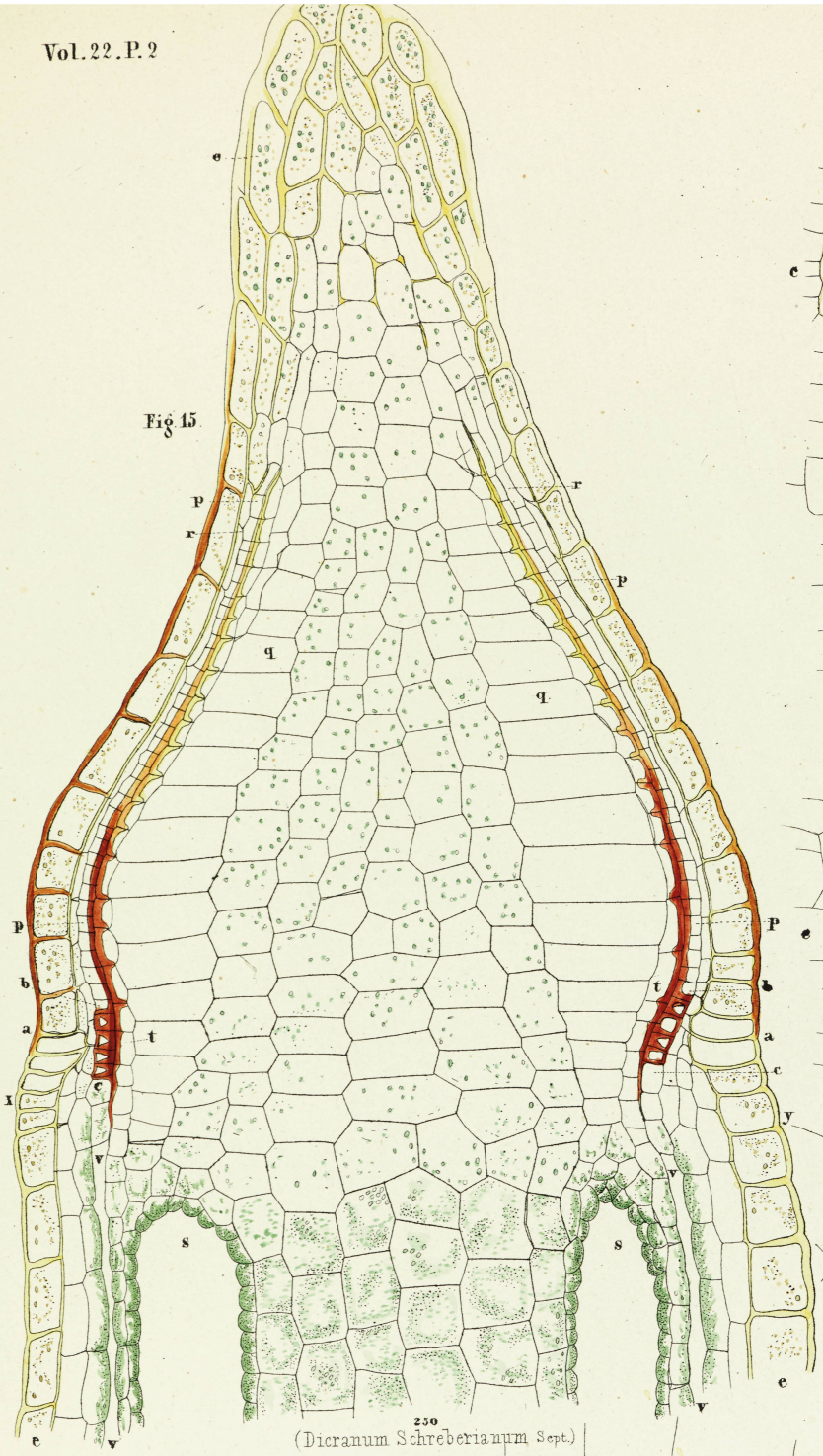
Fig. 15. Longitudinal section from the upper part of a mature capsule of *Dicranum Schreberianum.* The capsule is somewhat lopsided (uneven), insofar as on the left side at *x* some cells protrude more than on the other side at *y.* Magnification x 250.

[original page 603]

Fig. 16. Part of a longitudinal section taken from the side of a capsule of *Dicranum rufescens* presenting the base of the peristome and surrounding area. Magnification x 500.

Fig. 17. Part of a longitudinal section of a capsule of *Fissidens adianthoides*. Magnification x 175.

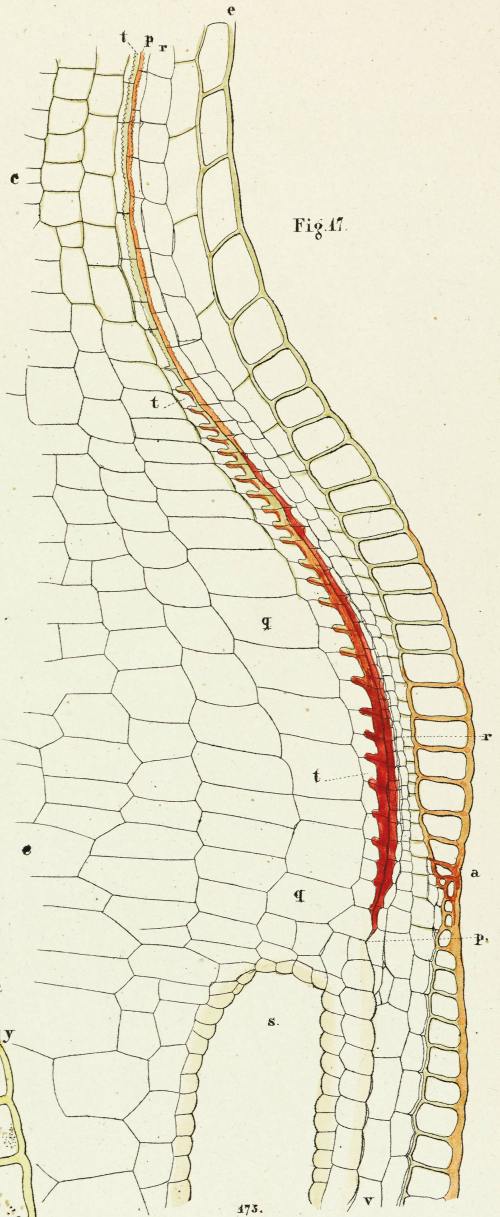
Fig. 15.



250

(Dicranum Schreberianum Sept.)

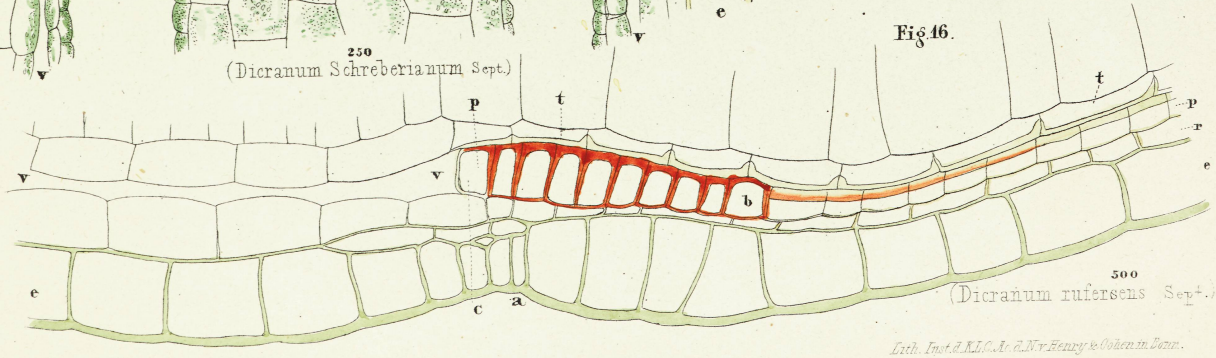
Fig. 17.



175.

(Fissidens adiantoides Dec.)

Fig. 16.



500

(Dicranum rufescens Sept.)

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Table LXI.

Fig. 18. Part of a transverse section below

Fig. 19. and above the annulus of a capsule of *Splachnum sphaericum.* Magnification x 250.

Fig. 20. Part of a longitudinal section of the same capsule and the same magnification.

Fig. 18.

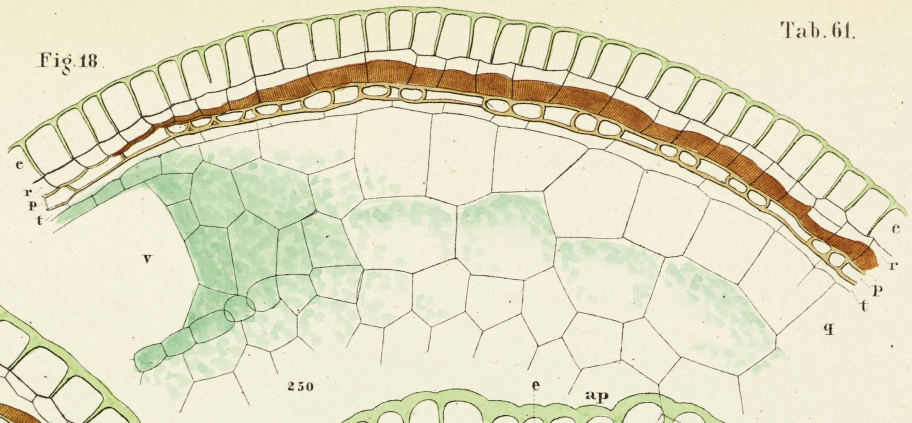
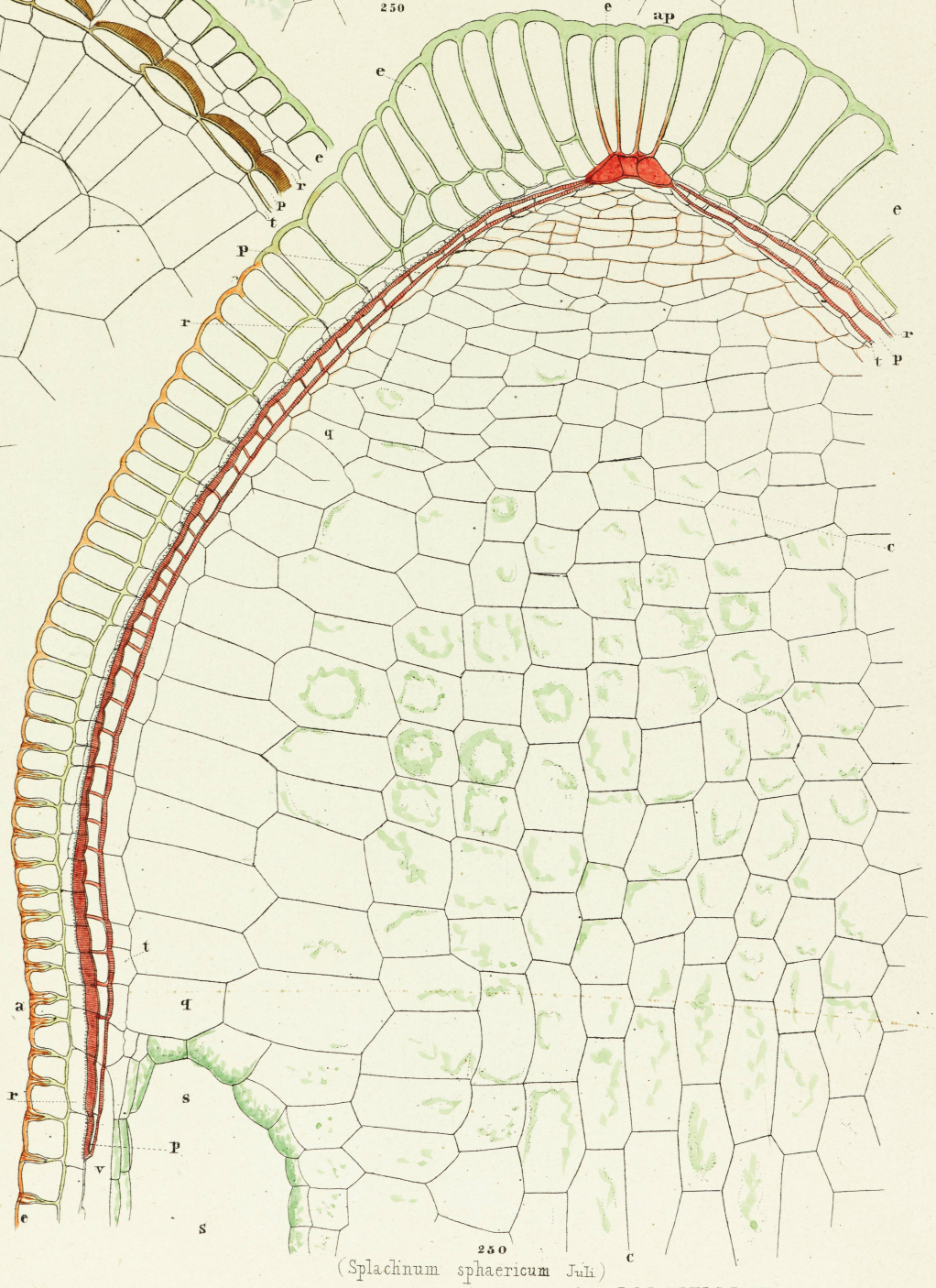


Fig. 19.

Fig. 20.



(Splachnum sphaericum Juli.)

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Table LXII.

Fig. 21. Part of a transverse section of a capsule of *Orthotrichum affine (pumilum).* Magnification x 700.

Fig. 22. Part of a longitudinal section, and

Fig. 23. of a transverse section of a capsule of *Aulacomnium palustre,* magnification x 170, for both. To notice is at the thickening of the outer peristome cell wall in Fig. 23. *pp* the dark part *x* and the bright part *y; x* shows the average strength of the tooth, *y* the lamella; compare the same letters in Fig. 22.

Fig. 24. Part of a longitudinal section of the upper half of a capsule of *Funaria hygrometrica.* Magnification x 250.

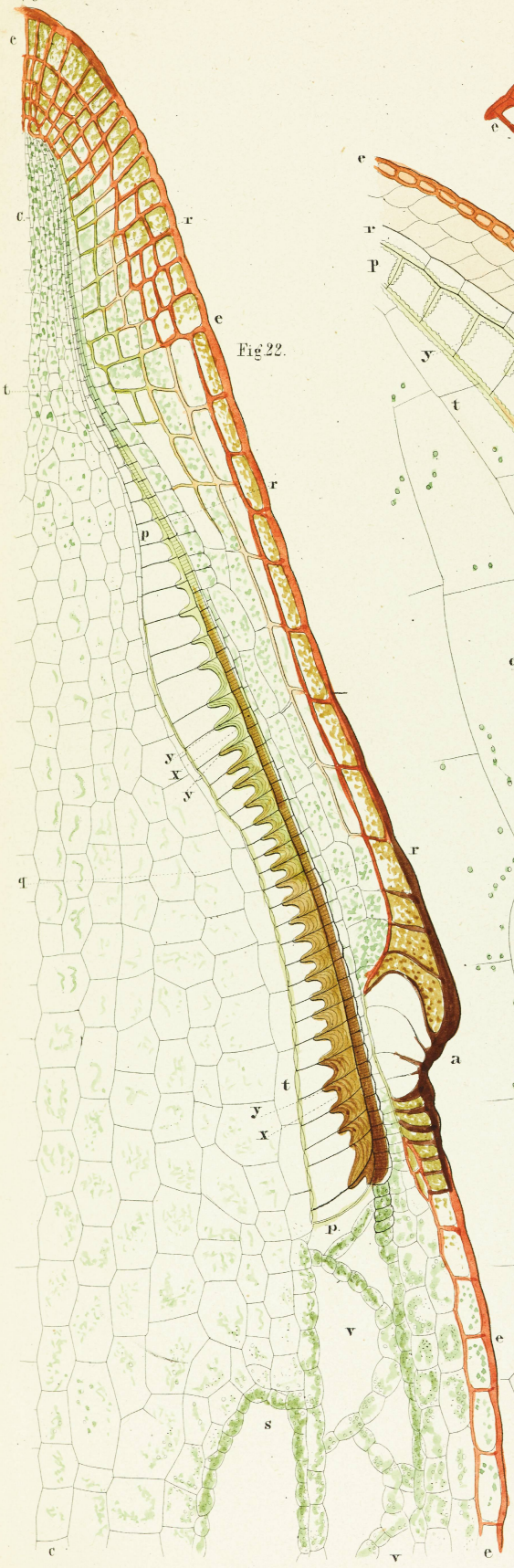

Fig. 22.

(Aulacomnion palustra Aug.)

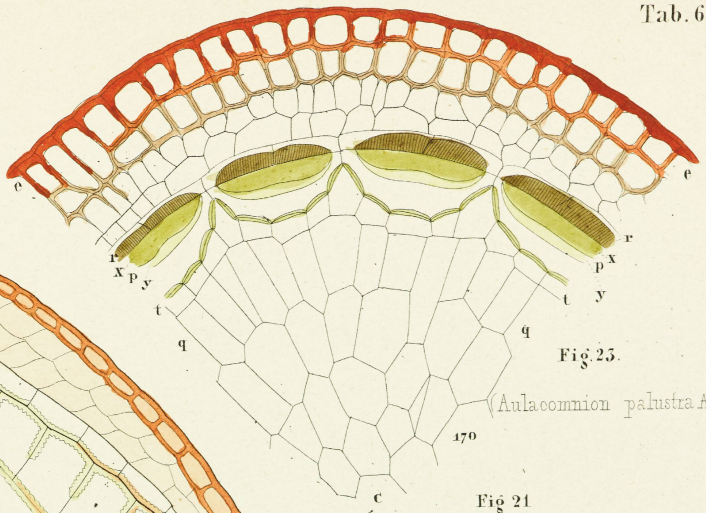

Fig. 23.

(Aulacomnion palustra Aug.)

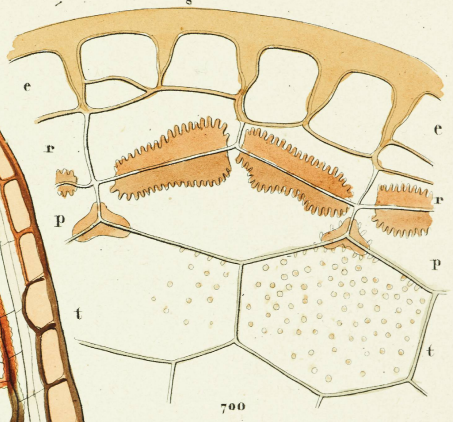

Fig. 21

(Orthotrichum affine Apr.)

Fig. 24.

(Funaria hygrometrica Aug.)

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Table LXIII.

Fig. 25-27. Transverse sections of the peristome cell layer of the same moss capsule; Fig. 25 of the base of the peristome, Fig. 26 somewhat higher up, and Fig. 27 again higher up. Magnification x 250.

Fig. 28. Part of a longitudinal section of the upper half of a capsule of *Bartramia fontana*. Magnification x 170. Signification of the letters in the text.

Fig. 29. Part of a longtudinal section, and

Fig. 30. of a transverse section of the upper half of a capsule of *Hypnum sylvaticum*. Fig. 29 magnification x 250, Fig. 30 x 170.

(Funaria hygrometrica Aug.)

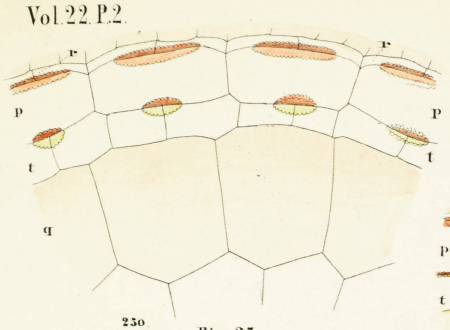


Fig. 27.

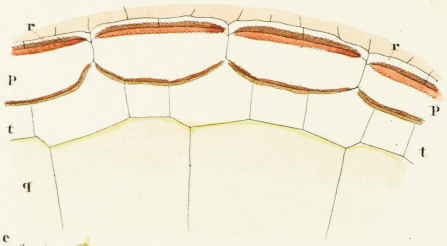


Fig. 25.

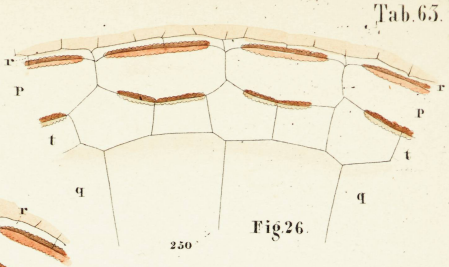


Fig. 26.

Fig. 28.

(Bartramia fontana Jan.)

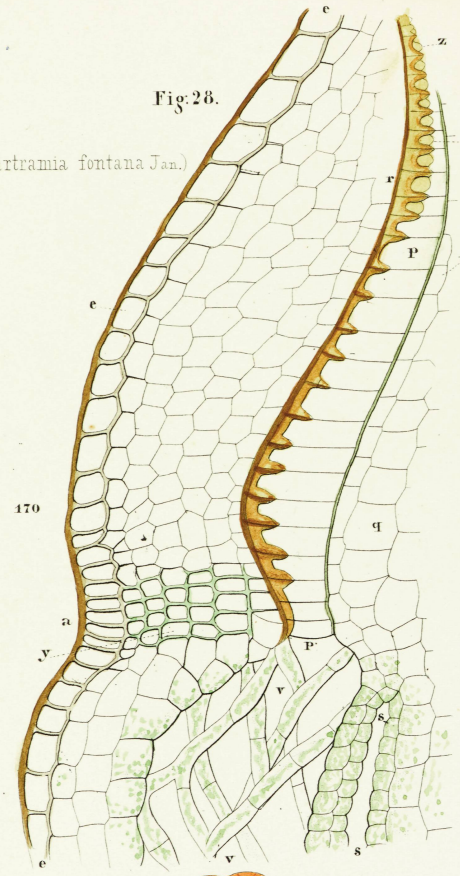
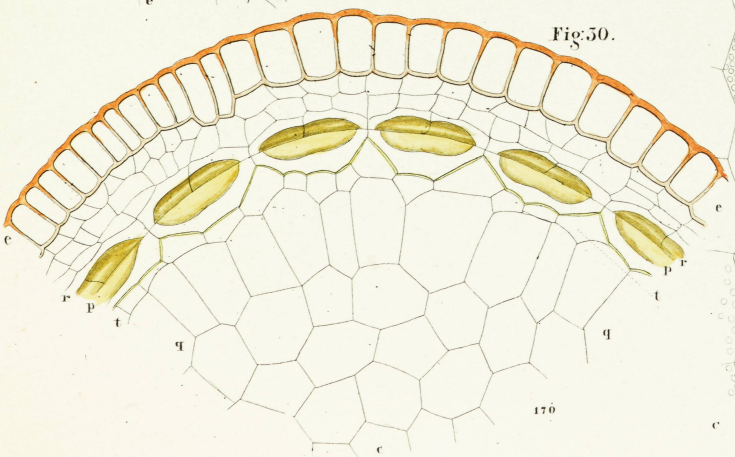


Fig. 29.

Fig. 30.



(Hypnum syloaticum Aug.)

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[original page 604]

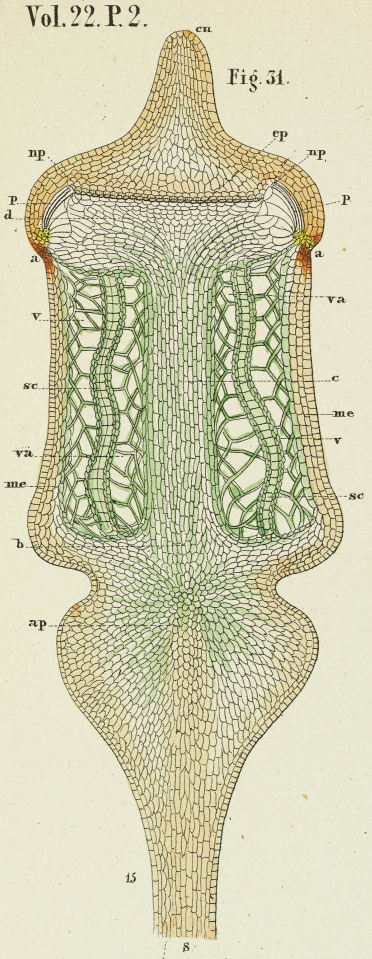
Table LXIV.

Fig. 31. Longitudinal section of a capsule of *Polytrichum piliferum,* magnification x 15, Fig. 31* Schematic presentation of the central part in transverse section.

Fig. 32. Part of a longitudinal section of a capsule of *Polytrichum commune* presenting the peristome and its nearest surrounding area, magnification x 250.

Fig. 38. Peristome teeth of *Polytrichum commune* with its cell base, magnification x 250.

Fig. 31.



(Polytrichum piliferum Aug.)

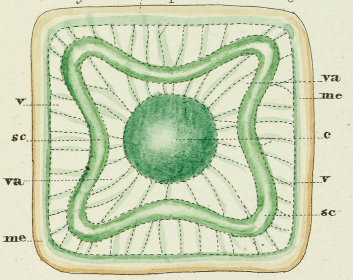


Fig. 31.*

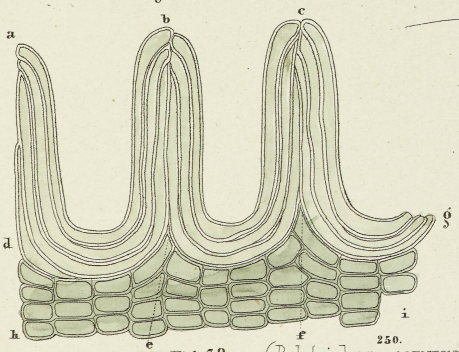


Fig. 38 (Polytrichum commune Aug.)

Fig. 32.

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Tables LXVI and LXV.

Fig. 33.-37. Transverse sections of capsules of the same moss and the same magnifications.

Fig. 33. At the base of the peristome, Fig. 34. At the middle of the peristome, Fig. 35. At the point of the peristome, and Fig. 36. of immediately above the peristome; Fig. 37. Still higher above, at the point of the capsule.

Fig. 33

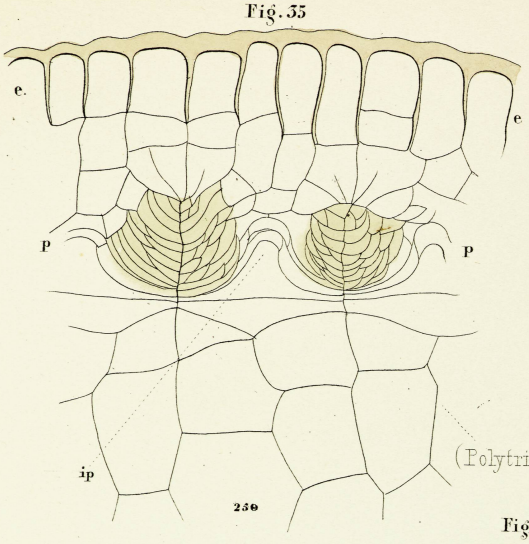
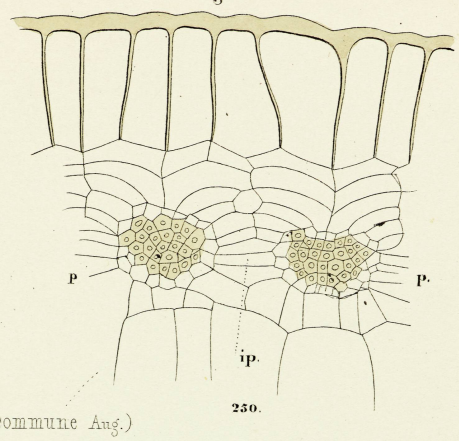
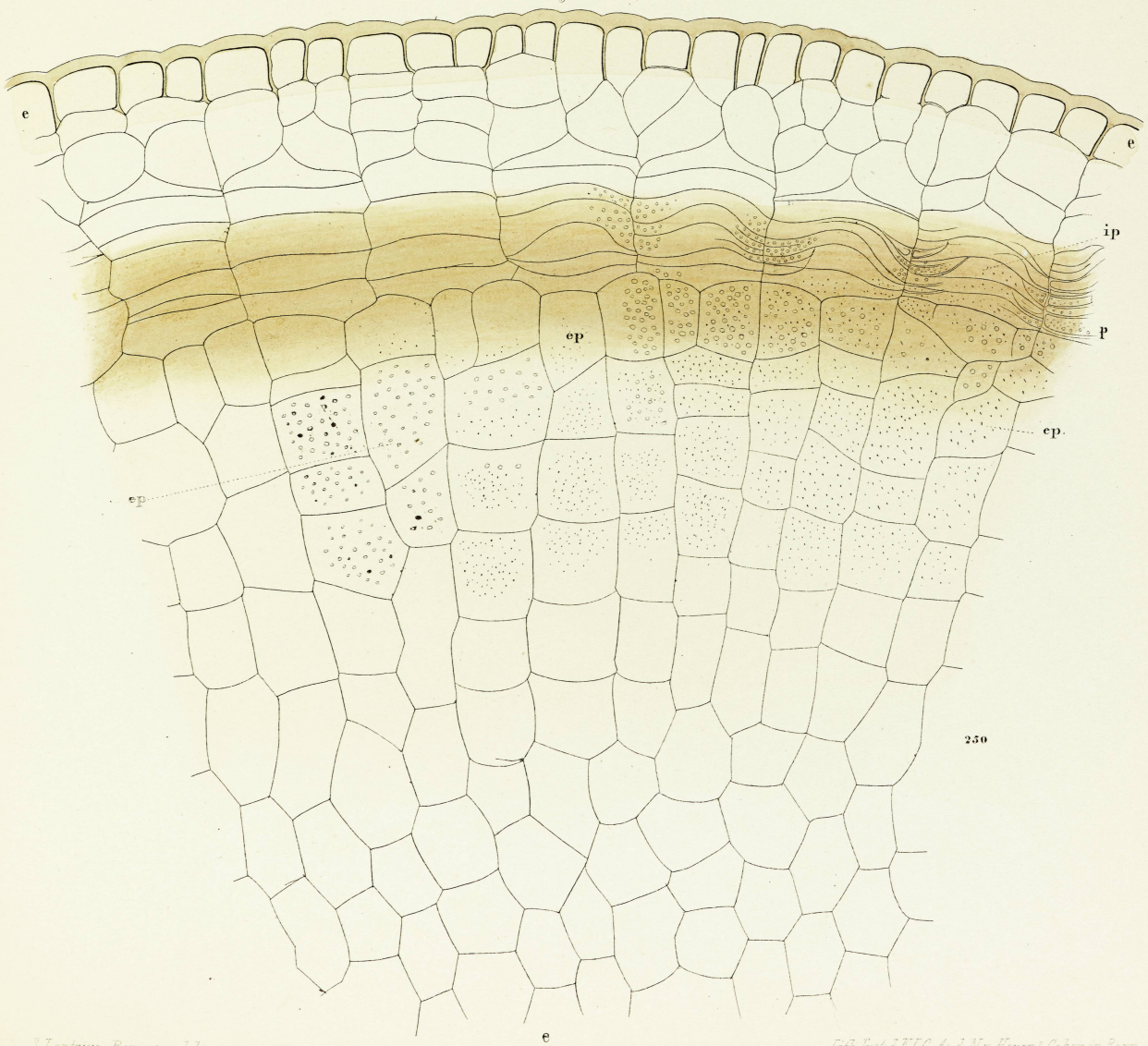


Fig. 34.



(Polytrichum commune Aug.)

Fig. 36.



S. Lantzius-Beninga del.

Lith. Inst. d. K.K.C. Ac. d. W. v. Henry v. Ochsenius in Bonn.

Tables LXVI and LXV.

Fig. 33.-37. Transverse sections of capsules of the same moss and the same magnifications.

Fig. 33. At the base of the peristome, Fig. 34. At the middle of the peristome, Fig. 35. At the point of the peristome, and Fig. 36. of immediately above the peristome; Fig. 37. Still higher above, at the point of the capsule.

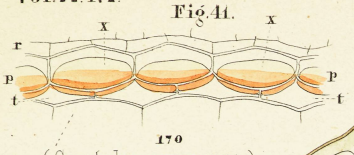
Table LXVI.

Fig. 39. Part of a transverse section of peristome teeth of a capsule of *Polytrichum urnigerum*, magnification x 500.

Fig. 40. Part of a transverse section of *Ceratodon purpureus,* cut in the middle of the peristome, magnification x 170.

Fig. 41. Transverse section of the base of the peristome of *Ceratodon purpureus* at *xx* where it is not yet separated in two cords as it is the case in Fig. 40. Both figures are drawn by a magnification x 170.

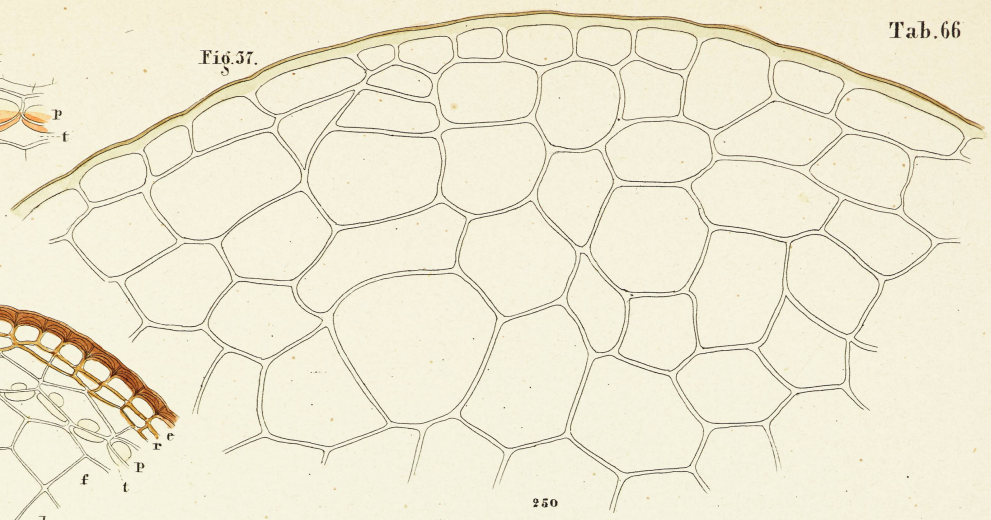
Fig. 41.



170

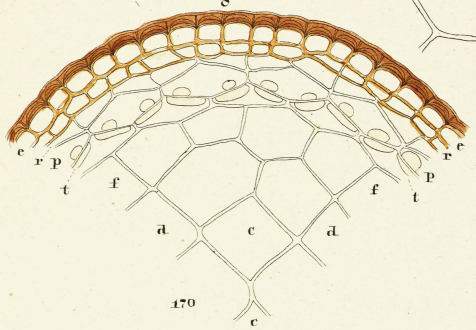
(Ceratodon purpurans.)

Fig. 37.



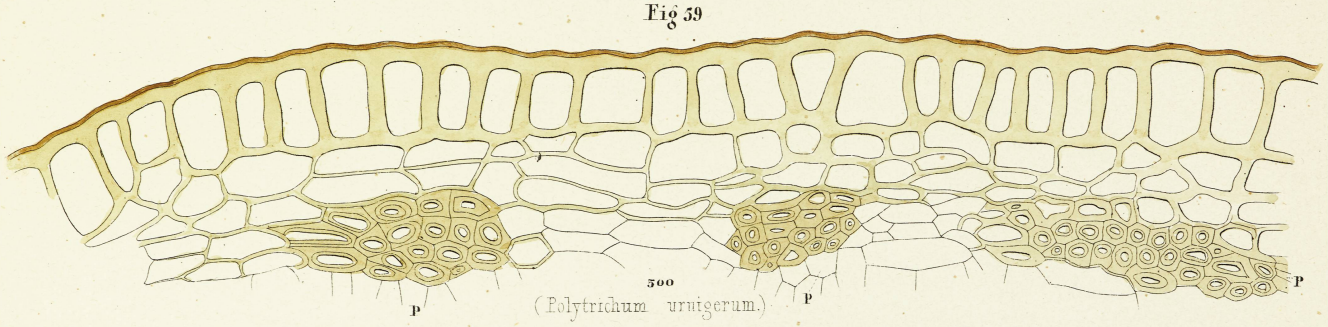
250

Fig. 40.



170

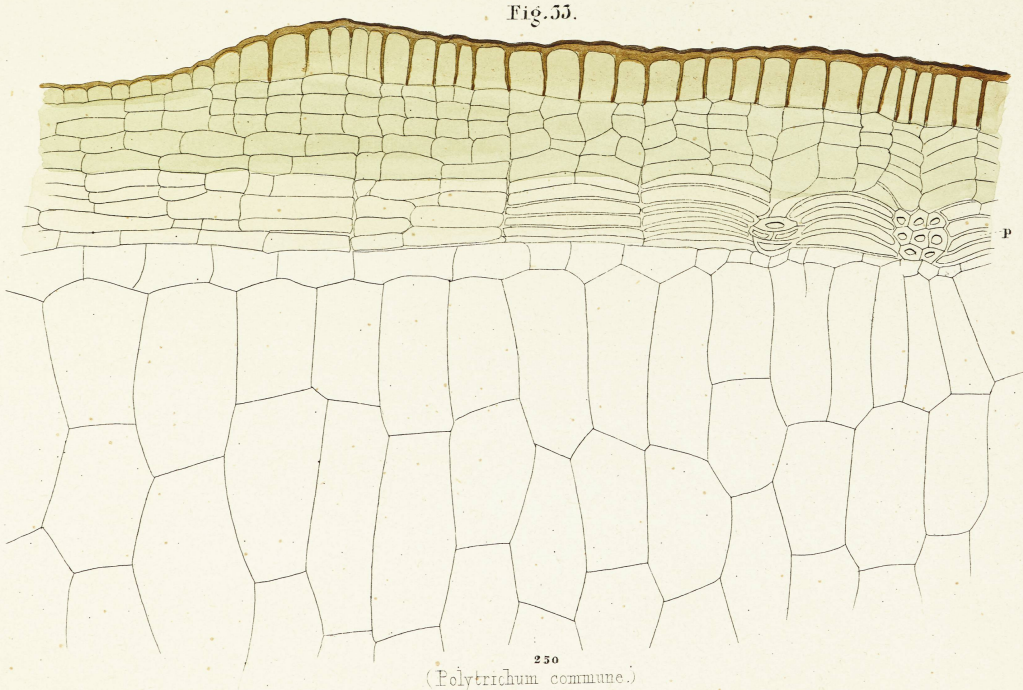
Fig. 39



500

(Polytrichum urnigerum.)

Fig. 35.



250

(Polytrichum commune.)

S. Lantzius-Beninger del.

Lith. Inst. d. K.L.C. N.v. Hermyr & Cohen in Bonn.


Meyn, Berlin.

BIELEFELD, R. (1897). Georg Boyung Scato Lantzius-Beninga. *Abhandlungen herausgegeben vom Naturwissenschaftlichen Verein zu Bremen* 15: 148-155, 1 Fig.

Georg Bojung Scato Lantzius-Beninga

By Rudolf Bielefeld, Norderney.

(With portrait)

G. B. Scato Lantzius Beninga descended from the old East-Frisian family of Lantzius-Beninga's, from which came different, excellent personalities. In the East-Frisian Geest landscape, three hours south of the pretty, small country town of Aurich is situated, surrounded by splendid forests of leafy trees, the idyllic estate Stiekelkamp, in the first decades of our century, run by Lantzius-Beninga's father, the chief forester G.B.S. Lantzius-Beninga, and the estate is still now in possession of the family Lantzius-Beninga. Here Georg Boyung Scato Lantzius-Beninga was born on the 12th of August 1815.

In his earliest youth this youngest son was extraordinarily delicate and, of all his brothers and sisters, the problem child of his loving parents. And, with a visible success, they looked after the delicate little boy. Nonetheless this slowly evolving boy learned to walk only in his seventh year. Hence the first and worrying phase of his physical development had come to an end. And now, in spite of his weakly built body, the intellectually evolved boy could not be fenced within the parental home. He would get out, this little young man: get out into the garden overgrown with marvellous beeches and firs, get out into the splendid, small wood surrounding the paternal estate, as it still is in our days. The parents' greatest wish was to take care of their small and delicately built son in their home for as long as possible; therefore they assigned him a competent, cheerful, private tutor to give him the first basic rudiments of human knowledge. In their free time they wandered through the woods and bushes to listen the singing of the birds in the forest, which interested Scato – it was his affectionate name. They roamed through the Heseler Gaste, situated south of Stiekelkamp, equipped with a net to catch butterflies or a specimen box (Botanisierbüchse), or as well, through the extended heathland, situated in the west, to capture the cheerfully fluttering butterflies, or to surprise a viper or to take home Flora's children.

At home, conducted by the well-informed teacher, the caught butterflies were spread out and, step by step, joined to form a small, pretty collection; in the same manner, through the installation of an herbarium, a promising and encouraging beginning was fashioned. All this was a great joy to the pupil, gifted with a good eye, and already in the very first stages of his intellectual development the sense for the later study of natural sciences was evoked.

Systematic physical exercises strengthened the will, and the many tiring excursions in the forests, the meadows and the heathlands helped the feeble boy such that, finally in his twelfth year, he safely could be sent to the grammar school after an adequate intellectual preparation. In the year 1827 he went, accompanied by the best wishes of his tenderly loving parents, to

the little town Norden to become a pupil of the local Gymnasium. Later on, from there he went to Aurich to the local grammar school, the Ulrichs-Gymnasium. What nature, so to speak, initially had missed in the evolution of the assiduous boy, now, relatively rapidly, caught up. At both schools the lessons evoked much pleasure for the boy eager to learn, the reason why Lantzius developed a great enthusiasm with which he won the love and affection of his teachers. Also unfamiliar to the young East-Frisian was the all glaring pushiness that had nothing in mind other than its own egoistical purposes. His open and frank straightness was not only not held against him but brought him the friendship of his school friends, as well as the respect of the teaching staff.

Starting in Aurich, often alone or in company with friends, he made botanical excursions to the nearby Eikebusch or the marvellous Egelser Forest. By this many-fold way he acquired a sound intellectual basis for his future studies, and also by physical exercises, and the often undertaken botanical strolls, he usefully supported his physical development; nevertheless he remained of a faintly noticeable small stature.

After the leaving of the Ulrichs-Gymnasium at Aurich he went to the royal seat of his Hannoverian fatherland to matriculate at the Polytechnikum. There he eagerly strived to follow his scientific studies, and the *deutsche Jugendfröhlichkeit* came into its own, too. Shortly afterwards, in his native country, he completed an apprenticeship as a pharmacist, and for a year, himself became assistant of the pharmacist in the village of Timmel nearby his parental home. After living the quiet rural life far from society, he wished to go back to the freshly pulsating life of the academic world. So he went (1840) to Berlin to the University to devote himself entirely to his beloved studies, the Natural Sciences. After the second semester, however, in the year 1841 he exchanged the Berliner Hochschule for the Georgia Augusta in Göttingen where he applied himself to botanical studies only. Particularly, he turned his attention to the investigation of cryptogams, and within them especially to the leafy mosses. The fruit of this serious work was his Inaugural-Dissertation, on the basis of it he was promoted to the degree of Doctor in Easter 1844; the title is: *"De evolutione sporidiorum in capsulis muscorum".* (Gött. 1844. 4). Two years later (1846) he habilitated there as a Privatdozent of the Faculty of Philosophy.

The first work published by Lantzius, which drew the attention of the scientific community to him, was the "Beiträge zur Kenntniss der Flora Ostfrieslands"; (Göttingen, by Vandenhoeck und Ruprecht, 1849). By commission of the Committee of the University in the spring and summer of 1847 Lantzius travelled the East-Frisian peninsula, and partly, the offshore group of islands, for the purpose of floristic research. The results of these systematically planned investigations had been put down in those contributions, originally drawn up only as a research report for the Royal Hannoverian Ministry of the Interior, but now, upon its request, printed in the format of Meyer's "Chloris Hannoverana" (Göttingen, by Vandenhoeck und Ruprecht, 1836) and made available to the general public. Observations, made later on by other botanists, revealed the extraordinary expert knowledge, reliability and care of this East-Frisian expert.*).

*) Compare C. Nöldeke: Flora der ostfriesischen Inseln, in the III. Vol. of these publications, and Fr. Buchenau: Kritische Studien zur Flora von Ostfriesland, in this part p. 82 ff.

On his strolls he often visited dear friends, and when he found interest in botany, he liked to speak about the results of the excursions in the nearby region. Especially he liked the dear home of his friend and teacher H.J. Sundermann in Hesel, a well-known Pestalozzian, who at that time had an extraordinary, extensive knowledge, and for decades was the leader of the East-Frisian teachers. So far as the very occupied Sundermann could find some time, he accompanied Lantzius on his strolls in the vicinity of Hesel. After their return, either to the teacher's home in Hesel, or to the paternal home in Stiekelkamp, just an hour away, the finds were carefully examined, listed and laid in a sleeve. Also compiled was a list of rare plants found in the area of Hesel, written by Lantzius himself. I could see the original. With his friend Sundermann he discussed repeatedly the edition of a Flora of East-Frisia, but the plan unhappily was not realised because in later years Lantzius was very occupied and these other occupations prevented a further botanical exploration of his native East-Frisian country. The herbarium, installed during his expedition through East-Frisia in the year 1847, and containing all specimens according to his statements, is in the collections of the Georgia Augusta in Göttingen.

Later on, in addition, he wrote the statements for the Flora of Norderney for the small work "Die Insel Norderney" edited by Dr. Riefkohl in the year 1861; however, the list has been "revised" by an unknown and totally incompetent hand who introduced incorrect statements which considerably diminished its value.

By his scientific research, showing a wide expert knowledge, the young scientist soon became known. Thus the *Naturforschende Gesellschaft in Emden* (East-Frisia) appointed him on the 21st February 1850 to its corresponding honorary member; he belonged to this organization until his death. But a much greater recognition was given to Lantzius the 15th May 1855 with the presentation of the diploma of the *Kaiserliche Leopoldinisch-Karolinische Akademie der Naturforscher,* which, at that time, flourished under the chairmanship of Nees von Esenbeck; with the presentation of the diploma to Lantzius, the society was never to regret his admission as member and collaborator. In the year 1850 he became Assistant of the Herbarium of the University in Göttingen; and on the 27th September 1852 the Philosophical Faculty of the Georgia Augusta appointed him as Assessor.

In the second part of the 22. vol. of "Nova acta", edited by the Leopoldina, Lantzius published the results of his investigations on the moss capsule under the title: *Beiträge zur Kenntniss des innern Baues der ausgewachsenen Mooskapsel etc.* In this paper the researcher really demonstrates his profound insight in his field and the extraordinarily precise investigations of the objects, and moreover, his exact knowledge of the cryptogams often evoked by his students astonishment and great surprise. The 11 lithographic print tables, with 41 figures, added to the work are real works of art, all drawn after nature by the author himself. Introduced in the text are critical comments concerning "Bryologia Europaea" of Bruch and Schimper with indications of frequent superficialities, many errors and inaccuracies, in contrast to the results found by himself, and on the basis of the research results of the perspicacious Robert Brown. Thanks to the author's precision, despite the decades passed since the publication of these contributions, even today they show an unreserved scientific value.

In the last decade of his life the tirelessly employed man was occupied with his work, of which, unhappily, only the first part was finished. Its title is the following: *Die unterscheidenden Merkmale der deutschen Pflanzenfamilien und –Geschlechter*. Erste Abteilung. Göttingen 1866. Verlag von Albert Rente". As all sound scientific works, this work also has a history. Some years earlier Lantzius fulfilled the wish of his students and published the lithographed tables of the Central German plant families and genera, usefully elaborated for the lessons by himself. These tables had been revised, essentially augmented, and explanatory illustrations of the family - and sexual characteristics added. Thus a work was created, distinguished by the restriction to that which is worth knowing and leaving aside all useless and superfluous elements. The illustrations, splendid and exact, had been engraved by the author on stone, and mostly after nature. The text, in the form of tables, is excellent in its clarity and compactness.

By his research, several times Lantzius came to new views, deviating from traditional opinions; but he did not look for pride in new names as other botanists. He introduced only one new genus *(Echinanthriscus);* the reasons are given in the introduction. Given the expert knowledge of the author, it could be expected that the work is up-to-date regarding the clarity of the tables, the understandable mode of expression, and the exemplary, instructive illustrations.

Therefore, many people encouraged him to publish the second part soon. Unhappily this was not granted to him; the inexorable death put a limit to his work. –

As an author and also as an academic teacher he was a person of great talent and diligence. His lectures were frequented, just as those of the two other botanists working at the University of Göttingen (Profs. Giesebach and Bartling). In the years between 1845-1870 nearly all the pharmacists from the kingdom, later the province of Hannover, sat at his feet. And not only their attention, no, their heart, too, they must give to him as soon as they came into contact with him. And how stimulating and interesting were the excursions he undertook with his students in the splendid area of Göttingen, provided with a rich flora! Several seniors, their eyes sparkling with joy, told me about the delightful hours they spent on these botanical strolls side by side with the highly respected and beloved teacher.*) But he was not only their teacher, but also their loyal friend and advisor. How sorry was he about a failed examination. With the most friendly care and real paternal fidelity he supervised those examination candidates that had to be examined during the German-French war and were then called up to arms. They all passed. He had not only a profound scientific formation but also a true nobleness of heart that was one of his most outstanding characteristics. As an East-Frisian he was a man of an unshakable honesty and often of a Germanic rough straightness, driving him at times to rash comments and frankness.

As everywhere, also here, existed unfeeling gossips, and consequently the colleagues of the Georgia Augusta by no means brightened up his life. Especially Hofrat Professor Dr. G. F. W. Meyer, very favoured by the Hanoverian court, was the most powerful and influential

*) I too, with hearty thankfulness, remember the academic lectures I had with Lantzius in the years 1850 and 51, and of the warm interest that he showed in me since.

Fr. Buchenau.

opponent, for a short time, working together with him at the Göttingen University. The beginning of the discord can no longer be disentangled; but already in the first years of Lantzius' academic teaching the relationship between both was anything but friendly. This is already visible in unequivocal plainness of the comments made by Hofrat G. F. W. Meyer in the preface (pages XIV-XVII) of his *Flora Hanoverana excursoria* (Göttingen, Vandenhoeck und Rupecht, 1849) on the *Beiträge zur Flora Ostfrieslands* of Lantzius, published in the same year, recognizing, however, that the *Beiträge* "demonstrated powerful expert knowledge and, what says more in our time, an honest striving for truth". These last words of Hofrat Meyer sound very strange because it is a well-known fact that in Meyer's *Flora Hanoverana* the localities etc. are often revealed to be unreliable. Therefore Hofrat Meyer is criticized*) in the botanical literature whilst the florists unanimously and unreservedly recognize the reliability of Lantzius' statements. Because of these highly unedifying relationships, in spite of his competence, recognized even by the opposing side, and his colleagues, Professor Dr. Grisebach and Professor Dr. Bartling, Lantzius had been recommended nowhere and remained for the rest of his life at the Georgia Augusta. During the period of office of King George V nobody considered awarding him a professor's chair. His students interceded on his behalf – without the suggestion of the man of unblemished honour that he was – with the committee of the University of Göttingen to promote him to a professor, but with a quite strange success. In the No. 12 of the IV. year of the 'Pharmaceutische Wochenschrift' (Speyer) of the 25th March 1871, we can read, in a short obituary at the death of Lantzius-Beninga: "Obviously his scientific activity, besides his extensive teaching, was restrained by the fact that he missed always the encouragement during the period of office of Ernst August and George V and of the Committee of the University. Nevertheless that most of the students in Botany attended his lectures the authorities could not decide to promote him to an associate professor. Therefore he spent nearly a quarter of a century as Privatdocent and assistant at the herbarium of the University, and later on as Assessor of the Philosophical faculty at the University. As the character of the *Welfentum* and their ministries may predict that the reason of this noticeable disregard of a great work can be found in the political and national conviction of the deceased and of which the through and through honourable man never made a secret. The injustice committed was to such an extent that, even under the rule of Borries, the students of the deceased could not fail to ask the Committee of the University for the appointment to an Extraordinary professor, but the consequence for the candidate was that the non-fixed part of his salary was withdrawn. Thanks to the ministry of Mühler the long lasting injustice against Lantzius found an end by the appointment at first to a member of the pharmaceutical examination commission and then to an extraordinary professor. In this position he was active at the University scarcely still nine month." –

At the end of January 1871 he fell ill with a malicious abscess in the armpit, ending with his death. He died after six weeks of a painful illness the 6th March 1871. At his grave stood his deeply distressed widow and six children (four sons and two daughters), for them he always

*) Compare also Professor Dr. Buchenau, Flora der nordwestdeutschen Tiefebene (Leipzig, Engelmann. 1894) preface, page IX and there: Kritische Studien zur Flora von Ostfriesland, in this issue p. 82 ff.

was a careful husband and father. Also his life as an academic teacher has been spoiled by unjustified neglect, all the more so his family life was a happy one. His wife, loyally loving him and his good children, knew how to drive away the cares. The eldest son went to sea and became a Ships Officer; the second one attended to Business science and lives now as businessman in Melbourne; the third one studied in Boston, was promoted there and became a doctor in Massachusetts where unhappily, already in 1894, he followed his father to the grave. The youngest of the sons studied at German Universities, after his promotion became first Executive Doctor of a Psychiatric hospital, and later on family doctor in Eltville on the Rhein where he is working, to great benefit, still today.

With Lantzius-Beninga passed away, a life full of work and full of the undaunted idealism, a markedly distinctive personality with real German qualities, a highly talented man of science whom, under favourable circumstances, would have had much more influence. But the position appropriate to his faculties was withheld from him by obstacles put in his way by unpopular persons. Several of his contemporaries have badly sinned against this man. May, therefore, the posterity bearing in mind the sad injustice, and grant him now the place in the genealogical table of the human mind which is due to him and rightly so! We East-Frisians will always regard him with justified pride as one of ours; he was a man who, even as a fine representative of the sciences, never denied his Frisian qualities, and remained faithful to his dear native country. Therefore honour to his memory! "Wohl dem, der seiner Väter nicht vergisst, der, froh von ihren Thaten, ihrer Grösse den Hörer unterhält und, still sich freuend, ans Ende dieser schönen Reihe sich geschlossen sieht!" §.

§ The latter quote originates from Johann Wolfgang von Goethe, *Iphigenie auf Tauris* I. 3. (1786) (eds.).